



OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.



DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact <u>publications@unido.org</u> for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

2.2.058



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Conversion of Prototypes at Electro Still Co.

UNIDO PROJECT NUMBER MP/IRA/97/196

CONTRACT NUMBER 98/071P



OCTOBER 1998

AL



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Table of Contents

Section I

- 1- Synopsis
- 2- General Background
- 3- Electrosteel Background
- 4- Project Objectives
- 5- The Aim of Project
- 6- Scope of the Contract

Section II

- 1- Refrigeration Load Calculation for Water Cooler and Chest Freezer and Display Cases.
- 2- Transmission Load
- 3- Product Load
- 4- Internal Load
- 5- Infiltration Load
- 6- Total Refrigeration Load

Section III

1- Refrigeration Load Calculation for Water Cooler

Section IV

- Heat Leak Load Calculation of Prototypes
- 2. Compressor Selection
- 3. Saturation Properties Comparison Table of R12 & R134a



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

- 4. Load Calculation for Water Cooler Model EL-WC18
- Total Load for Water Cooler Model ELC-WC50C
- Load Calculation for Water Cooler Model ELC-WC50T
- 7. Total Load for Chest Freezer Model ELS-CF50
- 8. Load Calculation for Chest Freezer Model ELS-CF750
- Total Load for Chest Freezer Model ELS-CF220
- Load Calculation for Upright Show Case ELS-1889V
- 11. Total Load for Upright Show Case Model ELS-1982
- Total Load for Show Case ELS-1982 Model ELS-260-3F
- Total Load for Show Case ELS-1982 Model ELS-220-3F
- 14. Total Load for Show Case ELS-1982 Model ELS-1219F

Setion V

Activities

1. Training

Main Topics of the training course

- 1- Ozone Layer
- 2- Montreal Protocol
- 3- Implementation of CFC phase out
- 4- CFC altternatives
- 5- Introduction to R134a Refrigerant
- 6- Conversion of Prototypes
- 7- Refrigeration Load Calculation
- 8- Component Selection
- 9- Testing Prototypes
- 10- Trial Tests
- 11- Obtaining data from the test results
- 12- Test Results Analysis
- 13- Trial Production



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

14- Mass Production

- 2. Selection of Components
 - 1- Compressors
 - 2- Refrigerasnt Charge
 - 3- Capillary Tube Length
 - 4- Evaporator and Condenser
 - 5- Making Prototype



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

SECTION I

Synopsis

UNIDO's Project no. MP/IRA/97/196 was nominated by UNIDO to phase out ODS in the first group of Iranian Commercial Refrigerator Manufacturers. This project will be implemented in four major companies, Electrossteel, Zagross II, Yakhsaran, and Yakh Chavan.

General Background

This contract was achieved based on the UNIDO's request for proposal no. P.98/32 dated 24 February 1998, our proposal no. ANA/PRP/ES/01 and relevant terms of reference prepared by UNIDO and the requirement of Islamic Republic of Iran. The project will phase out, use of CFC11 and CFC12 for the production of Commercial Refrigerators in Four Refrigerator Manufacturers in Iran. The redefinition of the existing refrigerator models in these companies (Electrosteel, Zagross II, Yahksaran, and Yakhchavan) covers activities such as calculation and refrigeration system components selection



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Electro Steel Mfg. Co. Background

Electro Steel is a private company located in the Mashahad employing 150 personnel, it was established in 1977 and manufactures a wide range of commercial refrigeration equipment.

The company is wholly Iranian owned and all products are manufactured and sold in Iran.

- Iceland-type display case,6 and 12 m length
- Display cabinets for bakery products
- Open-type multi-deck cabinet, up to 3 m length, 2 m high
- Sales chilled display cabinet
- Chest freezers, 3 models
- Drinking water cooler, 3 models
- Milk coolers, 2,500 to 6,000 liters
- Sandwich panels, 2.7 to 12m length
- Cold chambers and cold stores



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of CFC-11 and CFC-12 in the production of commercial refrigeration equipment at Electro Steel through conversion to the use of HFC 134a as refrigerant for the cooling system and Cyclopentane as blowing agent for the polyurethane insulation foam.

The Aim of Project

The aim of the project is design, calculation and drafting for model redefinition of eight different models of commercial refrigerators and freezers as follows, i.e., to calculate the cooling capacity and selection of the cooling units of all models so that they could run the new ozone friendly refrigerant R134a instead of the ODP active CFC-12.

- 1) Ice-land Display one model.
- 2) Display Cabinet for Bakery
- 3) Open Type Multi-deck Cabinet
- 4) Sales Chilled Display Cabinet
- 5) Chest Freezers
- 6) Drinking Water Cooler
- 7) Milk Cooler
- 8) Cold Chamber

The Scope of the Contract

 A study has been made of eleven models manufactured by Electro Steel on;



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

- 1) Dimensional specifications
- 2) Type and insulation thickness
- 3) Refrigerating unit component details
- 4) Working performance
- 5) Energy Consumption
- 6) Optimization of R134a Refrigerant
- Selection of <u>HFC-134a</u> compatible components.
- Redesigning of the complete refrigeration circuit.
- Specifying necessary change in the cooling system if required.
- Preparation of one prototype per model.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Refrigeration Load Calculation for Water Cooler and Chest Freezer and Display cases

Refrigeration load consist of three individual components:

- 1- Transmission load;
 Heat transfer through side walls by conduction
- 2 Product load;
 Heat Removed from and produced by the products which are stored.
- 3 Internal load; Heat produced by internal sources such as lights, fan or heaters;
- 4 Infiltration load

 Heat gains associated with air entering the refrigerated space and door opening and etc.;

In this section, the above mentioned components will be discussed separately to analyze and extract the most useful and practical equipment's.

Transmission Load

Heat gain through walls of a refrigerated space depends on cabin Temperature, liner, insulation and cabin conductivity and also the surrounded ambient air. In other word, there are four different resistance opposing heat flows between cabin space and ambient air as given in resistance circuit.

Considering the above mentioned resistance, Rl, Rc and Ra are not comparable in magnitude with Ri (Insulation resistance) and so can be neglected in our calculations. Therefore, the resultant circuit and related equations is.

$$R = \frac{x}{KA}$$
 Heat Resistance

$$Q_{\tau L} = \frac{\Delta T}{R}$$
 Heat Transfer



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Where:

x = Insulation Thickness, mm

K = Insulation Conductivity, $\frac{Wmm}{m^2 \cdot C}$

A = Outside Area, m^2

 ΔT = Temperature difference (T_a - T_c), C

If the insulation thickness of side walls, back panels, top, bottom and door are different. Heat transfer for each part can be calculated separately and then summed for freezer and refrigerator compartments as necessary, heat transfer for each compartment should be calculated separately and then added together.

Product Load

Heat removed from products (meat, fruits, vegetables, water and etc.) to reduce temperature from receiving to storage temperature is known as product load. Following steps can be taken to calculated of product loads.

 $1\,$ - Heat removed from initial temperature (T_i) to storing temperature (T_{rs}) in refrigerator compartment is;

$$Q_{rs} = \dot{M} C (T_i - T_{rs})$$

Where:

 \dot{M} = Mass of product, Kg/h

C = Specific heat of product, Kcal / Kg

2 - Heat removed from initial temperature (Ti) to freezing temperature (Tf) is

$$Q_{af} = \dot{M} C (Ti - Tf)$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Where:

 \dot{M} = Mass of product, Kg/h

C = Specific heat of product above freezing point, Kcal / Kg

3 - Latent heat of fusion for products is equal to;

$$QL = \dot{M} h$$

Where h = Latent heat of product, Kcal / Kg

4 - Heat removed from freezing temperature (Tf) to final storage temperature (Tfs) is;

$$Q bf = M Cbf (Tf - Tfs)$$

Where:

C_{bf} = Specific heat of products below freezing temperature.

For upright freezers or chest freezer, total product load is

$$Q_{pl} = Q_{af} + Q_l + Q_{bf}$$

For storage products to some lower temperatures above freezing temperature in refrigerator display cases compartment is;

$$Qpl = Qrs$$

Internal Load

Electrical energy dissipated in the refrigerated space such as lights, fan motors, heaters, should be calculated as appropriate depending on type of display cases and other products.

Infiltration Load

Infiltration air load is the heat transfer due to exchanging of refrigerated air with ambient caused by opening of the door or leakage through the gasket area and /or



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

open top freezer of show cases. Infiltration load is one of the most important load components.

Total Refrigeration load

As it was mentioned before, transmission load (Q_II), product load (Q_PI) and internal load (Q_IL) can be calculated separately. For infiltration load (air exchange through doorways or gasket leakage), we have to take into account that depending on the type of models we have to consider different amount of heat gain, or a percentage of amount of the above mentioned components. (Transmission load, product load and internal load). For example;

 $Q_{TL} = 1.20 (Q_{TL} + Q_{PL} + Q_{TL})$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Refrigeration Load Calculation for different type of Water Coolers

Water cooler cabinet usually consist of a sheet metal housing built around a steel framework, inside this sheet housing there is usually a condensing unit, located near the floor, and above this is the water-cooling mechanism. The latter is the only part insulated (foamed plastic) from the room. The insulation is usually specially formed and between one and one half inches and two inches thick. These cabinets are made in such a way that one or more sides may be easily removed to gain access to the interior. The basin of the water cooler is generally made of porcelain-coated cast iron, porcelaicoated- steel, or stainless steel. Heat exchangers are frequently used on water coolers. These make use of the low temperature of waste water and the suction line to pre-cool the fresh water line to the evaporator coil.

Self-are of two types,

- 1- Bottle Type.
- 2- Tap water type

The bottle cooler usually uses a 20 to 25 liter bottle of water inverted on the top of the cabinet. Overflow and drain water are stored in a container built the cabinet. These coolers use air-cooled condensing units exclusively. They are used where water and drains are not available or where available the plumbing insulation may be expensive.

Water cooler using a plumbing supply and drain connection, must be installed according the relevant approved standards. The plumbing should be concealed, a hand shutoff valve should be installed in the fresh water line. Drain pipe at least 1 ½ inches in diameter provided, and rubber opening must be above the drain in such a way as to eliminate the chance for accidental siphoning of the drain water back into the fresh water system. The tap water models use variety of evaporator coil wrapped around the water-cooling tank.

Temperatures of the cooling water are variable depending on the persons who are drinking the water. We consider 10 C for the temperature of drinking water, while our inlet temperature is considered 24 C.

In large business establishment, in office buildings, or in factories, multiple water cooler, instead of individual ones, are popular. These coolers have one large condensing unit supplying many bubblers and these may be of many different types.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Water cooler is a device that usually is used in the public area to supply cold drinking water to the customers and different people. The appliance is mainly used in the Airports, Railways Station, Coach Terminals, Banks, Offices, Parks, and etc. therefore, it is hard to specify an standard for cold water consumption during the day from the water cooler.

We consider three refrigeration load components that should be taken into our consideration.

- 1- Heat gain by heat transmission from, main water storage tank wall insulation.
- 2- Heat removed from water entering to the water tank at the initial refrigeration system operating condition, (water stored in storage tank during the night, with normal ambient temperature) which is divided by 24 hrs.
- 3- Heat removed from Drinking Water flow that are consumed during designated operating hours " \dot{M} "

The problem of determining the refrigeration load of a water-cooled installation is basically a specific heat and heat leakage problem combination. The water is cooled to temperature which vary upward from about 4 degree centigrade, and the amoun heat removed from the water to cool it to a predetermined temperature is simple specific heat problem. The water, being maintained at these low temperature, results in a heat leakage from room into the water, and this part involves the heat leakage portion of installation.

$Q_1 = m C \triangle T$

Where:

Q₁ Total heat removed from total drinking water tank volume capacity (lit.) during specific period, related to compressor cooling capacity power in Watts, at initic compressor start up, and early in the morning. When the water temperature is 30 C.

m total weight of water in the water cooler storage tank in Kg. Considering th one litter of water at 24 C is equal to approximately one Kg.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

C Specific heat factor of water in Kcal/Kg °C

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water.

$$\mathbf{Q}_2 = \dot{M} \mathbf{C} \triangle \mathbf{T}$$

Q₂ Total heat removed from total drinking water flow (lit.) during specific period, 16 hours. In Kcal.

M total weight of water flow during 16 hours. in Kg.

C Specific heat factor of water in Kcal/Kg °C

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water temperature.

$$Q_3 = UA \triangle T$$

Where:

- Q3 Total Leak, gained through side wall of drinking water storage tank by conduction in Kcal..
- U Heat Resistance Coefficient Factor in Kcal/Sq. mt. C
- A Total Area which heat is transmitted by. In Sq. Mt.
- T Temperature difference (Ta Tc), where, T is ambient temperature, and Tc is final cooled water temperature.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Section III

Heat Leak Load Calculation of Prototypes

Calculation of refrigeration load is the basis for selecting system equipment. First step is selection of a suitable compressor with cooling capacity comparable to calculated load, then a capillary tube should be selected so that the compressor and tube fix a balance point at the desired evaporating temperature, also two evaporator and condenser should be selected to balance compressor capacity.

Compressor selection

Assuming 16 hours daily operating time for the compressor, the calculated refrigeration load will be modified to:

$$Qc = \frac{Q_{TL \times 24}}{16} = 1.5Q_{TL}$$

Where:

Qc = required cooling capacity

Saturation Properties Comparison

			R12					R134a		
Temp C	P Kpa	Entholpy Kj/Kg	Entholpy Kj/Kg	Sp.Vol Lit/Kg	Sp.Vol Lit/Kg	P Kpa	Entholpy Kj/Kg	Entholpy Kj/Kg	Sp. Vol Lit/Kg	Sp.Vol Lit/Kg
		hſ	hg	Vf	Vg		hf	hg	Vſ	Vg
-30	100.41	172.81	338.14	0.672	159.37	84.36	61.51	277.208	0.7100	0.2219
-26	118.72	176.38	339.96	0.677	136.28	101.65	66.56	212.96	0.7171	0.1868
-22	139.53	179.96	341.78	0.682	117.16	121.62	71.63	281.86	0.7243	0.1570
-18	163.04	183.56	343.58	0.688	101.24	144.56	76.72	284.19	0.7318	0.1313
-14	189.50	187.18	345.36	0.694	87.89	170.76	81.84	286.52	0.7396	0.1138
-10	219.12	190.82	347.13	0.700	76,64	200.51	86.98	288.85	0.7475	0.0941
-6	252.14	194.47	348.88	0.706	67.11	234.13	92.162	291,18	0.7558	0.0843
-4	270.01	196.31	349.75	0.709	62.89	252.49	94.76	292.35	0.7600	0.0784
-2	288.82	198.15	350.61	0.712	58.99	271.94	97.377	293,522	0.7643	0.0730
0	308.61	200.00	351.47	0.715	55.38	292.52	100,00	294.68	0.7687	0.0681
2	329.40	201.85	352.33	0.719	52.04	314.27	102.63	295.35	0.7732	0.0635
4	351.24	203.71	353,17	0.722	48.94	337.24	105.28	297.01	0.7777	0.0594
6	374.14	205.57	354.02	0,726	46,07	361.47	107.93	298017	0.7823	0.055:
8	398.15	207.44	354.85	0.729	43.40	387.01	110.60	299,33	0.7870	0.0520
10	423,30	209,32	355.68	0,733	40.91	413.90	113.29	300.49	0.7918	0.048



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Load Calculation of Water Cooler Model EL-WC18

1-

$$Q_1 = m C \triangle T$$

Where:

Q₁ Total heat removed from total drinking water tank volume capacity (lit.) during specific period, related to compressor cooling capacity power in Watts, at initial compressor start up, and early in the morning. When the water temperature is 24 C.

M total weight of original water in the water cooler storage tank in Kg. Considering that one litter of water at 24 C is equal to approximately one Kg.

$$M = 4.5$$
 liter = 4.5 Kg.

C Specific heat factor of water in Kcal/Kg $^{\circ}$ C = 1

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water.

$$Ti = 24$$
 °C and $Tc = 10$ °C

$$Ti - Tc = 24-10 = 14$$
 °C

$$Q_1 = m C$$
 $T = 4.5 \times 1 \times 14 = 63 \text{ Kcal} = 63 \times 1.163 = 73.3 \text{ Watts/24 hrs}$

 $Q_1 = 73.3 / 16$ water cooler operating time per day = 4.6 Watts

$Q_1 = 4.6 \text{ Watts}$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

2-

$$\mathbf{Q}_2 = \dot{M} \mathbf{C} \Delta \mathbf{T}$$

Q₂ Total heat removed from total drinking water flow (lit.) during specific period, 16 hours. In Kcal.

M total weight of water flow during 16 hours. in Kg. = $H \times N \times M$ for office building with 20 employees, where:

H = Total Water Cooler Usage Time (Hours) = 16

N = Number of person at the office = 20

M = 400 cc of water per person per hour (including waste water)

$$M = 0.4 \times 20 \times 16 = 128 \text{ lit.}$$

C Specific heat factor of water in Kcal/Kg $^{\circ}$ C = 1

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water temperature.

$$Ti = 24$$
 °C and $Tc = 10$ °C

$$Ti - Tc = 24-10 = 14$$
 °C

 $Q_2 = m \ C \quad T = 128 \ x \ 1 \ x \ 14 = 1792 \ Kcal = 1792 \ x \ 1.163 = 2084 \ Watts/16 \ hrs$

 $Q_2 = 2084/12$ compressor operating time per day = 173 Watts



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$Q_2 = 173.7 \text{ Watts}$

3-

$$Q_3 = UA \triangle T$$

Where:

- Q3 Total Leak, gained through side wall of drinking water storage tank by conduction in Kcal..
- U Heat Resistance Coefficient Factor in Kcal/Sq. mt. C

$$U = \frac{1}{x_{K}} = \frac{1}{0.05_{0.019}} = 0.38 \, \frac{K \, cal}{m^{2}}. \, ^{\circ}C$$

A The water storage tank is considered as cylinder with 32 cm diameter and 12.5 cm height, therefore total area which heat is transmitted by, in Sq. Mt. is calculated as follow.

 $A_1=A_2$ bottom ant top area =3.14 x 6.5x6.5= 133 square cm. 0.0133 sq. m.

A₃= Cylinder side wall = 3.14x13x34=1388 sq. cm = 0.1388 sq. m.

Where; $A_1 = A_2 =$ bottom and top surface area of the storage tank are the same,

$$A = A1 + A2 + A3 = 0.0133 + 0.0133 + 0.1388 = 0.1654 \text{ sq. m.}$$

T difference (Ta - Tc), where, T is ambient temperature, and Tc is final cooled water temperature.

$$Ta = 30 \, ^{\circ}C$$
 and $Tc = 10 \, ^{\circ}C$

$$Ta - Tc = 30-10 = 20$$
 °C

$$Q_3 = UA$$
 $T = 0.38 \times 0.1654 \times 20 = 1.25 \text{ Watts}$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Q3 = 4.35 Watts

$$Qt = Q1 + Q2 + Q3 = 4.7 + 173.7 + 1.26 = 179.7$$
 Watts

$$Q_{Grand Total} = Qt + 10\%$$
 safety factor = 197.6

Compressor R134a, Model FR6G (with total cooling capacity 225 watts at -10 C evaporating temperature) manufactured by DANFOSS, , is selected as a suitable compressor to replace R12 compressor model FR6B.

Harmatic Compressors 220 V

Danfoss Compressors

Appli-	Compressor	Dis-		pressor	Voltage		umbers	I						apacil	y					- 1		ower			Electrical	equipment			Compressor
ation	1	placemen	co	oling	and	Com-	Com-							Watts						- 1		umption	LST		st	HST		HST	
				. 4. 1	frequen-	pressor	pressor	l												- 1	W	/atts	PTC-	Starting	Starting	Starting	Cord	Cover	1
				ibient erature	Cies	1	with					Evao	oratin	a tem	oerati	re "C				- 1	Fvan	temp. °C	Starting device	relay	capacitor	device	relief		
		cm³		43°C	4	ļ	cooling	45	-40	26									10.1			-10 5	DEAICE		!			ļ	ł
UBP	TL2.5F	2.61	32 0	43 6	4	102G4200	Cooming	-43	-40	- 33	-30			65		.3	100	5	-10	13					ļ	ļ			ŤI
30 °C	TL3F	3.13	1.		1 - 1 -	102G4200	 				30	42		81		140	136		+		53 6-1	/8 -		11706007		 	ł	l	·
30 5	TL4F	3.86	 	· 	 	102G4400		 		26	44	61	. B2	108	137	170	-1/3		-+		80	120		11706007	1				
	TLS5F	5.08	 ;·	 	+ -	102G4520	 		\vdash	-14	70			161		_					109			11706003	117U5014		1	1	т
	TLS6F	5.70	1.	1	4	102G4620	 	1	1				140		232			-			119			117U6004			i		T
134a	TLS7F	b.49	1.	1	4	102G4720				60	86	118	158	205	260						135	205	113N0011	11706000	1		103N1006	103N2010	
	NL6F	6.1	1.		4	103G6606				52	75	109	151	200	257						115	185		117U6004			1		<u> </u>
.BP	NL7F	7.3	1,		4	103G6706				76		134	178	231	292						141 3	226		117U6000	117U5015		1		
-35°C	NL9F	8 35	1(2")		4	103G6802	103G6812	·			119			267							166 2 211 3	256		117U6000	11/05015				
	NL11F	11 15			4	103G6900	103G6910		\sqcup	110	150	200	267								211 :	324		117U6002					
	SC15F	15.3	5.(3.)		4	104G8500	104G8510		\sqcup		146			435					ļ		276	434	103N0002	117U6003		J			
	SC18F	177	5.(3.)		4	104G8800	104G8810	-		115				525	665	825					310 -	195		117U6005	117U5016		103N1004	103N2002	S .
	SC21F	20.95	5.(3.)		4	104G8100	104G8110	ļ		185			455	610		990		202	 		380 (117U6019		 			S
	TL3G	3 13	3/1	3/1	4.5	102G4350	ļ	<u> </u>			29	42	59	81	109	142 180	179					97 132 112 153		11706009	11705014	·	ł		
	TL4G TL5G	3.86 5.08	3/1	3/1	4-5 4-5	102G4452	 	├			44 56	61 76	82 105	107	180	225	225	276	415	495	100	150 205		117U6004 117U6000	1703014				
	FR6G	6.24	3/1	3/1	4.5	102G4550 103G6660	 				45		125	173	225	285			565	733	107	175 245	113N0011	11706000		 	Í	ļ	—
	FR7.5G	6 93	3/1	3/1	4.5		103G6690		┝─┤		65		148	105	250	313	395	500	620	\dashv	125	200 270	113140011	11706001			103N1006	103N2010	F
	FR8.5G	7.95	3/1	3/2	4.5		103G6790	 	 	 		126		232	298	380	470		710			235 320		117U6015	117U5015	 			F
34a	FR10G	9.05	3/1	3/2	4.5	103G6880		 	 			138		252	320	412	515	630	775		180	270 362		11706010			1		
-	FRIIG	11 15	3	3	4-5	103G6980	1	 				170		310		495	625	775			200 3	315 445		117U6010			1		
BP	SC10G	103	3	3	4.5	104G8000				25 60	60	115	190	265	365	480	610	760		1105	1/5 3	205 390	103N0002	11706002					
BP	SC12G	12.9	3/2	3/2	4.5	104G8240	104G8250			60	118	183		340		610	780	960	150	1350	235	365 495	103N0002	11706003	11705016		i		
35 C	SC15G	15.3	3/2	3/2	4.5	104G8520	104G8530						315	435	565	725						135 595		117U6005	11103010				
	SC18G	17.7	3/2	3/2			104G8830		L]	110	190	280	410	540	680	860	1080	1320	1620	1980	335	505 710	·	117U6019					
J	SC21G"	20 95	3	3	4-5	104G8140	L	ļ	$\vdash \vdash$	185	245	335	455	610	790	1020	1275	1570	1900	2260	385	575 795				117-7028	103111004	100112002	SC
1	SC12/12G	2 x 12.9	3	3	4	104G8280				120	236	366	520	680	920	1220	1560	1920 2	300	2700	470	730 990		117U6003	11705016	}	{	i	SC
	SC15/15G SC18/18G	2 x 15 3 2 x 17 7	3	3	4	104G8580	ļ	<u> </u>	\vdash	190	290	-400	630	8/0	1130	1450	1820	2240	2700	3220	550 1	870 1190 010 1420 1150 1590		11706005	11705016		1		SCI
	SC21/21G**	2 x 20 95	3	3	4	104G8880 104G8180	 	 		270	190	670	1010	1220	1580	2010	2550	3140	1000	1520	770	150 1500		117U6019		117-7028	ł		SC21
-	FR7GH	6.93			4-6	10406160	103G6692	-	1-1	3/0	430	-0/0	1010	200	260	330	415	525	65()	795	770	195 255		117U6016	117U5015	117-7028	103N1006	103N2010	JUL 1
34a	SC10GH	10.3	2(3)	3	4	104G8040	1000000	}	 					260	350	470	605	525 770	940	1140		280 385		117U6002	117U5016		100/1/000	100.12010	so
J-1	SC10GHH	10.3	2(3)	2(3)	4	10100010	104G8071		\Box		$\neg \neg$			260	350	470	605	770	940	1140		260 345		1110000	11703070	117-7011			SCI
BP	SC15GH	15.3	3	3	4	104G8560	T	1						435		730		1140				120 575		117U6005	117U5016		103N1004	103N2002	SC
15°C	SC15GHH	15.3	2(3)	2(3)	4	1	104G8571	1						435	570			1140				380 495				117-7012	1		SC
	SC18GH	17.7	3	3	4	104G8860	1	1									1080	1350	1665	2000		490 690		117U6019	117U5016				\$0
	SC10C	10.3	3	T	4	104L2516			95	155	240	325	435	560	700	850					300 - 380 -	420		117U6003]		
- 1	SC12C	12.9	3		4	104L2674		95	140	220	310	415	540	680										117U6005	117U5016				
	SC15CM	15.3	3		4	104L2848		115		270						1280					460 (117U6019					sc
122	SC18CM***	17.7	3	<u> </u>	4	104L2120	ļ	130	205				750			1500					495 (690				117-7012		103N2002	SC18
вр	SC21CM***	20 95	3	<u> </u>	4	104L2319		170	255	380	525	680	850	1085	1380	1720		-+			605	830		117U6003		117-7012	103N1004	103N2002	SC21
45°C	SC12/12C	2 x 10 3	3	-}	1 4	104L4076 104L4077	 	190	190	310	480 620	-020	1080	1360	1690	30.10		\rightarrow			600 l	100		11706005	11705016	}	ì)	SC
	SC15/15CM	2 x 12.9 2 x 15.3	3	+	 	104L4077		230	350	540	770	1020	1310	1680	2100	2560				_	920 1	280		11706019	11103010	·	ĺ		SC15
	SC18/18CM***				4	104L4081			410	620	900	1170	1500	1960	2460	3000		1		-	990 1	380				117-7012	1	i	SC18/18
	SC21/21CM***					104L4083		340	510	760	1050	1360	1700	2170	2760	3440		-		. [1	1210 i I	1660				117-7012	1		SC21/2
	SC10D	10.3	3		4		104L2517							510	655	835	1045	1295 1615	1580	1895		450 545 515 660		11706005	117U5016				
122	SC12D	12.9	3		7	1	10412684	匚						650	840	1070	1325	1615	1935	2290		515 660		11706011	11705016		}	}	
	SC15D	15.3	3		7		104L2839				oxdot]		800	1045	1325	1630	1975 2	2345	2750		575 715 900 1090				117-7010	103N1004	103N2002	
BP 15°C	SC10/10D	2 x 10.3		_	4	104L4084	ļ	 	 		ļ							2590				900 11090		11706005	117U5016				SC
,,,,	SC12/12D	2 x 12.9		+-	7	104L4085	ļ	₩			 							3230				030 1320		117U6011		113 42			sc
	SC15/15D	2 x 15 3		-}	7	104L 4086	 	1	100		100						3260	3950 4	1690	2200	250	150 1430		117110010		117-7010			SC
	FR6CL J	6.24	3		44	103U2670		90	120	150	190	250	310	390	470	200					250 :	223		117U6015	117U5015		103N1006	103N2010	FF
04A	FR8.5CL J SC10CL	7.95	3	+-	4	103U2890 104L2523	·	+	\vdash	160	240	320	4EO	500	750	920			\dashv		315 340	485		117U6010 117U6003				ļ 	S
60	SC12CL	12.9	3		4	104L2523	 	75	160	226	330	176	620	785		1155					435			11706003	117U5016				
45°C	SC15CL	15.3	1 3		- 4	104L2853	 	130			440					1390	-	- +				720		117U6003	11,03018				- S
	SC18CL	17.9	3	+	+-;	1041.2123	 	165	265		525					1595		-			605			11100013		117-7012	103N1004	103N2002	S
CL and	SCIOVIOCL	2 x 10.3	3	+-	1 - 1	104L4087	 	1-:		320	480	680	920	1190	1500	1840					680			117U6003		/5/2			SC10
IMILITY ELBJ	SC12/12CL	2 x 12.9		 	 1	104L4088	 		300	470	660	950	1260	1570	1930	2310					370 1	220		11706005	117U5016				SC12
-147	SC15/15CL	2 x 15.3	3		4	104L4089	I	260	- 420	630	880	1170	1500	1890	2310	2780					020 1			117U6019		L			SC 15
	SC18/18CL	2 x 17.7	3		4	1041.4090		330	530	760	1050	1380	1760	2190	2670	3190				\Box	210 1					117-7012			SC18
	TL4DL J	3.86	3	\perp	4	102U2038												525 850				235		117U6000	117U5014		103/11006	100112010	
104A	FR6DL 4	6.24	3		1	103U2680		\subseteq						\vdash								3/5		11706016	117U5015		100111177	103112010	· · · · · · · · ·
IBP	SC10DL J	10.3	3		4	104L2525	L		1		\sqcup				ļ	<u> </u>		1400				620		117U6005	117U5016				SC
V-15"C	SC12DL J	12.9	3		4	1041 2625	<u></u>	.	ļ					ļ				1760		L	.	775		11706019					SC
	SC15DL J	15.3	3	1	4	1041.2856					l		<u> </u>	⊢—	<u> </u>			2085				925		11706005		117-7012	103111004	103/12002	SC
				,	4	104L4091	1	1	1	1	: !		1	ı	1	1		2800		1	- 1	1240		117U6005		1	1		SCIG
umnary	SC12/12DL J	2 x 10.3	1 3			104L4092	·	·							·	t :		3520				1550		117U6019	117U5016				SC12/

Compressor cooling
1 = Static cooling
2 = Oil cooling
3 = Fee cooling
/ at HBP /

Voltages and frequencies 4 = 198-254 V, 50 Hz 5 = 198-254 V, 60 Hz, LBP 6 = 198-254 V, 60 Hz 7 = 198 42

Test conditions (CECOMAF)
Appeciation
Conductioning temperature
Antiberist temperature
Engineer
Limited Particle
Particl

R134a R22/R404A 55°C 45°C 32°C 32°C 32°C

Conversion of capacity is required at 32 C liquid lemmerature, fourthly fix capacity with one of the following linctors:

Aa. F. o 32 C li

Think F. o 32 C li

I Walt = 0 86 kcal/h I Walt = 3 41 Bliwh

Sufficient compressor cooling in subtropical Unit-sta (38-C) at 220V.
Not supplicable bulsive -45-C evaporating temperature in 43-C an serature
Min. air -44
I Directory of the service of the service



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Load Calculation of Water Cooler Model ELC- WC50C

1-

$$Q_1 = m C \triangle T$$

Where:

Q₁ Total heat removed from total drinking water tank volume capacity (lit.) during specific period, related to compressor cooling capacity power in Watts, at initial compressor start up, and early in the morning. When the water temperature is 24 C.

m total weight of original water in the water cooler storage tank in Kg. Considering that one litter of water at 24 C is equal to approximately one Kg.

$$M = 15$$
 liter = 15 Kg.

