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شرکت مهندسی سهند مینا (با مسئولیت محدود)

SAHAND MINA ENGINEERING CO.LTD.

22386 شماره: Our Ref.: تاریخ : Date:

Conversion of Prototypes into R134a Ozone Friendly Refrigerant at

AliSard, Pardis, Mohebi, Jalalzadeh, Meibod Tagarg and Shahab Companies

Project Number
MP/IRA/99/122

Contract Number, 99/230P

Final Report

May 2000

تهران ،خیابان شریعتی ، بالاتر از میرداماد ساختمان ۱۲۸۰ آپارتمان شماره ۱۲ کد پستی ۱۹۵۵۸ تلفن : ۲۲۵۰۳۳۰ ، ۲۲۷٤۹۳۶ نمابر: ۲۲۷٤۹۳۶
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PROJECT NO. MP/IRA/99/122

Final Report

Introduction

Please find below our Final report, concerning calculation and redesign of the prototypes. These prototypes Have been manufactured under our engineering supervision and have been 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 report could have satisfied the UNIDO in order to comply with our contract.

Synopsis

This report has been prepared based on the Contract between UNIDO and Sahandmina Engineering company.

This project will phase out the use of CFC-11 and CFC-12 in the production of commercial refrigeration equipment at Alisard, Pardis Yazd, Mohebi, Jalalzadeh, Meibod Tagarg and Shahab Companies. CFC-11, which is used as a foam blowing agent in the production of polyurethane foam will be replaced by **HCFC-141b** and CFC-12 which is used as the refrigerant in the cooling circuit of appliances will be replaced by **HFC-134a**. The project includes the modification of all cooling equipment produced and the conversion of the production facilities. The model redesign element of the project includes testing, trial manufacture and reliability tests. The cost of converting foaming machines to use HCFC-141b will be covered by the counterpart organizations.

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General Background

This report has been prepared and based on the UNIDO's contract and relevant terms of reference prepared by UNIDO and Sahandmina Co. Proposal to UNIDO.

The project will phase out, use of CFC-11 and CFC-12 for the production of Commercial Refrigerators at Alisard, Pardis Yazd, Mohebi, Jalalzadeh, Meibod Tagarg and Shahab Companies. The redefinition of the existing refrigerator models in this company covers activities such as calculation and refrigeration system components selection.

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Project Summary

The project relates to the six companies accounting for phasing out 50% of the use of ozone-depleting substances, in small and medium-size companies in the commercial and industrial refrigeration sector in Iran.

This proposal covers the conversion of different models and will phase out the use of 22.296 tones of CFC-11 and 22.680 tones of CFC-12 in the production of a range of commercial refrigeration equipment. CFC-11, which is used as a foam blowing agent in the production of polyurethane foam will be replaced by R141b and CFC-12 which is used as the refrigerant in the cooling circuit of equipment will be replaced by HFC 134a. The project includes technical assistance in design and implementation of the conversion.

The conversion of the production facilities includes all equipment necessary for charging and testing of refrigerating equipment and the equipment necessary for the production of polyurethane insulating foam.

The overall unconstrained CFC consumption in the Islamic Republic of Iran was projected to rise from 2,445 ODP tones in 1991 to 7,778 ODP tones in 2010. This corresponds to an overall annual growth rate of 6.5%. The annual growth rate for the domestic refrigeration sector, however, was estimated to be 12% in the period 1991 to 1995 and 4% between 1996 and 2010.

Most Commercial Refrigerators Companies manufacture several types of equipment from wide ranges of applications, including the following:

- display and sales cabinets for supermarkets and individual suppliers of food,
- upright and chest freezers for commercial application,
- different sizes of drinking water coolers,
- soft ice freezers,

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Company Backgrounds

All of small and medium size companies covered by this project in I.R.Iran are similar in nature and operate using similar manufacturing techniques. In common with commercial refrigeration companies through Article countries, production is generally on a batch or to order basis and most companies manufacture a range of equipment, which can be tailored to suit the needs of the customer.

Production lines are generally in open plan factory units or workshops and consist of a series of workstations at which particular task can be carried out such as assembly, brazing, charging etc. Work in progress is moved from one station to another using trolleys or conveyors. In the majority of cases production lines can be reconfigured to suit the particular production and market requirements of the time and large equipment items are built in situ, by move production equipment to the equipment. In the case of cold stores and large industrial refrigerators and freezers, these are often built in place on the client site. It is therefore necessary for the manufacturing companies to have portable charging and leak detection equipment. A brief overview of the company is given below.

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Companies background

Third Group Of Companies Identified For ODS Phase Out In The Commercial Refrigeration Sector

No	Name	Location	Type of products	ODS Consumption [Kgs/year]	
				CFC-12	CFC-11
1	AALISARD	YAZD	Freezers Display Cabinets Chest freezers Cold Stores Drinking Water Coolers	2050	3249
2	MOHEBI	YAZD	Drinking Water Coolers Freezers Fridge Freezers Box Freezers Refrigerators	4625	9590
3	PARDIS YAZD	YAZD	Open Display cases Refrigerator Open Display Freezer Refrigerated Display Case	5,800	3661
4	JALAL ZADEH	YAZD	Industrial Refrigerator Industrial Freezer Drinking water Cooler Cold Chamber Refrigerators	2,645	2030
5	MEIBOD TAGARG	YAZD	Drinking Water Cooler Display Cabinet Refrigerator	3170	0
6	SHAHAB Co.	ISFAHAN	Display cabinets Milk Coolers Water Coolers Mobile cold Stores Chest freezers Upright freezers	4390	3766
			Total	**22,680**	**22,296**
			Overall Total CFC-11 and CFC-12 [MT]: **44,976**		

ALISARD

Aalisard is a relatively small-scale enterprise located in Yazd city. It was established in 1982 employs 35 staff. There are two main assembly areas each with basic charging, and fabrication equipment and a single foaming machine, to which products are taken to be foamed by way of trolleys. Equipment is in

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reasonable condition for age and the operators appear to be well trained in normal assembly and charging methods, using simple charging cylinders and refrigerant gauges. Storage space restrictions mean that a several finished products often occupy the assembly areas. A single, locally made low pressure foaming machine is used for all production, a mixture of wooded and steel jigs and fixtures are used for all applications. The consumption of CFC-11 and CFC-12 for 1997 was 2.050 and 3.249 MT respectively.

MOHEBI

MOHEBI is a small commercial Refrigeration Company based in near Yazd City. It was established in 1988 and employs 39 staff in the manufacture of a range of commercial refrigeration equipment. The company occupies a fairly old factory with 3 assembly lines. Manufacturing equipment is in generally good condition. Operators appear to be well trained in the use of refrigerant charging equipment. The age of the factory means that the layout of the production equipment is not ideal but operator appear to be able to function adequately. A single small locally made low pressure foaming machine is used for all foaming applications with set of steel jigs and fixtures. The consumption of CFC-11 and CFC-12 for 1997 was 4.625 and 9.590 MT respectively.

PARDIS YAZD

PARDIS is a small commercial refrigeration company based in Yazd industrial complex outside Yazd City. It was established in 1991 and employs 25 staff in the manufacture of commercial refrigeration equipment. The company occupies a medium sized factory unit with a single main assembly area and well laid out fabrication and assembly equipment. The majority of labour takes place at the client site as the display cases produced are large. A single, locally made low pressure foaming machine is used for all production in conjunction with a set of relatively new steel jigs and fixtures. The production areas are clean and well presented and equipment is in relatively good condition. The consumption of CFC-11 and CFC-12 for 1997 was 5.800 and 3.661 MT respectively.

