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 publications@unido.org for further information concerning UNIDO publications.

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

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

22446

47p. tables graphs diagrams

Maurice Ind. ICEBERG موريس الصناعية

To: ***Mr. V. Koloskov***
Contracts Officer
General Services Section
Financial Performance Control Branch
Field Operation and Administration Division
UINDO, Vienna, Austria
Fax: 00 431 26026 6815

Date: 10 May 2000

Subject: ***Final Report***

Reference: **Contract Number 2000/012 , Project Number MP/JOR/99/111**

Dear Sir,

Please find attached herewith our final report .

Please also find enclosed our invoice number 30114 dated 10 May 2000.

Your prompt action in reviewing the final report & proceed the payment of our invoice is highly appreciated.

With regards

Maryo Al-Deek
Managing Director

مؤسسة موريس الديك
للثلاجات والمصنوعات المعدنية

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Table of Contents

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦-٦-٩٦٢ - فاكس : ٤٦١٣٣٤٠-٦-٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Introduction

We have the pleasure herewith to submit to you our Final report, concerning calculation and redesign of the prototypes made by the counterparts and they have been tested successfully at our hot chamber, at our site in Amman. These prototypes have been manufactured under our engineering supervision and were tested in accordance with appropriate ISO standard test procedure and relevant performance test characteristics for functionality and performance of the new Ozone friendly R134a refrigerant. We hope that this final report would fulfill UNIDO's requirement in order to comply with our contract. In this report provide you with test results of the prototypes which had been tested at our hot chamber. Total of 8 prototypes made by Riad Hedjawi Workshop, Al-Susi Workshop, Al-Khaled Workshop, Al-Shark Workshop. And were redesigned and tested by our engineering staffs to adopt with R134a refrigeration system circuit.

Activities

1- Visiting the counter parts premises at different occasions
2- Collecting Technical Data for redesign of the prototypes
3- Preparing Technical forms for prototype technical specifications
4- Reviewing the technical characteristics of the counterpart prototypes
5- Testing six prototypes at our hot chamber
6- Evaluating Performance Test Results
7- Performing necessary changes to the refrigeration system circuits
8- Advising the counterpart for proper use of R141b blowing agent in conjuction with R134a refrigerant.
9- Redesign of Refrigerant circuits
10- Selecting suitable compressors for new system.
11- Conducting training course at our premise 20 hrs, theoretical and practical subjects were thought to the participants. The main topics that were discussed in this course could be summarized as follow;

- An Introduction to Ozone Layer.
- An orientation to UNIDO CFC phase out project

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

- An Introduction to the Montreal Protocol Activities and implementing agencies
- Ozone Depleting Substances, such as CFCs, Brumides, Helons, Solvents etc.
- Alternatives to the ODS
- *An introduction to* R134a *as a suitable and acceptable substitute for* CFC-12 as ozone friendly refrigerants.
- Safey Precaution for use and maintenance of new refrigerant R134a
- Selection of suitable components for new refrigeration circuit system, such as Compressor, drier, and etc.
- Recovery, Recycling and Reclaiming of the ODS refrigerants such as CFC-12
- Methods of refrigeration load calculations, for the purpose of redesign and modification of the prototypes
- The purpose of of redesign, of the prototypes for converting the old refrigeration system into
- An introduction to the commercial appliance refrigeration system ciruit.
- Methods of testing prototypes, such as, Operational test for functionality and performance at different climetic condition.
- An introduction to the ISO standards for testing prototypes
- Short briefing about use of R141b blowing agent,
- Familiarization with the new vacuum and charging equipment, vacuum pump and charging board.
- Test results Evaluation.
- Refrigeration system adjustment.
- The material as sample for making prototypes were supplied mainly

In this report we also 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 will be 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 will be applied to the mainly to the amount of refrigerant charge and

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢ -٦- ٤١٦٠٧٨٦ - فاكس : ٩٦٢ -٦- ٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

length of capillary tube.Each prototypes should under go for 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 will be 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.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Riad Hedjawi Chest Freezer
Model RIAD –CF 600F

(a) Transmission Load Calculation

Dimension

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2 x (65x85)	1.12	50
Front & Back Panel	2 x (160x85)	2.72	50
Chest Door	160 x 65	1.04	50
Bottom Floor	160 x 65	1.04	50

Insulation Type: Pu Foam R141b expanded blowing PU foam
R141b Foam Thermal Conductivity: 0.018 W /mt.C
Temperature Difference: $(\Delta T) = 32 - (-25) = 57$ C
Ambient Temperature = 32 C
Freezer Air Temperature = - 25 C

Calculation :

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

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

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

Where :

U = Heat Resistance Coefficient Factor

K1 = Foam Thermal Conductivity
X1 = 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 = $[U A (T_a - T_f)]$

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

T_a = Ambient Temperature
T_f = Freezer air Temperature
U = 1 / (0.05/0.018) = 0.36 W/ sq.m C
A = 1.12 Sq. Mt.
Ta = 32 C, Tf = - 25 C
Q SideWalls = 0.36 x 1.12 x 57 = 23 Watts
Q SideWalls = 23 Watts

Q Front Wall = [U A (Ta - Tf)]
Ta = Ambient Temperature
Tf = Freezer air Temperature
U = 1 / (0.050/0.018) = 0.36 W/ sq.m C
A = 1.36 Sq. Mt.
Ta = 32 C, Tf = - 25 C
Q Front Wall = 0.36 x 1.07 x 57 = 27.9 Watts
$Q_{Front\ Wall}$ = 27.9 Watts

Q Back panel = [U A (Ta - Tf)]
Ta = Ambient Temperature
Tf = Freezer air Temperature
U = 1 / (0.050/0.018) = 0.36 W/ sq.m C
A = 1.36 Sq. Mt.
Ta = 42 C, Tf = - 25 C
Q back panel = 0.36 x 1.36 x 57 = 27.9 Watts

Q_{Top} = [U A (Ta - Tf)]
Ta = Ambient Temperature
Tf = Freezer air Temperature
U = 1 / (0.050/0.018) = 0.36 W/ sq.m C
A = 1.04 Sq. Mt.
Ta = 32 C, Tf = - 25 C
Q_{Top} = 0.36 x 0.81 x 57 = 21.3 Watts
Q_{Top} = 21.3 Watts

Q_{Bottom} = [U A (Ta - Tf)]
Ta = Ambient Temperature
Tf = Freezer air Temperature
U = 1/(0.050/ 0.018) = 0.36 W/ sq.m C
A = 1.04 Sq. Mt.
Ta = 42 C, Tf = - 25 C
Q_{Bottom} = 0.36 x 1.04 x 67 = 25.2Watts

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦-٦-٩٦٢ - فاكس : ٤٦١٣٣٤٠-٦-٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Total Heat Leaks;

$$Q_{TL} = 23 + 27.9 + 27.9 + 21.3 + 25.2 = 125 \text{ watts}$$

$$Q_{\text{Total Heat Leaks}} = 125 \text{ Watts}$$

Ice Making Capacity = 10$_{Kg}$ x 1 x (15 - 0) x1.163= 174 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 (174) = 17.4 Watts
Total Cooling Capacity Required is calculated as follows;

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

$$Q_{\text{Grand Total}} = 125 + 174 + 17 = 316 \text{ Watts}$$

$$Q_{\text{Grand Total}} = 316 \text{ Watts}$$

The suitable R134a compressor should be compatible with cooling capacity of 316 watt.

a) Transmission Load Calculation

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ ص.ب : ٩٢١٩٤٠ عمان - الأردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Refrigeration Load Calculation
Al-Susi Workshop Soft Drink Display Case
Model AS-160PEP

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (80x200)	3.2	40mm	18 c
Back Panel	65 x200	1.3	40mm	18 c
Bottom	80x65	0.52	40mm	18C
Top	80x65	0.52	40mm	28 c
Door	65x200	1.3	15mm	18 c

Insulation Type: Pu Foam with R141b blowing agent.
Thermal Conductivity for Foam = 0.0180 W/ mt. ° C
Thermal Conductivity for Double Glass and Air = 0.12 W/ mt. ° C
Temperature Difference Refrigerator Compartment:
ΔT = 32 - (+5) = 27 ° C
Ambient Temperature = 32 °C
Refrigerator Air Temperature = +14 °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

Due to the short thickness of cabinet out side panel (0.6 mm) and

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦-٦-٩٦٢ - فاكس : ٤٦١٣٣٤٠-٦-٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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 / (0.040/ 0.0180) = 0.45 W/ sq.m °C

A = 3.2 Sq. Mt., T_a = 32 °C, T_f = + 18 °C

therefore

$Q_{SideWalls}$ = 0.45 x 3.2 x 18 = 2.6 Watts

$Q_{SideWalls}$ = 2.6 Watts

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

U = 1 / [(0.015/ 0.12)] = 8 W/ sq.m °C ,

$T_a - T_r$= 18, A = 1.3,

Q_{doors} = 8 x 1.3 x18 = 187 Watts

Q_{doors} = 187 Watts

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

U = 0.45 w/sq. Mt. °C,

$T_a - T_r$= 28 , A = 0.52

Q_{top} = 0.45 x 0.52 x 28 = 6.5 Watts

Q_{top} = 6.5 Watts

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

U = 0.45 w/sq. Mt. °C,

$T_a - T_r$= 18 , A = 1.3

$Q_{back\ panel}$ = 0.45x 1.3 x 18 = 10.5 Watts

$Q_{back\ panel}$ = 10.5 Watts

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

U = 0.45 w/sq. Mt. °C,

$T_a - T_r$= 18, A = 0.52

$Q_{Bottom\ Surface}$ = 0.45x0.52 x 18 = 4.2 Watt

$Q_{Bottom\ Surface}$ = 4.2 Watts

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Total Refrigerator Heat Leak =2.6 +187 + 4.2 + 10.6 + 6.5 = 211 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 Soft Drink Bottels above

freezing point at +14 C, we consider 200 bottles of soft drink to be

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

stored in this refrigerator therefore we calculate as follow, each bottle contains 300 ml of soft drink