C Specific heat factor of water in Kcal/Kg $^{\circ}$ C = 1

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water.

$$Ti = 24$$
 °C and $Tc = 10$ °C

$$Ti - Tc = 24-10 = 14$$
 °C

$$Q_1 = m C$$
 $T = 15 \times 1 \times 14 = 210 \text{ Kcal} = 210 \times 1.163 = 244.23 \text{Watts/24 hrs}$

 $Q_1 = 244 / 16$ water cooler operating time per day = 15.2 Watts

$Q_1 = 15.2 \text{ Watts}$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

2-

$\mathbf{Q}_2 = \dot{M} \mathbf{C} \triangle \mathbf{T}$

Q₂ Total heat removed from total drinking water flow (lit.) during specific period, 16 hours. In Kcal.

M In a heavy manufacturing factory, like a foundry employs 50 men for a period of 8 hours, the water load per day would be

M = number of employee X working hour X amount of water used and wasted per person

H = Working Hour = 8

N = Number of number of employee = 50

M = Kg weight of water used per person per hour = 1/8 US Gal 0.472 lit

$$M = H \times N \times M = 8 \times 50 \times 0.472 = 189 \text{ lit.}$$

C Specific heat factor of water in Kcal/Kg $^{\circ}$ C = 1

Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water temperature.

$$Ti = 24$$
 °C and $Tc = 10$ °C

$$Ti - Tc = 24-10 = 14$$
 °C

 $Q_2 = m C$ $T = 189 \times 1 \times 14 = 2646 \text{ Kcal} = 2646 \times 1.163 = 3077 \text{ Watts/8}$ hrs. we consider maximum 80% compressor running time.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

 $Q_2 = 4949/6$ compressor operating time per day = 512.9 Watts

$Q_2 = 512.9 \text{ Watts}$

3-

 $Q_3 = UA \triangle T$

Where:

Q₃ Total Leak, gained through side wall of drinking water storage tank by conduction in Kcal..

U Heat Resistance Coefficient Factor in Kcal/Sq. mt. C

$$U = \frac{1}{x_{K}} = \frac{1}{0.005} = 0.38 \, \frac{K \, cal}{m^{2}} \cdot ^{\circ}C$$

A The water storage tank is considered as cylinder with 32 cm diameter and 14 cm height, therefore total area which heat is transmitted by, in Sq. Mt. is calculated as follow.

 $A_1 = A_2$ bottom ant top area = 3.14 x 13 x 13 = 530 square cm. 0.0530 sq. m.

A₃= Cylinder side wall = $3.14x \ 26 \ x \ 28 = 2286 \ sq. \ cm = 0.2286 \ sq. \ m.$

Where; $A_1 = A_2 = bottom$ and top surface area of the storage tank are the same,

$$A = A1 + A2 + A3 = 0.0530 + 0.0530 + 0.2286 = 0.3346$$
sq. m.

T difference (Ta - Tc), where, T is ambient temperature, and Tc is final cooled water temperature.

$$Ta = 30$$
 °C and $Tc = 10$ °C

$$Ta - Tc = 30-10 = 20$$
 °C

$$Q_3 = UA$$
 $T = 0.38 \times 0.3346 \times 20 = 2.54$ Watts

Hermatic Commessors 228 V



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Q3 = 2.54 Watts

$$Qt = Q1 + Q2 + Q3 = 15.2 + 512.9 + 2.54 = 530.6$$
 Watts

 $Q_{Grand\ Total} = 530$

Compressor R134a, Model Danfoss SC15G (with total cooling capacity 565 watts at -10 C evaporating temperature CECOMAF Standard with condensing temperature 55 C and liquid temperature 55 C) manufactured by DANFOSS, , is selected as a suitable compressor to replace R12 compressor model SC12B.

Appli cation	Compressor	placement		icor	and	Com-		l					,	Valla						1	COII	JulilyOn	į Eu.						
			Ami	bient	trequen- cies	pressor	pressor with					Eugas	ration		o e a tu	·• °C						Watts	PTC- Starting	Starting relay	Starting capacitor	Starting device	Cord	Cover	
		cm³		43°C	1	ĺ	oil cooling	-45	-40	- 35	-30		-20		-10	5	0	5	10	15		. temp. °C	device	ĺ		1			
мвр	TL2.5F	2.61	1.		4	102G4200						32	47	65	86	110	136				53	78	<u> </u>						TL2.5F
0/ 30 C	TL3F TL4F	3 13	1:		4	102G4300 102G4400				26	30	42 61		108	108	140	1/5					97 120	-	11706007	ł	<u> </u>			TL3F TL4F
	TLS5F	5.08	i		4	102G4520				44	70	93	123	161	207							172]	117U6004	117U5014				TLS5F
R134a	TLS6F TLS7F	5.70 6.49	1*		4	102G4620 102G4720		 		54 60			140 158		232 260			\dashv			119	181	113N0011	117U6004 117U6000	[103N1006	103N2010	TLS6F TLS7F
	NL6F	6.1	1.		4	103G6606									257							185	1	11706004					NL6F
LBP	NL7F NL9F	7.3	1(2')		4	103G6706	103G6812			76 92	99 119	134			292 337						141]	11706000	11705015				NL7F
-10/-35°C	NL11F	8.35	5.(3.)	 	4	103G6802 103G6900	103G6910	 			150					—					166 211		1	117U6000 117U6002	1	}			NL9F NL11F
1	SC15F	15.3	2.(3.)		4 4		104G8510				146				565						276		103N0002	117U6003	447115046		1001110011	1001111000	SC15F
	SC18F SC21F	20.95	5.(3.)	 	4		104G8810 104G8110	 		185	190 245	335		525 610	780	990		\dashv			310 380	600	 	117U6005 117U6019	117U5016		103N1004	103N2002	SC18F SC21F
	TL3G	3 13	3/1	3/1	4-5	102G4350					29	42	59	81	109	142	179	222	270	323	67	97 132		11706009					1L3G
	TL4G TL5G	3.86 5.08	3/1	3/1	4-5 4-5	102G4452 102G4550	-				56	76		107	137	180 225	225	276 345		395 495		112 153 150 205	1	117U6004	117U5014	·			TL4G TL5G
	FR6G	6.24	3/1	3/1	4-5	103G6660					45	85		173	225	285	355	450	565		107	175 245		117U6000			103N1006	103012010	FR6G
	FR7.5G FR8.5G	6.93 7.95	3/1 3/1	3/2	4·5 4·5		103G6690 103G6790	\vdash	_	_	65 82		148		250		395 470		710			200 270 235 320		117U6001 117U6015	11705015		100111000	100112010	FR7.5G FR8.5G
R134a	FR10G	9.05	3/1	3/2	4-5		103G6890						191		320	412		630	775			270 362		117U6U10	11703013				FR10G
нае	FR11G	11.15	3	3	4-5	103G6980								310		495	625 610	775 760	510	1105		315 445 285 390		117U6010 117U6002	ļ. 				FR11G SC10G
LBP	SC10G SC12G	10.3	3/2	3/2	4.5	104G8000 104G8240	104G8250	\vdash		25 60			190 260		365 160	480	780		910	1350		365 495		11706002	117U5016				SC120
15/-35 C	SC15G	15.3	3/2	3/2	4.5		104G8530						315		565	725	910	1120				435 595 505 710		11706005	11703016				SC15G SC18G
	SC18G SC21G"	17 7 20 95	3	3/2	4-5	104G8140	104G8830								680 790	1020	1275					575 795	 	117U6019		117-7028	103/11004	103/12002	\$C21G**
	SC12/12G	2 x 12.9	3	3	1	104G8280					236		520	680	920	1220						730 990		117U6003					SC12/12
}	SC15/15G SC18/18G	2 x 15 3	3	3	4	104G8580 104G8880	 	$\vdash \rightarrow$	\longrightarrow	190 220	380	560	820	1080	1360	1720	1820 2160	2640	3240	3960	670	1010 1420		117U6005 117U6019	117U5016)	SC15/15G SC16/16G
	SC21/21G**	2 x 20 95	3	3	4	104G8180				370	490	670	1010	1220	1580	2040	2550	3140	3800	4520	770	1150 1590				117-7028			\$C21/21G**
R134a	FR7GH SC10GH	6.93	2(3)	2(3)	4-6	104G8040	103G6692	 						200 260		330 470		525 770	940			195 255 280 385	 	117U6016 117U6002	117U5015 117U5016		103N1006	103/12010	FR7GH \$C10GH
	SC10GHH	10.3	2(3)	2(3)	4		104G8071							260	350	470	605	770	940	1140		260 345				117-7011		,	SC10GHH
HBP 157-15°C	SC15GH SC15GHH	15.3	2(3)	2(3)	4	104G8560	104G8571	├─┤	\longrightarrow					435	570	730	900			1730		420 575 380 495	 	117U6005	117U5016	117-7012	103N1004	103N2002	SC15GH SC15GHH
	SC18GH	177	3	3	4	104G8860	10400371				\exists			540	680	860		1350		2000		490 690		117U6019	11705016	11.7.7012			\$C18GH
	SC10C SC12C	103	3		4	104L2516 104L2674		50 95	95		310		435					-			300 380		-	117U6003 117U6005	117U5016	·	1	ł	SC10C SC12C
	SC15CM	15.3	3	<u> </u>	4	104L2848			175	270	385	510	655	840	1050	1280					460	640		117U6019					SC15CM
R22	SC18CM***	20.95	3_		4	104L2120 104L2319		130			450 525										495 605	830	 	 	 	117-7012	103N1004	103N2002	SC18CM***
LBP	SCIOVIOC	2 x 10 3	3		1-1-	104L4076	<u> </u>	100		310	480	650	870								600	840		117U6003			100111001		SC10/10C
-5/-45°C	SC12/12C SC15/15CM	2 x 12.9	3	ļ	4	104L4077 104L4079	<u> </u>	190				830		1360		3040					760 920	1100	 	117U6005 117U6019	11705016	ļ			SC12/12C SC15/15CM
	SC18/18CM*		3	 	4	104L4081		260	410	620	900	1170	1500	1960	2460	3000					990	1380		117000.0		117-7012	i		SC18/18CM***
	SC21/21CM**	2 x 20.95	3	ļ	4	104L4083	104L2517	340	510	760	1050	1360					1015	1296	1580	1895	1210	1660 450 545		117U6005	 	117-7012			SC21/21CM*** SC10D
R22	SC12D	129	3		7	<u> </u>	104L2517								840	1070	1325	1615	1935	2290		515 660		11706003	11705016		1		SC12D
нвр	SC15D SC10/10D	15 3 2 x 10 3	3	ļ	7	104L4084	104L2839		$\vdash \Box$	\Box			\neg	1020			1630 2090					575 715 900 1090		117U6005		117-7010	103711064	107115005	SC15D SC10/10D
15/- 15°C	SC12/12D	2 x 10.3		 	1 7	104L4084	 	╁┤		_				1300	1680	2140	2650	3230	3870	4580		1030 1320		11706003	117U5016				SC12/12D
	SC15/15D	2 x 15 3		\Box	7	104L4086						252	212	1600	2090	2650	3260	3950	4690	5500	350	1150 1430		117110010		117-7010			SC15/15D
	FR6CL J	6.24 7.95	3	 	4	103U2670 103U2890	+	90	120	150	190	320	310	390	470	560		-			315	355	1	117U6015	117U5015		103N1006	103/12010	FR6CL FR8.SCL
R404A	SC10CL	10.3	3		4	104L2523					240	340	460			920					340	485	-	117U6003					SC10CL
LBP -5/-45 °C	SC12CL SC15CL	12.9	3	-	4	104L2623 104L2853		75	150 210		330 440		630 750	785 945						 	435 510		 	117U6005 117U6019	117U5016	<u> </u>	}		SC12CL SC15CL
(FR6CL and	SC18CL	179	3	1	4	104L2123	t			380	525	690	880	1095	1335	1595					605	895				117-7012	103N1004	103N2002	SC18CL
FR8 5CL preliminary	SC10/10CL SC12/12CL	2 x 10.3 2 x 12.9			4	104L4087 104L4088		150	300		480 660		920								680 870		<u> </u>	117U6003 117U6005	117U5016			1	\$C10/10CL \$C12/12CL
data)	SC15/15CL	2 x 12.9 2 x 15.3		上	4	1041.4089		260	420	630	880	1170	1500	1890	2310	2780					1020	1440		11706003	11/05016				SC12/12CL SC15/15CL
	SC18/18CL	2 x 17 7		\vdash		104L4090		330	530	760	1050	1380	1760	2190	2670	3190	\Box	525			1210		 	117116000	117115014	117-7012		<u> </u>	SC18/18CL
	FREDL J	3.86	3	\vdash	4	102U2038 103U2680	 	+										525 850		 		3/5	1	117U6000 117U6016			103N1006	103112010	TL4DL FR6DL
R404A	SC10DL 4	10.3	3		4	1041.2525												1400				620		11706005	05			l	SCIODL
HBP 5(10)/-15°C	SC15DL J	12.9	3	·	4	104L2856	 										L	1760 2085		 		775 925		11706019	וטו	117-7012			SC12DL SC15DL
(Preliminary	SC10/10DL	2 x 10.3	3		4	104L4091												2800				1240		11706005	117U5016		103111004	103/12002	SC10/10DL
data)	SC12/12DL SC15/15DL				4	104L4092 104L4093	1	+	\vdash		$\vdash \dashv$					-		3520 4170		 		1850		117U6019		117-7012	-		SC12/12DL SC15/15DL
L	120121305	-1-4 19.3	1			, 10754033										ч				ــــــــــــــــــــــــــــــــــــــ	1	11030	·		<u> </u>	11177012		L	3013/1306

Voltages and frequencies 4 = 198-254 V, 50 Hz 5 = 198-254 V, 60 Hz, LBP 6 = 198-254 V 60 Hz 7 = 198-

R134a R22/R404A 55°C 45°C 32°C 32°C 32°C 32°C

Conversion of capacity
If a stated capacity is required at 32°C liquid
temperature, multiply the capacity with one
of the fullowing factors.

Ha: F to 32°C F

1032°C F

1032°C

1 Watt = 0 86 kcai/h 1 Watt = 3 41 Blu/h

Sufficient compressor cooling in subtropical climate (38-C) at 220V.
Not upplicable below 25-C evaporating temperature in 43-C at perature.
Min. at 15-dimensible from 1 min. (2005).



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Load Calculation of Front Two Taps Water Cooler Model ELC- WC50T

1-

$$Q_1 = m C \triangle T$$

Where:

Q1 Total heat removed from total drinking water tank volume capacity (lit.) during specific period, related to compressor cooling capacity power in Watts, at initial compressor start up, and early in the morning. When the water temperature is 24 C.

M total weight of original water in the water cooler storage tank in Kg. Considering that one litter of water at 24 C is equal to approximately one Kg.

$$M = 72.5$$
 liter = 72.5 Kg.

C Specific heat factor of water in Kcal/Kg $^{\circ}$ C = 1

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature, and Tc is final cooled water.

$$Ti = 24$$
 °C and $Tc = 10$ °C

$$Ti - Tc = 24-10 = 14$$
 °C

 $Q_1 = m C$ $T = 72.5 \times 1 \times 14 = 1015 \text{ Kcal} = 1015 \times 1.163 = 1180 \text{Watts/24 hrs}$

 $Q_1 = 1180 / 16$ water cooler operating time per day = 73.8 Watts

$Q_i = 73.8 \text{ Watts}$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

2-

$\mathbf{Q}_2 = \dot{M} \quad \mathbf{C} \triangle \mathbf{T}$

Q₂ Total heat removed from total drinking water flow (lit.) during specific period, 16 hours. In Kcal.

M In a heavy manufacturing factory, like a foundry employs 50 men for a period of 8 hours, the water load per day would be

M = number of employee X working hour X amount of water used and wasted per person

H = Working Hour = 8

N = Number of number of employee = 50

M = Kg weight of water used per person per hour = 1/8 US Gal 0.472 lit

$$M = H \times N \times M = 8 \times 50 \times 0.472 = 189 \text{ lit.}$$

C Specific heat factor of water in Kcal/Kg $^{\circ}$ C = 1

T Temperature difference (Ti - Tc), where, Ti is inlet water temperature and Tc is final cooled water temperature.

$$Ti = 24$$
 °C and $Tc = 10$ °C

$$Ti - Tc = 24-10 = 14$$
 °C



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

 $Q_2 = m C$ $T = 189 \times 1 \times 14 = 2646 \text{ Kcal} = 2646 \times 1.163 = 3077 \text{ Watts/8}$ hrs. we consider maximum 80% compressor running time.

 $Q_2 = 4949/6$ compressor operating time per day = 512.9 Watts

$Q_2 = 512.9$ Watts

3-

$$Q_3 = UA \triangle T$$

Where:

- Q₃ Total Leak, gained through side wall of drinking water storage tank by conduction in Kcal..
- U Heat Resistance Coefficient Factor in Kcal/Sq. mt. C

$$U = \frac{1}{x_{K}} = \frac{1}{0.005_{0.019}} = 0.38 \, \frac{K \, cal}{m^{2}} \, ^{2} \, ^{2}$$

A The water storage tank is considered as cylinder with 32 cm diameter and 14 cm height, therefore total area which heat is transmitted by in Sq. Mt. is calculated as follow.

 A_1 = A_2 bottom ant top area =50 x 50 = 2500 square cm. 0.2500 sq. m.

 $A_3 = A_4 = A_5 = A_6$ side wall = 50x33 = 1650 sq. cm = 0.1560 sq. m.

Where; $A_1 = A_2 =$ bottom and top surface area of the storage tank are the same,

$$A = A_1 + A_2 + A_3 + A_4 + A_5 + A_6 = 0.2500 + 0.2500 + 4x(0.1650) = 1.16$$
sq. m.

T difference (Ta - Tc), where, T is ambient temperature, and Tc is final cooled water temperature.

$$Ta = 30 \, ^{\circ}C$$
 and $Tc = 10 \, ^{\circ}C$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$Ta - Tc = 30-10 = 20$$
 °C

$$Q_3 = UA$$
 $T = 0.38 \times 1.16 \times 20 = 8.8 Watts$

$$Q_3 = 8.8 \text{ Watts}$$

$$Qt = Q1 + Q2 + Q3 = 73.8 + 512.9 + 8.8 = 595.5$$
 Watts

$$Q_{\text{Grand Total}} = 595$$

Compressor R134a, Model Danfoss SC15G (with total cooling capacity 565 watts at -10 C evaporating temperature CECOMAF Standard with condensing temperature 55 C and liquid temperature 55 C) manufactured by DANFOSS, , is selected as a suitable compressor to replace R12 compressor model SC12B.

Hermetic Compressors 220 V

Danfoss Compressors

Appli- cation	Compressor	Dis- placement		ressor pling	Voltage and	Code n	umbers Com-							apacit Watts							-	ower	<u>"</u> [LŚT		Electrical	equipment 12H	1 151	/HST	Compre
Callon		beramam	Amblent		frequen-	bressor	pressor							*****								Watts	-	PTC- Starting	Starting relay	Starting capacitor	Starting device	Cord	Cover	
		cm,	temp	erature 43°C	"""		oli	-45	-40	35						ure °C		5	10	15		-10	. 'C	device	,,,,,	сарасног	device	70,000		
МВР	TL2.5F	2.61	1,	130	4	102G4200						32	47	65	86	110	136	 -	<u> </u>	1.5	53	78				<u> </u>				TI.
30 C	TL3F	3.13	1.		1	102G4300					30	42	59	81	108	140	136 175				64	97			117U6007			1		
	TL4F TLS5F	3.86 5.08	1'	 	4	102G4400 102G4520	ļ			26	70	61	82	108	137	┢		-		\vdash	80 109				117U6009 117U6004	117U5014		4		T
	TLS6F	5.70	 	 	4	102G4620	 			54	78					 		 		1	119				11706004	11703014		1		
134a	TLS7F	6.49	1.		4	102G4720				60	86	118	158	205	260						135	205		113N0011	117U6000			103N1006	103N2010	T
LBP	NL6F NL7F	6.1 7.3	1.	<u> </u>	4	103G6606				52	75	109	151	200	257	├		1		\vdash	115				117U6004					
	NLSF	8.35	1(2')	 	4	103G6706 103G6802	103G6812	 		-76 -92	99	157	207	231 267	337	-		 			141 166	256			117U6000 117U6000	117U5015		-		ļ
V 35 C	NL11F	11.15	2.(3.)		4	103G6900	103G6910			110	150	200	267	350	449						211	324			117U6002			1	ļ.,	10
	SC15F	15.3	2*(3*)	 	4	104G8500 104G8800	104G8510	-		95				435		925		 		\vdash	276 310	434		103N0002	117U6003 117U6005	117U5016		103N1004	103142002	S
	SC18F SC21F	20.95	5.(3.)	 	4 4	104G8100	104G8110	-		115 185	190 245	335	455	525 610	780	990		1		\vdash	380	600	-+		11706003	11703010	<u> </u>	1 103/41004	103142002	
	TL3G	3 13	3/1	3/1	4-5	102G4350					29	42	59	81	109	142	179		270	323 395	67	97	132		11706009					
	YL4G TL5G	3.86 5.08	3/1 3/1	3/1	4.5	102G4452					44	61	62	107		180	225	345	333	395	100	112	153		117U6004 117U6000	117U5014				
	FR6G	6 24	3/1	3/1	4-5	102G4550 103G6660					56 45	85	125	173	225	225	355	450	565	333	107	175	245	113N0011	117U6000			1020116-06	103142010	
	FR7.5G	6 93	3/1	3/2	4-5	103G6680					65	103	148	195	250	313		500	620		125	200	270		117U6001			103111096	103112010	FF
134a	FR8.5G FR10G	7.95 9.05	3/1	3/2	4-5 4-5	103G6780 103G6880	103G6790				90	126	178	252	320	380 412	515	580 630	775		150	235	362		117U6015 117U6010	117U5015		1		F
	FR11G	11.15	3	3	4.5	103G6980	.5500050				110	170	235	310	385	495 480	625	775		1105	200	315	445		117U6010					F
НВР LBP	SC10G	10.3	3	3	4-5	104G8000				25	60	115	190	265	365	480	610	760	910	1105	175	285	390	103N0002	117U6002					S
/-35°C	SC12G SC15G	12.9	3/2	3/2	4-5	104G8240	104G8250 104G8530	-		60 95	118	183	260	340	460	725	780	960	1150	1350 1610	235	365	495	103N0002	117U6003 117U6005	117U5016	ļ	-		9
	SC18G	17.7	3/2	3/2	4-5	104G8820	104G8830	-		110	190	280	410	540	680	860	1080	1320	1620	1980	335	505	710		11706003			1		Š
	SC21G"	20.95	3	3	4-5	104G8140				185	245	335	455	610	790	1020	1275	1570	1900	1980 2260 2700	385	575	795				117-7028	103111004	103112002	sc
	SC12/12G SC15/15G	2 x 12.9 2 x 15.3	3	3	4	104G8280 104G8580		-		120	236	366	520	680	920	1220	1560	1920	2300	3220	550	730	990		117U6003 117U6005	117U5016		1	1	SCI
	SC18/18G	2 x 17.7	3	3	4	104G8880	 			220	380	560	820	1080	1360	1720	2160	2640	3240	3960	670	1010 1	1420		11706003	11703016		1		sci
	SC21/21G**	2 x 20 95	3	3	4	104G8180				370	490	670	1010	1220	1580	2040	2550	3140	3800	4520 795	770	1150 1	590				117-7028			SC21/
	FR7GH SC10GH	6.93	2(3)	2(3)	4-6	10100010	103G6692							200	260	330	415	525	650	795		195	255		11706016	117U5015		103N1006	103N2010	SC SC
R134a	SCIOGHH	10.3	2(3)	2(3)	4	104G8040	104G8071							260 260	350	470	605	770	840	1140	\dashv	260 260	345		11706002	11705016	117-7011	103841004 10384	1	SC 1
нвр	SC15GH	15.3	3	3	4	104G8560								435		730	_900	1140	1420	1730		420	575		11706005	11705016			103N2002	sc
V 15°C	SC15GHH SC18GH	15.3	2(3)	2(3)	4	10100000	104G8571			_				435				1140				380	495		117U6019	117U5016	117-7012	4		SC1
	SC10C	10.3	3	3	4	104G8860 104L2516	 	50	95	155	240	325	435	560	700	850	1000	1330	1003	2000	300	420	650		11706003	11703010	 	 		- 3C
	SC12C	12.9	3		4	104L2674		95	140	220	310	415	540	680	840	1020					380	550			117U6005	117U5016				s
	SC15CM	15.3	3	ļ	4	104L2848		115	175	270	385	510	655	840	1050	1280		 			460 495	640			117U6019	 	117-7012		ľ	SC 18
R22	SC18CM***	17.7 20.95	3		4	104L2120 104L2319		170	205	310	450 525	680	850	1085	1380	1720		+		\vdash	605	830	- 		 		117-7012	103N1004	103N2002	SC21
LBP	SC10/10C	2 x 10 3	3	1	4	104L4076		100	190	310	480	650	870	1120	1400	1700					600	840			117U6003			1		SCI
7-45°C	SC12/12C	2 x 12.9	3		4	104L4077		190	280	440	480 620	830	1080	1360	1680	2040		-			760				117U6005	117U5016	ļ			SC1
	SC15/15CM SC18/18CM***	2 x 15.3 2 x 17.7	3	·	4	104L4079 104L4081		230	350	540	770 900	1020	1310	1680	2100	2560		 	-	\vdash	920 990		\rightarrow		11706019		117-7012	-		SC15/ SC18/18
			3	 	1 1	10414083					1050			2170	2760	3440		1			1210	1660			!:		117-7012	1		SC21/21
	SC10D	10.3	3		4		104L2517							510	655	835	1045	1295	1580	1895		450	545		117U6005	117U5016				S
R22	SC12D SC15D	12.9	3		7 7	 	104L2684	 					 	650	840	1070	1325	1615	1935	2290		515 575	715		117U6011		117-7010	-		S
нвр	SC10/10D	15.3 2 x 10.3	3	+	4	104L4084	1041.2839	+	 				 	1020	1310	1670	2090	1975 2590	3160	3790		900			117U6005	431.22.	117-7010	103N1004	103N2002	SCI
V- 15′C	SC12/12D	2 x 12.9	3		7 7	104L4085								1300	1680	2140	2650	3230	3870	3790 4580 5500		1030	1320		117U6011	117U5016		<u> </u>	1	SC1:
	SC15/15D	2 x 15 3	3		7	104L4086		100	100		100	000	245	1600	2090	2650	3260	3950	4690	5500	250	1150	1430		11700015		117-7010			SCI
	FR6CL J	6.24 7.95	3		4	103U2670 103U2890	 	90	120	150	190	320	310	390	470	200		+		+	250 315	355			117U6015 117U6010	11705015		1031/1006	103N2010	FRI
1404A	SC10CL	10.3	3	<u> </u>	1 4	104L2523		<u> </u>		160	240	340	460	595	750	920		1			340				117U6003			ļ <u>.</u>		sc
L8P V-45°C	SC12CL	129	3	-	4	1041.2623			150	235	330	475	630	785	965	1155		1	ļ	\vdash	435				117U6005	117U5016		1	1	SC
R6CL and	SC15CL SC18CL	15.3 17.9	3	 	4 4	104L2853 104L2123			210		440 525							+		┼	510 605				117U6019		117-7012	103/11004	103N2002	SC
BB SCL	SCIONOCL	2 x 10.3	3	1	4	104L4087	t			320	480	680	920	1190	1500	1840	:				680	970	士		117U6003	<u> </u>		1.00,11004	.03.12002	SCIO
data)	SC12/12CL	2 x 12 9	3		4	1041.4088		150	300	470	660 880	950	1260	1570	1930	2310				\Box	870				117U6005	117U5016				SC12/
	SC15/15CL SC18/18CL	2 x 15.3 2 x 17 7	3	 	4	104L4089 104L4090	 	260	520	760	1050	1170	1760	2190	2670	2780	!	 		\vdash	1020	1790			117U6019	 	117-7012	-		SC15/ SC18/
	TL4OL J	3.86	3	 	+ 4	102U2038	 	330	530	700	1030	ıadı	1,700	150	120,0	13130	·	525		1	1217		235 375		117U6000	117U5014	117.7012	103111000	400440073	3C18
R404A	FR6DL J	6.24	3		4	103U2680	<u> </u>											850							11706016	117U5015		9001NE01	103N2010	F
HBP	SC10DL J	10.3	3		4	104L2525							I	ļ	1	\perp	<u> </u>	1400 1760	<u> </u>	↓	-I		620		117U6005	117U5016	<u> </u>	4 <u> </u>		SC
0)/-15°C	SC12DL J	12.9	3		4 4	104L2625 104L2856	 					<u></u>	├		-	-}	·	2085		+-			775 925		11706019		117-7012	1		SC SC
reiminary	SC10/10DL J	2 x 10.3	3	+	+ 4	104L2838	 	+	 				 	1	1	1		2800					1240		117U6005	117115010	117-7012 103N1004		103N2002	SC10/
data)	SC12/12DL 4	2 x 12.9	3		4	104L4092											=	3520		I		1	1550		117U6019	117U5016				SC12/
	SC15/15DL J	2 x 15 3	3		4	104L4093	1	1	1			l	1	1	1 .	1 -	1	4170	ı ¯	1	1		1850		1		117-7012	1	1	SC15/1

Compressor cooling
1 a Static cooling
2 a Oil cooling
3 a For Applied
/ a IHBP/L
()a Millianiania

Voltages and frequencies 4 • 198-254 V 50 Hz 5 = 198-254 V 60 Hz, LBP A = 198-254 V 60 Hz = 198-2-

Test conditions (CECOMAF)
Application
Condensing temporature 50°C 45°C
Ambient languages 32°C 32°C
Su emporati 32°C
I kpc (Albite 55°C)

Conversion of capacity
If a stated capacity is required at 32.C liquid
temperature, multiply the capacity with one
of the following factors:
a Fro 32.C liq
Frc 32.C liq

1 Wall = 0.86 kr. avh 1 Wall + 3.44 Bluth

Sufficient compressor cooling in subtropical climate (38°C) at 220V
 Not applicable betwe-25°C evaporating temperature in 13°C and An aiv s
 ED cooling to the cooling of the c



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Chest Freezer Model ELS-CF450

a) Transmission Load Calculation

Dimension

Difficusion	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2 x (71x70)	0.9940	65
Front & Back Panel	2 x (132x70)	1.8480	65
Chest Door	71 x 132	0.9372	65
Bottom Floor	71 x 132	0.9372	65

Insulation Type: Pu Foam Cyclopentane expanded blowing PU foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - (-18) = 61 \text{ C}$

Ambient Temperature = 43 C

Freezer Air Temperature = - 18 C

Calculation:

$$Q_{\text{TL}} = Q_{\text{side Walls}} + Q_{\text{Bottom}} + Q_{\text{Top}}$$

$$Q = U A (T_a - T_f)$$

$$U = \frac{1}{X_1 / K_1 + X_2 / K_2 + \dots}$$

Where:

U = Heat Resistance Coefficient Factor

 $K_1 = Foam Thermal Conductivity$

 $X_1 = Foam Thickness$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials have been considered negligible.