JALAL ZADEH

Jalal Zadeh is a relatively small commercial refrigeration company based in Meibod town in Yazd province. It was established in 1982 and employs 10 staff,

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in the manufacture of commercial refrigeration equipment. The company occupies a reasonably large factory unit with a single main assembly area and well laid out fabrication and assembly equipment. A single, locally made low pressure foaming machine is used for all production in conjunction with a set of relatively new steel jigs and fixtures. The production areas are clean and well presented and equipment is in relatively good condition. The consumption of CFC-11 and CFC-12 for 1997 was 2.645 and 2.030 MT respectively.

MEIBOD TAGARG

Meibod Tagarg is a is a small commercial refrigeration company based in Meibod town in Yazd province. It was established in 1980 and employs 13 staff, in the manufacture of commercial refrigeration equipment. The company occupies a small factory unit with a single main assembly area. Polystyrene panels are use for insulation and no foaming equipment is used. The consumption of CFC-12 for 1997 was 3.170 MT.

SHAHAB Co.

SHAHAB is a small commercial Refrigeration Company based in Isfahan City. It was established in 1982 and employs 28 staff in the manufacture of a range of commercial refrigeration equipment. The company occupies a fairly old factory with 2 assembly lines. Manufacturing equipment is generally in good condition. Operators appear to be well trained in the use of refrigerant charging equipment. The age of the factory means that the layout of the production equipment is not ideal but operator appear to be able to function adequately. A single locally made low-pressure foaming machine is used for all foaming applications with set of steel jigs and fixtures. The consumption of CFC-11 and CFC-12 for 1997 was 4.390 and 3.766 MT respectively.

Aim of the Project

The aim of the immediate project is to;

- Design, calculation and ing for model redefinition.
- Testing prototypes for functionality and performance criteria.

- 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.

Scope of the Contract

A study will be made for 6 models of commercial refrigerators made by Third Yazd Group Co. to specify;

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

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

Supply of the Material

Following components and material have been used to make prototypes .

- R134a Compressors
- R134a Refrigerant
- Refrigerant Accumulators
- Specially designed filter drier
- Specially designed evaporator and condenser

Activities

In this report we will describe the activities achieved during execution of the contract for implementation of the project.

- Site survey of the counterpart premises in order to be familiar with the counterpart facility and production line and also define the prototypes for conversion.

- Site survey of the counterpart premises in order to collect necessary data for calculation of prototype.
- Preparation of Technical data sheet in order to define detail technical specification
- Review the existing technical drawing for the purpose of assessment of possible changes in the design criteria.
- Review each prototype refrigeration circuit for determination of cooling circuit components
- Review and assessment of design criteria following cooling circuit component in order to minimize possible changes and design improvement.

    - Compressor technical specification
    - Condenser type, material and design criteria
    - Evaporator type, material and design criteria
    - Capillary tube design, dimensions and material
    - Filter drier, size and material
    - Determination of R12 refrigerant charge for each prototype in order to adjust R134a charge weight

- Coordination with the counterparts for performing, performance test after completion of making prototypes
- Calculation of prototypes in order to determine the size of R134a compressor and implement necessary changes to the cooling circuits
- Preparation of Performance Test Results Sheet, in order to record all data obtained during functional test.
- Achievement of Performance Test for each prototype
- Evaluation of test results sheet.
- Recommending appropriate changes to the refrigeration system component for necessary prototype improvement.
- Modifying necessary components.
- Supervision of Trial Production.

Preparation of prototypes for performance test as

The prototypes shall 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 length of capillary tube.

Each prototypes should under go for performance test at the following test criteria.

Pull down test at + 32 C

Continues 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.

The material as sample for making prototypes are supplied mainly from local market, due to the limitation for purchasing R134a compressor from local market we had to contact several manufacturers to find out the technical specification for appropriate compressor.

The prices for material specially R134a and R141b blended polyol are much higher than R12 and R11,

Training

Before making prototypes we conducted a training course to train the technical staffs 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 phases 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.
- Selecting Prototype Model
- Refrigeration System components Familiarization
- Heat Load Calculation
- Thermostat Selection and Adjustment
- Refrigerant Charging Methods
- Testing Prototypes
- Analyzing Prototype Test Results

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Following subjects were taught during conduction of the course:

Refrigeration Load Calculation for different types 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, porcelain coated - 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,

1- Bottle Type.
2- Tap water type

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

Water cooler using a plumbing supply and drain connection, must be installed according the relevant approved standards. The plumbing should be concealed, a hand shutoff valve should be installed in the fresh water line. Drain pipe at least 1 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

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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.

Heat gain by heat transmission from, main water storage tank wall insulation.

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.

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.

$Q1 = m\ C\ \Delta T$, Where:

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

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

$$Q2 = \dot{M} \; C \, \Delta T$$

Q2 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.

$$Q3 = UA \, \Delta T$$

Where:

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

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

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

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

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Refrigeration Load Calculation for different type of Domestic and Commercial Appliances

Refrigeration load consist of four individual components:

1- Transmission load;
Heat transfer through walls (sides, back panels, top and bottom) and door panel.

2 - Product load;
Heat Removed from and produced by the products which are brought and stored in the refrigerator;

3 - Internal load;
Heat produced by internal sources such as lights, fan or heaters;

4 - Infiltration load
Heat gains associated with air entering the refrigerated space;

The above mentioned components will be discussed separately to analyze and extract the most useful and practical equipment.

Transmission Load

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

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

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

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

Where:

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x = Insulation Thickness, mm

K = Insulation Conductivity, $Wmm/m^2 \cdot C$

A = Outside Area, m^2

$\Delta T =$ Temperature difference (Ta - Tc), C

If the insulation thickness of side walls, back panels, top, bottom and door are different, heat transfer for each part can be calculated separately and then summed for two door refrigerators, due to different cabin temperature of freezer and refrigerator compartments, heat transfer for each compartment should be calculated separately and then added together.

Product Load

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

1 - Heat removed from initial temperature (Ti) to storing temperature (Trs) in refrigerator compartment is;

$$Qrs = \dot{M} C (Ti - Trs)$$

Where:

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

C = Specific heat of product, Kcal / Kg

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

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

Where :

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

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

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

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

Where h = Latent heat of product, Kcal / Kg

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

$$Q\,bf = \dot{M}\ Cbf\ \ (\ Tf - Tfs\ )$$

Where: Cbf = Specific heat of products below freezing temperature.

For upright freezers or freezer compartment of refrigerators, total product load is

$$Qpl = Qaf + Ql + Qbf$$

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

$$Qpl = Qrs$$

Internal Load

Electrical energy dissipated in the refrigerated space such as lights, fan motors, heaters, ... are included in the internal heat load. Due to the little amount of consumption of lighting, the effect of lighting can be negligible and only electrical

heaters of two door refrigerators or fan motors (if exist) are considered in our load calculation.

Infiltration Load

Infiltration air load is the heat transfer due to exchanging of refrigerated air with ambient caused by opening of the door or leakage through the gasket area. Infiltration load is one of the most important load components and roughly it is about 20 % of total refrigeration load.

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Total Refrigeration load

As it was mentioned before, transmission load (Qtl), product load (Qpl) and internal load (Q il) can be calculated separately. For infiltration load (air exchange through doorways or gasket leakage), we can take into account from 10 to 25% of sum of the above mentioned components, (transmission load, product load and internal load). Therefore total refrigeration load can be expressed as:

$$QTL = 1.25\,(QTL + QPL + QIL)$$

As per **ASHREA** standard we can use following formula which is depended directly to the number of air change per day and internal volume of the appliance.

$$Q = (V \times N \times H) \div 86400$$

Where;

Q = Heat Load due to the Air Change
V = Appliance Internal Volume
H = Heat removed from cubic meter of air = 75000 jul/sec

Equipment Selection

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

and condenser should be selected to balance compressor capacity.