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

M = 300 x 200 = 60000 ml = kg
C = 0.999 Btu/(lb)F deg = 0.999 x 4.184 = 4.179 j/g K
T_1 = 28 C
T_2 = 5 C
Q = 60000x4.179x (28-5) =5768146 jul/86400 = 66 Watt

Internal Load
Motor Fan 16 Watt
Flourecent Lamps = 40 Watt
Door Opening
Refrigerator Internal Volume 800 lit.
Number of air change as per ASHREA standard = 70 per day
Heat removed per cubic meter of air 75000 j

Air Change load = (0.8x70x75000)/86400 = 48.6 Watt

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

Q_{Total} = 211 + 66 + 16 +40 + 46.6 = 381.6

Considering 20 % of Q total for safety factor

$Q_{Grand\ Total}$ = 381 + 20%(76) = 457watts

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 457 watt at + 14 degree centigrade evaporating temperature.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الأردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Load Calculation for Al-Susi Workshop Water Cooler

Model ASH-WC100

$Q_1 = m\ C\ \Delta T$, **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 °C = 1

ΔT 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

$Q_1 = m\ C\ \Delta T$ **= 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**

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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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

ΔT 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 ΔT = 96 x 1 x 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 ΔT, 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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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

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.

ΔT 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 ΔT = 0.696 x 0.96 x 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.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الأردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Load Calculation for Al-Khaled Workshop Water Cooler
Model KH-WC100

$Q_1 = m\,C\,\Delta T$, 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 °C = 1

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

$$Ti = 24\ °C \text{ and } Tc = 10°\ C$$

$$Ti - Tc = 24\text{-}10 = 14\ °C$$

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

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

$Q_1 = 54.3$ Watts

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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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

ΔT 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 ΔT = 96 x 1 x 14 = 1344 Kcal = 1344 x 1.163 = 1563 Watts/16 hrs

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

Q_2 = 122 Watts

Q_3 = UA ΔT, 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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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

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.

ΔT 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 ΔT = 0.696 x 0.96 x 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.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الأردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Introduction

This 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 eight 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 R141b 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.

The prototypes will be tested at our hot chamber for functionality and performance test, in order to assure the good performance of the compatible components selected for refrigeration system circuit, such as compressor and refrigerant weight and capillary tube at desired climatic condition, 32 degree centigrade.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦- ٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦- ٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Companies General Background

Al-Sharq Workshop

Al-Sharq Workshop was established in 1986. The company is 100% private. The company's CFC-1 I and CFC-12 consumption in 1997 was 5.230 metric tons, which is 3.4 % of the average CFC - 11 and CFC- 12 of commercial refrigerator sector (average sector consumption is 150 tons of ODS), for the period of 1995-1997. The company manufactures water cooler, commercial refrigerator, chest freezer and cold storage for local use. In 1997 the company produced 1065 units of different types of products and consumed 21775 Kg.PU Foam. The density' of the foam used is about 40 kg/cu. mt. The consumption of the PU foam and refrigerant are shown in table 2 and 3. The consumption of CFC- 11 and CFC-12 for 1997 was 3.040 and 2.190 Mt

Type of Ownership	Private
Year of Establishment	1986
Workshop Area Square Meter	250
Number of Employee	25
Number of Servicemen	3
Number of Models Produced	9
Total Production in 1997	1065
Total ODS Consumed in 1997 Mt.	5.230

RIAD HEDJAWI WORKSHOP

RIAD HEDJAWI WORKSHOP company established in 1982 is 100% private company. The company's CFC-1 1 and CFC-12 consumption in 1997 was 4.885 metric tons, which is 3.2 % of the average CFC - 11 and CFC- 12 of commercial refrigerator sector (average sector consumption is 150 tons of ODS), for the period of 1995-1997. The company manufactures, commercial refrigerator, and cold storage for local use. In 1997 the company produced 1200 units of different types of products. The density of the foam used is about 40 kgku. mt. The consumption of the PU foam and refrigerant are shown in table 2 and 3. The consumption of CFC-1 1 and CFC-12 for 1997 was 2.869 and 2.016 Mt.

Type of Ownership	Private
Year of Establishment	1982
Workshop Area Square Meter	250
Number of Employee	27
Number of Servicemen	2
Number of Models Produced	10
Total Production in 1997	1200
Total ODS Consumed in 1997 Mt.	4.885

Susi Workshop

Susi Workshop company established in 1992 is 100% private company. The company's CFC-1 1 and CFC-12 consumption in 1997 was 4.181 metric tons, which is 2.8 % of the average CFC - 11 and CFC- 12 of commercial refrigerator sector (average sector consumption is 150 tons of ODS), for the period of 1995-1997. The company manufactures water cooler, and commercial refrigerator, for local use. In 1997 the company produced 830 units of different types of products The density of the foam used is about 40 kg/cu. mt. The consumption of the PU foam and refrigerant are shown in table 2 and 3. The consumption of CFC-1 1 and CFC-12 for 1997 was 2.439 and 1.742 Mt.

Type of Ownership	Private
Year of Establishment	192

Workshop Area Square Meter	120
Number of Employee	11
Number of Servicemen	2
Number of Models Produced	5
Total Production in 1997	830
Total ODS Consumed in 1997 Mt.	4.181

Khalid Workshop

Khalid Workshop company established in 1992 is 100% private company. The company's CFC-1 l and CFC-12 consumption in 1997 was 3.443 metric tons, which is 2.3 % of the average CFC - 11 and CFC- 12 of commercial refrigerator sector (average sector consumption is 150 tons of ODS), for the period of 1995-1997. The company manufactures water cooler, commercial refrigerator, and chest freezer for local use. In 1997 the company produced 850 units of different types of products. The density of the foam used is about 40 kg/cu. mt. The consumption of the PU foam and refrigerant are shown in table 2 and 3. The consumption of CFC-1 1 and CFC-12 for 1997 was 2.011 and 1.432 Mt

Type of Ownership	Private
Year of Establishment	1992
Workshop Area Square Meter	150
Number of Employee	7
Number of Servicemen	2
Number of Models Produced	6
Total Production in 1997	850
Total ODS Consumed in 1997 Mt.	3.443

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

1- Aim of the Project

The aim of the immediate project is to;

1- Design, calculate and drafting for model redefinition for 8 models.
2- Testing 4 prototypes for functionality and performance criteria.
3- Redesign the cooling units of the all models so that they could run on the new Ozone friendly R134a instead of the ODP active CFC12.

4- Scope of the Contract

1- A study will be made for 8 models of commercial refrigerators made by four companies to specify;

- Dimensional specification;
- Type and thickness of insulation
- Refrigeration unit component details
- Working performance
- Energy consumption

2- Selection of HFC 134a compatible components
3- Redesign of the refrigeration circuit as necessary
4- Specifying necessary changes in the cooling system if required
5- Preparation of the trial equipment one prototype per model
6- Testing of four prototypes for functionality and performance
7- Evaluation of the test results

Refrigeration Load Calculation Al-Sharq Workshop
Upright Refrigerator Showcase Model AS-100

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	200x100	2	50mm	27 c
Top Surface	70x100	0.7	50mm	37 c
Bottom Surface	70x100	0.7	50mm	27 c
Door	200x100	2	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 aluminum inner liner (0.5 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

Q $_{door}$ = 1.6 x 2x 27 = 86 Watts

Q $_{door}$ = 86 Watts

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

U = 0.36 w/sq. Mt. °C,

$T_a - T_r = 27$

A = 2

Q $_{Back\ panel}$ = 0.36 x 2x 27 = 19.4 Watts

Q $_{Back\ panel}$ = 19.4 Watts

4 -Q $_{Top}$ = $[U A (T_a - T_r)]$

U = 0.34 w/sq. Mt. °C,

$T_a - T_r = 27$

A = 0.7

Q $_{Top}$ = 0.36x 0.7 x 37 = 9.3 Watts

Q $_{Top}$ = 9.3 Watts

5 -Q_{Bottom} = $[U A (T_a - T_r)]$
U = 0.34 w/sq. Mt. °C,
$T_a - T_r$= 27
A = 0.7
$Q_{Bottom\ Surface}$ = 0.36x 0.7x 27 = 6.8 Watts

$Q_{Bottom\ Surface}$ = 6.8 Watts

Total Refrigerator Heat Leak =27.2+86+19.4+9.3+6.8=148.7 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 initial 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,

$Q = mc(T_1\text{-}T_2)$
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

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

$Q_{Total} = 324 + 148.7 + 20 + 20 + 72.9 = 585.6$

Considering 10 % of Q total for safety factor

$Q_{Grand\ Total}$ = 585.6 + 10%(58.6) = **644** watts

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 644 watt at –10 degree centigrade evaporating temperature.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٩٦٢-٦-٤١٦٠٧٨٦ - فاكس : ٩٦٢-٦-٤٦١٣٣٤٠ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Refrigeration Load Calculation for Al-Khalid
Chest Freezer Model KH-300

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 :

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

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

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

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 Aluminum inner liner (0.5 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 x 0.96 x 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 x 1.92 x 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 x 0.72 x 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 x 0.72 x 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

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

Ice Making Capacity = 8Kg 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;

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

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

$Q_{Grand\ Total}$ = 287.32 Watts

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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Refrigeration Load Calculation Riad Hedjawi Co.
Upright Refrigerator Showcase Model RH-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 aluminum inner liner (0.5 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

3 -$Q_{Back\ panel}$ = [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

4 -Q_{Top} = [U A (T_a - T_r)]
U = 0.3 w/sq. Mt. °C,

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الأردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

$T_a - T_r = 37$
$A = 1.05$
$Q_{Top} = 0.3 \times 1.05 \times 37 = 11.65$ Watts

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

5 -$Q_{Bottom} = [U A (T_a - T_r)]$
$U = 0.3$ 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 initial 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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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

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

Considering 10 % of Q total for safety factor

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

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.

