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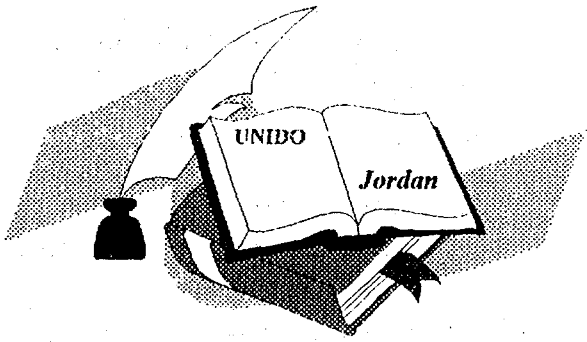
22229

MOHAMMAD TAHSEEN BAALBAKI & PARTNERS CO.

UNIDO Contract no 98/022

Conversion of Prototypes into R134a at Six Jordanian Commercial Refrigerator manufacture (First Group)

Final Report



Project Number MP/JOR/98/090

July 1999

Table of Content

Performance Test Sheet

Test Type Performance Test Sheet Number Baal-PFT-06 Date 11/09/77

Ambient Temperature 32°C	Relative Humidity % N/A	Product Name Water Cooler	Product Serial Number —
Type of Compressor Hermetic	Compressor Model Electrolux	Compressor Cooling Capacity 220	Compressor Power Input 250
Refrigerant Type R134a	Refrigerant Charge Weight 190 gm	Condenser Type and Length —	Evaporator Type —
Capillary Tube Length —	Thermostat Type Defrost	Thermostat Setting Normal	Test Run Time 600
Drier Type XH	Drier Weight 20		

Test Results

Description	Time																	
	1	2	3	5	6	7	8	9	10									
Evaporator Surface Temp	32	10	5	-2	-8	-10	-10	-10	-10									
Evaporator "M" Package Temperature	—	—	—	—	—	—	—	—	—									
Refrigerator Temp. "T1"	—	—	—	—	—	—	—	—	—									
Refrigerator Temp. "T2"	—	—	—	—	—	—	—	—	—									
Refrigerator Temp. "T3"	—	—	—	—	—	—	—	—	—									
Refrigerator Mean Temperature.	—	—	—	—	—	—	—	—	—									
Refrigerator Outside Walls Temperature	32	32	32	32	32	32	32	31	32									
Compressor Suction Temperature	45	44	47	45	48	45	40	38	32									
Compressor Discharge Temperature	91	95	94	99	96	98	77	98	96									
Compressor Shell temperature	102	105	114	115	112	110	106	108	105									
Condenser Mid Temperature	—	—	—	—	—	—	—	—	—									

Test Result Analysis

Voltage	Hertz	Starting Current	Working Current	Energy Consumption Kw/24hrs
220	50	2.3	1.11	4

Total Time Elapsed for Test Results	Compressor Running Time Percentage
600	72%

Remarks

Hot Chamber Operator Date and Signature	Laboratory Manager Date and Signature
KHALED	

Performance Test Sheet

Test Type Performance Test Sheet Number Baal- PFT -05 Date 9/7/99

Ambient Temperature	Relative Humidity %	Product Name	Product Serial Number
32°C	55%	UP Right Ref.	NON
Type of Compressor	**Compressor Model**	**Compressor Cooling Capacity**	**Compressor Power Input**
Hermetic	TECOMSEH	590	620
Refrigerant Type	**Refrigerant Charge Weight**	**Condenser Type and Length**	**Evaporator Type**
R134a	670	N/A	Fin & Tube
Capillary Tube Length	**Thermostat Type**	**Thermostat Setting**	**Test Run Time**
N/A	Defrost	Medium	480 min
Drier Type	**Drier Weight**		
XH	30 gm		

Test Results

Description	Time 1	2	3	4	5	6	7	8
Evaporator Surface Temp	20	10	5	0	-5	-15	-18	-15
Evaporator "M" Package Temperature	–	–	–	–	–	–	–	–
Refrigerator Temp. "T1"	32	20	10	8	7	5	5	5
Refrigerator Temp. "T2"	"	"	"	"	"	"	"	"
Refrigerator Temp. "T3"	"	"	"	"	"	"	"	"
Refrigerator Mean Temperature.	"	"	"	"	"	"	"	"
Refrigerator Outside Walls Temperature	32	32	32	32	32	32	32	32
Compressor Suction Temperature	45	40	40	45	38	37	35	32
Compressor Discharge Temperature	89	88	90	92	95	92	90	88
Compressor Shell temperature	99	98	100	102	105	102	100	102
Condenser Mid Temperature	44	45	50	43	42	45	45	50

Test Result Analysis

Voltage	Hertz	Starting Current	Working Current	Energy Consumption Kw/24hrs
220	50	4.3	1.39	12

Total Time Elapsed for Test Results	Compressor Running Time Percentage
480	75%

Remarks

Hot Chamber Operator Date and Signature	Laboratory Manager Date and Signature
KHALED	

Performance Test Sheet

Test Type Performance Test Sheet Number Baal-PFT-04 Date 4/7/99

Ambient Temperature	Relative Humidity %	Product Name	Product Serial Number
32°C	45%	chest Freezer	NON
Type of Compressor	**Compressor Model**	**Compressor Cooling Capacity**	**Compressor Power Input**
Hermetic	Gold Star	240	230
Refrigerant Type	**Refrigerant Charge Weight**	**Condenser Type and Length**	**Evaporator Type**
R134a	270	N/A	Tube in body
Capillary Tube Length	**Thermostat Type**	**Thermostat Setting**	**Test Run Time**
N/A	Defrost	Medium	1200
Drier Type	**Drier Weight**		
XH	20		