Compressor selection

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

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

Where :

Qc = required cooling capacity

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For selection of compressor from manufacturer's catalogue, we have to mention appropriate evaporating temperature;

- In refrigerators with ice compartment mounted inside, maximum evaporating temperature can be selected in order to have - 12 C (Two Stars) inside ice compartment.

- For upright freezers or freezer compartment of two door refrigerators, evaporating temperature should be in order to obtain -18 C (Three Stars) cabin temperature.

Capillary tube

Capillary tube is one of the most important components in refrigerator circuits . capillary acts as a pressure reducing device to meter the flow of refrigerant to the low pressure side (evaporator) of the system. In other word, capillary tube should be capable to pass refrigerant pumped by the compressor and feed it to evaporator at available load and demand conditions.

On the contrary of the R12 or R22 refrigerants, practical equations, charts or graphs are not available for calculation of capillary size in R134a refrigeration circuits. Comparing saturation properties of R134a with R12 at a certain temperature, R134a pressure is less than R12, therefore, capillary tube for R134a shall be adjusted at low evaporating temperatures in comparison with R12 system. The capillary for R134a refrigeration system must have an increase resistance which can be estimated about 10 - 15% increase in length for a definite bore. However the exact size (bore and length)

can be attainable after laboratory performance tests.

Condenser & Evaporator

The statically cooled condenser is designed for use in small refrigeration appliance with sufficient space for the necessary condenser area. These condensers are manufactured either in tube-on-finned plate type or wire-on-tube design. Assuming that compressor casing and tubing will dissipate 80% of the heat equivalent of electrical in put, the condenser should be capable to reject heat absorbed by the refrigerant in the evaporator plus 20% of compressor power input heat equivalent.

The evaporator should balance the selected compressor capacity, not the original calculated load. Most of the refrigerators mainly employ aluminum evaporators

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produced on the roll-bond principal, where wire-on tube evaporators are usually installed in upright freezers.

Due to the higher latent heat (hfg) of R134a in comparison with R12 and therefore less refrigerant charge in the system, it seems that evaporators and condensers used for R12 are also suitable for R134a refrigeration system. However more detailed information about role of these two components in the system would be cleared after laboratory performance tests. Therefore partial modifications should be done if needed.

Refrigerant charge

As mentioned in previous sections, R134a latent heat of vaporization is about 28-30% higher than R12 in temperature range -30 C up to + 10 C. Table 2-2 shows thermodynamics saturation properties (with respect to a certain temperature) for these two refrigerants. In practice, charging amount of R134a can be 10-15% less than R12 with the same refrigeration load.

R134a is capable to absorb more humidity of the oil in comparison with R12. Therefore, the filter drier selected for R134a should be a drier with 3A desiccant with 20% more molecular sieve (by weight) in comparison with conventional types.

Making Prototypes

- Prototype Model Selection
- Refrigeration System Components Selection
    1- Defrost Type
    2- No-Frost Type
- Familiarization with Refrigeration System Components
    1- Condenser
        a. Wire on Tube
        b. Tube welded on Plate
        c. Tune on Plate
        d. Tube in the Body
        e. Tube on the fins
    2- Capillary Tube
        a. Tube Length
        b. Tube Diameter
        c. Tube Material
    3- Expansion Valve
        a. Size
        b. Capacity
        c. Material
    4- Filter Direr
        a. Weight
        b. Material
        c. Model
    5- Evaporator
        a. *Roll Bond*

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b. Wire on Tube
c. Tube welded on Plate
d. Tune on Plate
e. Tube in the Body
f. Tube on the fins

- Refrigeration Load Calculation

1- Aim of Calculation

a. Model Re-Definition
b. Model Improvement
c. Model Modification
d. Conversion of Prototype
e. Model New Design

2- Methods of Refrigeration Load Calculation

a. ASHREA
b. Manufacturer
c. Institutes and Universities

3- Different Elements Required for Calculation

a. Heat Transfer

Dimension, Insulation, Ambient, Working Condition
Gasket, etc.

b. Product Load

Food, Material, Ice, Etc.

c. Infiltration

Door Opening, Air Replacement

d. Miscellaneous devices and apparatus

Light, Fan, Etc.

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- Compressor

1- Cooling System

  a. Static
  b. Oil
  c. Air

2- Pressure

  a. LBP (Low Back Pressure)
  b. HBP (High Back Pressure)
  c. MBP (Medium Back Pressure)

3- Model

  a. Hermetic
  b. Semi-Hermetic
  c. Open

4- Type of Refrigerant

  a. R12
  b. R134a
  c. Isobutene
  d. Blend

5- Accessories

  a. Capacitor Type
  b. Starting Relay
  c. Voltage, Frequency and Current
  d. Electrical Circuit

6- Mounting Compressor

  a. Refrigerant Fellow Direction
  b. Top on the Roof
  c. Bottom on Base
  d. Double Compressor Mounted

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7- Compressor Capacity

a. Watt
b. Horse Power
c. B.T.U/Hr
d. Kcal/Hr

8- Compressor Test Condition

CECOMAF

Evaporating Temp.	-25° C
Condensing Temp.	55° C
Ambiant Temp.	32° C
Suction Gas Temp.	32° C
Liquid Temp.	55° C
Volatage/Hertz	220V/50 Hz

Heat out Put= Capacity+Watt Consumption

ASHRAE

Evaporating Temp.	-23.3° C
Condensing Temp.	55° C
Ambiant Temp.	32° C
Suction Gas Temp.	32° C
Liquid Temp.	32° C
Volatage/Hertz	220V/50 Hz

Heat out Put= Capacity+Watt Consumption

ASHRAE to CECOMAF

Conversion of Capacity From CECOMAF into ASHRAE

R134a Multiply by 1.231
R22 Multiply by 1.097
R404 Multiply by 1.183
1 Watt = 0.86 Kcal/h
1 Watt = 3.41 BTU/h

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SAHAND MINA ENGINEERING CO.LTD.

شماره: Our Ref.: تاریخ: Date:

1 Kcal/h = 1.0162 Watt
1 BTU/h = 0.293 Watt

9- Evaporating Temp. and Selection of Compressor

10- *Thermostat*

Thermostat Adjustment

a. Cut-in Time – 5 to –15 Compressor Connected
b. Cut-out time –15 to –25 Compressor Dis-Connected
c. Thermostat Setting, Max. Med, Min
d. Thermostat Temperature Difference

- Refrigerant Type

1- CFC- 12
2- HFC-134a
3- Isobutene, R-600
4- Blend, (Isobutene+ Propane)

- Methods of Refrigerant Charging

1- Bottle, 13.5 Kg. Cylinder
2- Portable Charger
3- Production, Evacuation and Charging Equipment

- Refrigerant Charge Weight

1- Experimental, trial and error
2- Calculation
3- Comparison with other Refrigerants

- Refrigeration Leak Detection Procedure

1- Conventional Method, (water and Soap)
2- Portable Electronic Leak Detector
3- Production Electronic Leak Detector
4- Nitrogen, and Helium Leak Detection Procedure

- Accuracy and Precision of Leak Detection Procedure

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5- Conventional Method, (water and Soap)
6- Portable Electronic Leak Detector
7- Production Electronic Leak Detector
8- Nitrogen, and Helium Leak Detection Procedure