Load Calculation for Al-Susi Workshop Two Front Tap Water Cooler Model Susi 35

$Q_1 = m\ C\ \Delta T$, 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 $^{o}C = 1$

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

Ti = 24 ^{o}C and Tc = 10 ^{o}C

Ti – Tc = 24-10 = 14 ^{o}C

$Q_1 = m\ C\ \Delta T = 80 \times 1 \times 14 = 630$ 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

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦ -٦- ٩٦٢ - فاكس : ٤٦١٣٣٤٠ -٦- ٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الاردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

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

C **Specific heat factor of water in Kcal/Kg ^{o}C = 1**

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

T_i = 24 ^{o}C and T= 10 ^{o}C

$T_i - T_c$ = 24-10 = 14 ^{o}C

Q_2 = m C ΔT = 96 x 1 x 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 ΔT, 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

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

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.

$A_3 = A_4 = A_5 = A_6 = 50 \times 40$ = 2000 Sq. Cm. = 0.2 Sq. Mt.
A = (2 x 0.1600) + (4 x 0.2) = 0.96 Sq. Mt.

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

Ta = 30 ^{o}C and Tc = 10 ^{o}C

Ta – Tc = 30-10 = 20 ^{o}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.

هاتف المعرض : ٤٦٥٣٢٦٢ - المصنع : ٤١٦١٣٧٢ - فاكس : ٤١٦٠٧٨٦-٦-٩٦٢ - فاكس : ٤٦١٣٣٤٠-٦-٩٦٢ - ص.ب : ٩٢١٩٤٠ عمان - الأردن
Tel Showroom : 4653262 - Factory : 4161372 - Fax : 962 -6- 4160786 - Fax : 962 -6- 4613340 - P.O.Box : 921940 Amman - Jordan
E-mail: maurice@joinnet.com.jo

Printi g in Labaratory Of
Maurice Ind. [Jordan]

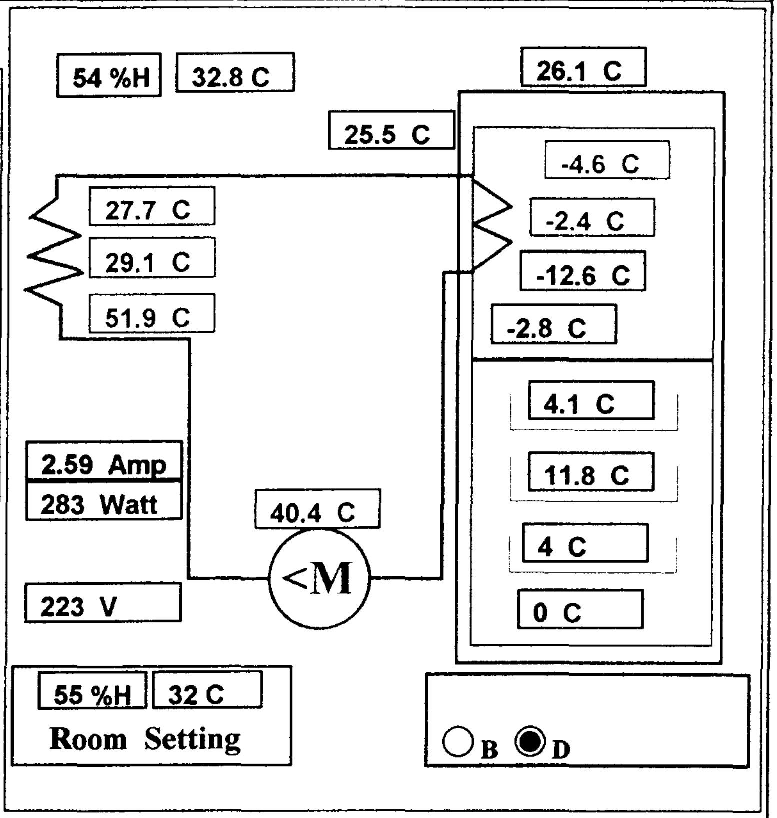
Maurice Ind. [Jordan]

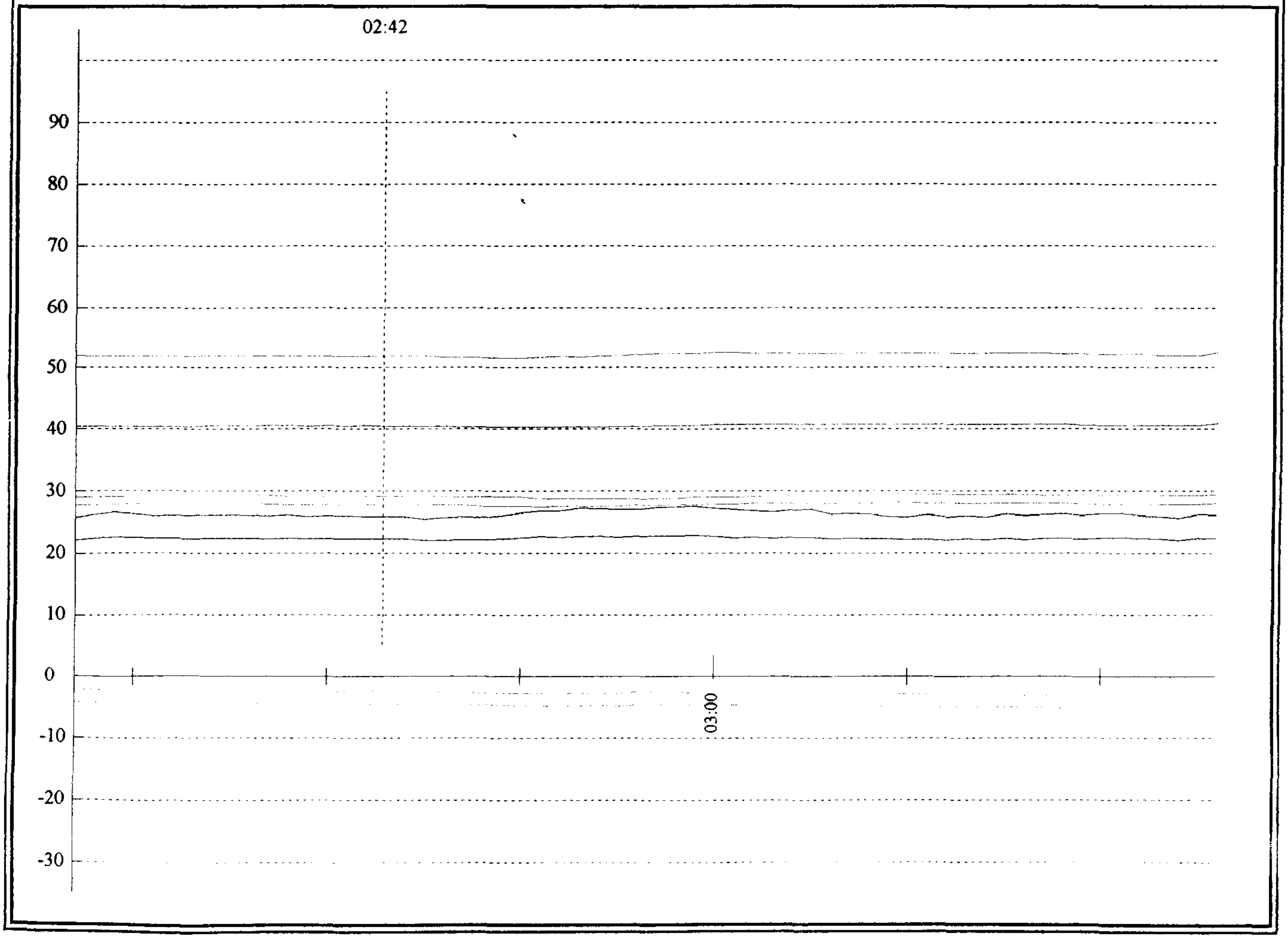
TestDate: 99/07/05 10:10   ***Report No.:*** ( ) - Page 1

PageTestName: Energy Consumtion   ***ReportDate:*** 2000/04/29 09:46

Page Result :

1 - Page Test Time	*1 Hours*
2 - Working Percent	*101 %On*
3 - Energy (Accord to page)	*2.121 kwh*
4 - Zoom Time	*2:43 Hour*
5 - Compr Current	*2.59 Amp*
6 - Evaprator Mean Temp	*-5.6 C*
7 - Cabin Mean Temp	*6.6 C*
8 - Crisp Temp	*0 C*
9 - Compr Temp	*40.4 C*
10- Condensor In Temp	*51.9 C*
11- Condensor Out Temp	*27.7 C*
12- Condition	*32.8 C 54 %H*
13- Volt	*Max=229 Mean=228 Min=221*
14-	
15-	
16-	
17-	





Industrial Control Research Center HotRoom Ver 5

AL SusiWorkShop

Printing In Labaratory Of
Maurice Ind. [Jordan]