Test Results

Description	Time																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Evaporator Surface Temp	20	10	5	0	-10	-15	-18	-22	-23	-24	-23	-22	-23	-22	-25	-24	-23	-22	-23
Evaporator "M" Package Temperature	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Refrigerator Temp. "T1"	28	18	15	5	-2	-8	-12	-15	-18	-19	-20	-18	-17	-17	-19	-20	-18	-18	-19
Refrigerator Temp. "T2"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Refrigerator Temp. "T3"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Refrigerator Mean Temperature.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Refrigerator Outside Walls Temperature	32	32	35	32	32	34	32	32	32	32	32	32	32	32	32	32	32	32	32
Compressor Suction Temperature	40	45	40	38	37	35	35	35	32	32	35	32	32	32	32	32	32	32	32
Compressor Discharge Temperature	87	89	89	91	92	90	91	92	90	89	88	87	88	85	89	91	92	95	91
Compressor Shell temperature	97	93	95	96	98	97	97	98	95	94	93	93	94	90	94	96	98	101	99
Condenser Mid Temperature	45	45	40	50	55	55	55	57	57	50	55	55	52	56	57	35	56	53	57

Test Result Analysis

Voltage	Hertz	Starting Current	Working Current	Energy Consumption Kw/24hrs
220	50	2.3	1.1	4

Total Time Elapsed for Test Results	Compressor Running Time Percentage
1200	65%

Remarks

Hot ~~Chamber Operator~~ Date and Signature	Laboratory Manager Date and Signature
KHALID	

Performance Test Sheet

Test Type Performance Test Sheet Number Baal-PFT-03 Date 2/7/99

Ambient Temperature 32 °C	Relative Humidity % 45	Product Name UP Right Ref.	Product Serial Number NON
Type of Compressor Hermetic	Compressor Model electrolux	Compressor Cooling Capacity 590	Compressor Power Input 620
Refrigerant Type R134a	Refrigerant Charge Weight 680	Condenser Type and Length N/A 4Rows	Evaporator Type Fin & Tube
Capillary Tube Length Not Available	Thermostat Type Defrost	Thermostat Setting Medium	Test Run Time 480 min
Drier Type XH	Drier Weight 30 grm		

Test Results

Description	Time																		
	1	2	3	4	5	6	7	8											
Evaporator Surface Temp	10	0	-12	-15	-18	-19	-18	-19											
Evaporator "M" Package Temperature	—	—	—	—	—	—	—	—	—	—	—	—							
Refrigerator Temp. "T1"	32	20	10	5	7	6	5	5											
Refrigerator Temp. "T2"	"	"	"	"	"	"	"	"											
Refrigerator Temp. "T3"	"	"	"	"	"	"	"	"											
Refrigerator Mean Temperature.	32	20	10	5	7	6	5	5											
Refrigerator Outside Walls Temperature	32	32	32	32	32	32	32	32											
Compressor Suction Temperature	38	35	40	39	37	40	45	48											
Compressor Discharge Temperature	98	99	105	107	102	103	98	96											
Compressor Shell temperature	105	105	107	109	111	115	116	120											
Condenser Mid Temperature	55	56	40	46	48	55	50	50											

Test Result Analysis

Voltage	Hertz	Starting Current	Working Current	Energy Consumption Kw/24hrs
220	50	4.95	1.38	10

Total Time Elapsed for Test Results	Compressor Running Time Percentage
480 Min	65%

Remarks

Hot Chamber Operator Date and Signature	Laboratory Manager Date and Signature
KHALED	

Performance Test Sheet

Test Type Performance Test Sheet Number Baal-PFT-02 Date 30/6/99

Ambient Temperature	Relative Humidity %	Product Name	Product Serial Number
32°C	45	Meat Show Case	NON
Type of Compressor	**Compressor Model**	**Compressor Cooling Capacity**	**Compressor Power Input**
Hermetic	Danfoss	380	410
Refrigerant Type	**Refrigerant Charge Weight**	**Condenser Type and Length**	**Evaporator Type**
R134a	540 grm.	4 Raws	Fin & Tube
Capillary Tube Length	**Thermostat Type**	**Thermostat Setting**	**Test Run Time**
Not Available	Defrost	Medium	12
Drier Type	**Drier Weight**		
XH	30 grm		

Test Results

Description	Time																		
	1	2	3	4	5	6	7	8	9	10	11	12							
Evaporator Surface Temp	+28	+18	+4	+0	-2	-6	-8	-9	-10	-15	-14	-15							
Evaporator "M" Package Temperature	-	-	-	-	-	-	-	-	-	-	-	-							
Refrigerator Temp. "T1"	32	25	20	10	12	8	7	3	5	4	5	4							
Refrigerator Temp. "T2"	"	"	"	"	"	"	"	"	"	"	"	"							
Refrigerator Temp. "T3"	"	"	"	"	"	"	"	"	"	"	"	"							
Refrigerator Mean Temperature.	32	25	20	10	12	8	7	3	5	4	5	4							
Refrigerator Outside Walls Temperature	32	32	32	32	32	32	32	32	32	32	32	32							
Compressor Suction Temperature	28	25	30	35	40	45	40	40	45	38	37	32							
Compressor Discharge Temperature	98	95	96	97	89	99	98	93	110	98	98	98							
Compressor Shell temperature	105	110	105	108	102	108	107	102	115	105	106	107							
Condenser Mid Temperature	52	48	50	52	54	55	55	55	56	57	55	55							

Test Result Analysis

Voltage	Hertz	Starting Current	Working Current	Energy Consumption Kw/24hrs
220	50	3.87	1.12	12

Total Time Elapsed for Test Results	Compressor Running Time Percentage
720	75%

Remarks

Hot Chamber Operator Date and Signature	Laboratory Manager Date and Signature
KHALED	

Performance Test Sheet

Test Type *Performance* Test Sheet Number *Band- PFT- 01* Date *28/6/99*

Ambient Temperature 32°c	Relative Humidity % 45	Product Name UP Right Ref.	Product Serial Number NON
Type of Compressor Helmetic	Compressor Model Danfoss	Compressor Cooling Capacity 680	Compressor Power Input 750
Refrigerant Type R134a	Refrigerant Charge Weight 580	Condenser Type and Length 4 Rows	Evaporator Type Fin & Tube
Capillary Tube Length 8 mt.	Thermostat Type Defrost	Thermostat Setting Medium	Test Run Time 24 hrs
Drier Type 25 Grm XH	Drier Weight 25 Grm		