- Recovery
- Recycling
- Reclaiming

Testing Prototypes

- Test Prototypes with R12 Refrigerant to get desired test results.
- Hot Chamber Specification
- Placing Prototypes at Hot Chamber
- *Mounting Sensors and their Place and Location*
- Testing Condition

1- Tropical "T" 43 °C
2- Sub-Tropical 38 °C
3- Normal 32 °C
4- Sub-Normal 28 °C
5- Cold 18 °C
6- Relative Humidity

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- Test Package
- « M » Package
- Meat
- Ice
- Different Tests
  1- Operational
  2- Performance
  3- Energy Consumption
  4- Ice Making
  5- Humidity
- Testing Procedure
  1- Pull Down
  2- Continuous Run
  3- Cyclic Run
- Duration of Test
- *Reading Test Results*
- Test Results Analysis

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Refrigeration Load Calculation for

Water Cooler and Chest Freezer and Display cases

Refrigeration load consist of three individual components:

1- Transmission load;
Heat transfer through side walls by conduction
2 - Product load;
Heat Removed from and produced by the products which are stored.
3 - Internal load;
Heat produced by internal sources such as lights, fan or heaters;
4 - Infiltration load
Heat gains associated with air entering the refrigerated space and door opening and etc.;

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

Transmission Load

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

$$T_{refrigerator} \leftarrow R_{liner} + R_{insulation} + R_{cabin} + R_{ambient} \leftarrow T_{ambient}$$

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

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

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

Where:

x = Insulation Thickness, mm

K = Insulation Conductivity, $Wmm/m^2 \cdot C$

A = Outside Area, m^2

ΔT = Temperature difference (T_a - T_c), C

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

Product Load

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

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

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

Where:

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

C = Specific heat of product, Kcal / Kg

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

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

Where:

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

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

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

$Q_L = \dot{M} h$

Where h = Latent heat of product, Kcal / Kg

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

$Q_{bf} = \dot{M}\ C_{bf}\ (Tf - Tfs)$

Where:

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

For upright freezers or chest freezer, total product load is

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

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

$Qpl = Qrs$

Internal Load

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

Infiltration Load

Infiltration air load is the heat transfer due to exchanging of refrigerated air with ambient caused by opening of the door or leakage through the gasket area and /or open top freezer of show cases. Infiltration load is one of the most important load components.

Total Refrigeration load

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

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

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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 600 Kg of meet to be stored in this refrigerator therefore we calculate as follow,

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

M = 600 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 = 600000x2.8x (25-5) =33600000 jul/86400 = 389 Watt

Internal Load

Motor Fan 16 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

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

$$Q_{Total} = 163 + 389 + 16 + 73 = 641$$

Considering 20 % of Q total for safety factor

$Q_{Grand\ Total}$ = 641 + 20%(128) = **<u>769</u>** watts

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 769watt at –15 degree centigrade evaporating temperature. We should select a compressor to be compatible with Electrolux compressor model S26TY.

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$U = 0.45$ w/sq. Mt. °C,
$T_a - T_r = 27$
$A = 1.6$
$Q_{Bottom\ Surface} = 0.45 \times 1.6 \times 27 = 19.4$ Watt
$Q_{Bottom\ Surface} = 19.4$ Watts

Total Refrigerator Heat Leak =39 +39 + 26.6 + 19.4 + 39= 163 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

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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 = + 5 °C

$Q_{SideWalls}$ = 0.45 x 3.2 x 27 = 39 Watts

$Q_{SideWalls}$ = 39 Watts

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

U = 1 / [(0.040/ 0.018)] = 0.45 W/ sq.m °C

T_a - T_r= 27

A = 3.2

Q_{doors} = 0.45 x 3.2 x 27 = 39 Watts

Q_{doors} = 39 Watts

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

U = 0.45 w/sq. Mt. °C,

T_a - T_r= 37

A = 1.6

Q_{top} = 0.45 x 1.6 x 37 = 26.6 Watts

Q_{top} = 26.6 Watts

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

U = 0.45 w/sq. Mt. °C,

T_a - T_r= 27

A = 3.2

$Q_{back\ panel}$ = 0.45x 3.2 x 27 = 39 Watts

$Q_{back\ panel}$ = 39 Watts

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

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Refrigeration Load Calculation
Alisard Upright Refrigerator Showcase Model 2200

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (90x200)	3.6	80mm	28 c
Back Panel	220x200	4.4	80mm	28c
Bottom	9022	1.98	80mm	28 C
Top Doors	9022 200x220	1.98 4.4	80mm 8mm	38 c 28 c

Insulation Type: Pu Foam with R141b blowing agent.
Thermal Conductivity for Foam = 0.0180 W/ mt. ° C
Temperature Difference Refrigerator Compartment:
$\Delta T = 32 - (+4) = 28$ ° C
Ambient Temperature = 32 °C
Refrigerator Air Temperature = +4 °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

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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 800 Kg of milk products to be stored in this refrigerator therefore we calculate as follow,

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

M = 800 kg
C = 0.87 Btu/(lb)F deg = 0.67 x 4.184 = 3.7 j/g K
T_1 = 25 C, T_2 = 5 C
Q = 800000x3.7x (25-5) =59200000 jul/86400 = 685 Watt
Internal Load
Electric Fan 2x10 = 20 Watt
Florescent Lamp = 20 watt
Door Opening
Refrigerator Internal Volume 1800 lit.
Number of air change as per ASHREA standard = 70 per day
Heat removed per cubic meter of air 75000 j
Air Change load = 1.8x70x75000/86400 = 109 Watt

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

$$Q_{Total} = 685 + 258.7 + 20 + 20 + 109 = 1092.7 = 1093$$

Considering 10 % of Q total for safety factor

$$Q_{Grand\ Total} = 1093 + 10\%(109) = 1202 \text{ watts}$$

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 1202 watt at –15 degree centigrade evaporating temperature. We select a compressor to match with Electrolux model S34TY

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$T_a - T_r = 27$, $A = 0.8$

$Q_{lower\ panel} = 0.45 \times 0.8 \times 27 = 9.7$ Watts

$Q_{lower\ panel} = 9.7$ Watts

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

U = 0.45 w/sq. Mt. °C,

$T_a - T_r = 27$, $A = 1.6$

$Q_{Top} = 0.45 \times 1.6 \times 27 = 19$ Watts

$Q_{Top} = 19$ Watts

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

U = 0.45 w/sq. Mt. °C,

$T_a - T_r = 37$

A = 1.6

$Q_{Bottom\ Surface} = 0.45 \times 1.6 \times 37 = 27$ Watts

$Q_{Bottom\ Surface} = 27$ Watts

Total Refrigerator Heat Leak =24+140+19+27+9.7+39 = 258.7 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

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

Where :

U = Heat Resistance Coefficient Factor, K_1 = Foam Thermal Conductivity

Therefore:

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

T_a = Ambient Temperature

T_r = refrigerator air Temperature

U = 1 / (0.040/ 0.0180) = 0.45 W/ sq.m °C

A = 1.96 Sq. Mt.,

T_a = 32 °C

T_f = + 5 °C

therefore

$Q_{SideWalls}$ = 0.45 x 1.96 x 27 = 24 Watts

$Q_{SideWalls}$ = 24 Watts

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

U = 1 / (0.015/ 0.024) = 1.6 W/ sq.m °C

$T_a - T_r$ = 27 , A = 3.24

Q_{door} = 1.6 x 3.24 x 27 = 140 Watts

Q_{door} = 140 Watts

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

U = 0.45 w/sq. Mt. °C,

$T_a - T_r$ = 27 , A = 3.2

$Q_{Back\ panel}$ = 0.45 x 3.2 x 27 = 39 Watts

$Q_{Back\ panel}$ = 39 Watts

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

U = 0.45 w/sq. Mt. °C,

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Refrigeration Load Calculation
Upright Refrigerator Showcase Model Pardis - 200

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (120x55) + 2x(80x40)	1.96	40mm	27 c
Back Panel	200x160	3.2	40mm	27 c
Top Surface	80x200	1.6	40mm	27 c
Lower Panel	40x200	0.8	40mm	27 c
Bottom Surface	80x200	1.6	40mm	37 c
Door	120x270	3.24	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.