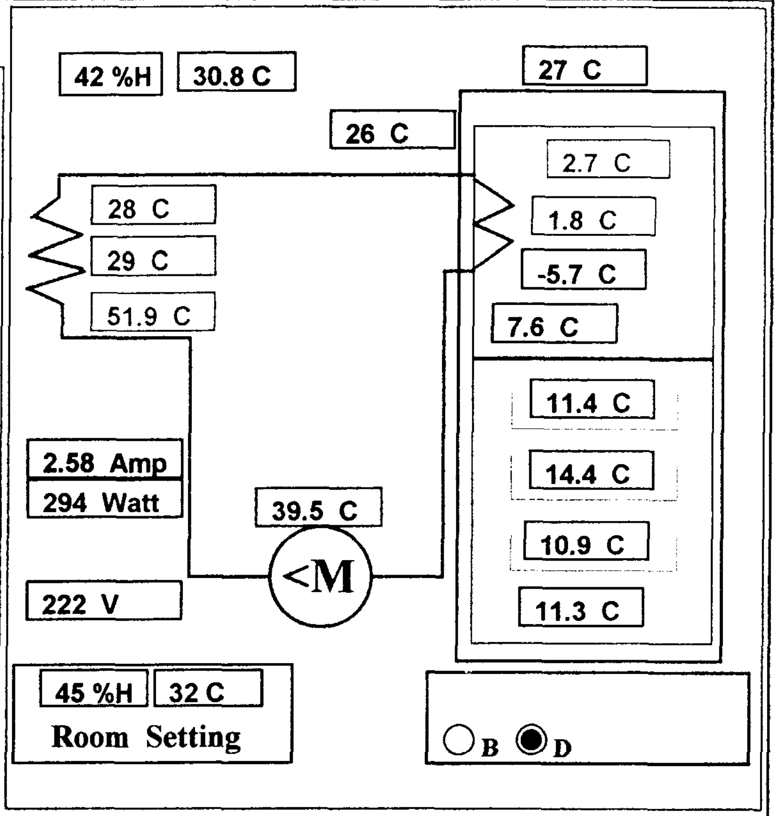
Maurice Ind. [Jordan]

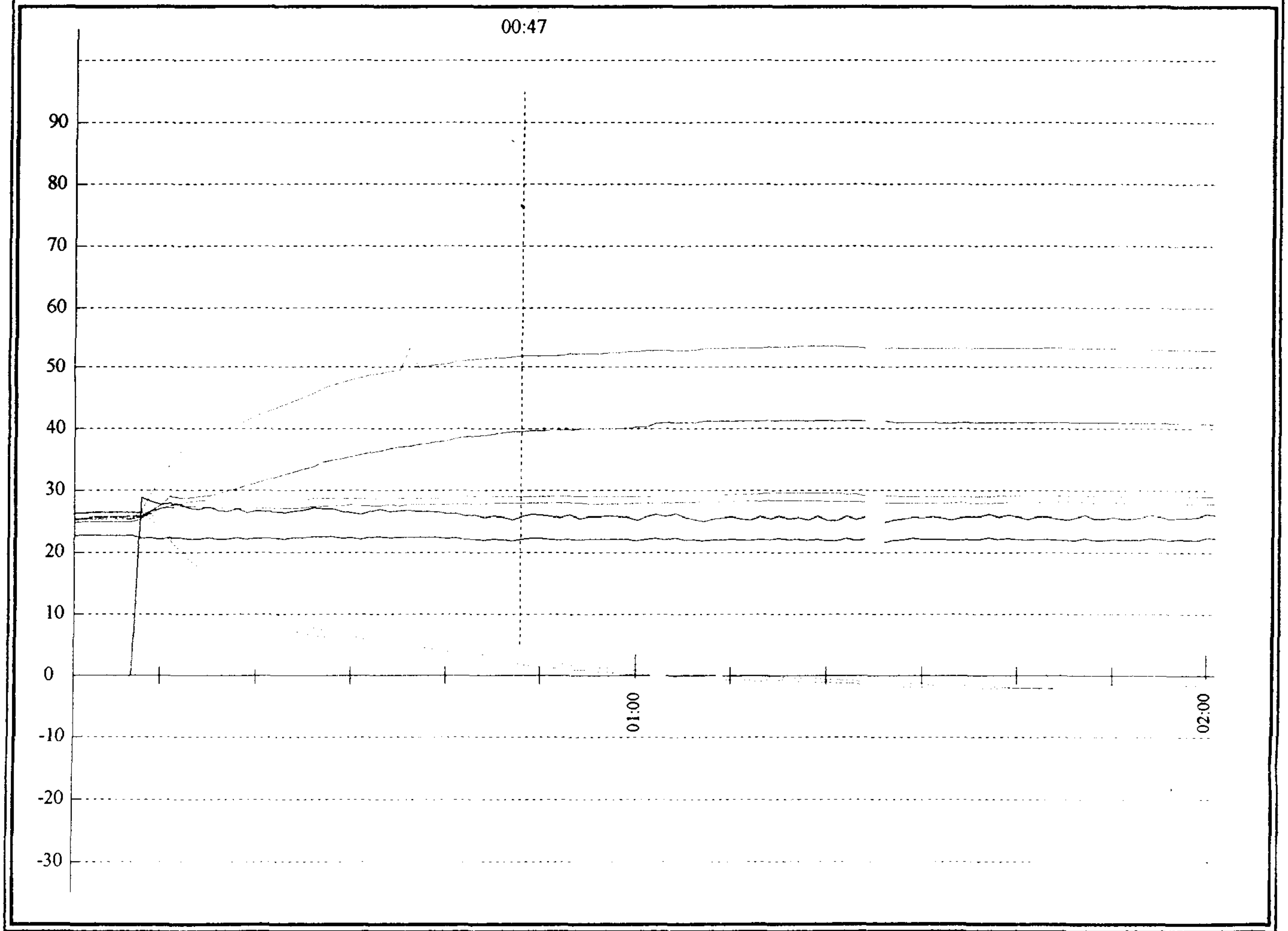
TestDate: 99/07/05 10:10 ***Report No.:*** ( ) - Page 1

PageTestName: Energy Consumtion ***ReportDate:*** 2000/04/29 09:44

Page Result :

1 - Page Test Time	*2 Hours*
2 - Working Percent	*94 %On*
3 - Energy (Accord to page)	*2.111 kwh*
4 - Zoom Time	*0:48 Hour*
5 - Compr Current	*2.58 Amp*
6 - Evaprator Mean Temp	*1.6 C*
7 - Cabin Mean Temp	*12.2 C*
8 - Crisp Temp	*11.3 C*
9 - Compr Temp	*39.5 C*
10- Condensor In Temp	*51.9 C*
11- Condensor Out Temp	*28 C*
12- Condition	*30.8 C 42 %H*
13- Volt	*Max=228 Mean=222 Min=217*
14-	
15-	
16-	
17-	





Industrial Control Research Center HotRoom Ver 5

Riad Hedjawi

Printing In Labaratory Of
Maurice Ind. [Jordan]

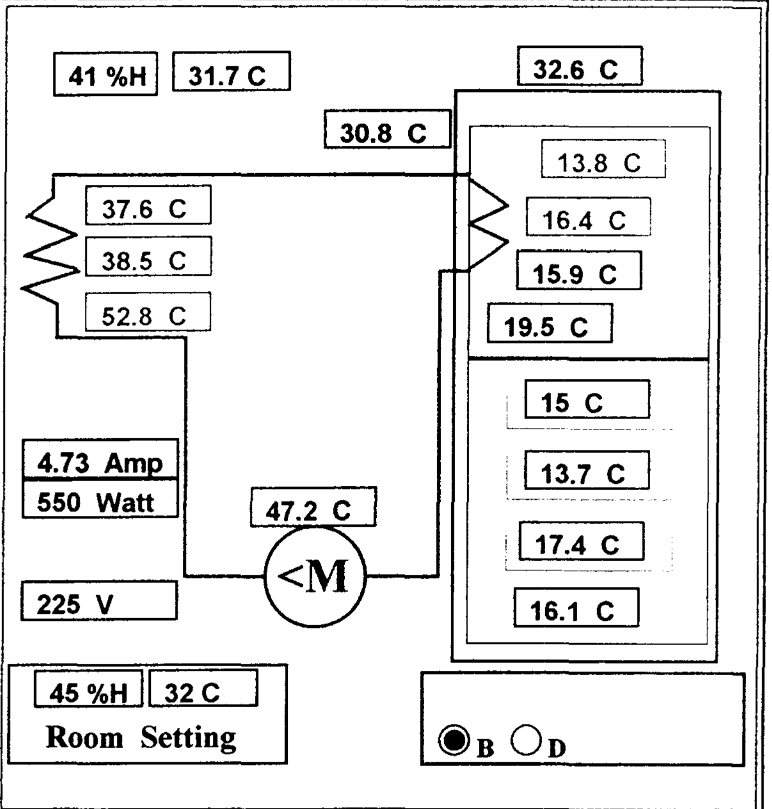
Maurice Ind. [Jordan]