Test Results

Description	Time																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	18	19	24
Evaporator Surface Temp	+18	+16	+10	+1	-5	-7	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
Evaporator "M" Package Temperature	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Refrigerator Temp. "T1"	+32	+30	+24	+20	+8	+7	+4	+5	+6	+5	+4	+6	+3	+2	+5	+4	+6	+3	+2
Refrigerator Temp. "T2"	+4	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃
Refrigerator Temp. "T3"	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃	+ 〃
Refrigerator Mean Temperature.	+32	+30	24	20	8	7	4	4	5	6	5	4	6	3	2	5	4	6	2
Refrigerator Outside Walls Temperature	+32	+ 〃	32 〃	32 〃	32 〃	32 〃	32	32	~	~	~	~	~	~	~	~	~	—	32
Compressor Suction Temperature	+32	+32	32	40	42	45	41	40	45	41	45	60	50	41	42	42	42	52	42
Compressor Discharge Temperature	+90	+80	98	78	100	101	102	103	90	98	95	93	96	95	95	98	95	95	92
Compressor Shell temperature	+110	+120	120	110	110	110	120	108	108	108	110	108	108	108	108	110	110	110	110
Condenser Mid Temperature	+55	+55	53	55	53	55	55	55	55	55	55	55	50	56	54	53	55	55	55
		+																	

Test Result Analysis

Voltage	Hertz	Starting Current	Working Current	Energy Consumption Kw/24hrs
220	50	4.38	1.28	8

Total Time Elapsed for Test Results	Compressor Running Time Percentage
1500 min	60%

Remarks

Hot Chamber Operator Date and Signature	Laboratory Manager Date and Signature
KHALED	

Introduction

This Draft Final report has been prepared based on Contract with UNIDO and relevant terms of references prepared by UNIDO. The aim of the contract is to develop and convert six models of currently in production, into Ozone Friendly Refrigerant cooling system.

Based on Montreal and Jordan agreement, R134a refrigerant was selected as suitable Ozone friendly Refrigerant replacement and an alternative for R12 refrigerant and also Cyclopentane as a substitute for R11.

This change to the cooling system requires significant modification and improvement of cooling system. Due to the enhanced physical and chemical properties of the main components of the cooling circuits must be replaced of adjusted as a consequence of substitution of R12 into R134a.

Please find below the calculation of prototypes for determination of cooling capacity of each prototypes and also selecting compatible compressor for substituting R12 compressor with R134a compressor, because this is the first step for making prototype. It is indeed a difficult job to find precise compressor capacity to much the installed R12 compressor in the Jordanian market.

The data which has been collected from each company will help us to calculate required refrigeration load that should be produced by the compressor and evaporators. For making prototypes our policy is to keep the existing size of condenser and evaporator and perform minor changes as required in cooing circuit, we think that minor adjustment will be required in refrigerant weight charge and probably in length of capillary tube.

In this report we will give some detailed technical data in different tables for each prototype model and then we calculate the refrigeration load calculation for each prototype.

The prototypes were tested under designated ambient temperature mostly at + 32 C, the test performance revealed that no significant changes is necessary for refrigeration system circuit, because the original size of evaporator and condensers are much bigger than cooling requirements.

The adjustment were applied to the mainly to the amount of refrigerant charge and length of capillary tube.

Each prototypes under gone performance test at the following test criteria.

Pull down test at + 32 C

Continuos run Test at = 32 C ambient temperature

Cyclic run test at + 32 C ambient temperature.

The test condition was selected in accordance with appropriate ISO test standards.

All prototypes were tested at existing hot chamber in our facilities in Awajan Amman

the test results sheet will be provided after necessary performance test evaluation and perform necessary modification.

Before making prototypes we conducted a training course to train the six companies to make their own prototypes and also make them familiar with the new technology.

The following topics were thought during the theatrical training course.

An orientation to UNIDO CFC phase out project.

Montreal Protocol

Ozone Layer and CFC side effect to Ozone layer

Familiarization with new R134a Refrigerant, application, safety precaution, use and maintenance.

Familiarization with the new vacuum and charging equipment, vacuum pump and charging board.

Recovery and recycling of R12 refrigerant, and also R134a.

Alternative for R11 and R12.

Some explanation about R141b blowing agent,

Selection of refrigeration components to be replaced with R12 refrigeration system.

Calculation and redesign of prototypes

Performance test

Test results Evaluation.

Refrigeration system adjustment.

Naim Dahdal Show Case
Model ND1200 Technical Specification

Show Case Upright Refrigerator	Type of Product
2000 x 700 x 1400 mm	Overall Dimension
50 mm	Wall Thickness
P.U. Foam R11	Type of Foam
40 Kg/m	Foam Density
110 ISO, 76 Polyol, 24 R11	Foam Mixing Ratio %
1200 lit.	Net Internal Volume
Hermetic, Air Cooled	Type of Compressor
650 Watts	Compressor Cooling Capacity
750 Watts	Power Input
Fin and Tube	Type of Condenser
Inside Dim. = 4, four rows	Size of Condenser
Fin and Tube	Type of Evaporator
R12	Type of Refrigerant
R12, = 650 Gr.	Refrigerant Charge
25 Gr.	Filter Drier Size
220/50	Power Source
- 10 °C	Designated Inside Evaporator Temperature
5 °C	Designated Inside Ref. Temperature
Standard 32 °C	Designated Operating Condition

Refrigeration Load Calculation
Upright Refrigerator Showcase Model ND-1200

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (200x70)	2.8	50mm	27 c
Back Panel	200x140	2.8	50mm	27 c
Top Surface	70x140	0.980	50mm	37 c
Bottom Surface	70x140	0.980	50mm	27 c
Door	200x140	2.8	15mm air	27 c

Insulation Type: Pu Foam with R141b blowing agent.