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

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

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T_f = Freezer air Temperature
U = 1/(0.050/ 0.0175) = 0.34 W/ sq.m C
A = 0.61 Sq. Mt.
T_a = 32 C, T_f = - 18 C
Q_{Bottom} = 0.34 x 0.61 x 50 = 10.4 Watts

Total Heat Leaks;

Q_{TL} = 14.8 + 15.9 + 10.4 + 10.4 + 13.3 = 64.8watts

$Q_{Total\ Heat\ Leaks}$ = 64.8 Watts

Ice Making Capacity = 5_{Kg} x 1 x (15 - 0) x1.163= 87 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 (87) = 9 Watts
Total Cooling Capacity Required is calculated as follows;

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

$Q_{Grand\ Total}$ = 64.8 + 87 + 9 = 160.8 Watts

$Q_{Grand\ Total}$ = 160.8 Watts

The suitable R134a compressor should be compatible with cooling capacity of 160.8 watt. A compressor compatible with DANFOSS model FR8.5 should be selected. This model of compressor can deliver 153 watts of cooling capacity at ASHREA standard condition.

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$U = 1 / (0.05/0.0175) = 0.34$ W/ sq.m C
A = 0.87 Sq. Mt.
$T_a = 32$ C, $T_f = -18$ C
$Q_{SideWalls} = 0.34 \times 0.87 \times 50 = 14.8$ Watts
$Q_{SideWalls} = 14.8$ Watts

$Q_{Front\ Wall} = [U A (T_a - T_f)]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
$U = 1 / (0.050/0.0175) = 0.34$ W/ sq.m C
A = 0.78 Sq. Mt.
$T_a = 32$ C, $T_f = -18$ C
$Q_{Front\ Wall} = 0.34 \times 0.78 \times 50 = 13.3$ Watts
$Q_{Front\ Wall} = 13.3$ Watts

$Q_{Back\ panel} = [U A (T_a - T_f)]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
$U = 1 / (0.050/0.0175) = 0.34$ W/ sq.m C
A = 0.78 Sq. Mt.
$T_a = 42$ C, $T_f = -18$ C
$Q_{back\ panel} = 0.34 \times 0.78 \times 60 = 15.9$ Watts

$Q_{Top} = [U A (T_a - T_f)]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
$U = 1 / (0.050/0.0175) = 0.34$ W/ sq.m C
A = 0.61 Sq. Mt.
$T_a = 32$ C, $T_f = -18$ C
$Q_{Top} = 0.36 \times 0.61 \times 50 =$ Watts
$Q_{Top} = 10.4$ Watts

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

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MOHEBBI Chest Freezer Model MDCF-100

a) Transmission Load Calculation

Dimension

	Dimension Cm.	Area (sq. mt.)	Insulation Thickness mm
Side Walls	2 x (58x75)	0.87	50
Front & Back Panel	2 x (125x85)	2X78=1.56	50
Chest Door	105x 0.58	0.61	50
Bottom Floor	105X0.58	0.810.61	50

Insulation Type: Pu Foam R141b expanded blowing PU foam
R141b Foam Thermal Conductivity: 0.018 W /mt.C
Temperature Difference: (ΔT) = 32 - (-18) = 50 C
Ambient Temperature = 32 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

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

T_a = Ambient Temperature
T_f = Freezer air Temperature

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$Q_{Top} = 0.36 \times 0.81 \times 57 = 17$ Watts
$Q_{Top} = 17$ Watts

$Q_{Bottom} = [U A (T_a - T_f)]$
T_a = Ambient Temperature
T_f = Freezer air Temperature
U = 1/(0.050/ 0.018) = 0.36 W/ sq.m C
A = 0.81 Sq. Mt.
T_a = 42 C, T_f = - 25 C
$Q_{Bottom} = 0.36 \times 0.81 \times 67 = 19$ Watts

Total Heat Leaks;

$Q_{TL} = 23 + 26 + 22 + 19 + 17 =$ 107 watts

$Q_{\text{Total Heat Leaks}} = 107$ Watts

Ice Making Capacity = $5_{Kg} \times 1 \times (15 - 0) \times 1.163 = 87$ 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 (87) = 9 Watts
Total Cooling Capacity Required is calculated as follows;

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

$Q_{\text{Grand Total}} = 107 + 87 + 9 = 203$ Watts

$Q_{\text{Grand Total}} = 203$ Watts

The suitable R134a compressor should be compatible with cooling capacity of 203 watt. A compressor compatible with Electrolux model P12Fw should be selected. Or Danfoss Model SC12G with cooling capacity of 183 watts at CECOMAF Condition and 226 watts at ASHREA CONDITION.

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

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.

T_a = 32 C, T_f = - 25 C

$Q_{SideWalls}$ = 0.36 x 1.12 x 57 = 23 Watts

$Q_{SideWalls}$ = 23 Watts

$Q_{Front\ Wall} = [U A (T_a - T_f)]$

T_a = Ambient Temperature

T_f = Freezer air Temperature

U = 1 / (0.050/0.018) = 0.36 W/ sq.m C

A = 1.07 Sq. Mt.

T_a = 32 C, T_f = - 25 C

$Q_{Front\ Wall}$ = 0.36 x 1.07 x 57 = 22 Watts

$Q_{Front\ Wall}$ = 22 Watts

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

T_a = Ambient Temperature

T_f = Freezer air Temperature

U = 1 / (0.050/0.018) = 0.36 W/ sq.m C

A = 1.07 Sq. Mt.

T_a = 42 C, T_f = - 25 C

$Q_{back\ panel}$ = 0.36 x 1.07 x 57 = 22 Watts

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

T_a = Ambient Temperature

T_f = Freezer air Temperature

U = 1 / (0.050/0.018) = 0.36 W/ sq.m C

A = 0.81 Sq. Mt.

T_a = 32 C, T_f = - 25 C

شرکت مهندسی سهند مینا (با مسئولیت محدود)
SAHAND MINA ENGINEERING CO.LTD.

شماره Our Ref.: تاریخ Date:

Jalal Zadeh Ice Cream Chest Freezer Model MDCF-120

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 (125x85)	2.14	50
Chest Door	120 x 65	0.81	50
Bottom Floor	120 x 65	0.81	50

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

Calculation :

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

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

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

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:

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

M = 600 kg
C = 0.67 Btu/(lb)F deg = 0.67 x 4.184 = 2.8 j/g K
T_1 = 25 C
T_2 = 4 C
Q = 600000x2.8x (25-4) =33600000 jul/86400 = 408Watt

Internal Load

Motor Fan 16 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} = 105 + 408+ 16 + 73 = 602

Considering 20 % of Q total for safety factor

$Q_{Grand\ Total}$ = 602 + 20%(128) = **723**watts

With respect to the above calculation we have to select a compressor of R134a with cooling capacity of approximately 723watt at –15 degree centigrade evaporating temperature. We should select a compressor to be compatible with Electrolux compressor model S26TY.