Therefore:

1-
$$Q_{SideWalls} = [UA(T_a - T_f)]$$

 T_a = Ambient Temperature T_f = Freezer air Temperature

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

 $A = 0.9940 \text{ Sq. Mt.}$
 $T_a = 43 \text{ C}$
 $T_f = -18 \text{ C}$

Q
$$_{\text{SideWalls}} = 0.29 \times 0.9940 \times 61 = 17.6 \text{ Watts}$$

2 -
$$Q$$
 Front & Back Walls = $[UA(T_a - T_f)]$

 T_a = Ambient Temperature T_f = Freezer air Temperature

Q Front & Back Walls =
$$0.29 \times 1.8480 \times 61 = 32.7$$
 Watts

$$3 - Q_{Top door} = [UA(Ta - Tf)]$$

Ta = Ambient Temperature



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Tf = Freezer air Temperature

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

 $A = 0.9372 \text{ Sq. Mt.}$
 $T_a = 43 \text{ C}$
 $T_f = -18 \text{ C}$

$$Q_{\text{Top door}} = 0.29 \times 09372 \times 61 = 16.6 \text{ Watts}$$

$$Q_{Top\ door} = 16.6 \text{ Watts}$$

$$4 - Q_{Bottom} = [UA(T_a - T_f)]$$

Ta = Ambient Temperature
Tf = Freezer air Temperature

$$U = 1/(0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

 $A = 0.9372 \text{ Sq. Mt.}$
 $T_a = 55 \text{ C}$
 $T_f = -18 \text{ C}$

$$Q_{Bottom} = 0.29 \times 0.9372 \times 73 = 20.6 \text{ Watts}$$

$$Q_{Bottom} = 19.8 Watts$$

Total Heat Leaks;

$$Q_{TL} = 17.6 + 32.7 + 16.6 + 19.8 = 86.7$$
 watts

b) Product Loads;

Through our knowledge, experience and facts and figures of calculation of Electro Still products we found out that calculation of product loads for each individual model depends upon many factors that we could mention briefly as follows:



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

- Product design;
- Product style;
- Company policy;
- Useful internal volume;
- Type of evaporator;
- Type of cellar compartment;
- Freezer volume;
- Culture of customer;
- Country of origin and etc.;

We consider 10 kg of Ice Making per hour capability for this model of chest freezer, with respect to the size of the model.

Ice Making Capacity = $10 \kappa_g x 1 x (15-0) x 1.163 = 174.45$ Watts

c) Heat gain through infiltration;

Total heat gain through infiltration (door opening, and gasket) are considered to 10 % of total heat gain by conduction and heat removed from products, therefore;

Heat gain by infiltration = $0.1 \times (\text{total heat leaks})$

Heat gain by infiltration = $0.1 \times (86.7) = 8.7 \text{ Watts}$

Total Cooling Capacity Required are calculated as follows;

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Ice Making}} + Q_{\text{Infiltration}}$$

$$\mathbf{Q}_{Grand\ Total} = 91.2 + 174.25 + 8.7 = 269.7\ Watts$$

$$Q_{Grand\ Total} = 269.7$$
 Watts

The Suitable Compressor selected for this Model is Danfoss SC18G with a total 280 watts cooling capacity, at – 25 C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

|--|

Appli- cation	Compressor	Dis placement	ent cooling and Com- Com- Walls frequen- pressor pressor				1		mpuon atts	Lb1	 	ĭ'	1 - 2 - 2 	r		1													
			Amt	oient	frequen- cies	pressor	pressor														Wa	alls	PTC- Starting	Starting relay	Starting capacitor	Starting device	Cord	Cover	
			tempe	rature	5.55		oii		·					g tem								emp. °C	device	14.07	Cupacitor		10,101		
		CW3		43°C			cooling	45	40	35	30	1		-15				5	10			10 5			<u> </u>	<u>}</u>		<u> </u>	
MBP 0/30 C	TL2.5F TL3F	2.61 3.13		-		102G4200 102G4300	 	<u> </u>			30	32 42	47 -	<u> </u>	108	110	136 175		****			78 97		11/06007	1		Į		TL2 5
w 30 c	TL4F	3.86	 -	-		102G4400			-	26	44	61	12	108		140	1/3	╁	-+			20		11706007	1	ļ	-{		TL-
	TLS5F	5 08	1.		1	102G4520				44	70			161							109 1			117U6004	117U5014	·	1	1	TLS
	TLS6F	5.70			4	102G4620		İ		54	78			182							119 1	81	113N0011	117U6004	1		103N1006	103N2010	TLS
A134a	TLS7F	6.49	1.		4	102G4720				60				205	260						135 2		713140011	117U6000			103111000	103142010	TLS
LBP	NL6F NL7F	6.1 7.3	1,		4	103G6606	<u> </u>			52			151		257 292						115 1			117U6004	1	ļ	_[NL NL
LOP	NL9F	8.35	1(2*)	<u> </u>	4	103G6706 103G6802	103G6812	-		76 92		157		231 267			$\overline{}$				141 2 166 2			117U6000	11705015	<u> </u>	-{	-	NL NL
10/ 35°C	NLIIF	11 15	2'(3')	 	1 4	103G6900		<u> </u>	-	110			267		449	 					211 3			117U6002	1	J	1	1	NLI
	SC15F	15.3	2*(3*)		4	104G8500	104G8510							435	565				-		276 4		103N0002	11706003			 		SCI
	SC18F	17.7	2.(3.)		4	104G8800	104G8810			115	190	280			665	825					310 4	95		117U6005	117U5016		103N1004	103N2002	SC1
	SC21F	20.95	5,(3,)		4	104G8100	104G8110			185		335		610	780	990		-			380 6			117U6019	ļ	ļ.—.—	ļ	 	SC2
	TL3G TL4G	3 13	-3/1 3/1	3/1	4.5	102G4350					29 44	12	<u>59</u>	81	109	142	225	276	333			97 132 12 153		117U6009 117U6004	11705014	 	-		TL:
	TLSG	3.86 5.08	3/1	3/1	4·5 4·5	102G4452 102G4550	├──		-		56	76	105	140	180	225	260					50 205		11706000	11703014		1	1	TL!
	FR6G	6.24	3/1	3/i-	4.5	103G6660	 				45	85	125		225	285	355	450	565		107 1	75 245	113N0011	117U6000			103N1006	103142010	FAC
	FR7.5G	6 93	3/1	3/2	4.5	103G6680	103G6690						148	195	250	313	395	500	620			00 270		11706001]		103111006	103172010	FR7.
	FR8.5G	7.95	3/1	3/2	4-5	103G6780	103G6790				82			232	298	380	470		710 775			35 320 70 362		11706015	11705015				FR8.
R134a	FRIOG FRIIG	9 05	3/1	3/2	4-5	103G6880	103G6890	 				138	191 235	310	320 385	412	515 625	776		\neg		15 445		117U6010	ł	ļ	1	}	FRI
нве	SC10G	10.3	3	3	4-5 4-5	103G6980 104G8000				25		115		265	365	495	610	760	910	105		85 390	103N0002	11706002		ļ	 	 	SCI
LBP	SC12G	12.9	3/2	3/2	4-5	104G8240	104G8250			60	118	183		340		610	780		1150 1			65 495	103N0002	117U6003	117U5016		1	į.	SCI
5/-35°C	SC15G	15 3	3/2	3/2	4-5	104G8520	104G8530					230	315	435	565	725	910	1120	1350	610	275 4	35 595		117U6005	11703016]		SC1
	SC18G SC21G"	17.7	3/2	3/2	4.5		104G8830		-+			280	410	540	680	860	1275	1320	1620 1	980	335 5	05 710 75 795		117U6019	ļ	117-7028	103N1004	103N2002	SC1
	SC12/12G	20 95 2 x 12.9	-3-	3	4.5	104G8140 104G8280	 	├					520	990	920	1220	1560	1920	2300 2	700		30 990		117U6003	 	117-7028	103/11004	103112002	SC12
	SC15/15G	2 x 15 3	3	3	1 1	104G8580			\vdash	190			630	870	1130	1450	1820	2240	2700	3220		70 1190		117U6005	117U5016		1	1	SC15/1
	SC18/18G	2 x 17.7	3	3	4	104G8880					380	560	820	1080	1360	1720	2160	2640	3240	3960	670 10	010 1420		117U6019]	1	SC18/1
	SC21/21G**	2 x 20 95	3	3		104G8180		ļ	$\vdash \dashv$	370	190	670	1010									150 1590		1202		117-7028	 		SC21/21
R134a	SC10GH	6.93	2(3)	2(3)	4-6	104G8040	103G6692				\dashv	-		260	260 350		415 605		650 940	1140		95 255 80 385		117U6016 117U6002	117U5015 117U5016	 	103N1006	103N2010	FR7
V 1348	SC10GHH	10.3	2(3)	2(3)	1-7-	10403040	104G8071		\vdash		$\neg +$			260	350	470	605			1140		60 345		11700002	11703010	117-7011	1		scioci
нвр	SC15GH	15.3	3	3	4	104G8560								435	570	730	900	1140	1420	1730		20 575		117U6005	11705016		103141004	103N2002	\$C150
5/ 15°C	SC15GHH	15.3	2(3)	2(3)	4		104G8571					_		435	570	730			1420			80 495				117-7012]		SC15G
	SC18GH SC10C	177	3	3	1	10408860		1		166	240	2016	125		680 700		1080	1350	1665			90 690 120		11706019	11705016	 	 	 	SC180 SC1
	SCI2C	15.0	3 -	 	4	1041.2516 1041.2574	·	95	95	155 220	310	325 415	540	000	840	1020		l				50		11706005	11705016		1		sci
	SCISCM	15.3	3		4	1041 2848		115	175	2/0	385	510	655	640	1050	1200		1			460 6	140		11706019		AFFE 1944	1		50150
R22	SC18CM***	17.7	3		4	104L2120		130	205			585										90				117-7012			SCIBCM
LBP	SC21CM***	20.95	3		4	104L2319	 	170	255			680						 				330		117U6003		117-7012	103111004	103N2002	SC21CM SC10/1
5/-45°C	SC10/10C SC12/12C	2 x 10 3	3		+ 4	104L4076 104L4077	 	190			480 620							\vdash			760 11			117U6003	11705016		1		SC12/1
	SC15/15CM	2 x 12.9 2 x 15.3	3	├──	4	104L4079		230	350	540	770	1020	1310	1680	2100	2560		1			920 12			117U6019	1		1		SC15/150
	SC18/18CM**		3		4	104L4081			410	620	900	1170	1500	1960	2460	3000					990 13					117-7012	j		SC18/18CM
	SC21/21CM**		3		4	104L4083		340	510	760	1050	1360	1700					<u> </u>			210 16				<u> </u>	117-7012	<u> </u>	ļ	SC21/21CM
	SC100 SC120	10.3	3	 	4	L	104L2517		 				_	510	655	835	1325	1295	1580	1895		50 545 15 660		117U6005 117U6011	11705016	<u> </u>	4		SC1
R22	SC15D	12.9	3	 	 7	 	104L2684 104L2839	+-	├─-					800	1045	1325	1630	1975	2345	2750		75 715		11/06011	 	117-7010	1		SC1
нвр	SC10/10D	2 x 10.3	3	 	4	104L4084	10412033	+	-		$\neg +$			1020	1310	1670	2090	2590	3160 3	3790		000 1090		117U6005	4470	7010	103N1004	103N2002	SCIOI
5/- 15 °C	SC12/12D	2 x 12.9	3		7	104L4085								1300	1680	2140	2650	3230	3870	4580	10	030 1320		11706011	117U5016]		SC12/1
	SC15/15D	2 x 15 3	3	\Box	7	104F 4086		<u> </u>									3260	3950	4690			150 1430				117-7010			SC15/1
	FR6CL J	6.24 7.95	3	<u> </u>	4	103U2670	}	90	120	150	190	250 320	310	390	470	560		 			250 3 315	555		117U6015	117U5015		103/11006	103112010	FR6
R404A	SC10CL	10.3	3	 	4	103U2890 104L2523	 	1		160	240		460	595	750	920	-	┼╌┤	\dashv			185		11706010	 	 		ł	SC10
LBP	SC12CL	129	3	1	+	1041 2623	 	75	150	235	330					1155					435 6	i10		117UG005	11705016		1		SC12
5/-45 °C	SCISCL	15.3	3		4	104L2853			210	315	440	565	750	945	1155	1390					510 7	720		117U6019	l]	1	SC15
RôCL and FRB SCL	SC18CL	17.9	3		1	1041.2123		165	265			690				1595					605 8			4450/2522		117-7012	103N1004	103N2002	SC18
duranary	SC10/10CL SC12/12CL	2 x 10.3 2 x 12.9	3	├	1-1-	104L4087 104L4088	 	150	300	320		950		1190 1570				+ $ $			680 9 870 13			117U6003 117U6005	117U5016		1	1	SC10/10 SC12/12
Julaj	SC15/15CL	2 x 15.3	3	\vdash	1 - 1	104L4088	 		420									$\vdash \dashv$	-+		1020 14			11706005	,,,,05018		1	1	SC12/12
	SC18/18CL	2 x 17.7	3		1	1041.4090			530												210 17					117-7012	1		SC18/18
	TL4DL J	3.86	3		4	102U2038												525				235		117U6000	117U5014		103N1006	103N2010	TL4
R404A	FR6DL _	6.24	3_	L	4	103U2680					\Box			<u> </u>				850	\Box			375		117U6016	117U5015		100111000	100112010	FR6
HBP	SC10DL J	10.3	3	 	4	104L2525	 	1-	\vdash					 	 —	├—	<u> </u>	1400 1760				620 775		117U6005	11705016]	4		SC10 SC12
10V-15°C	SC15DL J	12.9	3	}	4-4	104L2625 104L2856	 	 	 						 			2085	+	-+	+	925		117U6019	-	117-7012	4		SC12
Preliminary	SC10/10DL		3	 	1-4	104L4091	 	1	-		\vdash			\vdash	+-	+-		2800				1240		117U6005		111.7012	103N1004	103N2002	SC 10/100
oata)	SC12/12DL -	2 x 12.9	3		4	104L4092		1										3520		_+		1550		117U6019	117U5016	<u> </u>	1	}	SC12/12/
	SC15/15DL	1 2 x 15 3	3	1	4	104L4093		$\overline{}$							Γ			4170				1850			1	117-7012	1	1	SC15/15

Con	npressor cooling Static cooling
2 .	Oil cooling
•	ig at Hills
()=	VIIBLUTHAR

Voltages and frequencies 4 ± 198-254 V, 50 Hz 5 ± 198-254 V, 60 Hz, LBP 6 ± 198-754 V KO Hz 7 = 19 J Hz

i Walt = 0.86 kcavh i Walt = 3.41 Bluth

Sufficient compressor cooling in subtropical climate (38-C) at 220V.
 Not applicable below 25-C evaporating temperature in 43-C. Imperatur
 Min a rows
 Total Construction (1997).



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Chest Freezer Model ELS-CF750

a) Transmission Load Calculation

Dimension

<u>zmension</u>	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2 x (72.5x82)	1.1890	65
Front & Back Panel	2 x (189x82)	3.0995	65
Chest Door	72.5 x 189	1.370	65
Bottom Floor	72.5 x 189	1.370	65

Insulation Type: Pu Foam Cyclopentane expanded blowing PU foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - (-18) = 61 \text{ C}$

Ambient Temperature = 43 C Freezer Air Temperature = - 18 C

Calculation:

$$Q_{\text{TL}} = Q_{\text{side Walls}} + Q_{\text{Bottom}} + Q_{\text{Top}}$$

$$Q = U A (T_a - T_f)$$

$$U = \frac{1}{X_1 / K_1 + X_2 / K_2 + \dots}$$

Where:

U = Heat Resistance Coefficient Factor

 $K_1 = Foam Thermal Conductivity$

 $X_1 = Foam Thickness$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials—have been considered negligible.

Therefore:

1-
$$Q_{\text{SideWalls}} = [U A (T_a - T_f)]$$

T_a = Ambient Temperature
T_f = Freezer air Temperature

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

 $A = 1.189 \text{ Sq. Mt.}$
 $T_a = 43 \text{ C}$
 $T_f = -18 \text{ C}$

Q
$$_{\text{SideWalls}} = 0.29 \text{ x } 1.189 \text{ x } 61 = 21 \text{ Watts}$$

2 -
$$Q$$
 Front & Back Walls = $[UA(Ta - Tf)]$

 T_a = Ambient Temperature T_f = Freezer air Temperature

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

 $A = 3.0995 \text{ Sq. Mt.}$
 $T_a = 43 \text{ C}$
 $T_f = -18 \text{ C}$

Q Front & Back Walls =
$$0.29 \times 3.0995 \times 61 = 54.8$$
 Watts

$$3 - Q_{Top door} = [UA(T_a - T_f)]$$

T_a = Ambient Temperature T_f = Freezer air Temperature



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

$$A = 1.370 \text{ Sq. Mt.}$$

$$T_a = 43 C$$

$$T_f = -18 C$$

$$Q_{\text{Top door}} = 0.29 \text{ x } 1.370 \text{ x } 61 = 24.2 \text{ Watts}$$

$$Q_{Top\ door} = 24.2 Watts$$

$$4 - Q_{Bottom} = [UA(T_a - T_f)]$$

Ta = Ambient Temperature

Tf = Freezer air Temperature

$$U = 1/(0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

$$A = 1.370 \text{ Sq. Mt.}$$

$$T_a = 55 C$$

$$T_f = -18 \text{ C}$$

$$Q_{Bottom} = 0.29 \text{ x } 1.37 \text{ x } 73 = 29 \text{ Watts}$$

$$Q_{Bottom} = 29 Watts$$

Total Heat Leaks;

$$Q_{\text{TL}} = 21 + 54.8 + 24.2 + 29 = 129 \text{watts}$$

$$Q$$
 Total Heat Leaks = 129 Watts

b) Product Loads;

Through our knowledge, experience and facts and figures of calculation of Electro Still products we found out that calculation of product loads for each individual model depends upon many factors that we could mention briefly as follows:



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

- Product design;
- Product style;
- Company policy;
- Useful internal volume;
- Type of evaporator;
- Type of cellar compartment;
- Freezer volume;
- Culture of customer;
- Country of origin and etc.;

We consider 10 kg of Ice Making per hour capability for this model of chest freezer, with respect to the size of the model.

Ice Making Capacity = $24 \kappa_g x 1 x (15-0) x1.163 = 418.7$ Watts

c) Heat gain through infiltration;

Total heat gain through infiltration (door opening, and gasket) are considered to 10 % of total heat gain by conduction and heat removed from products, therefore;

Heat gain by infiltration = $0.1 \times (\text{total heat leaks})$

Heat gain by infiltration = $0.1 \times (129) = 13$ Watts

Total Cooling Capacity Required are calculated as follows;

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Ice Making}} + Q_{\text{Infiltration}}$$

QGrand Total =
$$129 + 418.7 + 13 = 460.7$$
 Watts

$$Q_{\text{Grand Total}} = 561 \text{ Watts}$$

The Suitable Compressor selected for this Model is Danfoss SC18/18G with a total 560 watts cooling capacity, at – 25 C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature).

Harmatic	Compressors	220 1
nemenc	COURDIGSSOLS	220

Appli- cation	Compressor	Dis- placement		ressor oling	Voltage and	Code n	Com-	1					'	Capaci Watts						İ		ower umption	LST	Н:		equipment HST	ier	/HST	Compress
COUNT		hierameur	200	wed	frequen-	pressor	pressor	1						TVAILS	•							Vatts	PTC-	Starting	Starting	Starting	Cord	Cover	1
		[bient	cies		with					_								l			Starting	relay	capacitor	device	relief	1	
				erature		1	oil	ļ,				<u> </u>			<u> </u>	ure "C						temp. C	device				ļ		
		cm,		43°C			cooling	45	40	35	-30			-15				5	10	15		-10 5			<u> </u>			1	<u> </u>
MBP √-30 C	TL2.5F YL3F	2.61 3.13	1,	 	4	102G4200 102G4300	-	\vdash			30	42	47 59		108	110				∤	53 64	78 97		117U6007	ļ		1	ĺ	TL2
30 0	TL4F	3.86		\vdash	4-	102G4400				26	14	61	82		137		1/3	++			80	120		11706007	1		-		TI
ì	TLS5F	5.08	<u>i.</u>	1	4	102G4520	 	_		44	70			161				11			80 109	172		117U6004	11705014		1		TLS
	TLS6F	5.70	1.		4	102G4620					78	105	140	182	232						119	181	113N0011	117U6004	1		103N1006	103N2010	TLS
R134a	TLS7F	6.49	1.		4	102G4720					86			205				\Box			135	205	113110011	117U6000			103/1/000	103142010	TLS
LBP	NL6F NL7F	6.1	1.	 	4	103G6606 103G6706	 			52 76	75 99		151		257 292						115			117U6004	1		Į		NL NL
	NL9F	8.35	1(2')			103G6802	103G6812			92	119	157	207									256		11706000	11705015				
0/35°C	NL11F	11 15	2'(3')	<u> </u>	4	103G6900	103G6910			110	150	200	267	350	449						211	324		11706002	1	İ	1	İ	/IL
	SC15F	15.3	2*(3*)		4	104G8500				95	146	230									276		103N0002	117U6003					sc
	SC18F	17.7	5,(3,)		4	104G8800				115	190	280 335										495 600		117U6005 117U6019	117U5016		103N1004	103N2002	SC1
	SC21F TL3G	20 95 3 13	2°(3°)	3/1	4-5	104G8100 102G4350	104G8110		\vdash	185	245 29	42	455 59	810	109		179	222	270	323		97 132		11706009		 	 	 	IL
	TL4G	3.86		3/1	4.5	102G4452	·	-	-		44	61	82	107					333	395		112 153		117U6004	11705014		1		TL
	TL5G	5 08	3/1	3/1	4.5	102G4550					56	76	105	140	180	225	280	345	415	495	100	150 205		117UG000	1		1	·	ŢL.
1	FR6G	6.24	3/1	3/1	4-5	103G6660					45			173					565			175 245	113N0011	117U6000	1		103N1006	1037/2010	FR7.
	FR7.5G FR8.5G	6 93 7.95	3/1 3/1	3/2	4·5 4·5	103G6680	103G6690 103G6790	<u> </u>			65		148						710			200 270 235 320		117U6001 117U6015	11705015		٠.	i	FRA.
A134a	FR10G	9 05	3/1	3/2	4-5		103G6890	 			90				320				775			270 362		117U6010	1	l	1		FRI
	FRIIG	11.15	3	3	4-5	103G6980					110					495	625	775			200	315 445		117U6010	1		1		FRI
HBP LBP	SC10G	10.3	3	3	4.5	104G8000				25	60	115	190					760				285 390	1031/0005	117U6002					SC1
5/-35 C	SC12G SC15G	129	3/2	3/2	4.5	104G8240		<u> </u>		60 95	118	183 230							1150 1350			365 495 435 595	103N0002	117U6003	117U5016		1	ł	SC1
	SC18G	15.3	3/2	3/2	4-5	104G8520	104G8530 104G8830		-	110	190	280	410									505 710		11706003	1		†		SC1
	SC21G"	20 95	3	3	4.5	104G8140	1040000			185	245	335	455					1570		2260		575 795				117-7028	103111004	103/12002	SC21
	SC12/12G	2 x 12.9	3	3	4	104G8280				120	236	366	520	UUU	920	1230	1560	1920	2300	2700		730 990		11706003	l		1		SC12
	SC15/15G	2 x 15 3.	_3	3	4	1040ิยิ2ย์ดี	ļ <u> </u>			190	290	160				1450			2700	3220		870 1190		11706005	11705016		1		SC15/1
	SC18/18G SC21/21G**	2 x 17 7 2 x 20 95	3	3	4	104G8880 104G8180	 			220	380 490	500				1 172°C 1 2040		2640 3140	3240 3800	3960		1010 1420 1150 1590		11706019	1	117 70291	1	1	SC18/1 SC21/21
	FR7GH	6.93	2(3)	2(3)	4.6	104(16160	103G6692	 		370	450	070	1010	200						795		195 255		11706016	11705015	1	10301006	100112010	FR7
R134a	SC10GH	103	3	3	4	104G8040								260	350	470	605	770		1140		280 385		11706002	11705016			1	SC10
	SC10GHH	10.3	2(3)	2(3)	4		104G8071							260					940			260 345				117-7011		1	SC10G
HBP 5/15°C	SC15GH SC15GHH	15.3	3	3	4	104G8560	10100571	 					₩	435 435					1420 1420			420 575 380 495		117U6005	117U5016	117-7012	103N1004	103N2002	SC 15G
	SC18GH	15 3	2(3)	2(3)	4	104688860	104G8571		 				├	540						2000		490 690		11706019	11705016	117.7012	1		SCIB
	SC10C	103	3	1	4	104L2516		50	95	155	240	325	435					1	13.000		300	120		11706003		t	 	1	5C1
ĺ	SC12C	12 9	3		4	104L2674		95	140							1020						550		117U6005	117U5016]	İ	SC1
	SC15CM	15.3	3	ļ	4	104L2848		115	175	270	385			840							460			117U6019	⊢—	117-7012	4	1	SC150 SC18CM
R22	SC18CM***	17.7 20.95	3	1	4	104L2120 104L2319		170	205 255	310 380	450 525	585 680			1230			+			495 605			 		117-7012	103N1004	103N2002	SC21CM
LBP	SC10/10C	2 x 10 3	3	 	4	104L2319	-	100		310				1120				+-	-	-	600			11706003		1,012	103111004	103112002	SCIO
¥ 45 C	SC12/12C	2 x 12.9	3		4	104L4077		190	280		620			1360							760			117U6005	117U5016]	1	SC12/1
	SC15/15CM	2 x 15.3	3		4	104L4079			350	540	770	1020	1310	1680							920			117U6019	1]		SC15/150
	SC18/18CM***		3	1	4	104L4081			410							3000		1		1	1210			ļ	 	117-7012	-		SC18/18CM SC21/21CM
	SC21/21CM***	10.3	3	 	4	1041.4083	104L2517	340	510	760	1050	1360	1700	510				1295	1580			450 545		11706005	 	117-7012		-	SC21/21CM SC1
R22	SC12D	12.9	3	†	7	 	10412684	 		 -	 	 	1	650			1329	1615	1935	2290		515 660		11706003	11705016		1		SCI
	SC15D	153	3		7	L	104L2839							800	104	5 1325	1630	1975	2345	2750		575 715		·		117-7010	103111004	103/12002	SC1
HBP 5/-15°C	SC10/10D	2 x 10.3	3		4	104L4084								1020	1310	1670	2090	2590	3160	3790		900 1090		11706005	117U5016		103/11/004	103/12/02	SCIWI
3/· 13 C	SC12/12D	2 x 12.9	3	 	7 7	104L4085	ļ		-	ļ		├	 	1300				3230				1030 1320 1150 1430		11706011		117-7010	.[SC12/1
	SC15/15D FR6CL J	2 x 15 3 6 24	3	 	4	104L 4086 103U2670	 	90	120	150	190	250	310	390		560		3950	4090	3300		355		11706015	 	<u> </u>	 	 	SC15/1 FR6
	FR8.5CL J	7.95	3	1	1 4	103U2890	1	1 30	120	1.50	1.50	320		1 350	1 7/1	1300		1			315			11706010	11705015		103111006	103/12010	FR8.5
R404A	SC10CL	10.3	3		4	104L2523				160		340	460		750							485		117U6003					SC10
LBP V-45°C	SC12CL	129	3		4	1041.2623		75	150		330		630			1155	š					610		117U6005	117U5016				SC12
	SC15CL SC18CL	15.3 17.9	3	 	4	104L2853	+	130		315			750			5 1390					510 605	720		117U6019	 	117-7012	103N1004	103N2002	SC15
R8 SCL	SC10/10CL	2 x 10.3	3	 	4-	104L2123 104L4087	 	165	265	380 320	525 480					5 1595		+	\dashv	-	680			117U6003	 	117-7012	103/11/004	103N2002	SC18 SC10/10
elinunary dalai	SC12/12CL	2 x 12.9	3	 	1-1-	104L4088		150	300	470	660					2310		1			870			117U6005	117U5016		1		SC12/12
udidi	SC15/15CL	2 x 15.3	3	<u> </u>	4	104L4089		260	420	630	880	1170	1500	1890	231	2780					1020	1440		117U6019			1		SC15/15
	SC18/18CL	2 x 17 7	3		4	1041.4090		330	530	760	1050	1380	1760	2190	267	3190	2				1210				<u> </u>	117-7012		ļ	SC18/18
	TL4DL J	3 86	3	 	4	102U2038	ļ	↓	<u> </u>	1		 -	 	+	—	+	- ,	525				375		117U6000	117U5014	ļ	103N1006	103N2010	TL4
A404A	FR6DL J	6.24	3	 	4	103U2680 104L2525	-				 	ļ	 				- 1	850 1400			 	620		117U6016 117U6005	11705015	 		ļ	FR6 SC10
нве	SC12DL J	12.9	3	+	1	1041,2625	 	├─	 	\vdash	 	 		+				1760				775		11706005	11705016				SC12
0y-15°C	SC15DL J	15.3	3	 	1	10412856	-			1	 							2085				925		1		117-7012	10001114.00	trateature	SC151
reumunary	SC10/10DL J	2 x 10.3	3		4	104L4091												2800				1240		117U6005	117U5016		103111604	103142002	SC 10/100
TBUILDING I	SC12/12DL -		3		4	104L4092												3520				1550		117U6019					SC12/120

Compressor coulting
1 = State cooling
2 = Oil cooling
3 = ng
/ = CHBP/1
()= Attain style

Voltages and frequencies 4 = 198 254 V 50142 5 = 198 254 V 50142 (BP 6 = 198 251 V 50142 = 198-2 Z

Test conditions (CLCOMAF)
Application
Combinated immortation
Antiment temperature
S2 C 32 C
S intitipula 32 C
Financial State S5 C
Financial S5 C
Financial S5 C
Financial S5 C
Financial S5 C
Financial S5 C
Financial S5 C

Conversion of capacity support at 12 C liqued interesting country support at 12 C liqued interesting country with some of the following factors 3 22 C for 12 C for 1 22 C for 1 C for

1 Walt - 0 86 to ach 1 Walt - 1 11 8866

Callbronst compressor conting in subtrape at continues (30 Cycle 2017). If it in appearance (30 Cycle 2017) are continued to the week of Convergenceing temporary and a 4.1 Cycle are continued to the continue of the continued to



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Chest Freezer Model ELS-CF220

a) Transmission Load Calculation

Dimension

Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
2 x (54.5x78.5)	0.8556	65
$2 \times (101 \times 78.5)$	1.5857	65
101 x 54.5	0.55	65
72.5 x 132	0.55	65
	Cm. 2 x (54.5x78.5) 2 x (101x78.5) 101 x 54.5	Cm. (sq. mt.) 2 x (54.5x78.5) 0.8556 2 x (101x78.5) 1.5857 101 x 54.5 0.55

Insulation Type: Pu Foam Cyclopentane expanded blowing PU foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - (-18) = 61 \text{ C}$

Ambient Temperature = 43 C Freezer Air Temperature = - 18 C

Calculation:

$$Q_{TL} = Q_{\text{side Walls}} + Q_{\text{Bottom}} + Q_{\text{Top}}$$

$$Q = U A (T_a - T_f)$$

$$U = \frac{1}{X_1 / K_1 + X_2 / K_2 + \dots}$$

Where:

U = Heat Resistance Coefficient Factor

 K_1 = Foam Thermal Conductivity

 $X_1 = Foam Thickness$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials—have been considered negligible.