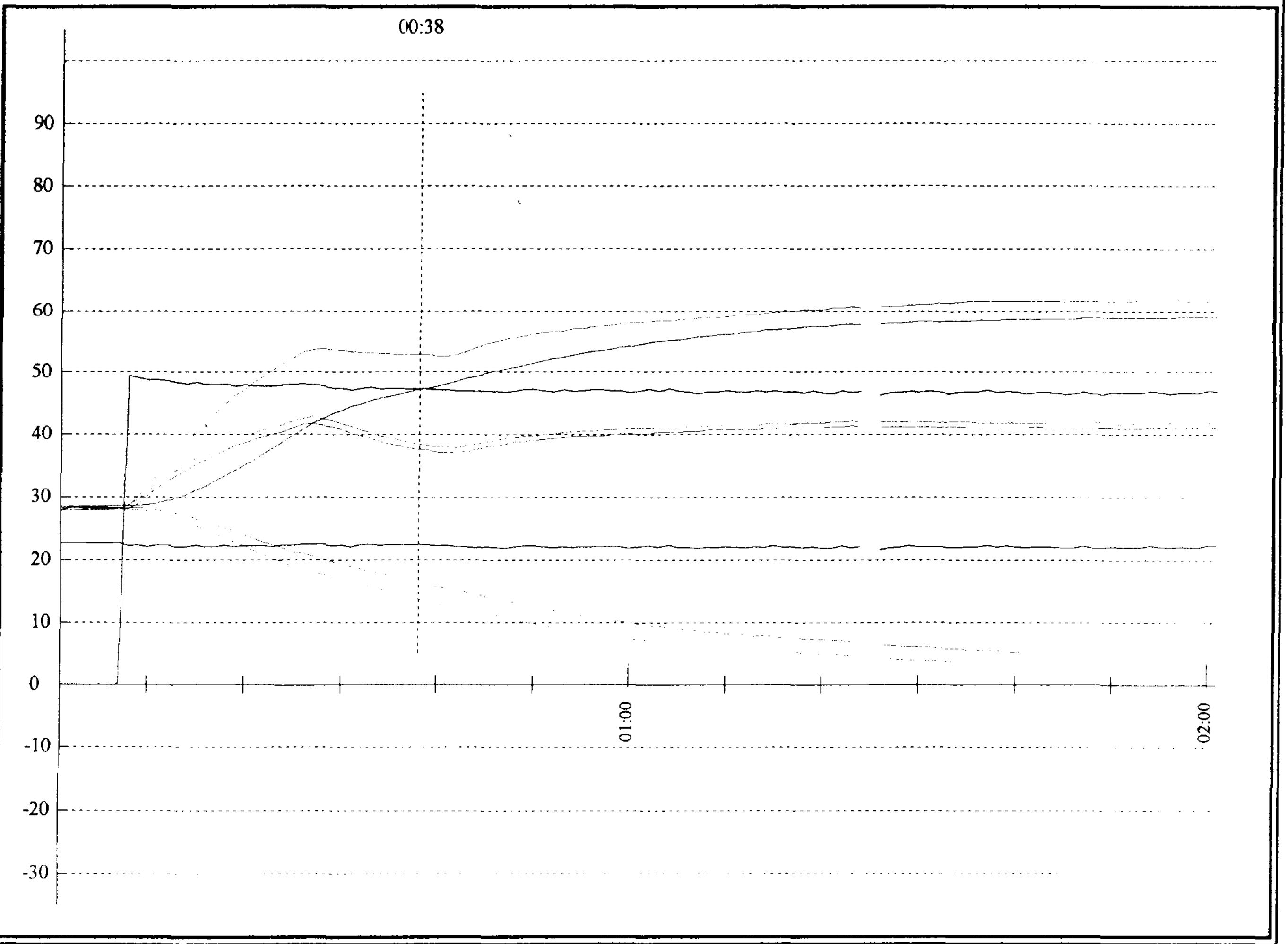
TestDate: **99/07/05 10:10** ***Report No.:*** **( ) - Page 1**

PageTestName: **Energy Consumtion** ***ReportDate:*** **2000/04/29 09:39**

Page Result :

1 - Page Test Time	*2*	*Hours*
2 - Working Percent	*94*	*%On*
3 - Energy (Accord to page)	*3.147*	*kwh*
4 - Zoom Time	*0:38*	*Hour*
5 - Compr Current	*4.73*	*Amp*
6 - Evaprator Mean Temp	*16.4*	*C*
7 - Cabin Mean Temp	*15.3*	*C*
8 - Crisp Temp	*16.1*	*C*
9 - Compr Temp	*47.2*	*C*
10- Condensor In Temp	*52.8*	*C*
11- Condensor Out Temp	*37.6*	*C*
12- Condition	*31.7 C*	*41 %H*
13- Volt	*Max=228 Mean=222 Min=217*	
14-		
15-		
16-		
17-		





Industrial Control Research Center HotRoom Ver 5

Printing In Labaratory Of
Maurice Ind. [Jordan]

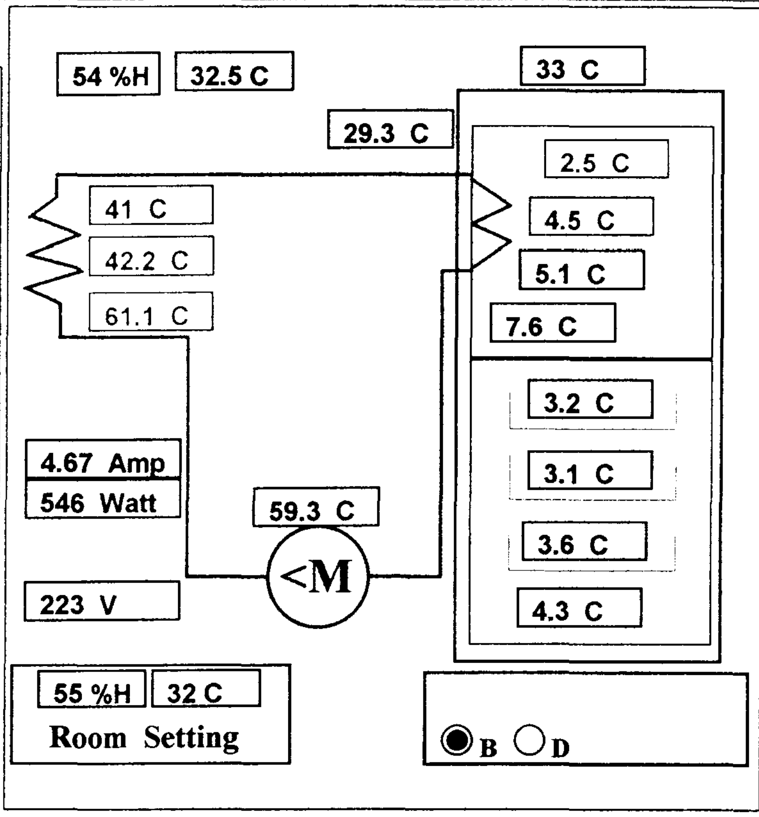
Maurice Ind. [Jordan]

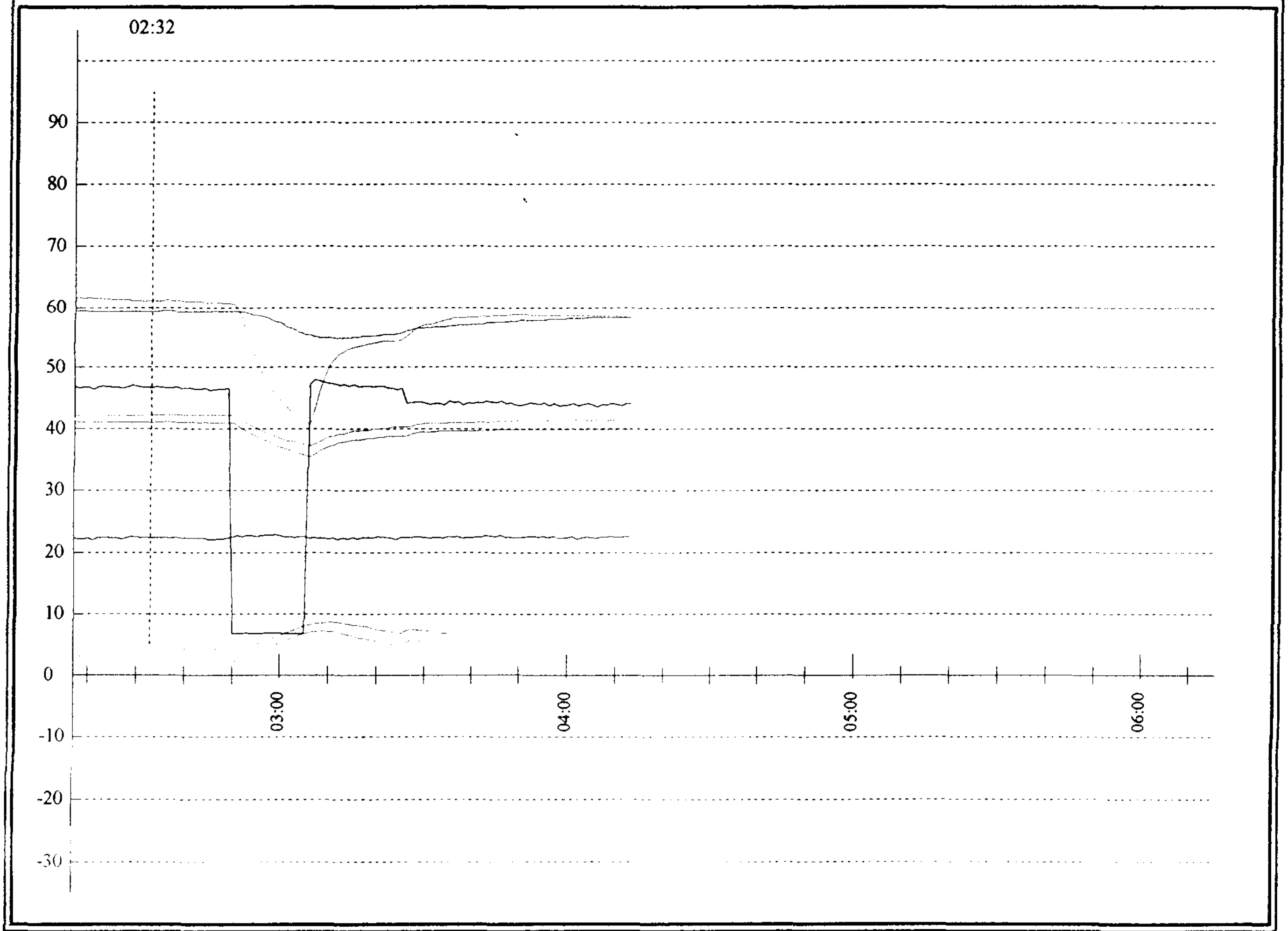
TestDate: **99/07/05 10:10** *Report No.:* ( ) - Page 1