Thermal Conductivity for Foam = 0.0180 W/ mt. ° C

Thermal Conductivity for Air at -12 at 1 atm. =0.02367 W/mt. ° C

Temperature Difference Refrigerator Compartment:
$\Delta T = 32 - (+5) = 27\ ° C$
Ambient Temperature = 32 °C
Refrigerator Air Temperature = +5 °C

Calculation :

Heat Leak For Refrigerator Compartment.

$$Q_{TL} = Q_{SW} + Q_{Back\ Panel} + Q_{door} + Q_{Bottom} + Q_{Top}$$

$$Q = U\ A\ (T_a - T_r)$$

$$U = \frac{1}{X_1 / K_1}$$

Where :

U = Heat Resistance Coefficient Factor
K_1 = Foam Thermal Conductivity

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-$Q_{SideWalls}$ = [U A (T_a - T_r)]

T_a = Ambient Temperature
T_r = refrigerator air Temperature

U = 1 / (0.050/ 0.0180) = 0.36 W/ sq.m °C

A = 2.8 Sq. Mt.,
T_a = 32 °C
T_f = + 5 °C
therefore
$Q_{SideWalls}$ = 0.36 x 2.8 x 27 = 27.22 Watts

$Q_{SideWalls}$ = 27.2 Watts

2 -Q_{Door} = [U A (T_a - T_r)]

U = 1 / (0.015/ 0.024) = 1.6 W/ sq.m °C
T_a - T_r= 27
A = 2.8

Q_{door} = 1.6 x 2.8 x 27 = 120 Watts

Q_{door} = 120 Watts

2 -$Q_{Back\ panel}$ = [U A (T_a - T_r)]

U = 0.36 w/sq. Mt. °C,
T_a - T_r= 27
A = 2.8

$Q_{Back\ panel}$ = 0.36 x 2.8 x 27 = 27.2 Watts

$Q_{Back\ panel}$ = 27.2 Watts

3 -Q_{Top} = [U A (T_a - T_r)]

$U = 0.34$ w/sq. Mt. °C,
$T_a - T_r = 27$
$A = 0.980$

$Q_{Top} = 0.36 \times 0.98 \times 37 = 13$ Watts

$$Q_{Top} = 13 \text{ Watts}$$

3 -$Q_{Bottom} = [\,U A\,(T_a - T_r)\,]$

$U = 0.34$ w/sq. Mt. °C,
$T_a - T_r = 27$
$A = 0.980$

$Q_{Bottom\ Surface} = 0.36 \times 0.98 \times 27 = 9.5$Watts

$$Q_{Bottom\ Surface} = 9.5 \text{ Watts}$$

Total Refrigerator Heat Leak =27.2+120+27.2+13+9.5=196.9 W

__Product Load__

A product placed in a refrigerator at a temperature higher than the storage temperature will lose heat until it reaches the storage temperature. The quantity of heat to be removed may be calculated from knowledge of the product, including its state upon entering the refrigerator, its final state, its weight, specific heat above and below freezing point, its freezing temperature and latent heat. When a definite weight of product is cooled from one state and temperature to another state and temperature, some or all of the following calculations must be made:

Heat removal from intial temperature to some lower temperature above freezing.

$$Q = mc(T_1 - T_2)$$

Heat removal from initial temperature to freezing point of product.

$$Q = mc(T_i - T_f)$$

Heat removal to freeze product.

$$Q = mh_{if}$$

Heat removal from freezing point to final temperature below freezing.

$$Q = mc(T_f - T_3)$$

Where

Q = heat removed, Kj
M = weight of product, kg
C = specific heat of product above freezing point, Kj/Kg. K
T_1 = initial temp. C
T_2 = lower temperature above freezing, C
T_f = freezing temperature of product, C
H_{if} = latent heat of fusion, kj per kg

Since this product is mainly used for storing fresh Lamb meet and beef above freezing point at +5 C, we consider 500 Kg of meet to be stored in this refrigerator therefore we calculate as follow,

$$Q = mc(T_1 - T_2)$$

M = 500 kg
C = 0.67 Btu/(lb)F deg = 0.67 x 4.184 = 2.8 j/g K
T_1 = 25 C
T_2 = 5 C
Q = 500000x2.8x (25-5) =28000000 jul/86400 = 324 Watt

Internal Load

Electric Fan 2x10 = 20 Watt
Florescent Lamp = 20 watt

Door Opening
Refrigerator Internal Volume 1200 lit.
Number of air change as per ASHREA standard = 70 per day
Heat removed per cubic meter of air 75000 j

Air Change load = 1.2x70x75000/86400 = 72.9 Watt

$$Q_{Total} = Q_{heat\ leak} + Q_{product\ load} + Q_{internal\ load} + Q_{air\ change}$$

$$Q_{Total} = 324 + 196.9 + 20 + 20 + 72.9 = 633.8$$

Considering 10 % of Q total for safety factor

$$Q_{\text{Grand Total}} = 633.8 + 10\%(63.4) = 697.2 \text{ watts}$$

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 697.2 watt at –10 degree centigrade evaporating temperature.

Al- Amer Meat Show Case
Model A-1.55M Technical Specification

Show Case	Type of Product
1550 x 600 x 1400 mm	Overall Dimension
60 mm	Wall Thickness
P.U. Foam R11	Type of Foam
40 Kg/m	Foam Density
110 ISO, 76 Polyol, 24 R11	Foam Mixing Ratio %
600 lit.	Net Internal Volume
Hermetic, Air Cooled	Type of Compressor
380 Watts	Compressor Cooling Capacity
400Watts	Power Input
Fin and Tube	Type of Condenser
Inside Dim. = 4, four rows	Size of Condenser
Fin and Tube = 15 meter	Type of Evaporator
R12	Type of Refrigerant
R12, = 600 Gr.	Refrigerant Charge
25 Gr.	Filter Drier Size
220/50	Power Source
- 10 °C	Designated Inside Evaporator Temperature
5 °C	Designated Inside Ref. Temperature
Standard 32 °C	Designated Operating Condition

Refrigeration Load Calculation
Upright Refrigerator Showcase Model A-1.55M

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (100x75)	1.5	60mm	27 c
Lower Back Panel	155x75	1.16	60	27 c
Upper Back Panel	155x65	1.01	15 mm air	27 C
Display Shield Glass	155x102	1.58	10mm	27 c
Bottom Surface	155x100	1.55	60mm	37 c

Insulation Type: Pu Foam with R141b blowing agent.