Therefore:

1-
$$Q_{SideWalls} = [UA(T_a - T_f)]$$

. T_a = Ambient Temperature T_f = Freezer air Temperature

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

 $A = 0.8556 \text{ Sq. Mt.}$
 $T_a = 43 \text{ C}$
 $T_f = -18 \text{ C}$

Q sideWalls =
$$0.29 \times 0.8556 \times 61 = 15.1$$
 Watts

$$Q_{\text{SideWalls}} = 15.1 \text{ Watts}$$

2 -
$$Q$$
 Front & Back Walls = $[UA(Ta - Tf)]$

 T_a = Ambient Temperature T_f = Freezer air Temperature U = 1 / (0.065/0.019) = 0.29 W/ sq.m C A = 1.5857 Sq. Mt. $T_a = 43$ C $T_f = -18$ C

Q Front & Back Walls =
$$0.29 \times 1.5857 \times 61 = 28$$
. Watts

Q Front & Back Walls = 28 Watts

3 -
$$Q_{Top door} = [U A (T_a - T_f)]$$

T_a = Ambient Temperature T_f = Freezer air Temperature



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$U = 1 / (0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

$$A = 0.550 \text{ Sq. Mt.}$$

$$T_a = 43 C$$

$$T_{\rm f} = -18 \, \rm C$$

$$Q_{\text{Top door}} = 0.29 \times 0550 \times 61 = 9.7 \text{ Watts}$$

$$4 - Q_{Bottom} = [UA(T_a - T_f)]$$

T_a = Ambient Temperature

Tf = Freezer air Temperature

$$U = 1/(0.065/0.019) = 0.29 \text{ W/ sq.m C}$$

$$A = 0.55 \text{ Sq. Mt.}$$

$$T_a = 55 \text{ C}$$

$$T_{\rm f} = -18 \, {\rm C}$$

Q Bottom =
$$0.29 \times 0.550 \times 73 = 20.6$$
 Watts

Total Heat Leaks;

$$Q_{TL} = 15.1 + 28 + 9.7 + 11.6 = 64.4$$
watts

b) Product Loads;

Through our knowledge, experience and facts and figures of calculation of Electro Still products we found out that calculation of product loads for each individual model depends upon many factors that we could mention briefly as follows:

- Product design;
- Product style;



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

- Company policy;
- Useful internal volume;
- Type of evaporator;
- Type of cellar compartment;
- Freezer volume;
- Culture of customer;
- Country of origin and etc.;

We consider 10 kg of Ice Making per hour capability for this model of chest freezer, with respect to the size of the model.

Ice Making Capacity = 6 Kg x 1 x (15-0) x1.163 = 104.7 Watts

c) Heat gain through infiltration;

Total heat gain through infiltration (door opening, and gasket) are considered to 10 % of total heat gain by conduction and heat removed from products, therefore;

Heat gain by infiltration = 0.1 x (total heat leaks)

Heat gain by infiltration = $0.1 \times (64.4) = 6.4 \text{ Watts}$

Total Cooling Capacity Required are calculated as follows;

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Ice Making}} + Q_{\text{Infiltration}}$$

Q_{Grand Total} =
$$64.4 + 104.7 + 6.4 = 175.5$$
 Watts

$$Q_{\text{Grand Total}} = 175.5 \text{ Watts}$$

The Suitable Compressor selected for this Model is Danfoss SC12G with a total 183 watts cooling capacity, at -25 C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

Hermetic Compressors 220 V	144, C - 2	, , , ,
----------------------------	------------	---------

Appli- cation	Compressor			ressor	Voitage	Code n	umbers	1						apacıt								ower	J			ednibuleur		/HST	Compr
Callon		placement	COC	olling	and frequen-	pressor	Com-							Watts								umption Vatts	LST PTC	Starting	Starting	HST Starting	Cord	Cover	.]
			Am	bient	cies	biessoi	with														,	*4113	Startin		capacitor	device	relief	Cover	1
		1	temp	erature		•	oil					Evapo	oratin	g tem	peratu	re "C					Evap.	temp. "C	device	,,	СБрасног	device	i ciici	ì	
		cm,	32°C	43°C	1		cooling	45	40	35	30	25	20	-15	-10	-5	0	5	10	15	-25	-10 5	1	1		!		1	1
ивр	TL2.5F	2.61	11		4	102G4200							47	65			136				53	78			1	<u> </u>	1	1	T
30 C	TL3F	3 13	1.		4	102G4300					30	42	59	81	108	140	175					97		117U6007			j		
	TL4F	3.86	1.	1	4	102G4400		_	\sqcup	26	44	61	82	108		L					80	120	-∔	117U6009				1	
	TLS5F TLS6F	5.70	1.	 	4	102G4520	ļ	ļ		44	70		123	161 182		<u> </u>		\longrightarrow				172	4	117U6004	117U5014		1	1	I
1134a	TLS7F	6 49	1.	┼	4	102G4620 102G4720	-			54 60	78 86		140 158	205		<u> </u>			\rightarrow		119		113000	117U6004 117U6000			103N1006	103N2010	T T
1348	NL6F	6.1	1.	 	1 4	103G6606	·			52	75	109	151	200				-+				185	-	117U6004			1	,	-
LBP	NL7F	7.3	1-	 	4	103G6706	<u> </u>			76	99	134	178		292	<u> </u>		-	\dashv		141		┪	11706000		·	1		
	NL9F	8.35	1(2")	 	4	103G6802	103G6812			92			207	267				\neg	-			256	1	117U6000	11705015		1	ł	
V 35 C	NLIIF	11 15	2.(3.)		4	103G6900	103G6910			110		200			449						211			117U6002]		1	i	ı
	SC15F	15.3	5.(3.)		4	104G8500	104G8510			95			315	435	565						276	434	103N00		.]				
	SC18F	17.7	5.(3.)		4	104G8800	104G8810		\sqcup	115			400	525	665	825						.195	<u> </u>	11706005	11705016		103111004	103012002	
	SC21F TL3G	20.95 3 13	2°(3°)		4	104G8100	104G8110		\vdash	185	245	335	455	610	780 109	990 142	179	200	220			97 102		117U6019 117U6009		ļ	 	ļ	
	TL4G	3.86	3/1	3/1	4-5	102G4350 102G4452					29	42 61	59 82	81 107	137			276				112 153		11706003	11705014		i	ì	
	TLSG	5.08	3/1	3/1	4.5	102G4550	 	 	-		56	76	105	140	180							150 209		11705000	1				
	FR6G	6 24	3/1	3/1	4-5	103G0660	ļ ————	t			45	85	125	173	225	285	355	450	565	—1.	107	175 245	1 131400	11 11706000	1		103111006	103042010	
	FR7.5G	6 93	3/1	3/2	4.5	103G6680					65	103	148	195	250	313	395	500	620		125	200 270		11706001	_]		10.31110.06	10.845010	F
	FR8.5G	7.95	3/1	3/2	4.5	103G6780		\perp			82		178	232	298				710			235 320		117U6015	11705015		4		F
134a	FR10G	9 05	3/1	3/2	4-5	103G6880	103G6890	ļ			90	138	191		320	412		630	/75			270 362		117U6010	-		-		
нвр	FR11G SC10G	10.15	3	3	4-5	103G6980 104G8000		-		25	60	170	235		385 365	195	625	760	010	1105		315 445 285 390		117U6010 12 117U6002		ļ	 	ļ	
BP	SC12G	12.9	3/2	3/2	4-5	104G8240	10468250					183					780					365 495			┥	 	1	l.	
-35 C	SC15G	153	3/2	3/2	4.5	104G8520		 		95				435	565	725						435 595		117U6005	11705016		1		
	SC18G	17.7	3/2	3/2	4.5	104G8820				110	190	280	410	540	680	860	1080	1320	1620	1980	335	505 710		117U6019	7		1		
	SC21G"	20.95	3	3	4-5	104G8140					245	335	455	610	790		1275					575 795				117-7028	103N1004	103N2002	S
	SC12/12G	2 x 12 9	3	3	1 4	104G8280		<u> </u>						680			1560					730 990		117U6003	-				S
	SC15/15G SC18/18G	2 x 15 3 2 x 17 7	3	3	4	104G8580		⊢		190	290	460	630	870	1130	1450	1820	2240 2	2700			870 119		117U6005	117U5016		4	1	SC
	SC21/21G**	2 x 20 95	3	3	4	104G8880 104G8180		├		220	380	670	1010	1220	1560	2010	2650	2040	3240	1520	770	1010 142 1150 159	<u></u>	117U6019		117-7028	4	İ	SC21
	FR7GH	6 93	2(3)	2(3)	4-6	10400100	103G6692			3/0	490	970	1010	200	260	330	415	525	650	795	770	195 255		117U6016	117U5015	117-1028	103N1006	1031/2010	3021
134a	SC10GH	103	3	3	1	104G8040	1000000	 	1	-+	-			260	350	470	605			1140		280 385		11706002	11705016	·	103/41000	103142010	S
	SCIOGHH	10.3	2(3)	2(3)	4	1	104G8071			\neg				260	350	470	605			1140		260 345				117-7011	1	1	SC
нвр	SC15GH	153	3	3	4	104G8560								435	570	730		1140				420 575		11706005	117U5016		103N1004	103/12002	SC
/ 15 C	SC15GHH	15.3	2(3)	2(3)	4	l	104G8571							435	570	730		1140				300 495				117-7012			SC
	SC18GH SC10C	17 7	3	3	+ + + -	104G8860 104L2516	 		00	155	240	200	435	540 560	680 700	850	1000	1350	1605	2000		490 690 420	<u> </u>	117U6019 117U6003	11705016		·	ļ	sc
	SC12C	129	3	· 	4	104L2674	 	95	95	220	310	325 415	540	560 630	840	1050						550		11706003	11705016			İ	
	SCISCM	15.3	3	 	1 - 1	104L2848		115	175		385	510	655	840		1280						640		11706019	117703010		1	i	sc
R22	SC18CM***	177	3	 	4	104L2120							750			1500						690		_		117-7012	1	į	SC16
	SC21CM***	20 95	3	-	4	10412319		170	255		525	680	850	1085	1380	1720						830				117-7012	103N1004	103N2002	SC2
LBP	SC10/10C	2 x 10 3	3		4	104L4076	Ĺ	100		310		650	870	1120							600			117U6003]		SC
45 C	SC12/12C	2 x 12.9	3		4	104L4077	l	190		440	620			1360							760			117U6005			.j	1	sc
	SC15/15CM	2 x 15.3	3		1 1	104L4079		230		540											920			117U6019			-		SC15
	SC18/18CM***		3	<u> </u>	+ + -	104L4081	ļ		410												990 1210					117-7012		1	SC18/1
	SC21/21CM***	10.3	3	+	4	104L4083	104L2517		510	/60	1050	1360	1700				1045	1295	1580			450 54	:	117U6005		117-7012	 	 	SC21/2
R22	SC12D	129	3	†	7	 	104L2684	1	H			\neg		650	840	1070	1325	1615	1935	2290		515 660		11706003	117U5016	<u> </u>	1		
	SC15D	15.3	3	1		1	104L2839	T	1					800	1045	1325	1630	1975	2345	2750		575 71		11.00011		117-7010	1	1	ļ
нвр	SC10/10D	2 x 10.3	3	1	4	104L4084	1		T					1020	1310	1670	2090	2590	3160	3790		900 109	o l	117U6005	11711010	1	103N1004	10.3112002	sc
- 15 °C	SC12/12D	2 x 12.9	3		7	10414085								1300	1680	2140	2650	3230	3870	4580		1030 132	ō	117U6011	11705016		1		SC
	SC15/15D	2 x 15 3	3	ļ	7	1041 4086		$\downarrow =$						1600	2090	2650	3260	3950	1690	5500		1150 143	0			117-7010	ļ	1	SC
	FR6CL J	6 24	3	+	4	10302670	 	90	120	150	190		310	390	470	560	{	∤-			250 315	355		117U6015	11705015		103111006	10302010	
404A	FR8.5CL J SC10CL	7 95	3	╁───		103U2890 104L2523		┼──		160	240	320 340	460	595	750	920						485		117U6010 117U6003		ļ		· · · · · · · · · · · · · · · · · · ·	FF
LBP	SC12CL	12.9	3	+	1 4	1041.2623	 	75	150	235					965	1155						610		11706005	117U5016				s
-45 C	SCISCL	15.3	3	—	4	104L2853	 		210						1155		\vdash	$\neg \dagger$	\dashv		510		 	11706019			1	1	Si
6CL and	SC18CL	179	_ 3		4	104L2123	1	165	265	380	525	690	880	1095	1335						605	895	1		1	117-7012	103N1004	103N2002	Š
18 5CL	SC10/10CL	2 x 10.3	3		4	104L4087				320	480	680	920	1190	1500						680	970		117U6003			}		SC10
uninary Jalai	SC12/12CL	2 x 12.9	3		4	104L4088		150	300		660	950	1260	1570	1930	2310			[870			11706005	11/U5016		.]	1	SC1
	SC15/15CL	2 x 15.3	3	-	4	104L4089		260	420	630	880	1170	1500	1890	2310	2780	\dashv				1020	1440	_	117U6019			1	1	SC1
	SC18/18CL	2 x 17 7	3	+	1 1	1041 4090	 	330	530	760	1050	1380	1760	15180	2670	3190		ene l	-		1210			117110000	1	117-7012	 	-	SC16
	FR6DL J	3.86	3	+	4	102U2038 103U2680	 	· 	 					\vdash	⊢	 -		525 850				235		117U6000 117U6016	117U5014 117U5015	ļ	103N1006	1031/2010	l
404A	SC10DL J	10.3	3	 	+ 4	10302680 104L2525	-	 								 - ;		1400		 +	├	620		11706016		·}	 	Į	S
нве	SC12OL J	12.9	3	+	+ 4	1041.2625	 	+-	+	-					 	 		1760		·		775		11706005	117U5016	}	1		
0¥-15°C	SC15DL J	15.3	3	-	+	104L2856	 	+	 				 		 -	 '		2085				92		11700019	+	117-7012	1		SC
eiminary	SC10/10DL J		3	+	1 - 4	104L4091	 	+	1		-			 	 	 		2800				124	0	117U6005	-	1	103N1004	103N2002	SC10
uummary Jala)	SC12/12DL J		3	1	1 4	104L4092	1	+	1	-				1				3520				155		117U6019	11705016	 	1	1	SC12

Voltages and frequencies 4 = 198-254 V 50 Hz 5 = 198-254 V 60 Hz, EBP 6 + 198-254 V 60 Hz 198-24.

Test conditions (CECOMAF)
Application
Constanting temporature
Constanting temporature
27 G 32 G
Ambient britisher 2 G
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramme along
Congramm

Conversion of capacity
If a stated capacity or required at 32. C liquid
temporature, multiply the capacity with one
of the following factors.
I con 12. C hope
I (10.1) I con 12. C hope
I (10.1) I con 12. C hope

1 Watt - 0 86 kraizh 1 Watt - 3 41 Bloch

Sufficient compressor coding in subtropical climate (38-C) in 2207.
 Hot applicable tolkick 25-G responsibility temperature at 1-G and in 1997 and 1200 at 27.
 Hot as p. 1997.

HBP/LE



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Transmission load calculation

Model Up Right Refrigerator Show Case Model ELS-1889V

Dimensions

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness
Side Walls	2x(86 x 200)	3.44	50
Back Panel	200 x 195	3.9	50
Top Roof	195 x 86	1.68	50
Bottom Floor	195 x 86	1.68	50
Door	200 x 195	3.9	50

Insulation Type: Pu Foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - 10 = 33 \text{ C}$

Ambient Temperature = 33 C

Refrigerator Air Temperature = 0 C

The refrigerator is designed to be used for keeping fresh lamb containing 67 % of lean. The initial fresh lamb temperature is considered to be 24 C. the specific heat of lamb containing 67% lean is 0.76 Kcal/hr kg. C.

Calculation:

$$Q_{TL} = Q_{sw} + Q_{BP} + Q_{BOTTOM} + Q_{TOP} + Q_{DOOR}$$

$$Q = U A (T_a - T_f)$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$U = \frac{1}{X_1/K_1 + X_2/K_2 + \dots}$$

Where:

U = Heat Resistance Coefficient Factor

 $K_1 = Foam Thermal Conductivity$

 $X_1 = Foam Thickness$

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials have been considered negligible.

Therefore:

1-
$$Q_{\text{Side Walls}} = [U \land (Ta - T_f)]$$

Ta = Ambient Temperature

Tr = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

$$A = 3.44$$
 Sq. Mt.

$$T_a = 33 \text{ C}$$

$$T_r = 0 C$$

$$Q_{\text{Side Walls}} = 0.38 \text{ x } 3.44 \text{ x } 33 = 43 \text{ Watts}$$

2 -
$$Q_{Back panel} = [U A (Ta - T_I)]$$

Ta = Ambient Temperature

 T_r = Refrigerator air Temperature

$$U = 1 / (0.050 / 0.019) = 0.38 \text{ W/ Sq. Mt. C}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$A = 3.9 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$
 $T_r = 0 \text{ C}$

$$Q_{Back\ panel} = 0.38\ x\ 3.9\ x\ 33 = 49\ Watts$$

$$3 - Q_{Top} = [U A (Ta - Tr)]$$

Ta = Ambient Temperature
Tr = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt C}$$

 $A = 1.68 \text{ Sq. Mt.}$
 $T_a = 45 \text{ C}$
 $T_r = 0 \text{ C}$

$$Q_{\text{Top}} = 0.38 \text{ x } 1.68 \text{ x } 45 = 28.7 \text{ Watts}$$

$$Q_{Top} = 28.7 \text{ Watts}$$

$$4 - Q_{Bottom} = [U A (T_a - T_f)]$$

T_a = Ambient Temperature T_r= Refrigertor air Temperature

$$U = 1/(0.050/0.019) = 0.38 \text{ W/Sq. Mt } C$$

 $A = 1.68 \text{ Sq. Mt.}$
 $T_a = 33 \text{ C}$
 $T_f = 0 \text{ C}$

Q Bottom =
$$0.38x \ 1.68 \ x \ 33 = 21 \ Watts$$

$$5 - Q_{Door} = [U A (T_a - T_f)]$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

According to ASHREA handbook of refrigeration and Standard Mechanical Engineering Handbook published by Mc Graw Hill Book Co. the thermal conductivity for Tempered glass and air are as follows. The refrigerator door cabinet is considered to be 5 mm Double Tempered Glass with 15 mm still air between two side glasses.

- a) Thermal conductivity for Tempered Glass at 366 degree of Kelvin is equal to 1 W/(m. K)
- b) Thermal Conductivity for air at 0 degree centigrade and 1 atmosphere pressure is equal 0.024 W/(m.K)

T_a = Ambient Temperature T_r= Refrigerator air Temperature Glass thickness = 5 mm

$$U = 1 / [(0.005/1) + (0.015/0.024) + (.005/1)] = 1.57 \text{ W/ Sq. Mt. C}$$

$$A = 3.9 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$
 $T_f = 0 \text{ C}$

$$Q_{Door} = 1.57 \times 3.9 \times 33 = 202.7 \text{ Watts}$$

$$Q_{Door} = 202.7 Watts$$

Total Heat Leaks;

$$Qr_L = 43 + 49 + 28.7 + 21 + 202.7 = 209.9$$

$$Q$$
 Total Heat Leaks = 344 Watts



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

b) Product Loads;

$Q = m C (T_{im} - T_{fm})$

Where;

Q = Total heat removed from fresh lamb meat. Per 24 hr

M = Total mass of lamb meat = 200 Kg.

C = 0.76 Kcal/24hrs. Kg. C

 $T_{im} = Lamb meat initial temperature = 24 C$

 $T_{fm} = Lamb meat final temperature = 0 C$

 $Q = 200 \times 0.76 \times (24-0) = 3648$ Kcal per 24 hrs

The total compressor operating time is considered 20 hours per day equals;

$$Q = 3648 / 20 = 182.4 \text{ Kcal/hr} = 212 \text{ Watt}$$

$$Q_{\text{Misc}} = Q_{\text{Electicity}} + Q_{\text{Infiltration}} + Q_{\text{Door Opening}} + Q_{\text{Etc.}}$$

According to our experience we can consider 20% of total heat removed from products and heat leaks through refrigerator walls for Q misc. therefore Total Cooling Capacity required is calculated as follows;

$$Q_{\text{Misc}} = 20\% \ (Q_{\text{Heat Leak}} + Q_{\text{Product Load}}) = 20\% \ x \ (344 + 212) = 111.2$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Product Loads}} + Q_{\text{ Misc.}}$$

$$Q_{Grand\ Total} = 344 + 212 + 111 = 634 \ Watts$$

Q_{Grand Total} = 667 Watts

The Suitable Compressor selected for this Model is Danfoss SC12/12G with a total 680 watts cooling capacity, or Compressor Model Danfoss SC15/15G with a total 870 watts cooling capacity at – 15 C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

Hermetic Compressors 220 V

Dunfoss Compressors

Appli-	Compressor	Dis-	Comp		Voltage		umbers	!						pacity	1					i		wer	ļ		Electrical	equipment	· · · · · · · · · · · · · · · · · · ·		Compres
cation		placement	coo	ling	and	Com-	Com-	1					1	Watts								mption	LST	Н:		HST		HST	
					tredneu-	pressor	pressor	İ													W	alts	PTC-	Starting	Starting	Starting	Cord	Cover	
			Amt	istore	Cles		oil					Evano	aataa	Jong	mratu	re "C				ı,	l vana t	omp. C	Starting	relay	capacitor	device	refief		
		cm,	32. C				cooling	45	161	35							. 1	ايم	10			10 5	device		Į.				
	TL2.5F			43 C		100000000	cooming		-40	13									-10										ri
МВР 30 С	TL3F	261	1.			102G4200	}	 	∤	 ∤	30	32	17.	65 81	ਹਿਹ 108	110 140	1,36				50 g	78	į.	1	}	-	ļ		, ,,,
-30 5-1	TLAF	3 13	- <u>-1</u>			102G4300 102G4400		li		26	44	42 61	59 .	108	137		173					20	ł	117U6007		\ ·	-	1	
	TLS5F	5 08			1	102G4400				14	70	93	123		207							72	ł	11706004	11705014		-{		
	TLS6F	5.70				102G4620	i			54	78		140	182								81	i	117U6004	11703014		1		10
1134a	TLS7F	6.49	1.		1	102G4720	 	1		60	80	118		205								U5	11300011	11706000	{		103111006	103042010	Ti
	NL6F	6.1	1		4	103G6606	 		-	52	75		151		257						115 1	85	1	117U6004			7		-
LBP	NL7F	73	1.		4	103G6706				76	99			231						1	141 2	26	1	11706000	1		1	ĺ	·
ì	NL9F	8.35	1(2")		4	103G6802	103G6812	. 1		92	119	157		267			\neg	$\neg +$	$\neg +$		166 2	56	1	11706000	117U5015	 	1	}	,
√ 35°C	NL11F	11 15	2'(3')		4	103G6900				110	150				449		\neg				166 2 211 3	24	1	117U6002	1		1	ì	11
1	SC15F	153	2*(3*)		4	104G8500	104G8510			95	146	230	315	435	565					2	276 4	34	103N0002	117U6003		l	1	1	S
	SC18F	17.7	2*(3*)		4	104G8800	104G8810			115	190	280	400	525	ô65	825				:	310 4	95	1	11706005	117U5016	I	103N1004	103N2002	50
	SC21F	20 95	2'(3')		4	104G8100	104G8110			185	245	335	455	610	780	990				13	380 6	00		117U6019			1	!	SC
	TL3G	3 13	3/1	3/1	4.5	102G4350					29	42	59	81	109		179	222				132	j	11706009				i i	1
	1L4G	3 80	3/1	3/1	4.5	102G4452					44	üΙ	82	107	137	180						12 153	}	117U6004	11705014		1	}	T
	TL5G	5 08	3/1	3/1 3/1	4.5	102G4550					45	· 76	105	140	180	27.75					100 . 1	50 205		11706000					
į	FREG	6 24	3/1	3/1	4-5	103Gou60		 				85	125	173	225	285		450	565			75 245	113140011	11706000	{	ļ	103/11666	103115010	FA FA
	FR7.5G FR8.5G	6 93 7 95	3/1 3/1	3/2	4.5	103G6680	103G6690				65	103	148	195 232	250	380	395 470	500 (580	620 710		125 2 150 2	00 270 35 320	1	117U6001 117U6015	117U5015	 -	1	1	FR
134a	FR10G	9 05	3/1	3/2 3/2	4-5	103G6780	103G6790 103G6890	\vdash			90	138	191	252	298 320			630	775		180 2	70 362	1	11706015	11/03013		1		
	FRIIG	11 15	3'-	3	4.5	103G6980	10303030	 			110	170	235	310	385	495				1 2		15 445	1	11706010	1		†	1	FF
нвр	SCIOG	103	3		4.5	10468000	——	-		25	60	115	190	265	365			760	010 1			85 390	103/10002	11706002					50
LBP	SC12G	129	3/2	3/2	4.5	104G8240	104G8250	 		25 60	118	183	260	310	160	610	780	960 [1	150 1	350 2	235 3	65 495	103N0002	11706003			1	1	sc
/-35°C	SC15G	15.3	3/2	3/2	4.5	104G8520	104G8530	11		95	145	230	315	435	505			120 1	350 1	610 2	275 4	35 595		11706005	11705016		1	1	50
	SC18G	17.7	3/2	3/2	4.5	104G8820	104G8830			110	190	280	410	5-10	เหน	860	1080	1320 1	620 1	980 :		05 710		11706019	1		1	1	Sc
	SC21G"	20.95	3	3	4.5	104G8140				185			455	610	790	1020	1275	1570 I	900 2	260	385 5	75 795				117-7928	10301004	103112002	SC2
	SC12/12G	2 x 12 9	3	3	4	104G8280	I			120			520	680	920	1220	1560	1920 2	300 2	700	470 7	30 990		117U6003	I]	ŀ	SC
-	SC15/15G	2 x 15 3	3	3	4	104G8580									1130		1820			220	550 8	70 1190	ļ	11706005	11705016		.]	1	SC15
	SC18/18G	2 x 17.7	3	3	4	104G8880					380	560		1080								010 1420		117U6019	ļ		1	j	SC16
	SC21/21G**	2 x 20 95	3	3	4	104G8180				370	490	670	1010									150 1590				117-7028	ļ	<u> </u>	\$C21/2
	FR7GH	6 93	2(3)	2(3)	4-6	ļ.,	103G6692	-							260				650			95 255	ļ	11706016	117U5015		103N1006	103N2010	FR
3134a	SC10GH	103	3	3	4	104G8040	ļ	ш	\vdash					260	350	470	605	770	940 1	140		80 385	ļ	117U6002	117U5016		4	1	SCI
нөр	SC10GHH	10.3	2(3)	2(3)	4	1	104G8071	igoplus							35C	470	605 900	770	940 1	140		60 345 20 575	ļ	1.200		117-7011		103N2002	SC10 SC1
/ 15 C	SC15GH SC15GHH	15.3	3	3	4	104G8560	104G8571	-	 					435 435	570	730 730			1420 1			20 575 80 495		117U6005	117U5016	117-7012	103N1004	103142002	SC15
	SC18GH	15 3	2(3) 3	2(3)	4	104G8860	104G6571	\vdash	\vdash						570	860	1080	1350	666 2	1,30		90 690	ļ	11706019	11705016	117.7012	1	İ	SCI
	SC10C	103	3	 _	1-1-	104036860	 	50	95	155	240	325	435				1000	1.550	1005			20	 	11706003	1110,3016	 	†	 	50
	SC12C	129				10412674		95	140	220	310	415	540	560 680	340	1020						50		11706005	11705016		1	İ	Sc
	SCISCM	153	3	\vdash	-	104L2848		115	175	270	385	510	655	840		1280					460 6	40		11706019	1			1	SCI
R22	SC18CM***	17.7	3		1	10412120	 	130	205	310	450	585	750	980	1230	1500					ล์ยรี ได้	90				117-7012	1	1	SCIBC
	SC21CM***	20 95	3		1	10412319		170	255	380	525	680	850	1085		1720						30				117-7012	10301004	103N2002	SC21C
LBP	SC10/10C	2 x 10 3	3		4	10414076		100	190	310	480	650	870	1120	1100	1700						110		11706003			1	Ì	SC10
/ 45°C	SC12/12C	2 x 12.9	3		4	104L4077		190	280	440	620	830	1080	1360	1680	3040						100	·	11706005	11705016			J	SC 12
	SC15/15CM	2 x 15.3			4	104L4079		230	350	540	770	1020	1310	1680	2100	2560	\rightarrow				920 1		ļ	11706019				1	SC15/1
	SC18/18CM***	2 x 17.7	3		4	104L4081	ļ	260	410	620	900	1170	1500	1960	2460	3000			-+		990 1		ļ	- 	 	117-7012	ļ		SC18/180
	SC21/21CM***	2 x 20 95	3	ļ	4	104L4083		340	510	760	1050	1360	1700	2170	2760	3440		1000		1000	1210 1		-	117110005	 	117-7012	 	ļ	SC21/210
	SC10D	10.3	3	⊢—	4	 	104L2517				⊢ l	 		510	655	835	1045 1325	1532	1580 1	895		150 545 15 660	·	117U6005	117U5016		4	!	SC
R22	SC12D	12.9	3		7	·	1041 2684						ļ¦	050	840	1070	1620	1076	1930 2	760		15 660	 	117U6011	 	117 7010	-	1	Si
нвр	SCIOUIOD	15.3 2 x 10 3	3	 	7	104L4084	1041.2839	\vdash						000	1043	1620	1630 2090 2650	2500	343	700	}	75 715 00 1090		11706005		117-7010	103N1G04	10302002	SC 10
√- 15 °C	SC12/12D	2 x 10 3			7	104L4084	·				 	-		1300	1680	2140	2650	32301	3870	1580		030 1320	·	11706005	117U5016		-		SC12
-	SC15/15D	2 x 15 3	3	 	7	1041 4086	 	 	\vdash		$\vdash \dashv$		 	1600	2040	2650	3260	3950	1690 6	500		150 1430		11750011	 	117-7010	-		SC15
	FR6CL J	624	3	 	4	103U2670	} -	90	120	150	190	250		390			3233	-3301	-300		250 3		 	117U6015	 	117.1010	 	 	FF
	FR8.5CL J	7 95	3	 	1	10302890	 	1 -	 '``	150		320	2.0	230	7,5	-500		-			315		1	11706010	117U5015		103N1006	103N2010	FRE
1404A	SC10CL	10.3	3	t	 -; -	1041.2523	-	 		160	240		460	595	750	920		$\neg +$	-+			185	1	117U6003	†			i	SC
LBP	SC12CL	12.9	3	1	4	1041.2623		75	150	235		475	630	785	965	1155						510	· · · · · · · · · · · · · · · · · · ·	11706005	11705016		1		sc
/-45 C	SC15CL	15.3	3	Γ	1	104L2853	1	130	210	315	440	585	750	945	1155							20		11706019	1		1	1	SC
GCL and 18 5CL	SC18CL	179	3		4	104L2123			265	380	525	690	880	1095	1335							395				117-7012	103N1004	103N2002	SC
18 5CL	SC10/10CL	2 x 10.3			4	104L4087		7		320	480	680	920	1190	1500	1840						70	1	11706003			1	l	5C10/
nimilary Jalai	SC12/12CL	2 x 12 9	3		4	1041.4088		150	300 420	470	660	950	1260	1570	1930			T				220	ļ	11706005	11705016		1		SC12/
	SC15/15CL	2 x 15.3	3	└	1	104L 4089	ļ	260	420	630	880	1170	1500	1890	2310	2780				[2	050 1	440	·	11706019	<u> </u>	ļ	1	1	SC15/
. — .	SC18/18CL	2 x 17 7		├ ──	4	1041 4090	 	330	530	760	1050	1380	1760	2190	2670	3190		607	-+	- 1	1210 Î	$\overline{}$		+	L	117-7012	ļ	<u> </u>	SC18/
	TL4DL J	3.86	3	 	1	102U2038		ļ	<u> </u>				ļ	<u> </u>	-		:	525				235		11706000	11705014		103010006	103112010	11
R404A	FR6DL 1	6 24	3	<u> </u>	1	10302680	·	ļ								 		850				3/5	·	11/06016	11705015		l	1	FF
нөр	SC10DL J	10.3	3		1 4	104L2525		↓				<u> </u>				 		1400 1760				- 620 775	ļ	117U6005	11705016		4	1	SC SC
	SC12DL J	12.9	3_			1041 2625												1760 2085					· · · · - ·	11706019		ļ; ,,; ·		1	501 501
			3	1	4	104L2856	1	1	<u> </u>							 		2800				925 1240		A		117-7612	103111004	10302002	501
10y-15"C	SC15DL J					1011 100																							
	SC10/100L J	2 x 10.3	3		4	104L4091 104L4092												3520				1550		11706005	11705016				SC10/1 SC12/1