PageTestName: Energy Consumtion *ReportDate:* 2000/04/29 09:41

Page Result :

1 - Page Test Time	*4 Hours*	
2 - Working Percent	*98 %On*	
3 - Energy (Accord to page)	*1.513 kwh*	
4 - Zoom Time	*2:33 Hour*	
5 - Compr Current	*4.67 Amp*	
6 - Evaprator Mean Temp	*4.9 C*	
7 - Cabin Mean Temp	*3.3 C*	
8 - Crisp Temp	*4.3 C*	
9 - Compr Temp	*59.3 C*	
10- Condensor In Temp	*61.1 C*	
11- Condensor Out Temp	*41 C*	
12- Condition	*32.5 C*	*54 %H*
13- Volt	*Max=229 Mean=109 Min=220*	
14-		
15-		
16-		
17-		





Industrial Control Research Center HotRoom Ver 5

Al- KHaled WorkShop

Printing In Labaratory Of
Maurice Ind. [Jordan]

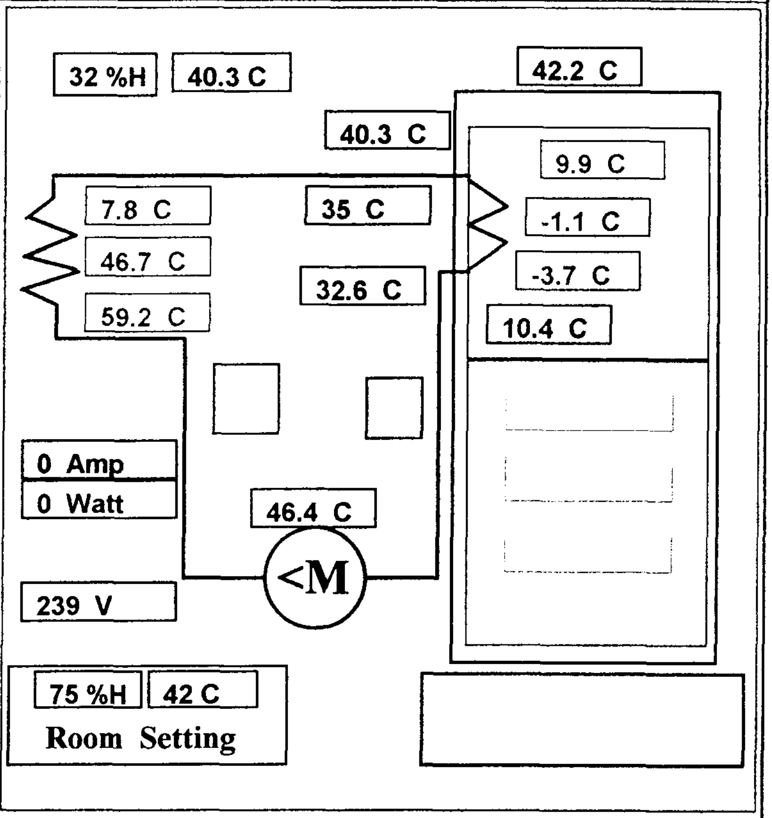
Maurice Ind. [Jordan]

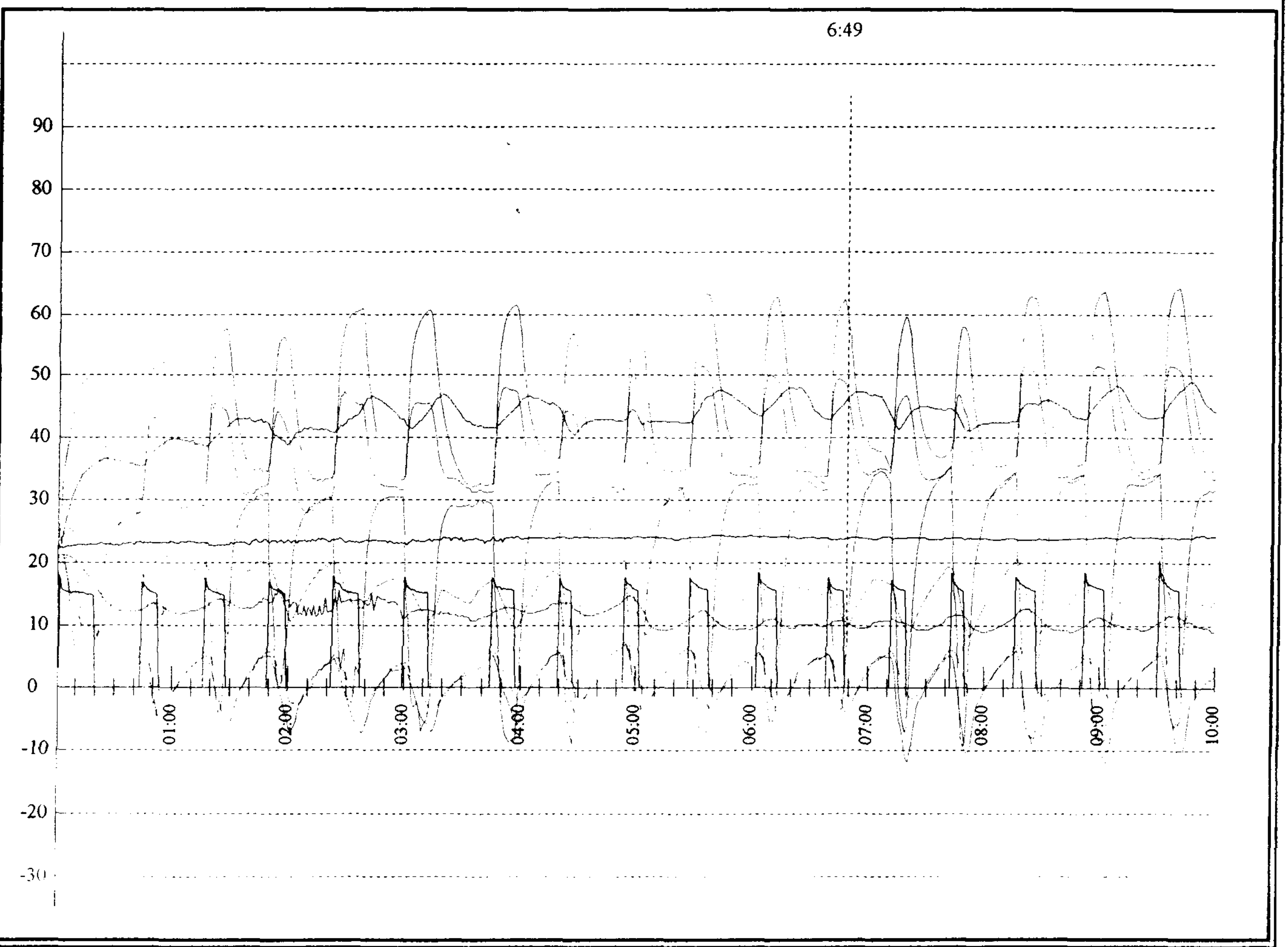
TestDate: 00/01/02 12:04 *Report No.:* ( ) - Page 1

PageTestName: Energy Consumtion *ReportDate:* 2000/04/29 09:27

Page Result :

1 - Page Test Time	*10 Hours*
2 - Working Percent	*29 %On*
3 - Energy (Accord to page)	*0.372 kwh*
4 - Zoom Time	*6:49 Hour*
5 - Compr Current	*00 Amp*
6 - Evaprator Mean Temp	*3.8 C*
7 - Cabin Mean Temp	*24.1 C*
8 - Crisp Temp	*24.7 C*
9 - Compr Temp	*46.4 C*
10- Condensor In Temp	*59.2 C*
11- Condensor Out Temp	*7.8 C*
12- Condition	*40.3 C 32 %H*
13- Volt	*Max=244 Mean=238 Min=224*
14-	
15-	
16-	
17-	





Industrial Control Research Center HotRoom Ver 5

Printing In Labaratory Of
Maurice Ind. [Jordan]

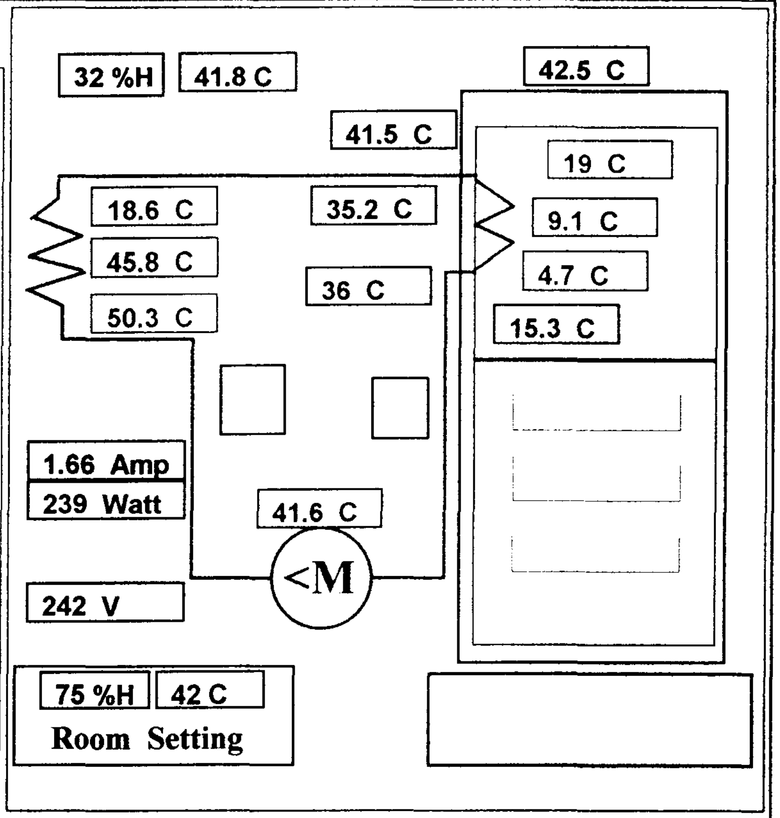
Maurice Ind. [Jordan]