Thermal Conductivity for Foam = 0.0180 W/ mt. ° C

Thermal Conductivity for still Air at -12 at1 atm. =0.02367 W/mt.° C

Temperature Difference Refrigerator Compartment:
$\Delta T = 32 - (+5) = 27\ ° C$
Ambient Temperature = 32 °C
Refrigerator Air Temperature = +5 °C

Calculation :

Heat Leak For Refrigerator Compartment.

$$Q_{TL} = Q_{SW} + Q_{Back\ Panel} + Q_{door} + Q_{Bottom} + Q_{front\ Shield\ Glass}$$

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

$$U = \frac{1}{X_1 / K_1}$$

Where :

U = Heat Resistance Coefficient Factor

K_1 = Foam Thermal Conductivity

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-$Q_{SideWalls} = [U A (T_a - T_r)]$

T_a = Ambient Temperature 32
T_r = refrigerator air Temperature 5

U = 1 / (0.060/ 0.0180) = 0.3 W/ sq.m °C

A = 1.5 Sq. Mt.,
T_a = 32 °C
T_f = + 5 °C
therefore
$Q_{SideWalls}$ = 0.3 x 1.5 x 27 = 12.2 Watts

$Q_{SideWalls}$ = 12.2 Watts

2 -$Q_{front\ shield\ glass} = [U A (T_a - T_r)]$

U = 1 / [(0.010/ 0.5)+(0.65/0.02362)] = 0.036 W/ sq.m °C
$T_a - T_r$= 27
A = 1.5

$Q_{front\ shield\ glass}$ = 0.036 x 1.5 x 27 = 1.5 Watts

$Q_{front\ shield\ glass}$ = 1.5 Watts

3 -$Q_{Upper\ Back\ panel} = [U A (T_a - T_r)]$

U = 1/(0.015/0.02362) = 1.57 w/sq. Mt. °C,
$T_a - T_r$= 27
A = 1.01

$Q_{Upper\ Back\ panel}$ = 1.57 x 1.01 x 27 = 42.8 Watts

$Q_{upper\ Back\ panel}$ = 42.8 Watts

4 -$Q_{\text{lower back panel}} = [U A (T_a - T_r)]$

U = 0.3 w/sq. Mt. °C,
$T_a - T_r = 27$
A = 1.16

$Q_{\text{lower back panel}} = 0.3 \times 1.16 \times 27 = 9.4$ Watts

$Q_{\text{lower back panel}} = 9.4$ Watts

5 -$Q_{\text{Bottom}} = [U A (T_a - T_r)]$

U = 0.3 w/sq. Mt. °C,
$T_a - T_r = 37$
A = 1.55

$Q_{\text{Bottom Surface}} = 0.3 \times 1.55 \times 37 = 17.2$ Watts

$Q_{\text{Bottom Surface}} = 17.2$ Watts

Total Refrigerator Heat Leak =12.2+1.5+9.4+42.8+17.2= 113.7 W

Product Load

A product placed in a refrigerator at a temperature higher than the storage temperature will lose heat until it reaches the storage temperature. The quantity of heat to be removed may be calculated from knowledge of the product, including its state upon entering the refrigerator, its final state, its weight, specific heat above and below freezing point, its freezing temperature and latent heat. When a definite weight of product is cooled from one state and temperature to another state and temperature, some or all of the following calculations must be made:

Heat removal from intial temperature to some lower temperature above freezing.

$$Q = mc(T_1-T_2)$$

Heat removal from initial temperature to freezing point of product.

$$Q = mc(T_i-T_f)$$

Heat removal to freeze product.

$$Q = mh_{if}$$

Heat removal from freezing point to final temperature below freezing.

$$Q = mc(T_f - T_3)$$

Where

- Q = heat removed, Kj
- M = weight of product, kg
- C = specific heat of product above freezing point, Kj/Kg. K
- T_1 = initial temp. C
- T_2 = lower temperature above freezing, C
- T_f = freezing temperature of product, C
- H_{if} = latent heat of fusion, kj per kg

Since this product is mainly used for storing fresh Lamb meet and beef above freezing point at +5 C, we consider 200 Kg of meet to be stored in this refrigerator therefore we calculate as follow,

$$Q = mc(T_1 - T_2)$$

M = 200 kg
C = 0.67 Btu/(lb)F deg = 0.67 x 4.184 = 2.8 j/g K
T_1 = 25 C
T_2 = 5 C
Q = 200000x2.8x (25-5) =11200000 jul/86400 = 129.6 Watt

Internal Load
Florescent Lamp = 2x12=24 watt

Door Opening
Refrigerator Internal Volume 600 lit.
Number of air change as per ASHREA standard = 70 per day
Heat removed per cubic meter of air 75000 j

Air Change load = 0.6x70x75000/86400 = 36.4 Watt

$$Q_{Total} = Q_{heat\ leak} + Q_{product\ load} + Q_{internal\ load} + Q_{air\ change}$$

$$Q_{Total} = 113.7 + 129.6 + 24 + 36.4 = 303.7$$

Considering 20 % of Q total for safety factor

$$Q_{Grand\ Total} = 303.7 + 20\%(303.7) = 364.5 \text{ watts}$$

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 364.5 watt at –10 degree centigrade evaporating temperature.

Malak Est. Up Right Refrigerator
Model MA-1600 Technical Specification

Show Case Upright Refrigerator	Type of Product
2000 x 850 x 1600 mm	Overall Dimension
60 mm	Wall Thickness
P.U. Foam R11	Type of Foam
40 Kg/m	Foam Density
110 ISO, 76 Polyol, 24 R11	Foam Mixing Ratio %
1200 lit.	Net Internal Volume
Aspera Model 6220	Type of Compressor
580 Watts	Compressor Cooling Capacity
650 Watts	Power Input
Fin and Tube	Type of Condenser
Inside Dim. = 4, four rows	Size of Condenser
Fin and Tube	Type of Evaporator
R12	Type of Refrigerant
R12, = 750 Gr.	Refrigerant Charge
25 Gr.	Filter Drier Size
220/50	Power Source
- 15 °C	Designated Inside Evaporator Temperature
5 °C	Designated Inside Ref. Temperature
Standard 32 °C	Designated Operating Condition

Refrigeration Load Calculation
Upright Refrigerator Showcase Model MA-1600

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (200x85)	3.4	60mm	27 c
Back Panel	200 x160	3.2	60mm	27 c
Top Surface	85 x 160	1.36	60mm	37 c
Bottom Surface	85 x 160	1.36	60mm	27 c
Door	200 x 160	3.2	60mm	27 c

Insulation Type: Pu Foam with R141b blowing agent.