Compressor cooling

1 × Static cooling

2 * Oil cooling

3 * Farmound

HBP/LE

Voltages and frequencies 4 = 198-254 V, 50 Hz 5 = 198-254 V, 60 Hz, LBP 6 = 198-254 V, 60 Hz 198-24

Test conditions (CECOMAF)
Application
Condensing temperature
Ambient temperature
Suc imperatu
Light, sture
2015 61111

101342 HC2/B404A 55 C 45 C 32 C 32 C 2 C 5 C

Conversion of capacity is dequared at 32 G liquid temperature, multiply the capacity with one of the balayand factors. From: 12 G liquid from the factors of the balayand factors.

T Wait z 0.86 kcakh T Watt z 3.41 Blu/b

Sulficient compressor coving in submylacal smooth (18-C) at 2207. This capital and power 25-C evaporating temperature in 13-C and are trees or ature at 2 form in large.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Transmission load calculation Upright Refrigerator Show Case Model ELS-1982

Dimensions

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness
Side Walls	2x(82 x 200)	3.28	50
Back Panel	200 x 200	4	50
Top Roof	200 x 82	1.64	50
Bottom Floor	200 x 82	1.68	50
Door	200 x 200	4	50

Insulation Type: Pu Foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 33 - 10 = 33 \text{ C}$

Ambient Temperature = 43 C

Refrigerator Air Temperature = 0 C

The refrigerator is designed to be used for keeping fresh lamb containing 67 % of lean. The initial fresh lamb temperature is considered to be 24 C. the specific heat of lamb containing 67% lean is 0.76 Kcal/hr kg. C.

Calculation:

$$Q_{TL} = Q_{SW} + Q_{BP} + Q_{BOTTOM} + Q_{TOP} + Q_{DOOR}$$

$$Q = U A (T_a - T_f)$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$U = \frac{1}{X_1/K_1 + X_2/K_2 + \dots}$$

Where:

U = Heat Resistance Coefficient Factor

K₁ = Foam Thermal Conductivity

 $X_1 = Foam Thickness$

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials have been considered negligible.

Therefore:

1-
$$Q_{\text{Side Walls}} = [U \land (Ta - Tf)]$$

Ta = Ambient Temperature

 T_r = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

$$A = 3.28$$
Sq. Mt.

$$T_a = 33 C$$

$$T_r = 10 C$$

Q side Walls =
$$0.38 \times 3.28 \times 23 = 26.7$$
 Watts

$$Q_{side Walls} = 26.7 Watts$$

2 -
$$Q_{Back panel} = [U A (Ta - Tr)]$$

Ta = Ambient Temperature

 T_r = Refrigerator air Temperature

$$U = 1 / (0.050 / 0.019) = 0.38 \text{ W/ Sq. Mt. C}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$A = 4 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$
 $T_r = 10 \text{ C}$

$$Q_{Back\ panel} = 0.38 \times 4 \times 23 = 49 \text{ Watts}$$

$$3 - Q_{Top} = [U A (Ta - Tf)]$$

Ta = Ambient Temperature
Tr = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt C}$$

 $A = 1.64 \text{ Sq. Mt.}$
 $T_a = 45 \text{ C}$
 $T_r = 10 \text{ C}$

$$Q_{Top} = 0.38 \times 1.64 \times 35 = 22 \text{ Watts}$$

$$Q_{Top} = 22 \text{ Watts}$$

4 -
$$Q_{Bottom} = [U A (Ta - Tf)]$$

T_a = Ambient Temperature T_r= Refrigertor air Temperature

$$U = 1/(0.050/0.019) = 0.38 \text{ W/Sq. Mt. C}$$

 $A = 1.64 \text{ Sq. Mt.}$
 $T_a = 33 \text{ C}$
 $T_f = 10 \text{ C}$

$$Q_{Bottom} = 0.38x \ 1.64 \ x \ 23 = 14 \ Watts$$

$$5 - Q_{Dooi} = [U A (Ta - Tf)]$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

According to ASHREA handbook of refrigeration and Standard Mechanical Engineering Handbook published by Mc Graw Hill Book Co. the thermal conductivity for Tempered glass and air are as follows. The refrigerator door cabinet is considered to be 5 mm Double Tempered Glass with 15 mm still air between two side glasses.

- c) Thermal conductivity for Tempered Glass at 366 degree of Kelvin is equal to 1 W/(m. K)
- d) Thermal Conductivity for air at 0 degree centigrade and 1 atmosphere pressure is equal 0.024 W/(m.K)

T_a = Ambient Temperature T_r= Refrigerator air Temperature Glass thickness = 5 mm

$$U = 1 / [(0.005/1) + (0.015/0.024) + (.005/1)] = 1.57 W/ Sq. Mt. C$$

$$A = 4 \text{ Sq. Mt.}$$

$$T_a = 33 \text{ C}$$

$$T_f = 10 \text{ C}$$

$$Q_{Door} = 1.57 \times 4 \times 23 = 144 \text{ Watts}$$

$$Q_{Door} = 144 \text{ Watts}$$

Total Heat Leaks;

$$Q_{TL} = 41 + 35 + 22 + 14 + 144 = 256$$

$$Q$$
 Total Heat Leaks = 256 Watts



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

b) Product Loads;

$Q = m C (T_{im} - T_{fm})$

Where;

Q = Total heat removed from mixed fresh fruit and vegetables. Per 24 hr

M = Total mass of fresh fruit and vegetables = 100 Kg.

C Lettuce = $4.060x \ 0.23885 = 0.969 \ \text{Kcal/24hrs}$. Kg. C

C spinach = 4.000 x 0.23885 = 0.955 Kcal/24 hrs. Kg. C

 $C_{Radish} = 4.060x \ 0.23885 = 0.969 \ Kcal/24hrs. \ Kg. \ C$

 $C_{Apple} = 3.78x \ 0.23885 = 0.903 \ Kcal/24hrs. \ Kg. \ C$

 $C \text{ cherries} = 3.78x \ 0.23885 = 0.903 \ \text{Kcal/24hrs. Kg. C}$

 $C_{Average} = (0.969 + 0.955 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. Kg. } C$

 T_{iv} = Fresh Fruit and Vegetable initial temperature = 25 C

 T_{fv} = Fresh Fruit and Vegetable final temperature = 10 C

 $Q = 300 \times 0.0.934 \times (25-10) = 4903$ Kcal per 24 hrs

The total compressor operating time is considered 20 hours per day equals;



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Q = 4903 / 20 = 245. Kcal/hr = 285 Watt

$$Q_{\text{Misc}} = Q_{\text{Electicity}} + Q_{\text{Infiltration}} + Q_{\text{Door Opening}} + Q_{\text{Etc.}}$$

According to our experience we can consider 20% of total heat removed from products and heat leaks through refrigerator walls for Q misc. therefore Total Cooling Capacity required is calculated as follows;

$$Q_{\text{Misc}} = 20\% (Q_{\text{Heat Leak}} + Q_{\text{Product Load}}) = 20\% x (256 + 285) = 108$$

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Product Loads}} + Q_{\text{ Misc.}}$$

$$Q_{Grand\ Total} = 256 + 285 + 108 = 649 \text{ Watts}$$

$$Q_{\text{Grand Total}} = 649 \text{ Watts}$$

The Suitable Compressor selected for this Model I Danfoss SC21G with a total 680 watts cooling capacity at -10C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

	Compres					,																							
Appli- cation	Compressor	Dis- placement		ressor oling	Voltage and trequen-	Code n	Com- pressor	-						ipacity Vatts						1	CONS	ower umption Valts	LŠT PTC:	Starting	ST Starting	HST Starting	LST.	Cover	
			tempe	bient erature	cies		with oil cooling							temp			₁		1			temp. C	Starting device	relay	capacitor	device	relial	3010.	
мвр	TL2.5F	2.61	32.0	43 °C	4	1020 1200	cooming	45	40	35		32			·10		0	5	10	15		-10 5		ļ	<u> </u>		·	 	
MBP 0/ 30 C	TL3F	3 13			 	102G4200 102G4300	 	-	 +	-				81		110	175				53 64	78	ł	11706007			1		TL.
	TL4F	3 86			1	102G4400	i	-	 	26					137	-170	-1/3		+			120	1	11706007	1	}	1	į	}
	TLS5F	5 08	1.		1	102G4520	1	1	\vdash	44					207							172		11706004	11705014		1		TL
	TLS6F	5 70	1.		4	102G4620				54			140	182	232						119	181	11300011	117U6004	1		103011606	10302010	TL
A134a	TLS7F	6.49			1 4	102G4720				60					260			[205] ''3''07''	11706000	l		103111006	103142910	ŢL.
LBP	NL6F NL7F	7.3	1.	<u> </u>	1 1	103G6606	{		ll	52					257							1H5	Į	11706004	1		1		,
LOP	NL9F	8.35	1(2*)		1	103G6706 103G6802	103G6812	-	├	76 92		134			292 337						141	226	Į	11706000	11705015		}		
10/-35 C	NLITE	11 15	5,(3,)	 	+		103G6910	 	 - 			200			449						166 211		1	117U6000 117U6002	i	·	1	ł	7
	SC15F	15.3	2.(3.)		4		104G8510				146				505						276		103N0002	11706003					SC
	SC18F	177	2'(3')		4	104G8800	104G8810			115	190	280				825					310			117U6005	117U5016		103N1604	103/42/002	Sc
	SC21F	20.95	2*(3*)		4		104G8110			185				610		990					380			117U6019	<u> </u>				S
	TL3G	3 13	3/1	3/1	4.5	102G4350	ļ <u></u>				29								270		67	97 132 112 153	1	11706009		ļ	1		
	TL4G	3.86	3/1	3/1	4-5	102G4452	ļ <u></u>	 	\vdash	_					137					395	83	112 153	1	117U6004	117U5014		1		
	TL5G	5.08	3/1	3/1	4.5	102G4550	ļ		 							225		345 450		495		150 205 175 245	113N0011	117U6000		 	ł		
	FR6G FR7.5G	6 24	3/1	3/1	4-5	103G6660 103G6680	103G6690	-	\vdash			103		173		285 -			620			200 270	1 I JINOOTT	117U6000 117U6001	1		103N1006	103112010	FR
	FR8.5G	7.95	3/1	3/2	4.5		103G6790		├─ ─┼		82	126	178	232					710			235 320	1	117U6015	11705015		†		FR
R134a	FR10G	9 05	3/1	3/2	4.5	103G6880		1			90	138	191	252	320	412	515	630	775		180	270 362	1	117U6010]		1		FF
	FRIIG	11.15	3	3	4.5	103G6980					110	170	235	310	385	495	625	775			200	315 445	1	117U6010]		FI
HBP LBP	SC10G	10.3	3	3	4.5	104G8000				25		115			365			760				285 390	103140002	117U6002					S
V-35 C	SC12G	12.9	3/2	3/2	4.5		104G8250			60		183						960				365 495	103N0002	117U6003	117U5016		ļ		S
	SC15G	153	3/2	3/2	4.5		104G8530				145.						910	1120	1350	16101			ļ	11706005			ļ	j	S
	SC18G SC21G**	17.7 20.95	3/2	3/2	4.5	104G8820 104G8140						280 335			680 790		1080 1275					505 710 575 795	l	117U6019		117-7028	103N1004	103/12/02	SC:
	SC12/12G	2 x 12 9	3	3	4-5	104G8280	 	-	 - -			366					1560					730 990		117U6003		117-7020	103111004	103112002	sc
	SC15/15G	2 x 15.3	3	3	4	104G8580	 	1				160				1450				3220		870 1190	j	11706005	117U5016	\	1		SCI
	SC18/18G	2 x 17.7	3	3	4	104G8880	 															1010 1420	·	117U6019			1		SCIE
	SC21/21G**	2 x 20 95	3	3	4	104G8180		—	1		490			1220	1580	2040	2550	3140	3800	4520	770	1150 1590				117-7028	1		SC21/2
	FA7GH	6.93	2(3)	2(3)	4-6		103G6692							200		330	415	525	650	795		195 255		117U6016	117U5015		103N100o	103N2010	FR
R134a	SC10GH	10.3	3	3	4	104G8040	ļ <u>.</u>		$\vdash \vdash$						350				940			280 385		117U6002	117U5016	 	1		SCI
нвр	SC10GHH SC15GH	10.3	2(3)	2(3)	4	10100500	104G8071	├ ─	<u> </u>						350 570				940			260 345 420 575		1.7110000	117115015	117-7011		103N2002	SC10
5/ 15 C	SC15GHH	15.3	3 2(3)	2(3)	1 4	104G8560	104G8571	-	 	-	-+				570	730	900					380 495	 	117U6005	117U5016	117-7012	103N1004	103112002	\$C15
	SC18GH	17.7	3	3	4	104G8860	10400371	1	 		-+	\dashv			680		1080					490 690		117U6019	11705016	117-70-12	1	ł	SCI
	SC10C	10.3	3	-	4	104L2516		50	95	155	240	325			700			-	-		300			117U6003					SC
	SC12C	129	3		4	104L2674		95	140	220	310	415			840							550		117U6005	117U5016		1		S
	SC15CM	15.3	3		4	104L2848		115		270				840				_	=		460			117U6019			1		SCI
R22	SC18CM***	17.7	3	ļ	4	104L2120		130						980							495		<u></u>	ļ		117-7012		10/115000	SC180
LBP	SC21CM***	20.95	3	ļ	 	104L2319	ļ	170						1085 1120	1380							830		11706000		117-7012	103N1604	102145005	SC210
45 C	SC12/12C	2 x 10 3	3		4	104L4076	·	100		310 440				1360					f			1100	1	11706005	11705016		l		SCIZ
	SC15/15CM	2 x 15 3	3		1	1041 4079	1	230						1680					t			1280		11706019			i		SC15/1
	SC18/18CM***	2 x 17 7	3		4	1041.4081		260	410	620	900	1170	1500	(8961	2460	3000						1380	1			117 /012	1		SC18/180
	SC21/21CM***	2 x 20 95	3		-4	1041.4083		340	510	760	1050	1360							}		1210		<u> </u>			117 7012			SC21/210
	SC10D	10.3	3	ļ	1		1041.2517		1			[1045		1580			450 545		11706005	11705016		1		5
R22	SC12D SC15D	12 9	3		 ;		104L2684 104L2839										1325 1630		1935			515 660 575 715		111/06011		117 1111	1		S
нвр	SC10/10D	2 x 10 3	3	1	1 4	1041,4084	10455039	+	+								2090					900 1090	J	117UG005		131.501e	10301054	103/12002	SCIO
5/- 15 °C	SC12/12D	2 x 12.9	3	\vdash	+-;-	104L4085	· ————	· 	1	\rightarrow							2650					1030 1320		11706011	11705016	ļ	1		SCI
	SC15/15D	2 x 15 3	3		7	104L4086						_					3260					1150 1430			I	117-7010	1		SCI
	FR6CL J	6 24	3		4	103U2670		90	120	150	190	250				560					250	355		117U6015	11705015		103N1006	103N2010	FI
7404A	FR8.5CL J	7.95	3		4	103U2890						320									315			117U6010	11703013		103111008	100112010	FRE
LBP	SC10CL	10.3	3_	-	4	104L2523	 	1-	آييا	160				595								485	ļ. <u>. </u>	117U6003		<u></u>			SC
SV-45 C	SC12CL SC15CL	12.9	3	ļ	1 1	1041.2623	 				330				965						435 510			117U6005	117U5016		4		sc
RBCL and	SC18CL	17.9	3	 	4	104L2853 104L2123	 	165	210 265		525			1095								720 895	 	117U6019		117-7012	103N1004	103N2002	SC
R8 SCL	SC10/10CL	2 x 10 3	3	-	+	104L4087	 	103	1 200		480							-+			680		 	117U6003		1	1031410094	100142002	SC 10/
diminary Jaia;	SC12/12CL	2 x 12.9	3	1	+	104L4088	 	150	300	470	660	950	1260	1570	1930	2310					870	1220	1	11706005	117U5016		1		SC12
J216)	SC15/15CL	2 x 15.3	3		4	104L4089		260	420	630	880	1170	1500	1890	2310	2780					1020	1440	1	117U6019			1		SC15/
	SC18/18CL	2 x 17 7	3		1	1041.4090		330	530	760	1050	1380	760	2190	26/0	3190 i					1210					117-7012	L		SC18/
	TL4DL =	3.86	3		4	102U2038				\Box			1	[]		T	525		T		235		117U6000	117U5014		103111006	103/12010	T
R404A	FR6DL _	6 24	3	-	1	10302680	ļ		I I	[[.					 - -	850				375	ļ	117U6016	117U5015	ļ			F
нвр	SC10DL J	10.3	3	 	4	104L2525	 	₩								ــــــا		1760				775	ļ	11706005	11705016		1		SC
10V-15"C	SC12DL J	129	3		4	104L2625	·	—					··}			L		2085				925	ł	11706019	ļ	117 7010	1		SC
	SC10/10DL J		3	+	4-4-	104L2856	 	 	 							ا		2800		<u> </u>		1240	}	11706005	}	117-7012	103111004	103112002	SC10/1
reumanary Jaiai	SC12/12DL J		-3	 		104L4092			1							· 'n		3520				1550		11706019	11705016	·	1	ĺ	SC12/1

Voltages and frequencies 4 = 198-254 V, 50 Hz 5 = 158-254 V, 60 Hz, LBP 6 = 198-254 V, 60 Hz 198-247 - 50 Hz

Conversion of capacity is required at 32 °C liquid temperature, multiply the capacity with one of the following factors:

From: 12 °C liquid 123 °C liquid 1

1 Watt = 0 86 kcallh 1 Watt = 3 41 Blu/h

Sulfinent compressor cooling in subtropical commite (38-C) at 2207.
Not adolinate below -25-C evaporating temperature in 43-C attainent temperature at 2409.
In aid 5p



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Show Case Model ELS-260-3F Heat Load Calculation

Heat Load

Total heat load consists of the amount of heat to be removed from cabinet during a certain period. This is dependent on two main factors:

- 1- Heat Leakage Load
- 2- Heat usage of Product load.

The heat leakage load or heat transfer load is total amount of heat that leaks through the walls, windows, ceiling, and floor of the cabinet.

The Heat usage or product load, is the sum of the heat load of cooling the contents to cabinet temperature, cooling of air changes, removing respiration heat from fresh or live vegetables, meat, removing heat released by electric lights, electric motors and the like, and heat given off by people entering and/or working in the cabinet.

Heat Leakage Variables

There are five factors, which affect heat leakage.

- 1- Time. The longer the period of time, the more heat will leak through a certain wall. The standard time unit used for computation is the 24 hour period in refrigeration situation.
- 2- Temperature difference. The temperature difference is an important factor in heat leakage into the cabinet.
- 3-Insulation Thickness. The thicker the insulation, the less heat flow through it.
- 4- Kind of Insulation. The kind of insulation or the material used, is an important consideration in the construction of the cabinet.



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

5- Area of the Cabinet. Just as size of a pipe determination how much water will flow through it. So the more the area through which heat may leak the greater the heat flow will be. The common unit used for determining the heat flow is square meter of area.

Determination Usage Load, Product Load

The total heat load of refrigerator cabinet, in addition to being dependent upon the heat leaking through walls and windows is also affected by the heat to be removed from articles in the cabinet, the air change and other sources of heat. This heat is called heat usage, or product load, and it is caused by changes of air in the cabinet, by products to be cooled, by lights and motors which may be used inside the box, and by the occupancy of the box.

Refrigerator equipment manufacturers have developed a standard where by you may obtain a fairy accurate estimate of the usage heat load. The method is as follows;

The cabinet is classified as the type of service to be performed. Under this classification come florist's cabinets, grocery boxes, normal market coolers, fresh meat cabinets, and restaurant and short order boxes. This load depends in detail upon the following basic factors:

- 1- Temperature difference between exterior and interior of cabinet.
- 2- Volume of cabinet (internal).
- 3- Type of Service.
- 4- Time.

It is impossible to calculate, using a typical installation and determine the amount of food put into the refrigerator, how many times the door is opened, and for how long a period of time the employees are inside the cabinet. This is a laborious process and, unless carefully performed, discrepancies are bound to appear in the results.

The usual procedure to determine the usage heat load is as follows:



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

- 1- The temperature difference is the same value as that used for heat leakage into the cabinet.
- 2- Volume of the cabinet is computed from inside diameters.
- 3- Next determine under what type service the cabinet is being used, such as average, heavy or long storage. The service load is also dependent on cabinet size, the smaller the cabinet the more heat load is caused by products. A meat market, for instance, may be one in either a small neighborhood store or it may be in a supermarket.
- 4- Time, 24 hour. There would, of course, be considered variation in the amount of heat to be removed from the cabinet content. From the table we can find the load for three conditions.

After the total volume of the box has been calculated, the load for each cubic foot is determined by referring to the table, if the cabinet appears to have average product with a temperature difference of 60 F., and has a volume of 300 cu. ft. the amount of heat to be removed from each cubic feet will be 78 BTU per 24 hours. We multiply this value by the total volume in cubic feet, and a fairy accurate estimate of the product load may be obtained. The table gives the heat usage over a period of 24 hours as this time is the established standard.

Heat Usage = Usage BTU x Volume in cu. ft.

Through our knowledge, experience and facts and figures we believe that calculation of product loads for each individual model depends upon many factors that we could mention briefly as follows:

- Product design;
- Product style;
- Company policy;
- Useful internal volume;
- Type of evaporator,
- Type of cellar compartment:
- Freezer volume;
- Culture of customer;
- Country of origin and etc.;



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Transmission load calculation Show Case Model ELS-2603F

Dimensions

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2x(144x90)	2.592	50
Upper Front Panel	72x260	1.872	15 (glass and air)
Lower Front Panel	72x260	1.872	50
Back Panel	144x260	3.744	50
Top Panel	80x260	2.080	50
Bottom Panel	90x260	2.340	50

Insulation Type: Pu Foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - 10 = 33 \text{ C}$

Ambient Temperature = 33 C

Refrigerator Air Temperature = 10 C

The refrigerator is designed to be used for keeping fresh lamb containing 67 % of lean. The initial fresh lamb temperature is considered to be 24 C. the specific heat of lamb containing 67% lean is 0.76 Kcal/hr kg. C.

Calculation:

$$Q_{TL} = Q_{SW} + Q_{BP} + Q_{Bottom} + Q_{Top} + Q_{Upper\ Door} + Q_{Lower\ front\ Panel}$$

$$Q = U A (T_a - T_f)$$

$$U = \frac{1}{X_1/K_1 + X_2/K_2 + \dots}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Where:

U = Heat Resistance Coefficient Factor

 $K_1 = Foam Thermal Conductivity$

 $X_1 = Foam Thickness$

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials have been considered negligible.

Therefore:

$$Q_{\text{side }Walls} = [U A (Ta - Tf)]$$

Ta = Ambient Temperature

 $T_r = Refrigerator$ air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

$$A = 2.592 \text{ Sq. Mt.}$$

$$T_a = 33 \text{ C}$$

$$T_{r} = 10 \text{ C}$$

$$Q_{\text{Side Walls}} = 0.38 \text{ x } 2.592 \text{ x } 23 = 22.6 \text{ Watts}$$

2 -
$$Q_{Back panel} = [U A (Ta - Tr)]$$

Ta = Ambient Temperature

 T_1 = Refrigerator air Temperature

$$U = 1 / (0.050 / 0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

$$A = 3.744 \text{ Sq. Mt.}$$

$$T_a = 33 \text{ C}$$

$$T_{\rm r} = 10 \, {\rm C}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

 $Q_{Back panel} = 0.38 \times 3.744 \times 23 = 32.7 \text{ Watts}$

Q Back panel = 32.7 Watts

 $3 - Q_{Top} = [U A (Ta - Tf)]$

 $T_a = Ambient Temperature$

Tr = Refrigerator air Temperature

U = 1 / (0.050/0.019) = 0.38 W/ Sq. Mt C

A = 2.080 Sq. Mt.

 $T_a = 33 C$

 $T_r = 10 C$

 $Q_{Top} = 0.38 \times 2.080 \times 23 = 18.2 \text{ Watts}$

 $Q_{Top} = 18.2 \text{ Watts}$

 $4 - Q_{Bottom} = [U A (T_a - T_f)]$

Ta = Ambient Temperature

Tr= Refrigertor air Temperature

U = 1/(0.050/0.019) = 0.38 W/Sq. Mt C

A = 2.340 Sq. Mt.

 $T_a = 45 C$

 $T_f = 10 C$

 $Q_{Bottom} = 0.38x \ 2.340 \ x \ 35 = 31.1 \ Watts$

Q Bottom=31.1 Watts

5 - $Q_{Lower Front Panel} = [U A (T_a - T_f)]$

 $T_a = Ambient Temperature$

T₁= Refrigertor air Temperature



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$U = 1/(0.050/0.019) = 0.38 \text{ W/Sq. Mt. } C$$

 $A = 1.872 \text{ Sq. Mt.}$
 $T_a = 33 \text{ C}$
 $T_f = 10 \text{ C}$

Q Lower Front Panel =
$$0.38x \ 1.872 \ x \ 23 = 16.4 \ Watts$$

6 -
$$Q_{Upper\ Door} = [U\ A\ (T_a - T_f)]$$

According to ASHREA handbook of refrigeration and Standard Mechanical Engineering Handbook published by Mc Graw Hill Book Co. the thermal conductivity for Tempered glass and air are as follows. The refrigerator door cabinet is considered to be 5 mm Double Tempered Glass with 15 mm still air between two side glasses.