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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 +4 C, we consider 600 Kg of meet to be stored in this refrigerator therefore we calculate as follow,

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

T_a = Ambient Temperature 32

T_r = refrigerator air Temperature 4

U = 1 / (0.080/ 0.0180) = 0.22 W/ sq.m °C

A = 4.4 Sq. Mt., T_a = 32 °C, T_f = + 4 °C

therefore

$Q_{SideWalls}$ = 0.22 x 4.4 x 28 = 22.2 Watts

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

U = 1 / [(0.080/ 0.018)] = 0.22 W/ sq.m °C ,

$T_a - T_r$= 28, A = 3.2,

Q_{doors} = 0.2 x 4.4 x 28 = 27.1 Watts Q_{doors} = 27.1 Watts

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

U = 0.22 w/sq. Mt. °C,

$T_a - T_r$= 38 , **A = 1.98**

Q_{top} = 0.22 x 1.98 x 38 = 16.5 Watts

Q_{top} = 16.5 Watts

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

U = 0.22 w/sq. Mt. °C,

$T_a - T_r$= 28 , A = 4.4

$Q_{back\ panel}$ = 0.22x 4.4 x 28 = 27.1 Watts

$Q_{back\ panel}$ =27.1 Watts

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

U = 0.22 w/sq. Mt. °C,

$T_a - T_r$= 28, A = 1.98

$Q_{Bottom\ Surface}$ = 0.22x 1.98 x 28 = 12.2 Watt

$Q_{Bottom\ Surface}$ = 12.2 Watts

Total Refrigerator Heat Leak =22.2 +27.1 + 16.5 + 12.2 + 27.1= 105 W

تهران ،خیابان شریعتی ، بالاتر از میرداماد ساختمان ۱۲۸۰ آپارتمان شماره ۱۲ کد پستی ۱۹۵۵۸ تلفن : ۲۲۵۰۲۳۰ ، ۲۲۷۴۹۳۶ نمابر: ۲۲۷۴۹۳۶
No 12, Building 1280,Shariati Ave.,Tehran 19558 Iran. Tel.:+98 21 225 03 30 Tel.Fax :+98 21 227 49 36
e.mail, sahandmina@hotmail. com

شرکت مهندسی سهند مینا (با مسئولیت محدود)
SAHAND MINA ENGINEERING CO.LTD.

:شماره Our Ref.: تاریخ : Date:

Refrigeration Load Calculation
Upright Refrigerator Showcase Shahab-160

a) Transmission load calculation

Refrigerator Compartment	Dimension Cm.	Area (sq.mt.)	Insulation Thickness	Temp. Difference
Side Walls	2 x (80x200)	3.2	40mm	27 c
Back Panel	160x200	3.2	40mm	27 c
Bottom	80x200	1.6	40mm	27 C
Top	80x200	1.6	40mm	37 c
Doors	160x200	3.2	40mm	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

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$\dot{M}$ 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 = 50

M = Kg weight of water in one Glass of Water = 0.2 Kg

$\dot{M}$ = 2(16 x 50 x 0.2) = lit. + 20% Waste Water = 384

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

Q2 = m C ΔT = 384 x 1 x 14 = 5376 Kcal = 5376 x 1.163 = 6252 Watts/16 hrs

Q2 = 1563/12.8 compressor operating time per day = 122 Watts

<u>Q2 = 260 Watts</u>

Q3 = UA ΔT, Where: **Q3**Total Leak, gained through side wall of drinking water storage tank by conduction in Kcal..

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

$$U = \frac{1}{x/K} = \frac{1}{0.060/0.018} = 0.33 \ Kcal/m^2.°C$$

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

Side walls area = (80+80+40+40)x50=1.2 Sq. Mt.

Upper and Lower Sides= 2(40x80)=0.64

Total Area=1.2+0.64=1.84

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

Q3 = UA ΔT = 0.33 x 1.84 x 20 = 12.1Watts

Q3 = 12.1 Watts

Qt = Q1 + Q2 + Q3 = 33.9 + 260 + 12.1 = 306 + 20% safety factor =

<u>367 Watts</u>

Compressor R134a, Model FR7GH (total cooling capacity 525 watts) manufactured by Danfoss, is selected as a suitable compressor to replace R12 compressor model SC21B to operate at –10 C evaporating temperature.

شماره: Our Ref.: تاریخ : Date:

Load Calculation for Water Cooler 50 liters
Maibod Tagrag Company.

Q1 = m C ΔT, Where:

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

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

Tank depth 28 Cm. Tank Height 38 Cm, Width 68 Cm
Approximate tank volume = M = 50 liter = 50 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

Q1 = m C ΔT = 50 x 1 x 14 = 700 Kcal = 700 x 1.163 = 814 Watts/24 hrs

Q1 = 814 /24 water cooler operating time per day = 33.9 Watts

Q1 = 33.9 Watts

$Q2 = \dot{M} \; C \, \Delta T$

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

شماره: Our Ref.:　　　　　　　　　　　　تاریخ: Date:

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

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

$$Q2 = \dot{M} \ C \Delta T$$

Q2 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.

$$Q3 = UA \Delta T$$

Where:

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

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

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

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

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:

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, porcelai coated - 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,

1- Bottle Type.
2- Tap water type

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

Water cooler using a plumbing supply and drain connection, must be installed according the relevant approved standards. The plumbing should be concealed, a hand shutoff valve should be installed in the fresh water line. Drain pipe at least 1 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.