Thermal Conductivity for Foam = 0.0180 W/ mt. ° C

Temperature Difference Refrigerator Compartment:
$\Delta T = 32 - (+5) = 27\ ^\circ C$
Ambient Temperature = 32 °C
Refrigerator Air Temperature = +5 °C

Calculation :

Heat Leak For Refrigerator Compartment.

$$Q_{TL} = Q_{SW} + Q_{Back\ Panel} + Q_{door} + Q_{Bottom} + Q_{Top}$$

$$Q = U\,A\,(T_a - T_r)$$

$$U = \frac{1}{X_1 / K_1}$$

Where :

U = Heat Resistance Coefficient Factor
K_1 = Foam Thermal Conductivity

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-$Q_{SideWalls} = [U A (T_a - T_r)]$

T_a = Ambient Temperature
T_r = refrigerator air Temperature

U = 1 / (0.060/ 0.0180) = 0.3 W/ sq.m °C

A = 3.4 Sq. Mt.,
T_a = 32 °C
T_r = + 5 °C
therefore
$Q_{SideWalls}$ = 0.3 x 3.4 x 27 = 27.54 Watts

$Q_{SideWalls}$ = 27.54 Watts

2 -$Q_{Door} = [U A (T_a - T_r)]$

U = 1 / (0.015/ 0.018) = 0.3 W/ sq.m °C
$T_a - T_r = 27$
A = 3.2

Q_{door} = 0.3 x 3.2 x 27 = 25.92 Watts

Q_{door} = 25.92 Watts

2 -$Q_{Back\ panel} = [U A (T_a - T_r)]$

U = 0.3 w/sq. Mt. °C,
$T_a - T_r = 27$
A = 3.2

$Q_{Back\ panel}$ = 0.3 x 3.2 x 27 = 25.92 Watts

$Q_{Back\ panel}$ = 25.92 Watts

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

U = 0.3 w/sq. Mt. °C,

$T_a - T_r = 27$
A = 1.3

$Q_{Top} = 0.3x\ 1.3\ x\ 37 = 14.43$ Watts

$Q_{Top} = 14.43$ Watts

3 -$Q_{Bottom} = [\ U\ A\ (\ T_a - T_r\ )\ ]$

U = 0.3 w/sq. Mt. °C,
$T_a - T_r = 27$
A = 1.3

$Q_{Bottom\ Surface} = 0.3x\ 1.3\ x\ 27 = 10.53$ Watts

$Q_{Bottom\ Surface} = 10.53$ Watts

Total Refrigerator Heat Leak =

27.54+25.92+14.43+10.53+25.92=104.34W

Product Load

A product placed in a refrigerator at a temperature higher than the storage temperature will lose heat until it reaches the storage temperature. The quantity of heat to be removed may be calculated from knowledge of the product, including its state upon entering the refrigerator, its final state, its weight, specific heat above and below freezing point, its freezing temperature and latent heat. When a definite weight of product is cooled from one state and temperature to another state and temperature, some or all of the following calculations must be made:

Heat removal from intial temperature to some lower temperature above freezing.

$$Q = mc(T_1-T_2)$$

Heat removal from initial temperature to freezing point of product.

$$Q = mc(T_i-T_f)$$

Heat removal to freeze product.

$$Q = mh_{if}$$

Heat removal from freezing point to final temperature below freezing.

$$Q = mc(T_f - T_3)$$

Where

Q = heat removed, Kj
M = weight of product, kg
C = specific heat of product above freezing point, Kj/Kg. K
T_1 = initial temp. C
T_2 = lower temperature above freezing, C
T_f = freezing temperature of product, C
H_{if} = latent heat of fusion, kj per kg

Since this product is mainly used for storing fresh Lamb meet and beef above freezing point at +5 C, we consider 500 Kg of meet to be stored in this refrigerator therefore we calculate as follow,

$$Q = mc(T_1 - T_2)$$

M = 500 kg
C = 0.67 Btu/(lb)F deg = 0.67 x 4.184 = 2.8 j/g K
T_1 = 25 C
T_2 = 5 C
Q = 500000x2.8x (25-5) =28000000 jul/86400 = 324 Watt

Internal Load

Electric Fan 2x10 = 20 Watt
Florescent Lamp = 20 watt

Door Opening
Refrigerator Internal Volume 1200 lit.
Number of air change as per ASHREA standard = 70 per day
Heat removed per cubic meter of air 75000 j

Air Change load = 1.2x70x75000/86400 = 72.9 Watt

$$Q_{Total} = Q_{heat\ leak} + Q_{product\ load} + Q_{internal\ load} + Q_{air\ change}$$

$$Q_{Total} = 104.3 + 324 + 20 + 72.9 = 521.2$$

Considering 10 % of Q total for safety factor

$Q_{Grand\ Total}$ = 521.2 + 10%(52) = 573 watts

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 573 watt at –10 degree centigrade evaporating temperature.

Burhan Al-Awartani Chest Freezer
Model BU-500 Technical Specification

Chest Freezer	Type of Product
1200 x 600 x 800 mm	Overall Dimension
50 mm	Wall Thickness
P.U. Foam R11	Type of Foam
40 Kg/m	Foam Density
110 ISO, 76 Polyol, 24 R11	Foam Mixing Ratio %
500 lit.	Net Internal Volume
Techomseh Model AE4ZF9	Type of Compressor
235 Watts	Compressor Cooling Capacity
250Watts	Power Input
Fin and Tube	Type of Condenser
Tube in Body	Type of Evaporator
R12	Type of Refrigerant
R12, = 300 Gr.	Refrigerant Charge
15 Gr.	Filter Drier Size
220/50	Power Source
- 18 °C	Designated Inside Evaporator Temperature
5 °C	Designated Inside Ref. Temperature
Standard 32 °C	Designated Operating Condition

Chest Freezer Model BU-500

a) Transmission Load Calculation

Dimension

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2 x (60x80)	0.96	60
Front & Back Panel	2 x (120x80)	1.92	60
Chest Door	120 x 60	0.72	60
Bottom Floor	120 x 60	0.72	60

Insulation Type: Pu Foam R141b expanded blowing PU foam
R141b Foam Thermal Conductivity: 0.018 W /mt.C
Temperature Difference: (ΔT) = 43 - (-18) = 61 C
Ambient Temperature = 43 C
Freezer Air Temperature = - 18 C