- e) Thermal conductivity for Tempered Glass at 366 degree of Kelvin is equal to 1 W/(m. K)
- f) Thermal Conductivity for air at 0 degree centigrade and 1 atmosphere pressure is equal 0.024 W/(m.K)

T_a = Ambient Temperature
Tr= Refrigerator air Temperature
Glass thickness = 5 mm

$$U = 1 / [(0.005/1) + (0.015/0.024) + (.005/1)] = 1.57 \text{ W/ Sq. Mt. C}$$

$$A = 1.872 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$
 $T_f = 10 \text{ C}$

Q upper Door =
$$1.57 \times 1.872 \times 23 = 67.6 \text{ Watts}$$

$$Q_{Door} = 67.6Watts$$

Total Heat Leaks:



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$Q_{TL} = 22.6 + 32.7 + 18.2 + 31.1 + 16.4 + 67.4 = 189$$

b) Product Loads;

$O = m C (T_{im} - T_{fin})$

Where;

Q = Total heat removed from mixed fresh fruit and vegetables. Per 24 hr

M = Total mass of fresh fruit and vegetables = 100 Kg.

C Lettuce = $4.060x \ 0.23885 = 0.969 \ \text{Kcal/24hrs}$. Kg. C

 $C \text{ spinach} = 4.000 x \ 0.23885 = 0.955 \text{ Kcal/24hrs. Kg. } C$

 $C_{\text{Radish}} = 4.060 \text{x} \ 0.23885 = 0.969 \text{ Kcal/24hrs}. \text{ Kg. } C$

 $C_{Apple} = 3.78 \times 0.23885 = 0.903 \text{ Kcal/24hrs. Kg. C}$

 $C \text{ cherries} = 3.78x \ 0.23885 = 0.903 \ \text{Keal/24hrs. Kg. C}$

 $C_{Average} = (0.969 + 0.955 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. Kg. } C_{Average} = (0.969 + 0.955 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. Kg. } C_{Average} = (0.969 + 0.955 + 0.969 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. } C_{Average} = (0.969 + 0.969 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. } C_{Average} = (0.969 + 0.969 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. } C_{Average} = (0.969 + 0.969 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. } C_{Average} = (0.969 + 0.969 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. } C_{Average} = (0.969 + 0.969 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. } C_{Average} = (0.969 + 0.969$

 T_{iv} = Fresh Fruit and Vegetable initial temperature = 25 C

 T_{fv} = Fresh Fruit and Vegetable final temperature = 10 C

 $Q = 150 \times 0.0.934 \times (25-10) = 2101$ Kcal per 24 hrs

The total compressor operating time is considered 20 hours per day equals;



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Q = 2101 / 20 = 105 Kcal/hr = 122 Watt

$$Q_{\mathrm{Misc}} = Q_{\mathrm{Electicity}} + Q_{\mathrm{Infiltration}} + Q_{\mathrm{Door\ Opening}} + Q_{\mathrm{Etc.}}$$

According to our experience we can consider 20% of total heat removed from products and heat leaks through refrigerator walls for Q misc. therefore Total Cooling Capacity required is calculated as follows;

$$Q_{\text{Misc}} = 20\% (Q_{\text{Heat Leak}} + Q_{\text{Product Load}}) = 20\% x (189 + 122) = 62.2$$

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Product Loads}} + Q_{\text{Misc.}}$$

$$Q_{Grand\ Total} = 189 + 122 + 62.2 = 320 \ Watts$$

$$Q_{\text{Grand Total}} = 373 \text{ Watts}$$

The Suitable Compressor selected for this Model is FR11G with a total 385 watts cooling capacity at -10C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

Appli- cation	Compressor	Dis-		pressor	Voltage	Code n	umbers Com-	Capacity Walls						ower Sumption	LST	ن ا	Electrical ST	equipheri Luct	l "" " rés	tinet	1								
Catton		biacamer		-	trequen-	pressor	pressor	{						Wans								Walts	PIC	Starting	Starting	Starting	Cord	Cover	.}
}	1	i		erature	Cies		with	1				Evape	oratin	g tem	oeratu	ıre "C				- 1	Evap	. temp. "C	Starting device	relay	capacitor	device	relief]	
		cw,		43°C			cooling	-45	40	- 35				-15			 -	5	10	15	.25	-10 5]					
мвр	TL2.5F	2.61	1.		4	102G4200							47		86		136				53	78		<u> </u>			1	T	TL2.5F
0/ 30 C	TL3F TL4F	3 13	1:		4	102G4300 102G4400	<u> </u>	<u> </u>			30 44	42 61	59 82	81 108		140	175				64 80	97 120	4	117U6007 117U6009			1	1	TLOF
)	TLS5F	5.08	1	 		102G4400 102G4520		 '	\vdash	26 14	70			161		 			-		109	172	4	117U6004	117U5014	}	-	1	TL4F TLS5F
	TLS6F	5 70	1.		4	102G4620					78			182							119	181	113N0011	117U6004	1			107110010	TLS6F
R134a	TLS7F	6 19	_1-			102G4720				60	86			205								205	113140011	117U6000	<u> </u>		103N1006	103/12010	TLS7F
LBP	NL6F NL7F	73	1:	 		103G6606 103G6706	 	ļ		52 76	75		151 178		257 292	<u> </u>					115	185 226	-	11706004			4	1	NL6F
}	NL9F	8.35	1(2*)			103G6802	103G6812	<u> </u>			119			267								256	{	11706000	11705015			1	HL9F
-10/ 35 C	NL11F	11.15	5.(3.1		4	103G6900	103G6910					200			449						211			117U6002	1		1	1	HLITE
	SC15F SC18F	15.3 17.7	5,(3,)		4	104G8500 104G8800	104G8510 104G8810	-				230 280	315 400	435 525	565 665	1000					276 310	434	103N0002	11706003	11705016				SC15F
	SC21F	20 95	5.(3.)			104G8100	104G8110				245		455	610		990						600		117U6005 117U6019	11705016		103/11004	103112002	SC18F SC21F
	TL3G	3 13	3/1	3/1	4.5	102G4350					29	42	59	81	109	142	179	222	270	323	67	97 132		11700009				T	1L3G
	TL4G TL5G	3.86	3/1	3/1	4-5	102G4452					44	61	82	107	137	180	225	276	333 415	395	83	112 153	.]	117U6004	11705014]		TL4G
	FREQ	5.08 6.24	3/1	3/1	4-5	102G4550 103G6660	 		 		- 56 - 45	85	125		180 225	225	280 355	345 450	565	495	100	150 205 175 245	113N0011	117UG000 117U6000	 	 	1		TL5G FR6G
	FR7.5G	6 93	3/1	3/2	4.5	103G6880	103G6690				65	103	148	195	250		395	500	620		125	200 270		117U6001	1		103N1006	103N2010	FR7.5G
R134a	FR8.5G FR10G	7.95 9.05	3/1	3/2	4.5	103G6780								232	298	380	515	580 630	710		150	235 320 270 362	7	11705015	11705015		-	1	FR8.5G
7114	FR11G	11 15	3	3	4.5	103G6980	103G8890	 	-+					310		412	625		1/3	-		315 445		11706010	1	 	1		FR10G FR11G
	SC10G	10.3	3	3	4.5	104G8000				25	60	115	190	265	365	480	610	760		1105	175	285 390	103N0002	117U6002					SC10G
LBP	SC12G SC15G	12.9	3/2	3/2	4.5	104G8240								340		610	780			1350		365 495		117U6003	11705016]		SC12G
	SC18G	15.3 17.7	3/2	3/2	4-5	104G8520 104G8820							410	43 <u>5</u>	565 680	725		1320		1610		435 595 505 710		117U6005 117U6019	-{		-	1	SC15G SC18G
	SC21G"	20 95	3	3	4.5	104G8140	10400030		 					610		1020		1570	1900	2260		575 795		1.1700013		117-7028	103111004	103112002	SC21G**
	SC12/12G	2 x 12 9	_3	3	4	104G8280				120	236	366	520	680	920	1220	1560	1920	5300	2700		730 990		117U6003	1		1		SC12/12
1	SC15/15G SC18/18G	2 x 15 3	3	3	4	104G8580 104G8880		}	 		290						1820					870 1190 1010 1420		11706005	11705016			1	SC15/15G
		2 x 20 95	3	3		104G8180	 	<u> </u>	 		490	670	1010	1220	1580	2040	2550	3140	3800	4520	770	1150 1590	<u> </u>	1.1700013	}	117-7028	-		SC18/18G SC21/21G**
	FR7GH	6.93	2(3)	2(3)	4-6		103G6692									330	415	525	650	795		195 255		117U6016	117U5015		100011006	103N2010	FR7GH
R134a	SC10GH SC10GHH	103	3	3		104G8040	10.00074				 			260	350			770		1140		280 385 260 345		117U6002	11705016		70		SC10GH
нер	SC15GH	15.3	2(3)	2(3)	4	104G8560	104G8071		 					435	350 570	470 730	900	1140		1730		260 345 420 575		11706005	11705016	117-7011	10301004	103/12002	SC10GHH SC15GH
15/ 15°C	SC15GHH	15.3	2(3)	2(3)	4	1010000	104G8571				-			435	570			1140				380 495			11.239.2	117-7012	10.371004	100.12.002	SC15GHH
	SC18GH	17 7	3	3	4	104G8860				=				540		860	1080	1350	1665	2000		490 690		11706019	11705016				SC18GH
-	SC10C SC12C	10.3 12.9	3	┼	4	104L2516 104L2674	 	95	95 140		310		435 540	560 680		1020						550	· 	11706003	11/U5016		-		SC10C SC12C
ł	SC15CM	15.3	3	 		104L2848		115				510		840		1280						640		117U6019	11703010		1	1	SC15CM
R22	SC18CM***	17.7	3		4	104L2120		130	205	310	450	585	750	980	1230	1500					495					117-7012]	1	SC18CM***
LBP	SC21CM***	20 95	3	-	4	1041.2319	ļ	170	255		525			1085							605 600	830	 	11706003	ļ	117-7012	103N1004	103N2002	SC21CM*** SC10/10C
-5/ 45 C	SC10/10C SC12/12C	2 x 10.3 2 x 12.9	3		4	104L4076 104L4077		100	280	310 440	620			1120 1360		2040		 			760			11706005	11705016		1	1	SC12/12C
Ì	SC15/15CM	2 x 15.3	3	 	1	10414079	<u> </u>	230	350					1680		2560					920	1280		117U6019]	1	SC15/15CM
	SC18/18CM***	2 x 17.7	3		4	1041 4081		260	410	620				1960		3000					990					117-7012]	1	SC18/18CM***
	SC21/21CM*** SC10D	2 x 20 95	3		4	1041.4083	1041.2517	340	510	760	1050	Ouci	1700	510	2760	3440	1045	1200	17.80		1210	450 545	 	11700005	ļ	117 7012	·	· 	SC21/21CIA***
R22	SC12D	12 9	3	┼	7	 	1041 2684	\vdash							840	1070	1325	1615	1935	2290		515 660		11706011	11705016	1			SC12D
нве	SC15D	15.3	3		7		104L2839							800	1045	1325	1630	1975	2345			575 715				117-7010	103111004	103112002	SC15D
15/ 15 C	SC10/10D SC12/120	2 x 10 3 2 x 12 9	3	-	7	104L4084	·}	┼—-						1020			2090 2650					1030 1320		117U6005	11705016		10.5.1	103.420.2	SC10/10D
	SC15/15D	2 x 15 3	3		7	104L4085	 	├		1		-		1600	2090	2650	3260	3950	4690	5500		1150 1430		11706011		117-7010	-		SC12/120 SC15/15D
	FR6CL _	6 24	3		4	103U2670		90	120	150	190	250	310	390	470	560					250	355		11706015	117U5015		103/11006	103/12010	FRECL
R404A	FR8.5CL _	7.95	3		4	103U2890						320						<u> </u>			315			11706010	11703013		103711006	103112010	FR8.5CL
LBP	SC10CL SC12CL	10.3	3	+	4	104L2523 104L2623	 	75	150	160 235		340		785	750	1155			 -			485 610	 	117U6003 117U6005	11705016		-		SC10CL SC12CL
-5/-45 C	SC15CL	15.3	3	 	4	1041.2853	1			315			750		1155				_		510		1	11706019	1	 	1		SC15CL
(FRéCL and	SC18CL	179	3		4	104L2123		165		380	525	690	880	1095	1335	1595					605	895				117-7012	103N1004	103N2002	SC18CL
FR8 5CL preliminary	SC10/10CL SC12/12CL	2 x 10.3	3		4	104L4087	ļ	150	100		480										680 870		·	11706003	117115010	<u></u>	-		SC10/10CL
J3(a)	SC15/15CL	2 x 15.3	3	 	4-4-	104L4088 104L4089	 		300 420		880							-	-		1020		 	117U6005 117U6019	11705016	 	1		SC12/12CL SC15/15CL
	SC18/18CL	2 x 17.7	3		4	1041.4090			530												1210	1790				117-7012	-		SC18/18CL
	TL4DL J	3.86	3		4	102U2038										\vdash	,	525				· 235		117U6000	117U5014		103N1006	103N2010	TL40L
R404A	FR6DL J	6.24	3		4	103U2680 104L2525	ļ									 	, <u>-</u>	850 1400			{	375 620		117U6016	117U5015			1.55.120.0	FREDL SC10DL
нвр	SC12DL J	12.9	3			104L2525	 	┪	 				—	 		+	<u></u>	1760				775		11706005	11705016	}	1		SCIOOL
5(10)/-15°C	SC15DL J	15.3	3		1	1041.2856	t	1	1					<u> </u>	_			2085				925			1	117-7012	103111004	103N2002	SC15DL
Preliminary	SC10/10DL J		3		4	104L4091	T		I							T		2800			=	1240		11706005	117U5016		103/11004	103/12/02	SC10/100L
زرادل	SC12/12DL J		3		4	104L4092 104L4093	 	 										3520 4170		- 1		1550 1850		11706019		117-7012	-{		SC12/12DL
		1 2 1 3 3	1		11	L 1041 4093	1	1	L		l			L	1	.1	L	141/0	I	i L	1	11850	.L	.1	!	1 114-4015	1	1	SC15/15DL

Compressor cooling

1 = Static cooling

2 = Oit cooling

ng at HB

Transition

Voltages and frequencies 4 - 198-254 V. 50 Hz 5 - 198-254 V. 60 Hz, LBP 6 - 198-984 V. 60 Hz 7 = 11 30 Hz

Test conditions (CECOMAF)
Application
Condensing lumperature
Ambient temperature
Jas leng
Lington (Lington) H1344 H12/H404A 55°C 45°C 32°C 32°C 32°C 55°C

Conversion of capacity
If a stated capacity is required at 32. C liqued
temperature, notificity the capacity with one
of the following factors
11344 C to 32 231
122 C to 32 097

1 Watt + 0 66 Fraith 1 Watt + 3 41 Bluzh

Sufficient Compressor Cooling in Sulfitopical Comme Ltd. Cl. in 2207. Not supplicate Subor 25. Classificating temperature in 43. Classification Supplies and Mark. Mail. Comment (mes.)



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Transmission load calculation Show Case Model ELS-220-3F

Dimensions

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2x(144x90)	2.592	50
Upper Front Panel	72x220	1.584	15 (glass and air)
Lower Front Panel	72x220	1.584	50
Back Panel	144x220	3.168	50
Top Panel	80x220	1.76	50
Bottom Panel	90x220	1.98	50

Insulation Type: Pu Foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - 10 = 33 \text{ C}$

Ambient Temperature = 33 C

Refrigerator Air Temperature = 10 C

The refrigerator is designed to be used for keeping fresh lamb containing 67 % of lean. The initial fresh lamb temperature is considered to be 24 C. the specific heat of lamb containing 67% lean is 0.76 Kcal/hr kg. C.

Calculation:

$$Q_{TL} = Q_{SW} + Q_{BP} + Q_{Bottom} + Q_{Top} + Q_{Upper Door} + Q_{Lower front Panel}$$

$$Q = U A (T_a - T_f)$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$U = \frac{1}{X_1/K_1 + X_2/K_2 + \dots}$$

Where:

U = Heat Resistance Coefficient Factor

 $K_1 = Foam Thermal Conductivity$

 $X_1 = Foam Thickness$

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials have been considered negligible.

Therefore:

1-
$$Q_{\text{Side }Walls} = [U \land (Ta - Tf)]$$

 T_a = Ambient Temperature

 T_r = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

$$A = 2.592 \text{ Sq. Mt.}$$

$$T_a = 33 C$$

$$T_r = 10 \text{ C}$$

$$Q_{\text{Side Walls}} = 0.38 \text{ x } 2.592 \text{ x } 23 = 22.6 \text{ Watts}$$

2 -
$$Q_{Back panel} = [U A (Ta - Tr)]$$

Ta = Ambient Temperature

Tr = Refrigerator air Temperature

$$U = 1 / (0.050 / 0.019) = 0.38 \text{ W/ Sq. Mt. C}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$A = 3.168 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$

$$T_r = 10 \text{ C}$$

$$Q_{Back\ panel} = 0.38 \times 3.168 \times 23 = 27.7 \text{ Watts}$$

$$Q_{Back panel} = 27.7 Watts$$

$$Q_{Top} = [U A (Ta - T_f)]$$

 $T_a = Ambient Temperature$

Tr = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt C}$$

$$A = 1.76 \text{ Sq. Mt.}$$

$$T_a = 33 C$$

$$T_r = 10 C$$

$$Q_{Top} = 0.38 \times 1.76 \times 23 = 15.4 \text{ Watts}$$

$$Q_{\text{Top}} = 15.4 \text{ Watts}$$

4 -
$$Q_{Bottom} = [U A (T_a - T_f)]$$

Ta = Ambient Temperature

T₁= Refrigertor air Temperature

$$U = 1/(0.050/0.019) = 0.38 \text{ W/Sq. Mt } C$$

$$A = 1.98 \text{ Sq. Mt.}$$

$$T_a = 45 C$$

$$T_f = 10 C$$

$$Q_{Bottom} = 0.38x \cdot 1.98 \cdot x \cdot 35 = 26.3 \text{ Watts}$$

5 -
$$Q$$
 Lower Front Panel = $[U A (T_a - T_f)]$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

T_a = Ambient Temperature T_r= Refrigertor air Temperature

$$U = 1/(0.050/0.019) = 0.38 \text{ W/Sq. Mt } C$$

 $A = 1.584 \text{ Sq. Mt.}$
 $T_a = 33 \text{ C}$
 $T_f = 10 \text{ C}$

Q Lower Front Panel =
$$0.38x \ 1.584 \ x \ 23 = 13.8 \ Watts$$

Q Lower Front Panel = 16.8 Watts

6 -
$$Q$$
 Upper Front Door = $[U A (T_a - T_f)]$

According to ASHREA handbook of refrigeration and Standard Mechanical Engineering Handbook published by Mc Graw Hill Book Co. the thermal conductivity for Tempered glass and air are as follows. The refrigerator door cabinet is considered to be 5 mm Double Tempered Glass with 15 mm still air between two side glasses.

- g) Thermal conductivity for Tempered Glass at 366 degree of Kelvin is equal to 1 W/(m. K)
- h) Thermal Conductivity for air at 0 degree centigrade and 1 atmosphere pressure is equal 0.024 W/(m.K)

T_a = Ambient Temperature T_r= Refrigerator air Temperature Glass thickness = 5 mm

$$U = 1 / [(0.005/1) + (0.015/0.008) + (.005/1)] = 1.57 \text{ W/ Sq. Mt. C}$$

$$A = 1.584 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$
 $T_f = 10 \text{ C}$

$$Q_{\text{Upper Door}} = 1.57 \text{ x } 1.584 \text{ x } 23 = 57.2 \text{ Watts}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

 $Q_{Door} = 57.2 \text{ Watts}$

Total Heat Leaks;

$$Q_{TL} = 22.6 + 13.8 + 57.2 + 27.7 + 15.4 + 26.3 = 163$$

Q Total Heat Leaks = 163 Watts

b) Product Loads;

$Q = m C (T_{im} - T_{fm})$

Where;

Q = Total heat removed from mixed fresh fruit and vegetables. Per 24 hr

M = Total mass of fresh fruit and vegetables = 100 Kg.

 $C_{\text{Lettuce}} = 4.060 \text{x} \ 0.23885 = 0.969 \ \text{Kcal}/24 \text{hrs. Kg. C}$

C spinach = $4.000x \ 0.23885 = 0.955 \ \text{Kcal/24hrs}$. Kg. C

C Radish = 4.060 x 0.23885 = 0.969 Kcal/24hrs. Kg. C

 $C_{Apple} = 3.78 \times 0.23885 = 0.903 \text{ Kcal/24hrs. Kg. C}$

C cherries = $3.78x \ 0.23885 = 0.903 \ \text{Kcal/24hrs}$. Kg. C

 $C_{Average} = (0.969 + 0.955 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal}/24\text{hrs. Kg. } C$

 T_{iv} = Fresh Fruit and Vegetable initial temperature = 25 C

 T_{fv} = Fresh Fruit and Vegetable final temperature = 10 C

 $Q = 100 \times 0.0.934 \times (25-5) = 1868$ Kcal per 24 hrs



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

The total compressor operating time is considered 20 hours per day equals;

$$Q = 1868 / 20 = 93.4 \text{ Kcal/hr} = 111.4 \text{ Watt}$$

$$Q_{\text{Misc}} = Q_{\text{Electicity}} + Q_{\text{Infiltration}} + Q_{\text{Door Opening}} + Q_{\text{Etc.}}$$

According to our experience we can consider 20% of total heat removed from products and heat leaks through refrigerator walls for Q misc. therefore Total Cooling Capacity required is calculated as follows;

$$Q_{\text{Misc}} = 20\% (Q_{\text{Heat Leak}} + Q_{\text{Product Load}}) = 20\% x (163 + 111.4) = 55$$

$$Q_{\text{Grand Total}} = Q_{\text{Heat Leaks}} + Q_{\text{Product Loads}} + Q_{\text{ Misc.}}$$

$$Q_{Grand\ Total} = 163 + 111.4 + 55 = 329 \text{ Watts}$$

$$Q_{\tt Grand\ Total} = 329\ {\tt Watts}$$

The Suitable Compressor selected for this Model is Danfoss FR10G with a total 320 watts cooling capacity, at -10 C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

Hermetic Compressors 220 V

Dunfoss Compressors

Appli- ation	Compressor	Dis- placement		ressor iling	Voltage and	Coden	Umbers Com-	1						apacit Watts	7							ower Sumpto	on	LST	1 н		equipment HST	1.1	/ 115 (Compri
		,			tredneu-	bressor	pressor	l														Walls		PIC	Starting	Starting	Starting	Cord	Cover	1
		1		bient	cles	•	with																	Starting	relay	capacitor	device	relief	1	İ
				eralure			oil	ļ,				Evapo								,		temp.		device	ļ		1			
	l	cm ₃	32~C	43°C			cooling	45	40	35	-30	-25		-15				5	10	15	-25	-10	5				!		1	!
18P	TL2.5F	2.61	1.		4	102G4200								65			136				53	78								тт
30 C	TL3F	3 13	!'		4	102G4300					30	42	59	81	108	140	175	L			64	97			11706007]	
	TL4F	3.86	i.		4	102G4400			\vdash		44	61		108		Ь—		 			80	120			11706009		İ	1	}	
	TLS5F	5 08	1.		4	102G4520	ļ			44	70_	93	123	161	207	 		L				172			11706004	117U5014				
	TLS6F	5 70	1.		4	102G4620					78			182				 		├	119	181		113N0011	117U6004			103N1006	103N2010	
134a	TLS7F NL6F	6.49	-1·		4	102G4720	 			60 52	86	118	158	205	260			 	-	\vdash	135 115	205			117U6000 117U6004			1		
8P	NL7F	73	1.	 	4	103G6606 103G6706				76	99	134			292	\vdash		 		\vdash		226			11706004			1	ĺ	
	NL9F	8.35	1(2*)	├ ──		103G6802	103G6812	 		92		157			337			 				256			11706000	11705015		4		———
35° C	NL11F	11 15	2'(3')	 	4	103G6900		 				200				├─		1			211	324			117U6002			1		
	SC15F	15.3	2*(3*)	-	4	104G8500		_				230				-		1			276			103N0002	117U6003			i	!	
	SC18F	177	2.(3.)		4		104G8810			115	190		400	525	665	825					310	495			11706005	117U5016		103111004	103042002	
	SC21F	20.95	2'(3')	1	4	104G8100	104G8110				245			610	780						380	600			11706019			1	I	
	TL3G	3 13	3/1	3/1	4.5	102G4350					29	42	59	81	109	142	179	222	270	323	67	97	132		11706009				i -	
	TL4G	3 86	3/1	3/1	4-5	102G4452					44	61	82	107	137	180	225	276	333	395		112	153		11706004	11705014		1		
	TLSG	5 08	3/1	3/1	4.5	102G4550			LI		56	76	105	140	180	225	280		415	495	100		205	113N0011	11706000			1	1	
	FR6G FR7.5G	6 24	3/1 3/1	3/1 3/2	4.5	103G6660 103G6680	103G6690		 		45 65	103	125	173	225 250	285 313	355		565 020	 			245	FIGNODII	11706000			103N1006	103742010	F
	FR8.5G	7.95	3/1	3/2	4.5	103G6780					82	126		232	298		470		710	\vdash		235	320		11705001	11705015		1 .		F
34a	FRIOG	9 05	3/1	3/2	4.5						90	138	191	252	320	412	515	630	775		180	2/0	362		11706010		ł	1		
	FRIIG	11 15	3	3/2	4-5	103036980					110	170	235	310	385	495	625	775			200	315	445	******	11706010					
BP BP	SC10G	10.3	3	3	4.5	104G8000				25	60	115		265	365		610			1105			390	2000/4501	11706002		ļ	1	_	
35 C	SC12G	12.9	3/2	3/2	4.5	104G8240					118		260	340	460			960					495	103N0002	117U6003	117U5016			ļ	
	SC15G	15.3	3/2	3/2	4.5	104G8520	104G8530	<u> </u>		95		230		435	565	725	910	1120	1350	1610	275	435			117U6005	1		Į.	}	
	SC18G SC21G"	17.7	3/2	3/2	4-5		104G8830	\vdash	-	110	190	280		540 610	680	1020	1080	1320 1570	1000	1980		505 575	710		117U6019		117-7028	103111004	103112002	S
	SC12/12G	20 95 2 x 12 9	3	3	4-5	104G8140 104G8280	 	 		120	245 236	335 366		680		1220		1920							11706003		117-7028	103/11004	103112002	S
	SC15/15G	2 x 15.3	3	3		104G8580	 				290	460		870		1450		2240							11706005	11705016	<u> </u>	1	i	SC
	SC18/18G	2 x 17 7	3	3		104G8880	 			220	380	560	820	1080	1360			2640							117U6019	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		İ	ĺ	SC
	SC21/21G**	2 x 20 95	3	3	4	104G8180				370		670	1010	1220	1580	2040	2550	3140	3800	4520	770	1150 1					117-7028	!		SC21
	FR7GH	6.93	2(3)	2(3)	4-6	-13-22-22-	103G6692			-				200	260			525	650	795		195	255		117U6016	117U5015		103N1006	103N2010	F
134a	SC10GH	103	3	3	4	104G8040								260	350		605		940				385		117U6002	117US016				SC
	SC10GHH	10.3	2(3)	2(3)	4		104G8071							-00	350				940				345				117-7011	I		SCI
BP	SC15GH	15.3	3	3	4	104G8560					~			435	570					1730			575		LIVURGOS	14303016		16361004	10 312902	50
15 C	SCISGHH	15.3	2(3)	2(3)	4		104Gn571		ļl					435 540	2/0			1350		1730		380				11705016	117 /012	1	1	SCI
	SC18GH SC10C	177	3	3	4	104C8860 104t 2516	<u> </u>		95	155	210	304	1715			850 850		1.350	1665		300		690		11706019	11707,016			· · · · · · · · · · · · · · · · · · ·	
	SC12C	129	3	+	1	104L2674	 	95	140	220	310	325 415	540	UUU.	840	1020		11		ł l	380	550			11706005	11705016		1]	
	SC15CM	15.3	3-	 	1	104L2848	 		175	270	385	510				1280		1-1		\vdash		640			11706019	************		103141604	103/12002	sc
122	SC18CM***	17.7	3	1	4	104L2120	 			310		585				1500		1		1		690	i	j			117-/012			SC18
	SC21CM***	20.95	3		4	104L2319		170	255	380	525	680	850	1085	1380	1720					605						117-7012			SC21
.BP	SC10/10C	2 x 10 3	3		4	104L4076		100				650									600				11700003					SC
45 C	SC12/12C	2 x 12 9	3		4	104L4077	l	190	280	440	620	830	1080	1360	1680	2040		1				1100			117U6005	11705016	l			sci
	SC15/15CM	2 x 15.3	3		4	104L4079		230	350	540	770	1020	1310	1680	2100	2560		\vdash		1	920		\rightarrow		11706019					SC15
	SC18/18CM**		3	<u> </u>	4	104L4081	ļ		410									11			990 1210			{·		·	117-7012			SC18/18
	SC21/21CM**	2 x 20 95	3	 	4	1041,4083	10110617	340	510	760	1050	1360	1700			835		1295	1680				545		11706005		117-7012		 	5021/21
R22	SC12D	129	3	+	7		104L2517 104L2684							650	840	1070	1325	1615	1935	2290			660		11706003	117U5016	ļ	1	!	<u>-</u>
	SC150	15.3	3	+	7	·	104L2839		 					800		1325	1630	1975	2345	2750		575			1,,,500,1,		117-7010	1	1	ļ
186	SC10/10D	2 x 10.3	3	1	4	104L4084	1	 	\vdash					1020				2590				900			11706005	4.50.7	1	10301-004	100142002	sc
- 15 °C	SC12/12D	2 x 12.9	3	1	7	104L4085		t	П	\dashv				1300	1680	2140	2650	3230	3870	4580		1030			117U6011	117U5016		1		sc.
	SC15/15D	2 x 15 3	3		7	104L 4086								1600	2090	2650	3260	3950		5500		1150					117-7010	i		sc
	FR6CL J	6.24	3		4	103U2670		90	120	150	190		310	390	470	560					250	355			11706015	117U5015		103/11006	103/12010	
104A	FR8.5CL _	7 95	3	ļ	4	103U2890		1				320			<u> </u>	·		$\vdash \vdash$		$\vdash \vdash$	315				11706010			1,75,110,00	.0312010	FF
.BP	SC10CL	10.3	3	ļ	4	104L2523	<u> </u>	1		160				595						 	340	485 610			117U6003		 	1	1	s
-45 C	SC12CL	129	3	 	4	1041 2623	<u> </u>	75	150		330	475	630	785	965			┧							117U6005	117U5016			1	S.
	SC15CL	15.3	3		4	104L2853		130				585				1390		1		├	510 605	720 895	 -}		11706019		117-7012	103/11004	manacac	Se Se
CL and 8 SCL	SC18CL SC10/10CL	2 x 10 3	3	 	- 4	104L 2123	 	165	265	380	525 480	680	920	1100	1500	1595	:	\vdash		┼─┤	680	970	-+		117U6003	·	117-7012	103111004	103N2002	SCIO
пинагу	SC12/12CL	2 x 12 9	3	 	 	104L4087	 	150	300							2310		+-		\vdash	870				11706003	11705016		1	1	SCI
u(a)	SC15/15CL	2 x 15 3	3	1	1 1	104L4089	·		420									\Box		\Box	1020				117U6019			1	1	SCIS
	SC18/18CL	2 x 17 7	3		4	104L4090			530												1210						117-7012	1	1	SCIE
	TL4DL J	3.86	3		4	102U2038		T							Ī.,	I		525					235		117U6000	117U5014		103N1006	100110015	·
404A	FR6DL J	6 24	3		4	103U2680									Ι			850					375		11706016	117U5015		103141006	103N2010	
	SC10DL J	10.3	3		4	104L2525												1400					620		117U6005	117U5016		1		so
1BP	SC12DL J	12.9	3	L	4	1041 2625	L						L		ļ	1		1760		<u> </u>			775		117U6019	11703016]	1	SC
)/-15°C	100.000	15.3	3		4	104L2856							L	<u> </u>	ļ	1		2085		11	I		925		L		117-7012	103N1004	103N2002	SC
niminary	SC10/10DL .		3		4	104L4091										ļ <u>.</u>		2800		↓]			1240		11706005	117U5016		1		SCIO
Jaiaj	SC12/12DL -		3		4	1041.4092			\Box				ļ	Į	 	 	-	3520		├ ─			1550		11706019			1	1	SC12
	SC15/15DL .	JI 2 x 15 3	3	1	4	104L4093	1	1	1	1	1	i l	ı	I	1	F	1	4170		1 1	- 1		1850		1	!	117-7012	1	1	SC15

Compressor cooling

1 = Static cooling
2 = Oil cooling
2 = Oil cooling
ing at ht
1 per segmentive

Voltages and frequencies 4 = 198:254 V 50 Hz 5 = 198:254 V, 50 Hz, LBP 6 = 198-254 V, 60 Hz 7 = 1 50 Hz

H134a R22/R404A 55°C 45°C 32°C 32°C 32°C 32°C 32°C 21°C

Conversion of capacity
If a state of copusity is required at 32. C figure
temperature, nothlight the capacity with one
of the following factors:
1134a C to 32. 231
1222 C to 32. (2)2

1 Watt = 0.86 keath 1 Watt = 141 Blu/h

Sufficient Compressor cooling in subtropical consiste (SEC) at 2009.