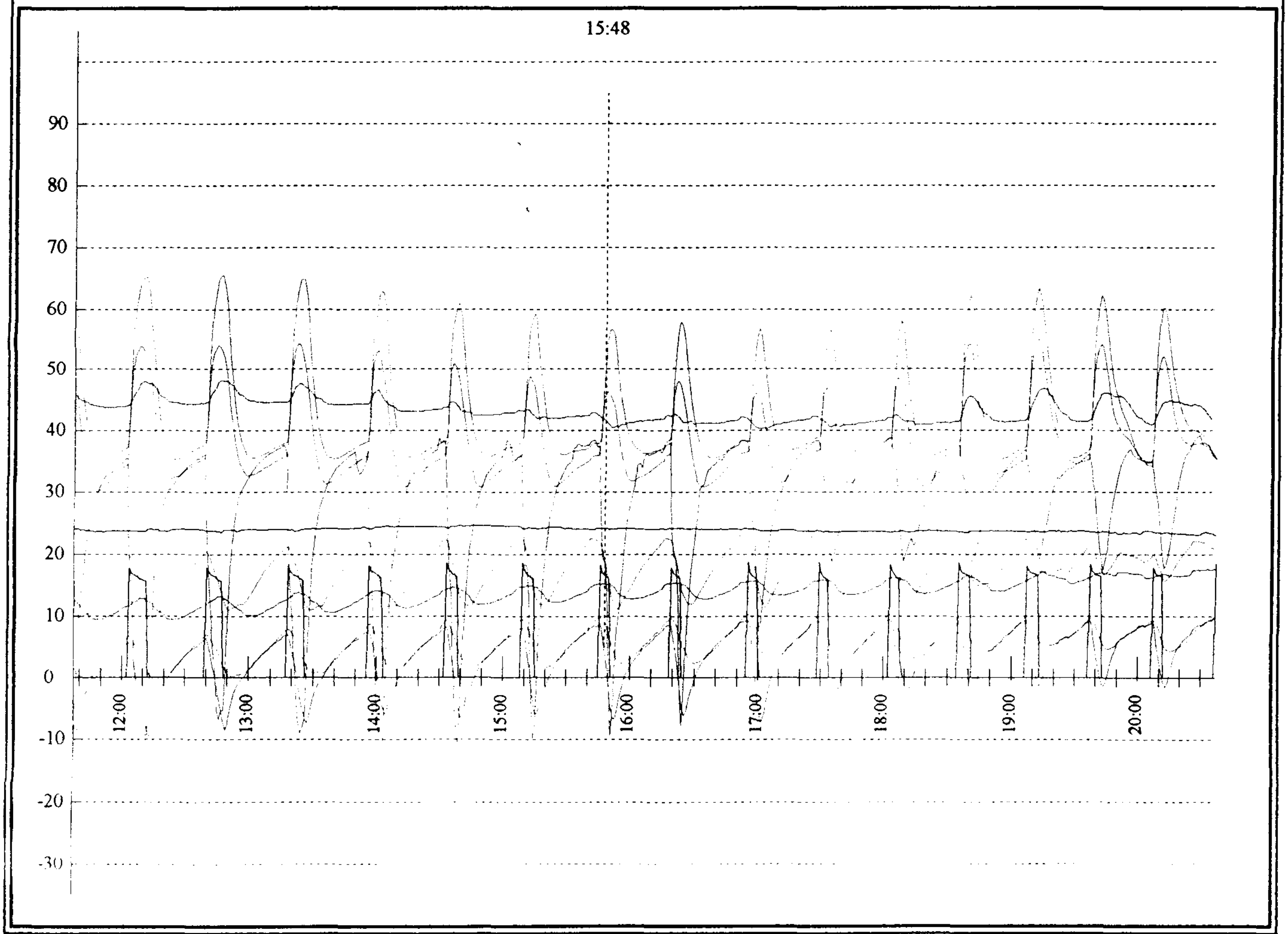
TestDate: **00/01/02 12:04** ***Report No.:*** ( ) - Page 1

PageTestName: Energy Consumtion ***ReportDate:*** 2000/04/29 09:31

Page Result :

1 - Page Test Time	*9 Hours*	
2 - Working Percent	*17 %On*	
3 - Energy (Accord to page)	*0.305 kwh*	
4 - Zoom Time	*15:48 Hour*	
5 - Compr Current	*1.66 Amp*	
6 - Evaprator Mean Temp	*12 C*	
7 - Cabin Mean Temp	*26.5 C*	
8 - Crisp Temp	*27 C*	
9 - Compr Temp	*41.6 C*	
10- Condensor In Temp	*50.3 C*	
11- Condensor Out Temp	*18.6 C*	
12- Condition	*41.8 C*	*32 %H*
13- Volt	*Max=247 Mean=240 Min=230*	
14-		
15-		
16-		
17-		





Industrial Control Research Center HotRoom Ver 5

AL Stark workshop

Printing In Labaratory Of
Maurice Ind. [Jordan]

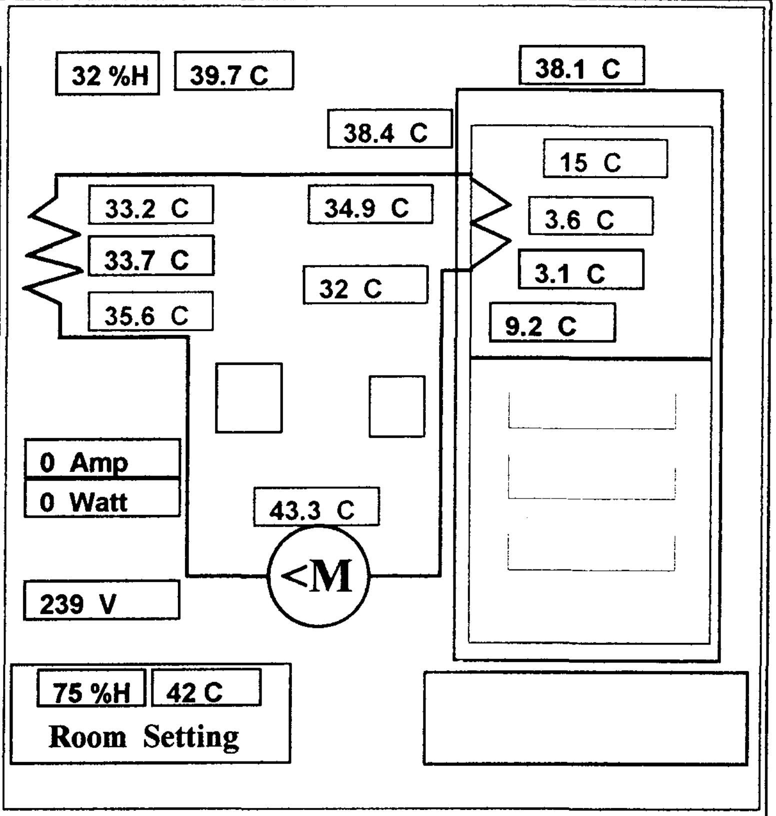
Maurice Ind. [Jordan]

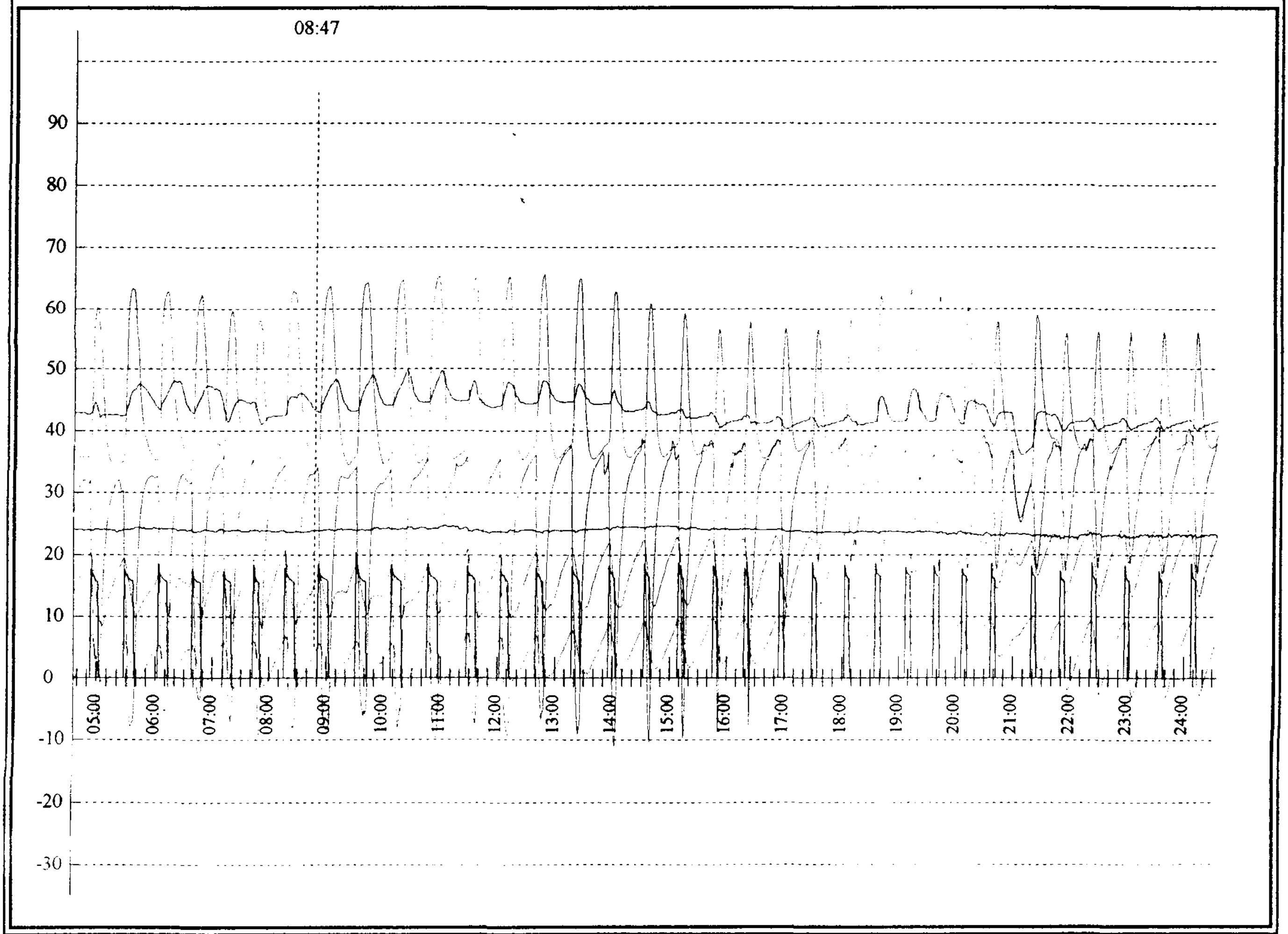
TestDate: **00/01/02 12:04** ***Report No.:*** **( ) - Page 1**