Calculation :

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

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

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

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:

$Q_{SideWalls} = [U A (T_a - T_f)]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
U = 1 / (0.06/0.018) = 0.3 W/ sq.m C
A = 0.96 Sq. Mt.
T_a = 43 C

$T_f = -18$ C

$Q_{SideWalls} = 0.3 \times 0.96 \times 61 = 19.35$ Watts

$Q_{SideWalls} = 17.57$ Watts

$Q_{Front \,\&\, Back\, Walls} = [\, U\, A\, (T_a - T_f)\,]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
$U = 1 / (0.060/0.018) = 0.3$ W/ sq.m C
$A = 1.92$ Sq. Mt.
$T_a = 43$ C
$T_f = -18$ C
$Q_{Front \,\&\, Back\, Walls} = 0.3 \times 1.92 \times 61 = 35.14$ Watts

$Q_{Front \,\&\, Back\, Walls} = 35.14$ Watts

$Q_{Top} = [\, U\, A\, (T_a - T_f)\,]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
$U = 1 / (0.060/0.018) = 0.3$ W/ sq.m C
$A = 1.12$ Sq. Mt.
$T_a = 43$ C
$T_f = -18$ C

$Q_{Top} = 0.3 \times 0.72 \times 61 = 13.18$ Watts

$Q_{Top} = 19.13$ Watts

$Q_{Bottom} = [\, U\, A\, (T_a - T_f)\,]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
$U = 1/(0.060/0.018) = 0.3$ W/ sq.m C
$A = 0.72$ Sq. Mt.
$T_a = 55$ C
$T_f = -18$ C
$Q_{Bottom} = 0.3 \times 0.72 \times 73 = 15.76$ Watts

$Q_{Bottom} = 15.76$ Watts

Total Heat Leaks;

$Q_{TL} = 17.57 + 35.14 + 13.18 + 15.76 = 81.65$ watts

$$Q_{\text{Total Heat Leaks}} = 81.65 \text{ Watts}$$

Ice Making Capacity = 8_{Kg} x 1 x (15 - 0) x1.163= 139.56 Watts

c) Heat gain through infiltration;

We consider 10% safety factor for door opening and infiltration

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

Heat gain by infiltration = 0.1 x (81.65) = 8.2 Watts

Total Cooling Capacity Required is calculated as follows;

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

$$Q_{\text{Grand Total}} = 81.65 + 139.56 + 8.2 = 287.32 \text{ Watts}$$

$$Q_{\text{Grand Total}} = 287.32 \text{ Watts}$$

The suitable R134a compressor should be compatible with cooling capacity of 287 watt.

Eissa Hedjawi Up Right Refrigerator
Model EH-1500 Technical Specification

Show Case Upright Refrigerator	Type of Product
2000 x 700 x 1500 mm	Overall Dimension
60 mm	Wall Thickness
P.U. Foam R11	Type of Foam
40 Kg/m	Foam Density
110 ISO, 76 Polyol, 24 R11	Foam Mixing Ratio %
1200 lit.	Net Internal Volume
Aspera Model 6220	Type of Compressor
580 Watts	Compressor Cooling Capacity
650 Watts	Power Input
Fin and Tube	Type of Condenser
Inside Dim. = 4, four rows	Size of Condenser
Fin and Tube	Type of Evaporator
R12	Type of Refrigerant
R12, = 750 Gr.	Refrigerant Charge
25 Gr.	Filter Drier Size
220/50	Power Source
- 15 °C	Designated Inside Evaporator Temperature
5 °C	Designated Inside Ref. Temperature
Standard 32 °C	Designated Operating Condition

Refrigeration Load Calculation
Upright Refrigerator Showcase Model EH-1500

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (200x70)	2.8	60mm	27 c
Back Panel	200x150	3	60mm	27 c
Top Surface	70x150	1.05	60mm	37 c
Bottom Surface	70x150	1.05	60mm	27 c
Door	200x150	3	60mm	27 c

Insulation Type: Pu Foam with R141b blowing agent.

Thermal Conductivity for Foam = 0.0180 W/ mt. ° C

Temperature Difference Refrigerator Compartment:
$\Delta T = 32 - (+5) = 27\ ° C$
Ambient Temperature = 32 °C
Refrigerator Air Temperature = +5 °C

Calculation :

Heat Leak For Refrigerator Compartment.

$$Q_{TL} = Q_{SW} + Q_{Back\ Panel} + Q_{door} + Q_{Bottom} + Q_{Top}$$

$$Q = U\,A\,(T_a - T_r)$$

$$U = \frac{1}{X_1 / K_1}$$

Where :

U = Heat Resistance Coefficient Factor
K_1 = Foam Thermal Conductivity

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-$Q_{SideWalls}$ = $[U A (T_a - T_r)]$

T_a = Ambient Temperature
T_r = refrigerator air Temperature

U = 1 / (0.060/ 0.0180) = 0.3 W/ sq.m °C

A = 2.8 Sq. Mt.,
T_a = 32 °C
T_f = + 5 °C
therefore
$Q_{SideWalls}$ = 0.3 x 2.8 x 27 = 22.68 Watts

$Q_{SideWalls}$ = 22.68 Watts

2 -Q_{Door} = $[U A (T_a - T_r)]$

U = 1 / (0.015/ 0.018) = 0.3 W/ sq.m °C
$T_a - T_r$= 27
A = 3
Q_{door} = 0.3 x 33 x 27 = 24.3 Watts

Q_{door} = 24.3 Watts

2 -$Q_{Back\ panel}$ = $[U A (T_a - T_r)]$

U = 0.3 w/sq. Mt. °C,
$T_a - T_r$= 27
A = 3

$Q_{Back\ panel}$ = 0.3 x 3x 27 = 24.3 Watts

$Q_{Back\ panel}$ = 24.3 Watts

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

U = 0.3 w/sq. Mt. °C,

$T_a - T_r = 37$
A = 1.05

$Q_{Top} = 0.3 \times 1.05 \times 37 = 11.65$ Watts

$$Q_{Top} = 11.65 \text{ Watts}$$

3 -$Q_{Bottom} = [\,U\,A\,(T_a - T_r)\,]$

U = 0.3 w/sq. Mt. °C,
$T_a - T_r = 27$
A = 1.05

$Q_{Bottom\ Surface} = 0.3 \times 1.05 \times 27 = 8.5$ Watts

$$Q_{Bottom\ Surface} = 8.5 \text{ Watts}$$

Total Refrigerator Heat Leak =

22.68+24.3+11.65+8.5+24.3= 91.43

Product Load

A product placed in a refrigerator at a temperature higher than the storage temperature will lose heat until it reaches the storage temperature. The quantity of heat to be removed may be calculated from knowledge of the product, including its state upon entering the refrigerator, its final state, its weight, specific heat above and below freezing point, its freezing temperature and latent heat. When a definite weight of product is cooled from one state and temperature to another state and temperature, some or all of the following calculations must be made:

Heat removal from intial temperature to some lower temperature above freezing.

$$Q = mc(T_1 - T_2)$$

Heat removal from initial temperature to freezing point of product.

$$Q = mc(T_i - T_f)$$

Heat removal to freeze product.

$$Q = mh_{if}$$

Heat removal from freezing point to final temperature below freezing.

$$Q = mc(T_f - T_3)$$

Where

Q = heat removed, Kj
M = weight of product, kg
C = specific heat of product above freezing point, Kj/Kg. K
T_1 = initial temp. C
T_2 = lower temperature above freezing, C
T_f = freezing temperature of product, C
H_{if} = latent heat of fusion, kj per kg

Since this product is mainly used for storing fresh Lamb meet and beef above freezing point at +5 C, we consider 500 Kg of meet to be stored in this refrigerator therefore we calculate as follow,

$$Q = mc(T_1 - T_2)$$

M = 500 kg
C = 0.67 Btu/(lb)F deg = 0.67 x 4.184 = 2.8 j/g K
T_1 = 25 C
T_2 = 5 C
Q = 500000x2.8x (25-5) =28000000 jul/86400 = 324 Watt

Internal Load

Electric Fan 2x10 = 20 Watt
Florescent Lamp = 20 watt

Door Opening
Refrigerator Internal Volume 1200 lit.
Number of air change as per ASHREA standard = 70 per day
Heat removed per cubic meter of air 75000 j

Air Change load = 1.2x70x75000/86400 = 72.9 Watt

$$Q_{Total} = Q_{heat\ leak} + Q_{product\ load} + Q_{internal\ load} + Q_{air\ change}$$

$$Q_{Total} = 91.43 + 324 + 20 + 72.9 = 508$$

Considering 10 % of Q total for safety factor

$$Q_{\text{Grand Total}} = 508 + 10\%(51) = 559 \text{ watts}$$

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 559 watt at –10 degree centigrade evaporating temperature.

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-cooler are of two types,

Bottle Type.
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 ? 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 bubbles and these may be of many different types.

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 amount 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.

$Q_1 = m\ C\ \Delta T$, Where:

Q_1 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 30 C.

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

$$Q_2 = \dot{M}\ C\ \Delta T$$

Q_2 Total heat removed from total drinking water flow (lit.) during specific period, 16 hours. In Kcal.

$\dot{M}$ 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.

$$Q_3 = UA\,\Delta T$$

Where:

Q_3 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.

Load Calculation for Golf Workshop Two Front Tap Water Cooler Model G – 80

$Q_1 = m\ C\ \Delta T$, Where:

Q_1 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 = 80 liter = 45 Kg.

C Specific heat factor of water in Kcal/Kg ºC = 1

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

Ti = 24 ºC and Tc = 10 ºC

Ti – Tc = 24-10 = 14 ºC

$Q_1 = m\ C\ \Delta T$ = 80 x 1 x 14 = 630 Kcal = 630 x 1.163 = 1302 Watts/24 hrs

Q_1 = 1302 /24 water cooler operating time per day = 54.3 Watts

Q_1 = 54.3 Watts

$Q_2 = \dot{M}\ C\ \Delta T$

Q_2 Total heat removed from total drinking water flow (lit.) during specific period, 16 hours. In Kcal.

$\dot{M}$ total weight of water flow during 16 hours. in Kg. = H x N x M where:
H = Total Water Cooler Usage Time (Hours) = 16
N = Number of Glass of Drinking Water per Hour = 30
M = Kg weight of water in one Glass of Water = 0.2 Kg

$\dot{M}$ = 16 x 25 x 0.2 = 96 lit. + 20% Waste Water = 96

C Specific heat factor of water in Kcal/Kg ؛C = 1

?T Temperature d(Ti – Tc), where, Ti is inlet water temperature, and Tc is final cooled water temperature.

Ti = 24 ؛C and T= 10 ؛C

Ti – Tc = 24-10 = 14 ؛C

$Q_2 = m\,C\,\Delta T = 96 \times 1 \times 14 = 1344$ Kcal = 1344 x 1.163 = 1563 Watts/16 hrs

Q_2 = 1563/12.8 compressor operating time per day = 122 Watts

<u>Q_2 = 122 Watts</u>

$Q_3 = UA\,\Delta T$, Where:

Q_3 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

$$U = \frac{1}{x/K} = \frac{1}{0.025/0.0174} = 0.696\ Kcal/m^2.°C$$

A Total Area which heat is transmitted by. In Sq. Mt.

$$A = A_1 + A_2 + A_3 + A_4 + A_5 + A_6$$

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

Storage Tank Width x Length = 40 x 40 Cm.

Storage Tank Height = 50 Cm

$A_1 = A_2$ = 40 x 40 = 1600 Sq. Cm = 0.1600 Sq.Mt.

$A_3 = A_4 = A_5 = A_6$ = 50 x 40 = 2000 Sq. Cm. = 0.2 Sq. Mt.

A = (2 x 0.1600) + (4 x 0.2) = 0.96 Sq. Mt.

?T Temperature 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

$Q_3 = UA\,\Delta T = 0.696 \times 0.96 \times 20 =$ 13.4 Watts

Q_3 = 13.4 Watts

$Q_t = Q_1 + Q_2 + Q_3 = 54.3 + 122 + 13.4 = 189.7$ Watts

Compressor R134a, Model AZ 136 (total cooling capacity 177 watts) manufactured by L'uniteh Hermetic, Tecumseh, is selected as a suitable compressor to replace R12 compressor model 1410.