This supplication below as to evaporating temperature is 43.0 emperature.

Min Time



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Transmission load calculation Show Case Model ELS-1219F

Dimensions

	Dimension	Area (sq. mt.)	Insulation
	Cm.	_	Thickness mm
Side Walls	2x(137x84)	2.3	50
Glass Front Panel	193x111	2.14	(Double Glass and
			15 mm Still Air)
Lower Front Panel	193x80	1.54	50
Back Panel	193x137	2.64	50
Bottom Panel	193x84	1.62	50

Insulation Type: Pu Foam

Cyclopentane Foam Thermal Conductivity: 0.019 W /mt.C

Temperature Difference: $(\Delta T) = 43 - 10 = 33 \text{ C}$

Ambient Temperature = 33 C

Refrigerator Air Temperature = 10 C

The refrigerator is designed to be used for keeping fresh lamb containing 67 % of lean. The initial fresh lamb temperature is considered to be 24 C. the specific heat of lamb containing 67% lean is 0.76 Kcal/hr kg. C.

Calculation:

$$Q_{TL} = Q_{SW} + Q_{BP} + Q_{Bottom} + Q_{Top} + Q_{Upper\ Door} + Q_{Lower\ front\ Panel}$$

$$Q = U A (T_a - T_f)$$

$$U = \frac{1}{X_1 / K_1 + X_2 / K_2 + \dots}$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Where:

U = Heat Resistance Coefficient Factor

 $K_1 = Foam Thermal Conductivity$

 $X_1 = Foam Thickness$

Note: Due to the short thickness of cabinet out side panel (0.6 mm) and plastic inner liner (1.5 mm) heat resistance of these materials have been considered negligible.

Therefore:

1-
$$Q_{\text{Side Walls}} = [U \land (Ta - T_f)]$$

Ta = Ambient Temperature
Tr = Refrigerator air Temperature

$$U = 1 / (0.050/0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

 $A = 2.3 \text{ Sq. Mt.}$
 $T_a = 33 \text{ C}$
 $T_r = 10 \text{ C}$

$$Q_{\text{Side Walls}} = 0.38 \text{ x } 2.3 \text{ x } 23 = 20.1 \text{ Watts}$$

$$Q_{\text{Side Walls}} = 20.1 \text{ Watts}$$

$$2 - Q_{Back panel} = [U A (Ta - Tr)]$$

T_a = Ambient Temperature
T_r = Refrigerator air Temperature

$$U = 1 / (0.050 / 0.019) = 0.38 \text{ W/ Sq. Mt. C}$$

A Heat transferable area = 2.64 /2 = 1.32Sq. Mt.
 $T_a = 33 \text{ C}$
 $T_r = 10 \text{ C}$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

$$Q_{Back panel} = 0.38 \times 1.3 \times 23 = 11.4 \text{ Watts}$$

3 -
$$Q$$
 Front Site Glass and Top = $[U A (Ta - Tf)]$

According to ASHREA handbook of refrigeration and Standard Mechanical Engineering Handbook published by Mc Graw Hill Book Co. the thermal conductivity for Tempered glass and air are as follows. The refrigerator door cabinet is considered to be 5 mm Double Tempered Glass with 15 mm still air between two side glasses.

- i) Thermal conductivity for Tempered Glass at 366 degree of Kelvin is equal to 1 W/(m. K)
- j) Thermal Conductivity for air at 0 degree centigrade and 1 atmosphere pressure is equal 0.024 W/(m.K)

T_a = Ambient Temperature T_r= Refrigerator air Temperature Glass thickness = 5 mm

$$U = 1 / [(0.005/1) + (0.015/0.024) + (.005/1)] = 1.57 W/ Sq. Mt. C$$

$$A = 2.14 \text{ Sq. Mt.}$$

 $T_a = 33 \text{ C}$

$$T_f = 10 \text{ C}$$

Q Front Site Glass and Top =
$$1.57 \times 2.14 \times 23 = 77.3$$
 Watts

$$Q_{Top} = 77.3 \text{ Watts}$$

$$4 - Q_{Bottom} = [U A (T_a - T_f)]$$

T_a = Ambient Temperature
T₁= Refrigertor air Temperature



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

U = 1/(0.050/0.019) = 0.38 W/Sq. Mt C A = 1.62 Sq. Mt. $T_a = 45 \text{ C}$ $T_f = 10 \text{ C}$

Q Bottom =
$$0.38x \ 1.62 \ x \ 35 = 21.5 \ Watts$$

Q Bottom = $21.5 \ Watts$

Total Heat Leaks;

$$Q_{TL} = 20.1 + 77.3 + 11.4 + 32.7 + 21.5 = 144.5$$

$$Q$$
 Total Heat Leaks = 130 Watts

b) Product Loads;

$$Q = m C (T_{im} - T_{fm})$$

Where;

 Q_{TP} = Total heat removed from mixed fresh fruit, vegetables and fresh lamb meet. Per 24 hr

 M_1 = Total mass of fresh fruit and vegetables = 150 Kg. Fruit and Vegetables

$$C_{1,ettuce} = 4.060x \ 0.23885 = 0.969 \ Kcal/24hrs. \ Kg. \ C_{2,ettuce}$$

$$C \text{ spinach} = 4.000 \text{x } 0.23885 = 0.955 \text{ Kcal/24hrs. Kg. } C$$

$$C_{\text{Radish}} = 4.060 \text{x} \ 0.23885 = 0.969 \text{ Kcal/24hrs. Kg. C}$$

$$C_{\text{Apple}} = 3.78 \times 0.23885 = 0.903 \text{ Kcal/24hrs. Kg. } C$$



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

C Cherries = $3.78 \times 0.23885 = 0.903 \text{ Kcal/24hrs. Kg. C}$

 $C_{Average} = (0.969 + 0.955 + 0.969 + 0.903 + 0.903)/5 = 0.934 \text{ Kcal/24hrs. Kg. C}$

 T_{iv} = Fresh Fruit and Vegetable initial temperature = 25 C

 $T_{f'}$ = Fresh Fruit and Vegetable final temperature = 10 C

Q Fresh Fruit and Vegetables = $150 \times 0.0.934 \times (25-10) = 2101$ Kcal per 24 hrs

 M_2 = Total mass of lamb meat = 100 Kg.

C = 0.76 Kcal/24hrs. Kg. C

 T_{im} = Lamb meat initial temperature = 24 C

 T_{fm} = Lamb meat final temperature = 10 C

Q Fresh Lamb Meat = $150 \times 0.76 \times (28-10) = 2052$ Kcal per 24 hrs

 $Q_{\text{Total Product}} = Q_{\text{Fresh Lamb Meat}} + Q_{\text{Fresh Fruit and Vegetables}} = 2052 + 2101 = 3697$

The total compressor operating time is considered 20 hours per day equals;

 $Q_{\text{Total Product}} = 4062 / 16 = 253 \text{ Kcal/hr} = 295 \text{ Watt}$

 $Q_{\text{Misc}} = Q_{\text{Electicity}} + Q_{\text{Infiltration}} + Q_{\text{Door Opening}} + Q_{\text{Etc.}}$

According to our experience we can consider 40% of total heat removed from products and heat leaks through refrigerator walls for Q misc for this type of product, therefore



AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.

Total Cooling Capacity required is calculated as follows;

$$Q_{\text{Misc}} = 30\% (Q_{\text{Heat Leak}} + Q_{\text{Product Load}}) = 40\% x (130 + 295) = 127$$

$$Q_{\textit{Grand Total}} = Q_{\textit{Heat Leaks}} + Q_{\textit{Product Loads}} + Q_{\textit{Misc.}}$$

$$\mathbf{Q}_{\mathbf{Grand\ Total}} = 130 + 295 + 127 = 552 \ \mathbf{Watts}$$

$$Q_{\text{Grand Total}} = 552 \text{ Watts}$$

The Suitable Compressor selected for this Model is Danfoss SC15G with a total 565 watts cooling capacity, or Compressor Model Danfoss SC18G with a total 680 watts cooling capacity at -10C evaporating temperature at CECOMAF test condition, (55 degree condensing and liquid temperature)

	Compressor	Dis-	C	000000	Vollage	Code	umbore	T .	••				C.								ta								
Appli-		placement		pressor oling	Voltage and	Com-	umbers Com-	1						apacity Watts	'					1	CONSUM		LST	HS	ST	HST	LŠT/	HST	
					trequen-	pressor	pressor	•													Watt		PTC.	Starting	Starting	Starting	Cord	Cover	1
				nblent	cies		with					E ~ ~ ~										1	Starting	relay	capacitor	device	relief		
	İ	cm,		13°C	1	[oil cooling	- :- 1	40	75.1	30				oratu -10		. 1	٠ . ١	1		Evap, tan	: 1	device	}		1			
MRP	TL2.5F	261	12.0	13 C	 	10264200	Cooming	45	40	12	-30		4/		-100		136	-5	10	15	25 10	L. i				ļ			
0/ 30 C	TLOF	3 13	1:		4	10264200			\rightarrow	\rightarrow	30	12	59	65 81	100		175				57) 78 64 57			11706007		ł			11.2 ft.
: [TL4F	3 86	1.		4	10264400				26	44	61	82	108	137	. 12					80 120			11706009	l				IL.
	TLS5F	5 08	1.		1	102G4520					70	93	123	161	207						109 172			11706004	11705014	· ·	1		าเรีย
_	TLS6F	5.70	1.		4	102G4620									232						119 181		11300011	117U6004			103N10G6	103N2010	ILS
	TLS7F NL6F	6.49 6.1	7:			102G4720							158		260						135 205			117U6000		ļ	103111000	103112010	TLS
	NL7F	73	10		4	103G6606 103G6706							151		257 292						115 185 141 226			117U6004					NLC
	NL9F	8.35	1(2°)		1-1-	103G6802	103G6812	-				157			337				+		141 226 166 256			11706000	117U5015				HL:
-10/ 35 C	NL11F	11 15	2'(3'	 	1	103G6900	103G6910		$\neg \neg$	110		200			449						211 324			11706002					IIL1
	SC15F	15.3	2*(3*		4	104G8500	104G8510		_	95	146	230	315	435	565						276 434		103N0002	117U6003					SC1
	SC18F	17.7	2.(3.		4	104G8800	104G8810			115				525	665	825					310 495			117U6005	117U5016		103(11004	103/42002	SCI
	SC21F	20 95	2.(3.		1	10408100	104G8110			185		335				990					380 600			117U6019					SC2
	TL3G TL4G	- 3 13 3.86	3/1 3/1	3/1	4.5	102G4350					29		59 82	81	109	142	1/9	222			83 112			117U6009 117U6004	11705014				[L]
	TL5G	5.86	3/1	3/1	4-5	102G4452 102G4550				\longrightarrow $+$			105	107	180	180 225	225 280					205		11706004	11705014				TL5
ì	FR6G	624	3/1	3/1	4-5	103G6660					45					285	355		565		107 175		11300011	11706000			ii	42.04.05.45	FR6
	FR7.5G	6 93	3/1	3/2	4.5	103G6680	103G6690				65	103	148	195	250	313	395	500	620		125 200	270		11706001			103011666	16302010	FA75
	FR8.5G	7.95	3/1	3/2	4-5	103G6780	103G6790							232	298	380	470	580	710		150 235			11706015	11705015				FR8.5
	FR10G FR11G	9 05	3/1	3/2	4.5	103G6880	103G6890	 				138			320	412	515	630	775		180 2/0			11706010			ļ l		FR10
	SC10G	10.3	3	3	4.5	103G6980 104G8000		 				170		310 265		495 480	625 610	775 760	910		200 315 175 285		103N0002	117U6010 117U6002					FR11 SC10
LBP	SC12G	12.9	3/2	3/2	4-5	104G8240	104G8250	!							160	610	780		1150				103N0002	11706002					SC12
	SC15G	153	3/2	3/2	4-5	104G8520	10468530	1	\neg							725			1350					11706005	117U5016				SCIS
	\$C18G	17.7	3/2	3/2	4.5	10468820	104G8830					280			600	860			1620					11706019					SC 18
	\$C21G**	20 95	3	1 3	4-5	104G8140				185				610		1020		1570						L		117-7028	103111004	103142002	SC21G
	SC12/12G SC15/15G	2 x 12 9 2 x 15 3	3	3		104G8280 104G8580						366 460			920 1130			1920				990		117U6003	11705016		1		SC12/ SC15/15
	SC18/18G	2 x 17 7	3	3		104G8880									1360			2640				1420		11706003	11703010	}	1		SCIAVIA
	\$C21/21G**	2 × 20 95	3	1 3	1	104G8180		\Box			490							3140			770 1150			117000.5		117-7028			SC21/21G
	FR7GH	6.93	2(3)	2(3)	4-6		103G6692							200	260	330	415	525	650	795	195	255		11706016	117U5015		103N1006	103N2010	FR7G
R134a	SC10GH	10 3	3	3	4	104G8040		\sqcup							350		605	770	940	1140	280			117U6002	117U5016				SC100
нвр	SC10GHH SC15GH	10.3	2(3)	2(3)	4	10000000	104G8071	\vdash								470	605		940		260				717000	117-7011			SC10GH
	SC15GHH	15.3	2(3)	2(3)	4	104G8560	104G8571	-	-					435	570 570	730		1140				575		11706005	117U5016	117-7012	103N1004	103N2002	SC15G
	SC18GH	17.7	3	3	1 4	104G8860	10400071	1		-+			-		680			1350			490			11706019	11705016	1117.7012			SCIAG
	SC10C	103	.3		4	1041 2516		50	95			325		560	700	850					300 420			117U6003					SC16
	SC12C	12 9	3		1 4	1041 2674		95	140			415		080	840						380 350			11706005	11705016				'.C12
	SC15CM SC18CM***	15.3	3		1	1041.2848	ļ	115	175			510			1050						460 640 495 690			11706019		117-7012			50150 SC180M*
R22	SC21CM***	17.7 20.95	3	-		1041.2120		130	205 255			680		980 1085	1230 1380						495 690 605 830			l		117.7012	10301004	103/12/002	SC21CM
LBP	SCIO/IOC	2 x 10 3	3	 	1	1041.4076		100			480	650	870		1400	1700					600 810			11700003		117 7012 10 3141014	10,3,410,124	10.3(12)002	SCION
	SC12/12C	2 x 12.9	3		4	104L4077		190	280	440	620	830	1080	1360	1680						760 1100			11706005	11705016		! !		SC 12/12
	SC15/15CM	2 x 15 3	3		1	1041 4079		530	350	540	770	1020	1310	1680	2100	2560					920 1280			11706019					SC15/15C
	SC18/18CM*** SC21/21CM***	2 x 17.7	-3		 	1041.4081	 -		410 510												990 1380 1210 1660					117-7012	!		SC18/18CM*
	\$C10D	2 x 20 95	3	 	1-1-	104L4083	104L2517	340	210	/BU	10001	1,36367	.,,00		655		1045	1295	1580	1895	450			117U6005		117-7012			SC21/21CM
	SC120	12.9	3		7	T	1041 2684							050	840	1070	1325	1615	1935	2290	515	660		11706011	11705016				SC 12
нвр	SC15D	15.3	3	-	7	1000	104L2839	ļ				\Box		800	1045			1975		2750		715				117-7010	103/1117/04	103/12002	SC15
15/-15°C	SC10/10D SC12/12D	2 x 10 3	3		 	104L4084 104L4085	ļ			∮			{					2590				1090		11706005	11705016		.55.11,754		SC10/10
	SC15/15D	2 x 15 3	3	-	7 7	1041 4086	 	1	\vdash									3230 3950		5500		0 1320		11706011		117-7010			SC12/12 SC15/15
	FR6CL J	624	3	 	4	103U2670	 	90	120	150	190	250	310		470		32.00		1335		250 355			117U6015	447117	117-7010			FR6C
R404A	FR8.5CL J	7.95	3		1	103U2890	<u> </u>	1				320									315			11706010	117U5015		103N1006	103112010	FR8.50
LBP	SC10CL	103	3		1	1041 2523	ļ					340	460	595	750	920					340 485			11706003					SCIOC
-5/-45 C	SC12CL SC15CL	12 9 15.3	3		1 4	1041.2623	J	75	210				630 750	785		1155	<u></u>	\vdash	∤-		135 610 510 720			11700005	11705016				SC120
(FR6CL and	SC18CL	17.9	3		4-4-	1041.2853	 	165	265						1155 1335						510 720 605 895			11706019		117-7012	103111604	103N2002	SC150
FR8 5CL	SC10/10CL	2 x 10 3	3		4	104L4087	 	1,00		320					1500				+		680 970			117U6003		111-7012	103111007	103112002	SC1W10C
preliminary Jula)	SC12/12CL	2 x 12 9	3		1	1041.4088		150	300	470	660	950	1260	1570	1930	2310					870 1220			11706005	117U5016				SC12/12C
,	SC15/15CL	2 x 15.3	3		1	1041 4089		260	420		1900		1500	1890	2310	2780					1020 1440	יונ		11706019			! !		SC15/150
	SC18/18CL	2 x 17 7	3		1	1041 4090		3.30	530	760	1050	13880	1760	2190	2670	31:8		[}	1210 1798			ļ		117 7612			SCHWIRE
	FREDL 1	3 86	3		1 4	10202038	 	ļ	├		-							525 850				375		11706000	11705014		103/11/696	103/12010	11.40
R404A	SC10DL J	624	3-		 	10302660 104L2525	·	1							***			1400		 -		620		11706005	11705015				SC10E
HBP	SC12DL 4	12.9	3	+	+ ;	1041 2625	†											1760				775		11706019	117U5016				SC 120
5(10y-15°C	SC15DL J	15.3	3		4	104L2856		1.			_					l		2085				925				117-7012	103112334	Managaga	SC150
Prewninary	SC10/10DL 1		3		4	10474031		T										2800				1240		11706005	117U5016		103/11004	103112002	SC1W10C
42(1)	SC12/12DL J SC15/15DL J		3		4	104L4092 104L4093	ļ	ــــــ	\vdash									3520				1550 1850		11706019	,03010	L			SC12/120
																		4170								117-7012			SC15/15E

Voltages and frequencies 4 = 198-254 V 50 Hz 5 = 198-254 V 60 Hz, LBP 6 = 104-261 V 60 Hz 7 = 1 00 Hz

Test conditions (CECOMAF)
Application
Continuous temperature
Amount temperature
jus lump
source children, continuous
COMMENTATION COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMMENTATION
COMME

R134a R22/R404A 55°C 45°C 12°C 32°C 32°C 32°C

Conversion of capacity
If a Stated canadary is required at 32 C figure
disriperature, multiply the capacity with one
of the following factors:
1134a Co. 77 231
1774 Co. 37 2097
1774 Co. 37 2097

1 Watt = 0.86 kcavh 1 Watt = 3.41 Bluth

Sufficient compressor coding in subtropical chinate (38-C) at 220V.

Hot acquicitate below 25 C ovaporating temperature in 43 into a strong st

Tel + 98 21 205 8398 Fax + 98 21 205 8398

englige de personalité, de la commentation de la co



Table of a second second

Activities

Training

A course was conducted at the counterpart premises. Ten technical staffs consist of the following personnel participated in the course.

1- N	Ir. Sbaghian	Technician
2- N	1r Ghorbani	Technician
3- N	îr. Fallah	Technician
4- N	Ir. Amid	Technician
5- N	lr. Behrooz	Technician
6- N	Ir. Nezhad Ali	Technician
7- N	lansoori	Technician
8- N	1arvian	Engineer
9- Ir	mani	Engineer
10-	Mohamadzadeh	Engineer
11-	Miss Barati	Engineer

The main topics of the course are:

- 1- Ozone Layer
- 2- Montreal Protocol
- 3- Implementation of CFC phase out projects by UN agencies
- 4- CFC alternatives
- 5- An Introduction to R134a refrigerants
- 6- Conversion of prototypes into ozone layer friendly refrigerants
- 7- Refrigeration load calculation
- 8- Component selection
- 9- Testing Prototypes
- 10- Trial Tests
- 11- Obtaining data from the test results
- 12- Test results analysis
- 13- Trial production
- 14- Mass production



The Ozone Layer

The following subjects were discussed about ozone layer during the course.

Oxygen can exist in two stable forms. The normal form is gaseous oxygen, sometimes referred to as dioxygen but normally just oxygen or 02. Two oxygen atoms form each molecule. It is the gas which makes up about one fifth of air and is essential for almost all earthly life.

The other form is ozone. In trioxygen orO3, each molecule is made up of 3 oxygen atoms. This form is less stable than O2but nevertheless occurs naturally. It is produced whenO2 is split into single, radical 0 atoms which are unstable and will bond with whatever is available. On some cases this will be an O2 molecule and SO 03 is re-formed.

This happens most frequently in the upper atmosphere near the equator where the wavelength of the incident sunlight gives the correct amount of energy to split the oxygen molecules. Ozone can also form where the high voltage discharges take place, again because into two (0) radicals. Ozone gives the characteristic smell associated with high voltage switch gear.

Most atmospheric ozone exists in the stratosphere between altitude of 15 km and 50 km. It is thinly dispersed throughout this region. If all the ozone were "squashed" down to normal atmospheric pressure at sea level it would form a layer only 2 to 3 mm thick.

Ozone Layer as a UV Light Filter

The importance of this "layer" is as a filter of ultra-violet (UV) light. When UV light strikes an ozone molecule it breaks to form anO2molecule and a radical 0 with an associated release of energy.

He 1d Courts Free, 7 min Dead End Cemer, Tom St., Africa Avenue Tehran, 19176, fran Tel. + 98 21 205 8398

Fax + 98 21 205 8398

AYI GH MOU AVAR SHAHR ENGINEERING CO. LTD.



The UV is absorbed in this process. The radical 0 released may combine with an $\underline{0}$, molecule to re-form ozone, or with another radical 0 to fon-nO2, or with any other gases which are available. in the stratosphere.

Although the ozone is thinly dispersed it stops all the UV of certain frequencies and drastically reduces the infiltration of other frequencies. These frequencies are beneficial to life and are sometimes used for sterilisation. In fact one of the reasons that life on earth first developed in the sea is because there was no atmospheric oxygen levels or ozone to remove the UV light. The planet therefore remained sterile except for the levels in the oceans where the UV could not fully penetrate.

The filtering out of the UV light is crucial to life on our planet. If the existing balance is shifted there will be drastic effects on plant and animal life.

CFC's

The term CFC is short for Chloroflurocarbon. It refers to a series of compounds developed in the late 1920's which display an unparalleled range of qualities for use as refrigerants.

The molecules are based on either methane, CH4, or ethane, C2H6. One or more of the hydrogen, H atoms is replaced by chlorine, CI or fluorine, F.

The CFC refrigerants quickly replaced most other refrigerants with the exception of arnmonia,

NH3 (R717) in the majority of applications.

- The properties which led to this replacement were:
- Very low toxicity

AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.



- Non flammability
- Chemical stability
- Good thermodynamic properties (there is a CFC refrigerant suitable fo almost all normal
- applications)
- Good behaviour with oils
- Comparatively low price and ready availability
- Suitability for use with copper pipework

This combination of properties are also made CFC's the ideal propellants for aerosols and agents for foam blowing. They are also excellent de-greasers and so are used extensively in the electronics industry for component cleaning.

For many years7CFCs were thought to be totally environmentally friendly. However one of the properties which makes them good as refrigerants etc.. is leading to the current problem of ozone depletion.

Effect of CFC's on Ozone Layer

The long term chemical stability of the CFC's means that once they are released they remain in the atmosphere for many years. At low altitudes this is no problem. However, when they reach the upper atmosphere CFC'S, like ozone, are broken down by ultra violet light.

When CFC's are split in this way, it results in the release of free, radical chlorine atoms, which interfere with the normal formation of ozone.

He 1st Fourth Hear Annel Dead En I Sourer, Tour SL, Africa Asenge Tehran, 19176, Jran Tel + 98 21 205 8398

Fax + 98 21 205 8398

AYUGU NOU AVAR SHAUR UNGINEERING CO, LTD.



When ozone 03 IS split by ultra violet into gaseous oxygen 02 and radical oxygen atom 0, to form chlorine oxide CIO. The chlorine atom will then only "give up" its oxygen atom to another radical oxygen atom. In this way the presents of chlorine in the upper atmosphere is reducing the number of radical oxygen atoms available for the formation of ozone. Each chlorine atom is freed at the end of this process and so has the potential to stop the normal formation of many thousands of ozone molecules without itself being consumed.

In chemical terms the reactions are as follows:

Normal Reaction Reaction in the presence of chlorine

03 UV 02 + 0 03+Cl 02+ClO

02 + 0 03 *C/O* + 0 Cl +02

Net result 03 + 0 202

There has been a measured increase in the amount of free chlorine in the atmosphere from 2 to 3 parts per billion. Scientists now hold the opinion that CFC releases are responsible for the increase in chlorine level, is responsible for ozone depletion.

The Damage Done

There is considerable debate as to how much damage has been done. Measurements of the quantities of stratospheric ozone have only been carried out since the mid 1950's. The instrumentation used has increased in sophistication during this time and so the accuracy of measurement has improved. It is therefore difficult to say what is a normal, natural fluctuation in ozone and what is impending disaster.

Ho. 1/1 Fourth Hear, Amini Dearl End Council, Tour St., Africa Assenue Tehran, 19176, Iran Tel. 4 98 21 205 8398 Fax 4 98 21 205 8398

de mentale que de la grande de

AYEGH NOU AVAR SHAIR ENGMEERING CO. LTD.



There is similar thinning taking place over the Arctic but the weather system behaves slightly differently there and it has not yet been referred as a hole.

Increased Global Warming (The Greenhouse Effect)

CFC's (including HCFC's and others) are also contributing to an increase in global warming. Commonly known as the "Greenhouse Effect". This-is a totally separate environmental issue.

Global warming, is a natural phenomenon, the average global temperature is about +15 degrees Celsius supporting life throughout most of the planet. Without **natural** global warming by gases in the atmosphere the average temperature would probably be around - 18 degrees Celsius. Life as we know it would be unable to exist/

The activities of man are adding to the natural effect and causing an imbalance. This is sometimes referred to as "ANTHROPOGENIC GLOBAL WARMING"

The atmosphere allows solar radiation through to earth. This is mostly visible light predominantly in the yellow part of the visible spectrum. When this energy strikes the surface of the earth it is absorbed and some of it is re-radiated chiefly in the infra red part of the spectrum. Radiation of this wave length is absorbed and reflected by dense molecules (the so called greenhouse gases) in the lower part of the atmosphere, (troposphere).

This keeps the earth warmer than it otherwise would be. Some of the infra red radiated by the earth escapes 'into space and a natural balance between energy coming in and that going- out to space.

This cycle has been linked to the way a greenhouse works, hence the name "Greenhouse Effect". In fact a greenhouse mostly works Ho 1.1 Fourth Dear Aromi Deart End Corner, Tom St., Africa Avenue Tehran, 19176, Iran Tel. + 98.21.205.8398 Fax + 98.21.205.8398

AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.



in a different way, by not allowing hot air warmed by the sun to rise and escape.

Anthropogenic Global Warming refers to the extra warming of the earth and atmosphere caused by gases released by man and his activities. If the average temperature of the world is increased by only a few degrees there will be drastic changes in climate and a rise in sea levels.

CFC's and related chemicals are only part of this problem the main greenhouse gases are carbon dioxide (CO2), CFC's methane, nitrous oxide. They are each thought to contribute to the problem by the following percentages:

Carbon Dioxide 55% CFC's I I & 12 17% Other CFC's 7% Methane 15% Nitrous Oxide 7%

The quantities of CFC's released are small compared to other greenhouse gases such as carbon dioxide, C02 from power stations. However each Kg of CFC's has many thousands of times the effect of each Kg Of C02 SO in consideration of the environmental impact of CFC's this issue should also be addressed.

Ozone Depletion and "Greenhouse" Effect

If there is an increase in the amount of UV light reaching earth there may be an increase in skin cancers. "United states Environmental Protection Agency has calculated that for each 1% decrease in the concentration of ozone in the stratosphere there will be a 5% increase in non-malignant skin cancers each year.

UV light is also one of the major causes of cataracts of the eye; any increase in UV at ground level may increase the occurrence of this

He 1.1 Fouth Food Amini Dead End Corner, Tom St., Africa Asenua Belgan, 19176, Itan

AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.



Tel. + 98 21 205 8398 Fax + 98 21 205 8398

debilitating problem, not only humans, but also domestic, farm and wild animals.