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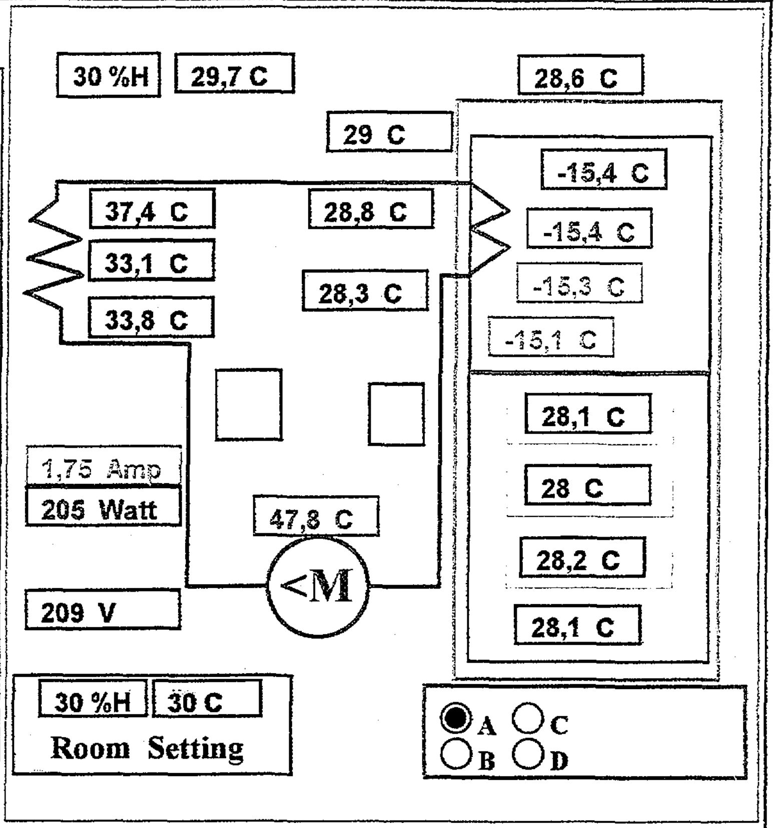
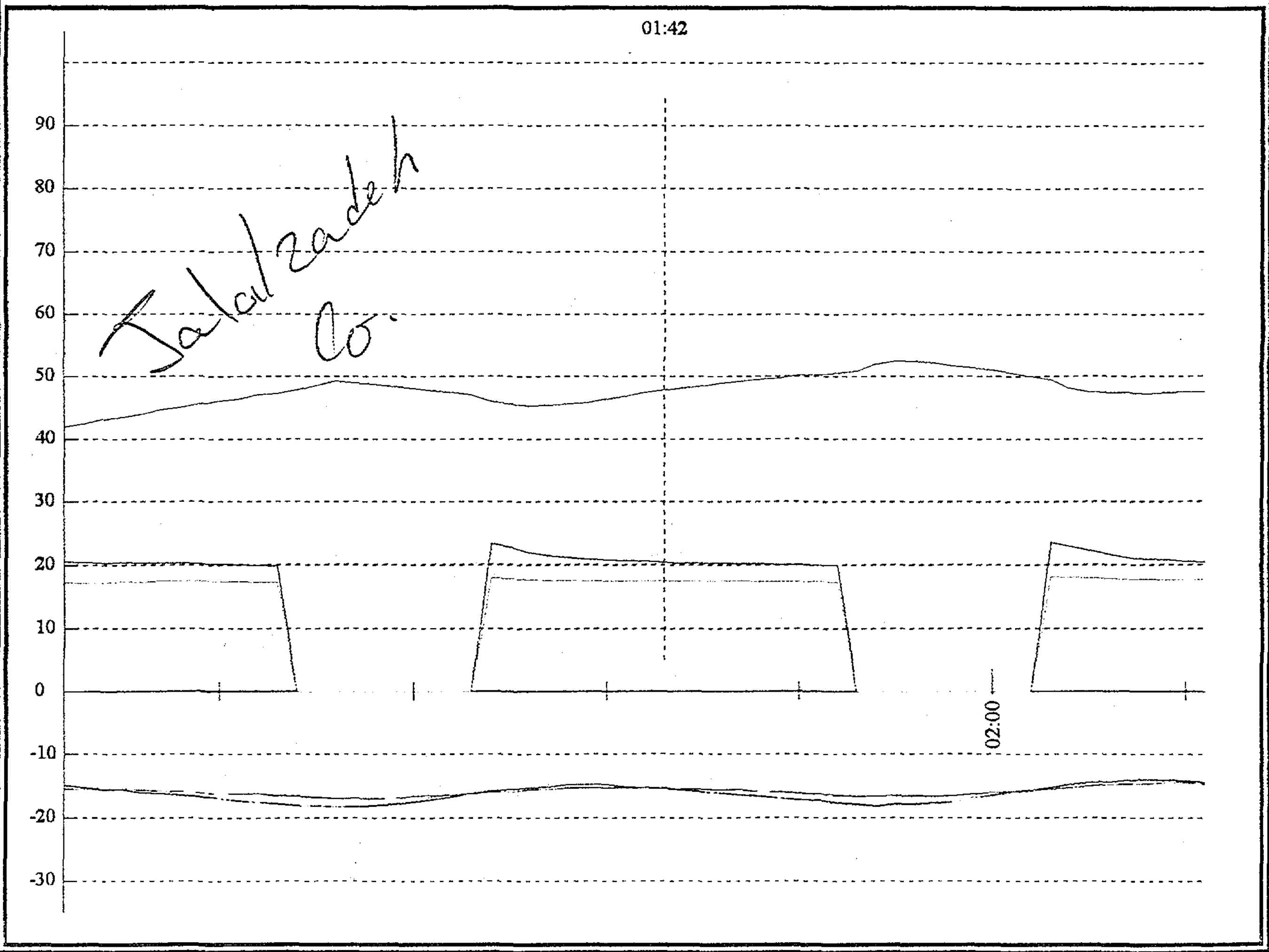
TestDate: **99/01/02 07:14** Report No.: ( ) - Page 2

PageTestName: **Energy Consumtion** ReportDate: **/01/1999 10:47**

Page Result :

1 - Page Test Time	1 Hours	
2 - Working Percent	67 %On	
3 - Energy (Accord to page)	0,654 kwh	
4 - Zoom Time	1:43 Hour	
5 - Compr Current	1,75 Amp	
6 - Evaprator Mean Temp	-15,3 C	
7 - Cabin Mean Temp	28,1 C	
8 - Crisp Temp	28,1 C	
9 - Compr Temp	47,8 C	
10- Condensor In Temp	33,8 C	
11- Condensor Out Temp	37,4 C	
12- Condition	29,7 C	30 %H
13- Volt	Max=215 Mean=213 Min=205	
14-		
15-		
16-		
17-		





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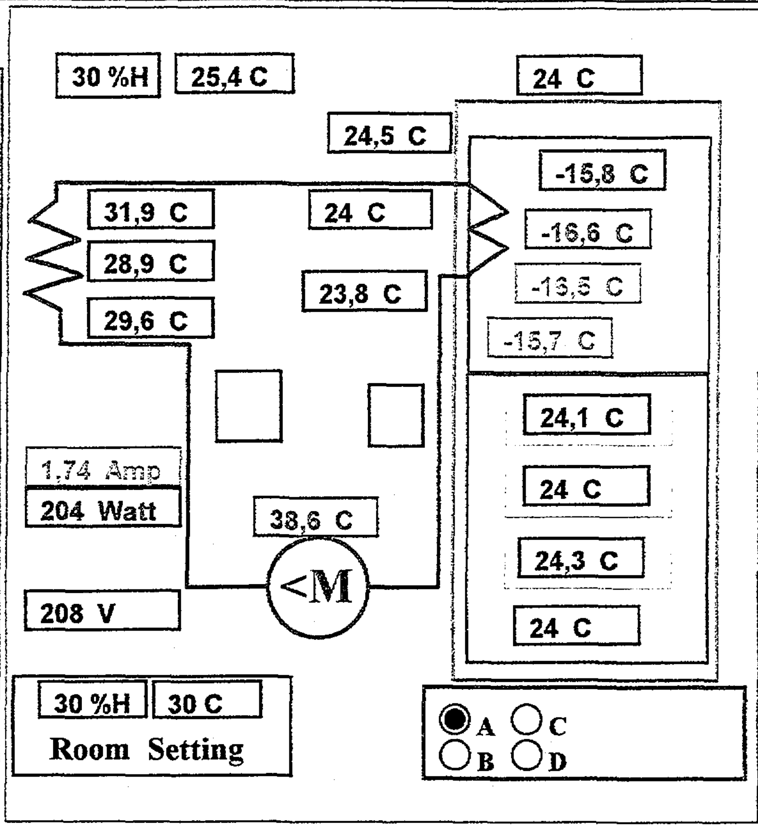
PM