PageTestName: **Energy Consumtion** ***ReportDate:*** **2000/04/29 09:55**

Page Result :

1 - Page Test Time	*20 Hours*	
2 - Working Percent	*20 %On*	
3 - Energy (Accord to page)	*0.316 kwh*	
4 - Zoom Time	*8:47 Hour*	
5 - Compr Current	*00 Amp*	
6 - Evaprator Mean Temp	*7.7 C*	
7 - Cabin Mean Temp	*24.7 C*	
8 - Crisp Temp	*25.4 C*	
9 - Compr Temp	*43.3 C*	
10- Condensor In Temp	*35.6 C*	
11- Condensor Out Temp	*33.2 C*	
12- Condition	*39.7 C*	*32 %H*
13- Volt	*Max=248 Mean=239 Min=224*	
14-		
15-		
16-		
17-		





Industrial Control Research Center HotRoom Ver 5

Printing In Labaratory Of
Maurice Ind. [Jordan]

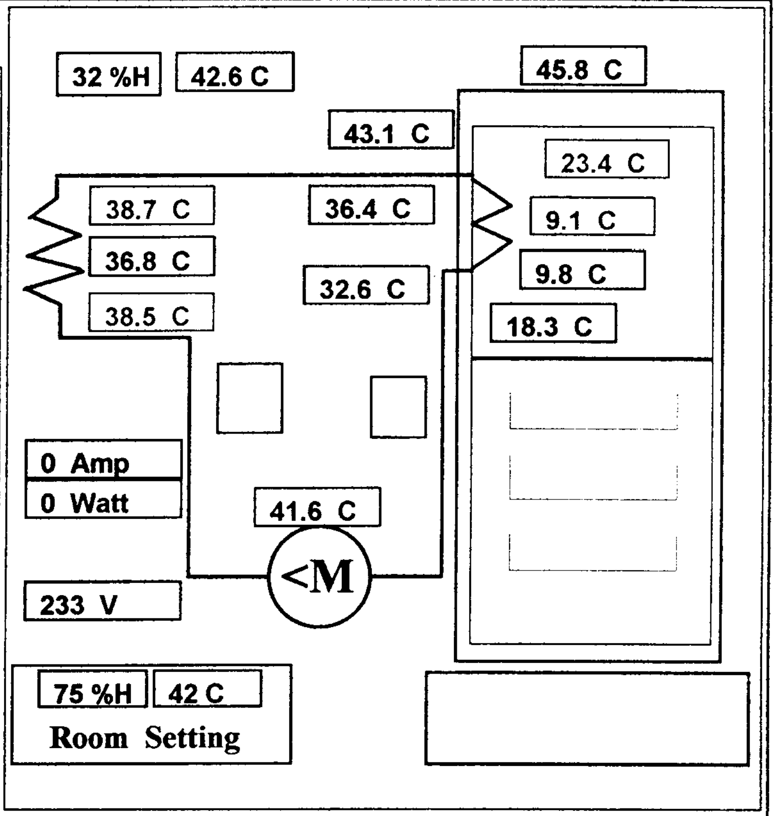
Maurice Ind. [Jordan]

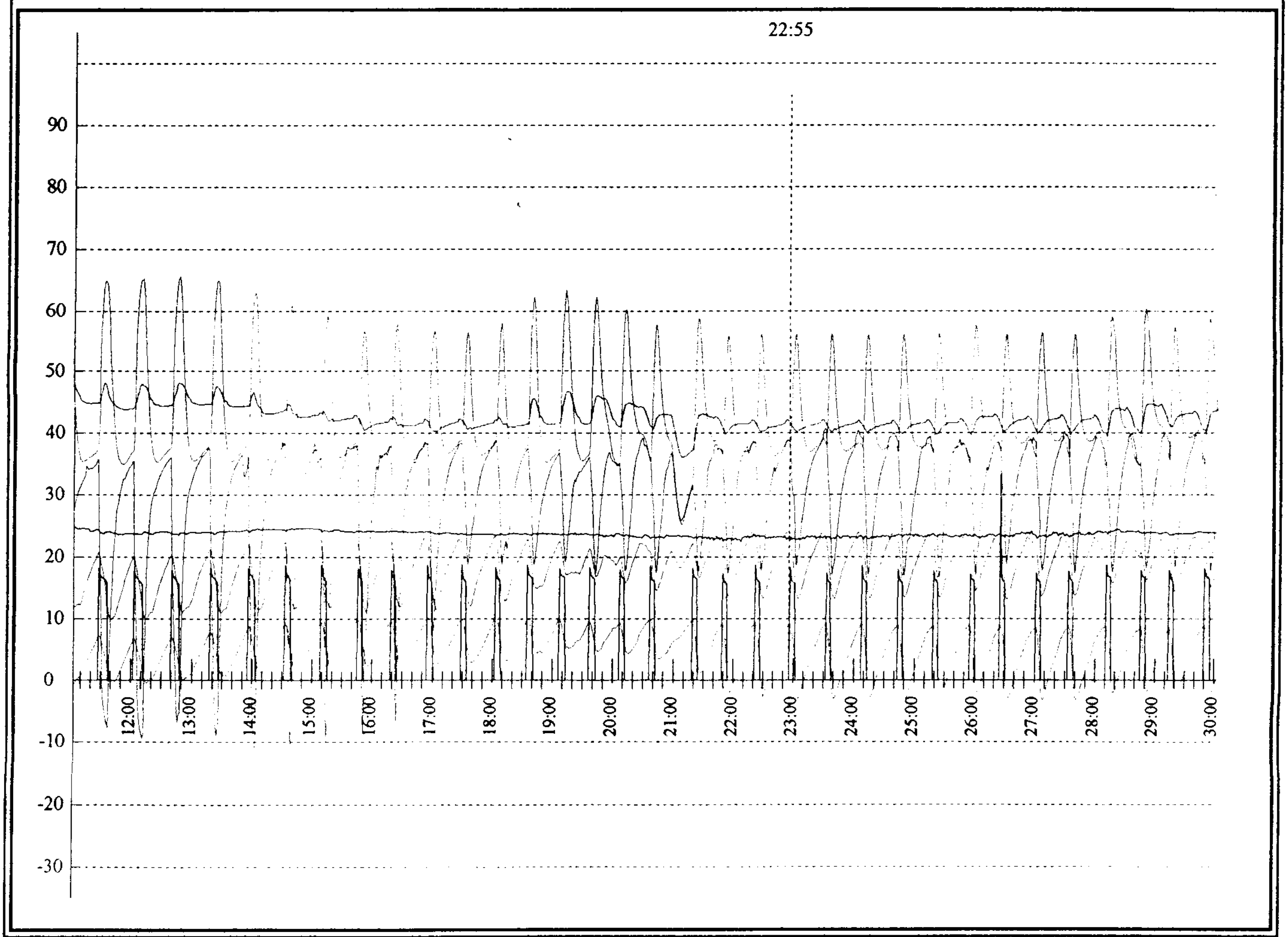
TestDate: 00/01/02 12:04 *Report No.:* ( ) - Page 1

PageTestName: Energy Consumtion *ReportDate:* 2000/04/29 09:58

Page Result :

1 - Page Test Time	*19 Hours*
2 - Working Percent	*16 %On*
3 - Energy (Accord to page)	*0.285 kwh*
4 - Zoom Time	*22:56 Hour*
5 - Compr Current	*00 Amp*
6 - Evaprator Mean Temp	*15.1 C*
7 - Cabin Mean Temp	*26.3 C*
8 - Crisp Temp	*26.9 C*
9 - Compr Temp	*41.6 C*
10- Condensor In Temp	*38.5 C*
11- Condensor Out Temp	*38.7 C*
12- Condition	*42.6 C 32 %H*
13- Volt	*Max=248 Mean=237 Min=224*
14-	
15-	
16-	
17-	





Industrial Control Research Center HotRoom Ver 5