Plants are very sensitive to the amount and quality of sunshine which they receive. An appreciable increase in the UV portion of sunlight could devastate plant life. Most at risk will be the hybrid, high yield varieties of wheat, soya beans etc. Which form a substantial part of mans diet.

It has also been established that changes in UV radiation levels have a serious effect on **Antarctic phytoplankton**. Any great reduction in the numbers of these single cell plants is effectively knocking out the first link in the food chain for all the southern oceans with inevitable consequences for half the worlds marine life.

If depletion of the ozone layer continues then **food production** is bound to be affected and world famine could be the end result, along with the medical problems mentioned earlier.

If there is no reduction in the emissions of greenhouse gases there is likely to be drastic changes in **weather patterns**.

Some effects of this are likely to be:

Increases in **sea level** due to thermal expansion and melting glaciers (not polar ice caps). Predictions of how much rise there will be vary widely but in every case huge areas now marginal, unproductive.

Increased frequency of **hot weather** will put great stress on crops and livestock.

If the changes are rapid, species of plants and animals may be **unable to migrate** fast enough to tolerable climate from their present ecosystems and so perish.

Ho. 1.1 Fourth Peor, Agent Dead Led Course, Tour St., Africa Avenue Tehran 19176, Iran

Tel + 98 21 205 8398 Fax + 98 21 205 8398

AYEGH NOU AVAR SHAHR LINGINEERING CO. LTD.



Forests may also be unable to adopt quickly enough.

Water **availability** and quality could be affected by quite small shifts in climate. No one really knows how rainfall patterns will change.

Changing sea temperatures may cause redistribution of fish and shifts in major currents.

More heat waves would cause more related deaths and possibly encourage the **spread of diseases** such as malaria.

The predictions widely. Like the ozone issue, no one really knows the most likely outcome, as man has never played with such a large chemistry set before.

Both ozone depletion and the greenhouse effect may have dire consequences for the planet. Even if the worst predictions prove incorrect we should surely make an effort to avert even the possibility of global catastrophe.

The Montreal Protocol,

FLUOROCARBON CONTROL AND ALTERNATIVES

Once the effects of fluorocarbon gases on the ozone layer were fully appreciated, negotiations were carried out under the supervision of the United National Environment Programme (UNEP) and the world Meteorological Organisation to limit their production.

Leading industrialised countries agreed on a CFC production control protocol. This agreement has become known as the Montreal Protocol. It was originally signed by 27 countries in September 1987 in Montreal. The protocol was then revised and agreed by about 60 countries at the London meeting in June 1990. By February 1991,

Fax + 98 21 205 8398

AMEGIENOU AMAR SHAHR ENGINEERING CO. LTD.



70 countries had signed the protocol, with China expected to sign later that year. The next revision of the Protocol took place in November 1992 in Copenhagen. Currently, nearly 150 countries have signed the protocol.

The main features of the protocol as updated in November 1992 were:

CFC's

- 1. By I st January 1994 production should be cut by 75% of 1986 levels.
- 2. By January 1996 production phased out.

The main controlled substances are CFCs 11, 12, 113, 114, 115. This also effect blends such as R502 (being a mixture of CFC 115 and HFC 22). Solvents and fire extinguishing agents were also controlled.

Trade restrictions on controlled substances, for example import and export bans to and from non-signatory countries, were also agreed. Other trade restrictions were agreed in principle.

HCFC's

Schedule of phase out:

35% by 2004 65% by 2010 90% by 2015 99.5 % by 2020 100% by 2030

Agreements were also made on their application, selection, emission, recovery, recycling and destruction.

Ho. 14. Fourth Floor, Amini Dead End Corner, Tour St., Africa Assenue Tehran, 19176, Iran Tel. + 98 21 205 8398

Fax + 98 21 205 8398

AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.



European Union Regulations

Although signatories of Montreal Protocol, the counties of the European Union have drawn up more stringent regulations, broadly similar to the Protocol in that they restrict production and

trade of "controlled substances". The European Regulations have an accelerated phased-out timetable.

Under the December 1992 revision of the regulations for CFC's the European Union phase out targets are:

CFC's

Date Percentage production of 1986 levels

01/01/94 15%

01/01/95 Total phase-out

HCFCs

Starting approximately in June 1995 and in stages at I January 1996, 1 January 1998 and I January 2000. Restrictions have also been placed on new equipment using R22 as a refrigerant.

The controlled substances are the same as for the Montreal Protocol. Both the Montreal Protocol and European Regulations provide for regular revision and updating based on scientific data on the environment.

THE PERSON NAMED IN COLUMN TWO IS NOT THE PERSON NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TWO IS NAMED IN COLUMN TW

AYEGH NOU AVAR SHAHR UNGINEERING CO. LTD.



In 1986 the EU countries produced about 440,00 tonnes of CFCs, 70% of which were consumed by the EU countries. This does not allow for substances that were imported. By 1993 European consumption of fluorocarbons had decreased to 120,00 tonnes.

Ozone depletion and global warming potential of fluorocarbons

Refrigerants have been rated according to their potential to damage the environment. These ratings are called Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). The higher the number, the greater their potential to cause damage.

ODPs are based on a "bench mark" of 1.0 for R I 1.

GWP's as shown below are based on a bench mark of Carbon Dioxide C02=1 and have been taken from UNEP/WMO scientific assessment 1994/1995.

The above represents the most common refrigerants. Manufacturers and suppliers will O'ive data for each of their products which are too numerous to include here.

Refrigerant replacement categories

There are three main categories when it comes to replacement refrigerants. These are:

- 1. Drop-ins: Refrigerant that can be substituted into an existing system without any work being required apart from very minor servicing, such as the replacement of a refrigerant filter drier.
- 2. Retrofitable refrigerants: refrigerants that can be substituted into an existing plant but only after certain changes have been made, such as substitution of a new type of lubricating or a modification of compressor speed.

PRINTED TO BEST OF THE PRINTED AND A STATE OF TH

AYUGUNOU AVAR SHAHR LNGINEERING CO. LTD.



3. Non retrofittable refrigerants: Refrigerants that cannot be used in existing equipment even with major modifications because of different operating pressures, materials, incompatibility and other potential problems.

European Standards

CEN Standard

Member states of the EEC have technical representatives working on a "CEN" standard for refrigerating systems and heat pumps.

CEN can be loosely translated as the "European Committee for Standardisation". CEN 182 European Standard for Refrigerating Systems and Heat Pumps, is expected to be adopted in 1991/1992. This is a comprehensive standard covering all aspects of a refrigeration system from design, installation etc.., through to maintenance and operation. One complete section of the standard will deal with Refrigerant Safety and Environmental requirements, Recovery, Reuse and Disposal.

The foreword of this section is likely to contain a statement urging all personnel involved in anyway with refrigerants to take steps to eliminate emissions. It will probably declare that this should be an objective throughout the design, installation and use of the equipment.

Briefly, to comply with the Standard, refrigerants will have to be handled safely, not emitted to atmosphere and recovered, recycled and reclaimed. This will have to be undertaken only by competent persons.

Cecomaf Recommendations

the 1st Fourth Coor Amini Tread End Corner, Tour St., Africa Account Tehran, 19176, Iran Tel. + 98 21 205 8398

Fax + 98 21 205 8398

AYLGH NOU AVAR SHAHR LINGINEERING CO. LTD.



The European Committee of Manufacturers of Refrigeration Equipment - CECOMAF - have published a document called "Reduction of Chloro-Fluoro - Carbon Emissions from Refrigerant Systems (see appendix 2B)

This publication deals with all aspects of refrigeration work from design through to end user instructions. It covers:

Refrigerant Piping - The need for greater use of brazed onions - fitting of isolating valves using flexible hoses for connections to pressure controls and minimising vibration in pipe work which is one of the biggest causes of leaks.

Leak Testing - The need to use dry nitrogen and soapy water, and the helium method to leak test new or opened systems and to check systems at regular intervals.

Fluorocarbon Users and Their Response

Refrigeration Industry

All people active in the refrigeration industry have an obligation to protect the environment against CFC emissions. Every effort must be made to save the CFC's that are presently held in refrigeration systems.

In the short term a reduction in CFC consumption can only be achieved by reducing refrigerant losses from existing systems. Estimates on the extent of losses from existing systems vary but it is generally accepted that between 30% and 40% of refrigerant consumption is used for servicing. This represents operational leakage's.

Ho. 1.1 Fourth Hose, Amini Dead End Corner, Four SL, Africa Assenue Tehran, 19176, Juan Tel. + 98 21 205 8398 Fax + 98 21 205 8398

AYEGH NOH AVAR SHAHR ENGINEERING CO. LTD.



It is important that leak testing and servicing techniques improve. Also there will be a greater need for the recovery and recycling of refrigerants.

R22 is likely to become more widely used in the short term.

The industry will also have to look closely at the possibility of using Ammonia more Widely.

To help minimise CFC emissions it is important that all staff now involved with refrigeration work are trained to show a proven ability in controlling CFC emissions. It is also vital that contractors show they are doing all they can to make their employees aware of the need to minimise the release of CFC'S.

To this end, it is important that end users only engage contractors, whose staff employ the latest techniques for protecting the environment.

Aerosol Manufacturers

CFC I I and 12 have been used in the aerosol industry since 1946. They are mainly used as a propellant. When pressurised inside a sealed can, together with the product they provide pressure to force the product out of the can.

The aerosol industry has switched to using hydrocarbon gases, mainly pentane and butane, as the propellant.

Pentane and Butane will not necessarily totally replace CFC's in all aerosols; in fact, some people see them only as medium term alternatives, the main problem being their flammability.

Dimethyl-Ether - DME - and related chemicals are related to the simple hydrocarbons propane and butane. They have been used in small quantities as aerosol propellants for many years but their use

Ho 1/4 Freehilloor, Apeni Head Fiel Conner,

Tour St., Afur,a Avenue Tehran, 19176, Iran Tel + 98 21 205 8398 Fax + 98 21 205 8398

AYEGH NOU AVAR SHAHR UNGINEERING CO. LTD.



has been limited by their relatively high cost. But as the aerosol industry looks for alternatives to CFC's the cost of DME is likely to come down. Like the hydrocarbons- DME - contains no chlorine and is therefore ozone friendly.

The British Aerosol Manufacturers Association has announced that 90% of CFC's will be replaced in their products by the end of 1989.

Compressed Gases

Compressed air or a number of similar gases can be used as aerosol propellants.

These gases include oxygen, nitrogen, nitrous oxide, and carbon dioxide. All these gases are ozone friendly and cheaper than CFC'S. They do have limitations in their use though. The major problem is that they tend to produce wet sprays and can lose pressure faster as they are used up, quicker than either hydrocarbons or CFC'S.

Manufactures are looking at ways of overcoming these problems. One method being investigated is the "bag-in-a-can". The product is placed in a flexible bag connected to a valve and surrounded by compressed gas. One advantage of this method is that the product doesn't have to be able to mix with the propellant.

Non-chemically Propelled Aerosols

Aerosols do not have to "powered" by a chemical. Old fashioned, manually operated systems such as scent sprays and pump dispensers work perfectly well.

Future trends

Of the new generation of CFC's being produced HCFC, 123 and HFC 134a are thought to be good candidates for aerosols.

He 1.1 Legate Llead Australicad End Corner Lour St., Africa Avenue Lehran, 19176, Itan Tel. + 98 21 205 8398

Fax + 98 21 205 8398

AVUGHTHOU AVAR SHARR ENGINEERING CO. LTD.



Foam Manufacturers

CFC's are widely used as blowing agents for a variety of plastic foams. The main types of foam which uses CFC's are:

Rigid polyurethane used in building and construction Refrigerator and freezer insulation

Rigid PU foam is closed cell foam blown with carbon dioxide. CFC I used to modify the density of the foam and to provide cooling during the curing stage of manufacture. In some cases CFC I I can be replaced with methylene chloride or water, but the introduction of CM (Combustion Modified) foams has meant an increasing reliance on the non flammable CFC I 1. Several companies are actively involved with the development of activated carbon recovery systems. These units are expensive but able to recover 40% of the blowing, agent used.

Polystyrene Foams for packing

Packin,j foams were traditionally blown with CFC 12 or a mixture of CFC's I I and 12, producing extra extruded sheets of foam which were then vacuum formed into meat trays, egg boxes and hamburger cartons.

Electronics and other cleaning applications

CFC 113 is used mainly as a cleaner and degreaser in the manufacture of printed circuit boards. It is used because during soldering, deposits of grime and metals are left on the board and have to be removed. CFC 113 is favoured because of its good solvent power and compatibility with the electronics attached to the board, it is non-flammable and has a low human toxicity level.

The 3.1 Fourth Door, As we bood End. Count, Tour M., Africa As entre Tehran 19176, Iran

Tel + 98 21 205 8398 Fax + 98 21 205 8398

AYEGH NOU AVAR SHAHR ENGMEERING CO. LTD.



One alternative to CFC 1 13 is Trichloroethane. It is a more powerful solvent which means it will clean away more flux and grease but will attack some sensitive plastic components. Trichloroethane is not completely ozone benign, therefore it is seen only as a short term alternative.

The future for electronics applications may be in the use of water based cleaners (i.e.: water plus detergent), although this may not be the total answer and more research needs to be done to find fully acceptable alternatives.

In dry cleaning CFC 113 is mainly used. HCFC 123 is likely to be an alternative in this field, but there is no readily available alternative at present.

Recovery of Used Refrigerants

To help minimise the loss of CFC's to the atmosphere when working on systems, every effort should be made to recover the refrigerant for future use. The refrigerant should be decanted into specially supplied cylinders. These cylinders are then returned to the appropriate chemical company, so the refrigerant can be reclaimed or recycled.

The chemical companies will only accept cylindrical-containing one refrigerant, for recycling. Mixtures cannot be recycled but will be collected for safe disposal, the cost of disposal will probably be passed on by the manufacturer to the contractor.

Also on the market, are Recovery and Reclaim stations. These machines will draw the refrigerant out from an existing system - separate any oil and other contaminant - dry the refrigerant and then store it. The refrigerant can then be put back into the system after the repair has been completed.

(in 1.) County (See Amin; Pead End County, Tour M. Africa Agenry

Total 14., Africa Aleman Tehran 19176, Iran Teh. + 98 21 205 8390 Eax + 98 21 205 8398

The second street of the second secon

AYLGH NOU AVAR SHAHR ENGINEERING CO. LTD.



An Introduction to R134a refrigerants

- Use and Applications
- Hazards, Health Care and Safety Precaution
 - Potential Hazards
 - Asphyxiation
 - Burns
 - De-composition in Naked Flames
 - Narcotic Sensation
 - Heart Effects
 - Safety Precaution
 - Goggles and rubber gloves
 - Workshop Ventilation
- Dehydration
 - Moisture effects to the refrigeration system
 - Maximum allowable moisture in refrigeration system
- Refrigeration System Evacuation
- Vacuum
- Refrigerant/refrigeration oil compatibility
- Leak Testing
- Cleanliness
- Refrigerant Recovery
- Refrigerant Recycling
- Refrigerant Reclamation
- Affect of R134a to system component
 - Capillary Tube
 - Compressor
 - Filter Drier
 - Condenser and Evaporator

Conversion of prototypes into ozone layer friendly refrigerants

- Preliminary Design of a new product
 - Overall Dimension
 - Refrigeration load calculation
 - Model Type

Fax + 98 21 205 8398

AYEGH NOU AVAR SHAHR LNGINEERING CO. LTD.



- Refrigeration System (No-Frost or Defrost)
- Internal Design of the products
- Material Used
- Air Circulation
- Type of Insulation
- Number and type of door
- Type and material of Door Gasket
- Operational Test
- Performance Test
- Renovation of a Product
 - Design Style
 - Material
 - Insulation
 - Energy Consumption
 - Internal Volume
 - Refrigeration System
 - Noise Level
 - Compressor
 - Performance Test
- Modification and Engineering Changes
 - Refrigeration System Optimisation
 - Performance Test
 - Major and Minor changes to the foam thickness, inner liner, door, cabinet and minor adjustment to the refrigeration system circuits
 - Material Changes, ABS, Polystyrine and etc.
- Conversion
 - Refrigeration load Calculation
 - Component Selection
 - Refrigeration System Adjustment
 - Compressor
 - Capillary Tube
 - Thermostat

AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.



- Condenser
- Evaporator
- Refrigerant Charge
- Evacuation
- Leak Test
- Environmental Test
 - Performance Test
 - ISO standard Test

Refrigeration load calculation

- Dimensional Studies
- Heat Transfer through side walls
- Product Load
- Infiltration, door opening Etc.
- Heat gain by miscellaneous apparatus, such as lights, electromoter, fans and etc.
- Calculation of Total Cooling Capacity
- Selection Compressor Cooling Capacity
- Component selection
- Testing Prototypes
- Trial Tests
- Obtaining data from the test results
- Test results analysis
- Trial production
- Mass production

Selection of Components

With respect to the refrigeration load calculations and refrigeration circuit design of each models. Following components were selected.

1- Compressors

He 1.1 Fourth thee Ardel Dead End Counci, Ten St., Africa Avenue Tehran, 19176, Iran Tel + 98 21 205 8398 Fax + 98 21 205 8398

AYEGH MOU AVAR SHAHR ENGINEERING CO. LTD.



- a) Water Chiller Model ELC-WC18, Danfoss FR6G
- b) Water Chiller Model ELC-WC50C, Danfoss SC15G
- c) Water Chiller Model ELC-WC50T, Danfoss SC15G
- d) Chest Freezer Model ELS-CF450, Danfoss SC18G
- e) Chest Freezer Model ELS-CF750, Danfoss SC18/18G
- f) Chest Freezer Model ELS-CF220, Danfoss SC12G
- g) Show Case Model EIS-1889V Danfoss SC12/12G
- h) Show Case Model ELS-1982 Danfoss SC21G
- i) Show Case Model ELS-260-3F Danfoss FR11G
- j) Show Case Model ELS-220-3F Danfoss FR10G
- k) Show Case Model ELS-1219F Danfoss SC15G

2- Refrigerant Charge

The refrigerant charges for different prototype models are varied. We tried to keep refrigerant charge weight same as R12 refrigerant models, for water chillers and chest freezer with total cooling capacity of less than 300 watts at the first step of testing prototypes we considered same refrigerant charges as R12. But for bigger size of Chest Freezers and Show Cases, we preferred to test the prototypes one by one at different conditions. Therefore we recommend that all prototypes should be charged as follows:

Water Chiller Model ELC-WC18, Refrigerant charge210 grams

He 1.1 Fourth Heat, Annue Dand Fiel Crency, Tour St., Africa 7 : enure Tehran, 19176, fran Tel. + 98 21 205 8308 Fax + 98 21 205 8398

AYEGH BOU AWAR SHAHR UNGBEERING CO. LTD.



- m) Water Chiller Model ELC-WC50C, Refrigerant charge = 600 grams
- n) Water Chiller Model ELC-WC50T, Refrigerant charge = 600 grams
- O) Chest Freezer Model ELS-CF450, 10% reduction of refrigerant weight = 480 grams
- p) Chest Freezer Model ELS-CF750, 10-15% reduction of refrigerant weight = 720 grams
- q) Chest Freezer Model ELS-CF220, Refrigerant charge = 380 grams
- r) Show Case Model EIS-1889V, 10-15% reduction of refrigerant weight = 1200 grams
- s) Show Case Model ELS-1982, 10-15% reduction of refrigerant weight = 720 grams
- t) Show Case Model ELS-260-3F, 10-15% reduction of refrigerant weight = 630 grams
- u) Show Case Model ELS-220-3F, 10-15% reduction of refrigerant weight = 630 grams
- v) Show Case Model ELS-1219F, 10-15% reduction of refrigerant weight = 630 grams

3- Capillary Tube Length

The length of capillary tube depending on internal refrigerant circuit volume should be adjusted, to correspond to the adequate delivery of refrigerant liquids into the refrigeration circuit. Therefore we recommend an increase of ten to fifty percent of capillary tube length.

4- Evaporator and Condenser

According to our experience of making prototypes and test results evaluation achieved in several project we did not changed the size of evaporator and condenser. Any changes must be done No. 1/1. Fourth Floor, Amini Dead End Corner, Tour St., Africa Avenue Tehran,19176, Iran Tel. + 98 21 205 8398 Fax + 98 21 205 8398

AYEGH NOU AVAR SHAHR ENGINEERING CO. LTD.



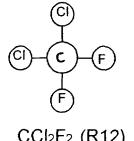
prior to making prototypes and at R12 refrigeration circuit optimisation programme.

Prototype Making

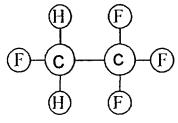
The prototypes have been manufactured successfully in accordance with the existing design and drawings and also advises given to the engineering department of the factory.

HFC134a, Refrigerant Use and Application

HFC134a is a HydroFluoroCarbon (CH2FCF3) to replace CF2Cl2, ChloroFluoroCarbon (CCl3F),



CCl₂F₂ (R12)



CH₂FC₃ (R134a)

Hazards, Health Care and Safety Precaution

Potential Hazards:

Asphyxiation, (Suffocating)

Since R134a is heavier than air it tends to concentrate on the floor, this situation may cause breathable air leading to dizziness, nausea, and fainting.

Burns

When liquid refrigerant R134a contacts the skin or eyes it boils off at -26.5 C, therefore it causes severe burns to the skin and possible blindness if it contact with the cornea.

Decomposition in naked flames

Although R134a is non flammable, and toxic decomposition products. It may be given off when contacts with naked flames. Acid fumes which are irritant are given off (released) first, and then phosgene which is highly toxic.

Narcotic sensation (effects)

At high concentration, normally in excess of 15% by volume, exposure to the vapors can cause a feeling of well being, or can be dangerously misleading.

Heart Effects

At high concentration, normally in excess of 15% by volume, exposure to the vapors can cause irregularities in heart beat, which in severe cases it can cause heart attack and possibly death.

Safety Precaution

Proper use of personal protective equipment such as; Goggles and Rubber Gloves help to reduce the hazards.

Workshop Ventilation also ensures the reduce of risks to health by losses of refrigerant into the workplace.

Cylinders should be stored in well ventilated areas, out of direct sunlight and away local heat sources. The cylinders should not restrained and not standing in water.

Adequate warnings should be displayed to warn people of their presence.

When handling refrigerants from systems that have suffered electrical burn out, be aware that refrigerant and oils may be acidic and thus pose a risk to health.

Dehydration

It is important to realize that moisture in a refrigeration system is directly the major cause of several other symptoms.

Moisture can be classified as visible (in form of water liquid) and invisible (in form of water vapor).

Water vapor can be found everywhere, in all solids, liquids and gases.

Content of water vapor in air is expressed as relative humidity. This gives the greatest trouble in refrigeration system. A single drop of water may look harmless, but to a refrigeration system it is a monster, the number one enemy to be combated by refrigeration service specialists.

Moisture can get into a system easily and is hard to get out.

Moisture effects to the refrigeration system

- "Freeze ups", moisture will be picked up by the refrigerant and become entrained in refrigerant line in a fine point of expansion. The ice crystal will retard or stop the flow of the refrigerant, causing a reduction or complete stoppage of cooling.
- As the expansion valve warms, due to the lack of refrigerant, the ice melts and moisture returns to the expansion valve and once more builds an intermittent cooling.
- Moisture can induce <u>Corrosion</u>, which can present serious trouble because often the effects of corrosion are not apparent until the real damage has occurred.

- 4. Moisture can alone in the form of water cause rust after a period of time. However, moisture plus refrigerant creates much more corrosion trouble.
- 5. Max. Allowable moisture in a system is 50 PPM
- 6. Refrigerant such as R12 containing chlorine will slowly hydrolyze with water and form hydrochloric acid, which greatly increases the corrosion of metals.
- 7. Heat increases the rate of corrosion due to acids because at higher temperature the acid forming process is accelerated. This acid will attack all kind of materials.
- 8. Refrigeration oil presents another problem caused by moisture. Refrigerant oil is an exception to the rule that "O il and water don't mix" in fact, refrigerant oil has an close relation with moisture and will absorb it rapidly if left open to the atmosphere.
- 9. Water change into acid emulsifies with refrigerant oil, the two forming a mixture of exceedingly fine globules. This effect is called "Slugging" of the oil and greatly reduces its lubricating ability.

- 10. Corrosion becomes troublesome from the operating standpoint when the metallic surface is eaten away and solid, detachable product is formed. This formation is commonly known as "sludge".
- 11. Sludge exists as slimy liquids, fine powders, granular solids or sticky solids and causes a variety of problems. They can plug fine strainers, expansion valves and capillary tubes. And because they usually contain acids they corrode whatever they stick to, accelerating damage.
- 12. To eliminate moisture it is necessary to take precaution and actions which will assure a moisture-free system. And one of the most effective ways to eliminate moisture from a system is through the use of <u>a high vacuum pump</u>.

System Evacuation

 Reducing the system pressure sufficiently to allow the heat from the atmosphere to vaporize any moisture left in the system is necessary before carrying out the charging process. 2. A system opened for any type of repair must be completely evacuated to remove air and moisture. The new refrigerant HFC134a is very much Hygroscopic and one of the lesser known factors regarding the use of HFC 134a is its tolerance to contaminants. It is believed that an HFC134a system will be somewhat less tolerant to contamination than CFC 12 which has always been relatively tolerant in range of adverse conditions such as moisture, air and dirt.

Always evacuate a system when:

- 1. Replacing compressor, condenser, drier, evaporator etc...
- 2. The system has no refrigerant.
- 3. The refricerant becomes contaminated.
- 4. The refuseant oil is changed.

It is recommended to use Vacuum Pump with 8 cubic meter per hour or more to obtain necessary vacuum pressure, for evacuating the system.

There are three basic parameters to consider for selection of vacuum pump.

- 1. Free air displacement, e.g. C.F.M. or cubic meter per hour,
- 2. Vacuum Performance, e.g. mm Hg, TORR etc...
- Water Vapor tolerance, e.g. max. allowable water content in the system, contamination and employment of vacuum pumps purely for dehydration work.

Vacuum

As we have stressed, refrigerant is sensitive to moisture in the system. To understand how water behaves and how to dry out a system, following natural laws must be understood. The boiling point of water varies depending on pressure. Pressure below atmosphere is called vacuum, and can be measured in:

Millibar (Mbar), Torr with reference to Mercury (Hg) height and Microns.

Atmospheric pressure (1 Atm) = 1 Kp/Cm 2 = 0,98 Bar 14,22 Lb/In 2 (79% N₂ and 20% O₂)

To obtain evaporation of water/moisture at room temperature, pressure must be 15 MBar only, means a vacuum of 1000-15=985Mbar.

Freezing point for moisture/water at 0 C deg. at 6,11 Mbar equal 760x6,11/1000=4.643, mmHg=4,64=4640 microns.

Refrigerant / Refrigeration Oil Compatibility;

R134a is not miscible with the traditional mineral oils that were popular with CFC refrigerants.

Polyester lubricants must be used, the compressor will be already charged with polyester lubricant.

R134a is a very hygroscopic and polyester lubricants are approximately 100 times more hygroscopic than mineral oils.

Leak and leak testing;

Because of R134a physical property, it easily leaks in comparison with R12. That is, it leaks more easily and therefore joints have to be carefully inspected for leaks before the refrigerant is charged into the system.

Traditional leak detectors search for Chlorine, and react against it. Therefore, they could not be used for R134a refrigeration system, because there are no Chlorine in R134a refrigerant. R134a is fluorinated Hydrocarbon.

The system should be leak tested prior to charging the refrigerant.

Oxygen free Nitrogen can be used to provide the pressure, with joints tested using soap and water.

Refrigerant Recovery

when refrigerators are to be serviced it is necessary to remove or recover the refrigerant from them.

Note that the capillary tube slows the process of recovery and must be taken into account.

Refrigerant Recycling

this is the process of cleaning the refrigerant by filtration and separation to remove oil, acids and moisture to improve its quality prior to re-use.

Refrigerant Reclamation

This is the process of returning the refrigerant to its original virgin condition in a specially built machine. Before and after processing the refrigerant would be analyzed in a specialist laboratory.

Capillary Tubes

The length of capillary tube vary from 1mt to 6 mt and inside diameter from 0.5 to 2 mm.

Liquid refrigerant enters the capillary tube from the condenser, and as it flows through the tube the pressure drops because of friction and acceleration of the refrigerant.

Some of the liquid flashes to vapor as refrigerant flows through the tube.

Capillary tubes are often installed in heat exchange with the suction line (sub-cooled) to retard the flashing of refrigerant flowing through the capillary tube.

Some Advantage and Disadvantage of Capillary Tube

Advantage;

No moving parts allow pressure equalization during off cycle so that low start torque motor can be used.

Disadvantage;

- 1) Not adjustable to changing load conditions, susceptible to clogging or blockage by foreign matter.
- 2) The mass of refrigerant charge is critical within close limit, it means that capillary tube is only suitable for hermetically sealed systems manufactured in carefully controlled environments and to high quality standards.

Cleanliness

::

Cleanliness of plant is associated with the experience of the initial installation and its subsequent need for servicing other than routine.

The procedure for new R134a plant are more stringent than those used for R12, attention being drawn, particularly to good evacuation and charging.

It is vital that the system is not contaminated with Chlorinated residues from charging manifolds and vacuum pumps previously used with R11 or R12, or any refrigerant containing chlorine.

The safe level of chlorinated residues is in the region of 200 PPM, but every endeavor should be made to eliminate traces of chlorine to zero.

In application where the plant is to be converted from R12 to R134a the situation is more critical as the installation will contain chlorine and possible chlorine residues.

Condenser and Evaporator Performance

R134a compared with R12 has a better thermal conductivity, higher latent heat and higher coefficients of heat transfer.

The specific volume of the vapor however, is greater as the evaporation temperature falls below about + 5 C.

The consequence of these properties is:

- A reduction of in capacity of about 10-25 % at LBP if an R12 compressor displacement is used, due to the higher specific volume.
- 2. At HBP compressor there should be an improvement in performance due to the higher thermal properties and lower viscosities (possibly up to 10% at 10% evaporating).
- Similarly there should be an improvement in performance at LBP if compressor with higher displacement is used.

- 4. With a new installation/ optimization of the evaporator and condenser should be considered to achieve the best balance with compressor, according to the experience if proper compressor is being selected there is no need to change condenser and evaporator capacity.
- 5. The effect of the lubricant on the above properties is however, still under review and the tendency is to keep the same evaporator to the condenser as selected for R12

Pressure drops in both evaporators and condensers will be less than R12

Filter Drier

Due to the hygroscopic property of R134a it is necessary to use a filter drier stronger than R12 drier with 1.4 capacity more, all manufacturers have recommended the replacement of 10 gram conventional drier with XH7 while 15 gram conventional drier should be replaced with XH9 new specially designed drier.