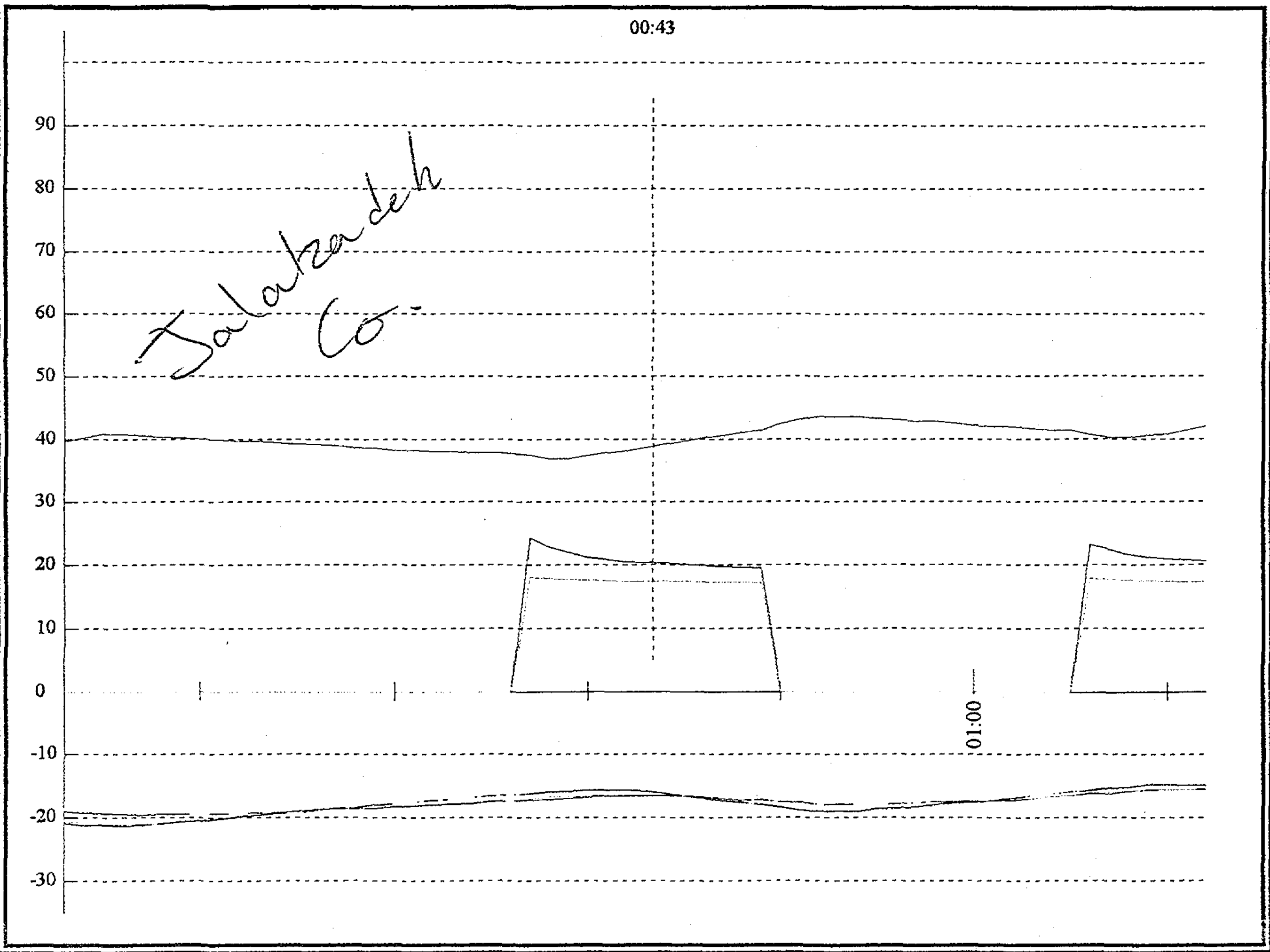
TestDate: **99/01/02 07:14** *Report No.:* ( ) - Page 1

PageTestName: **Energy Consumtion** *ReportDate:* /01/1999 10:44

Page Result :

1 - Page Test Time	*1 Hours*	
2 - Working Percent	*35 %On*	
3 - Energy (Accord to page)	*0,582 kwh*	
4 - Zoom Time	*0:43 Hour*	
5 - Compr Current	*1,74 Amp*	
6 - Evaprator Mean Temp	*-16,1 C*	
7 - Cabin Mean Temp	*24,1 C*	
8 - Crisp Temp	*24 C*	
9 - Compr Temp	*38,6 C*	
10- Condensor In Temp	*29,6 C*	
11- Condensor Out Temp	*31,9 C*	
12- Condition	*25,4 C*	*30 %H*
13- Volt	*Max=211 Mean=212 Min=205*	
14-		
15-		
16-		
17-		





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TestDate:	99/01/02 07:14	Report No.:	Spec & Remark
TestName:	Energy Consumtion	ReportDate:	/01/1999 11:09

Total Result :

1 - Total Test Time	3 Hours
2 - Working Percent	57 %On
3 - Energy	0,747 kwh
4 - Zoom Time	3:18 Hour
5 - Compr Current	00 Amp
6 - Evaprator Mean Temp	-16,2 C
7 - Cabin Mean Temp	28,2 C
8 - Crisp Temp	28,2 C
9 - Compr Temp	50,3 C
10- Condensor In Temp	26,2 C
11- Condensor Out Temp	32,7 C
12- Condition	28,9 C 30 %H
13- Volt	Max=215 Mean=211 Min=205
14-	
15-	
16-	
17-	

Product Spec :

1 - File Name	99010207.k14
2 - Test Kind	G
3 - Product Serial	...
4 - Product Name	ice c. fr.
5 - Product Model	ARF-12
6 - Product Capacity	300L
7 - Compressor Name	danfouse
8 - Compressor Model	10G
9 - Compressor Power	1/4
10 - Compressor Amper	
11 - Thermostat No.	3,5,7
12 - Thermostat Type	
13 -	
14 -	

Technical Manager: ICRC

Lab Chief : AZAR PENDAR

Lab Specialist: ZARE

Remark :

Comp.name:
Chife:
P.S 220V 50Hz AC

Remark :

Shahab Co.

sign :

Industrial Control Research Center HotRoom Ver 5

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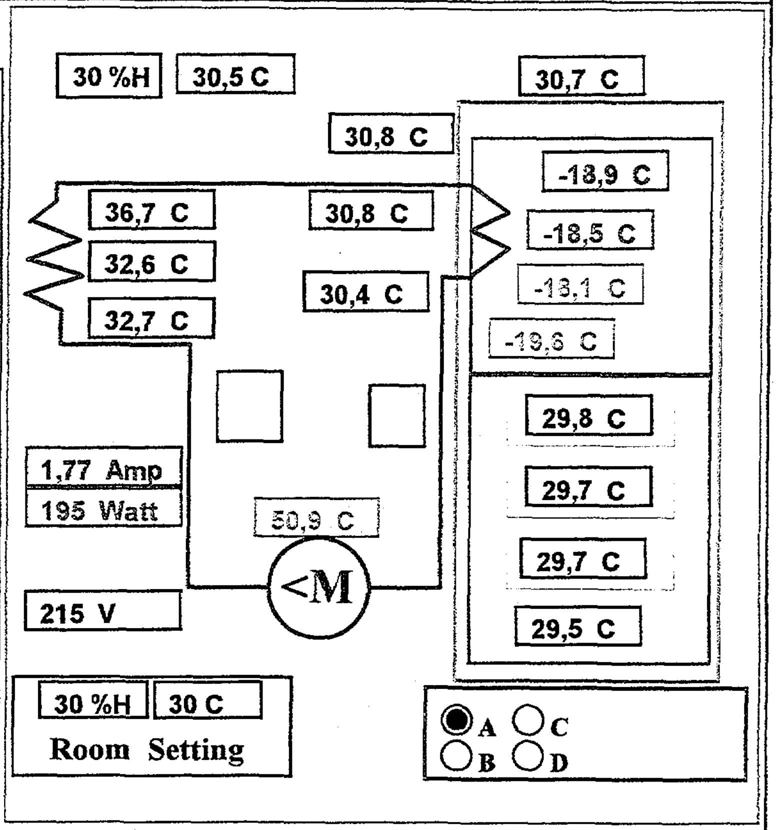
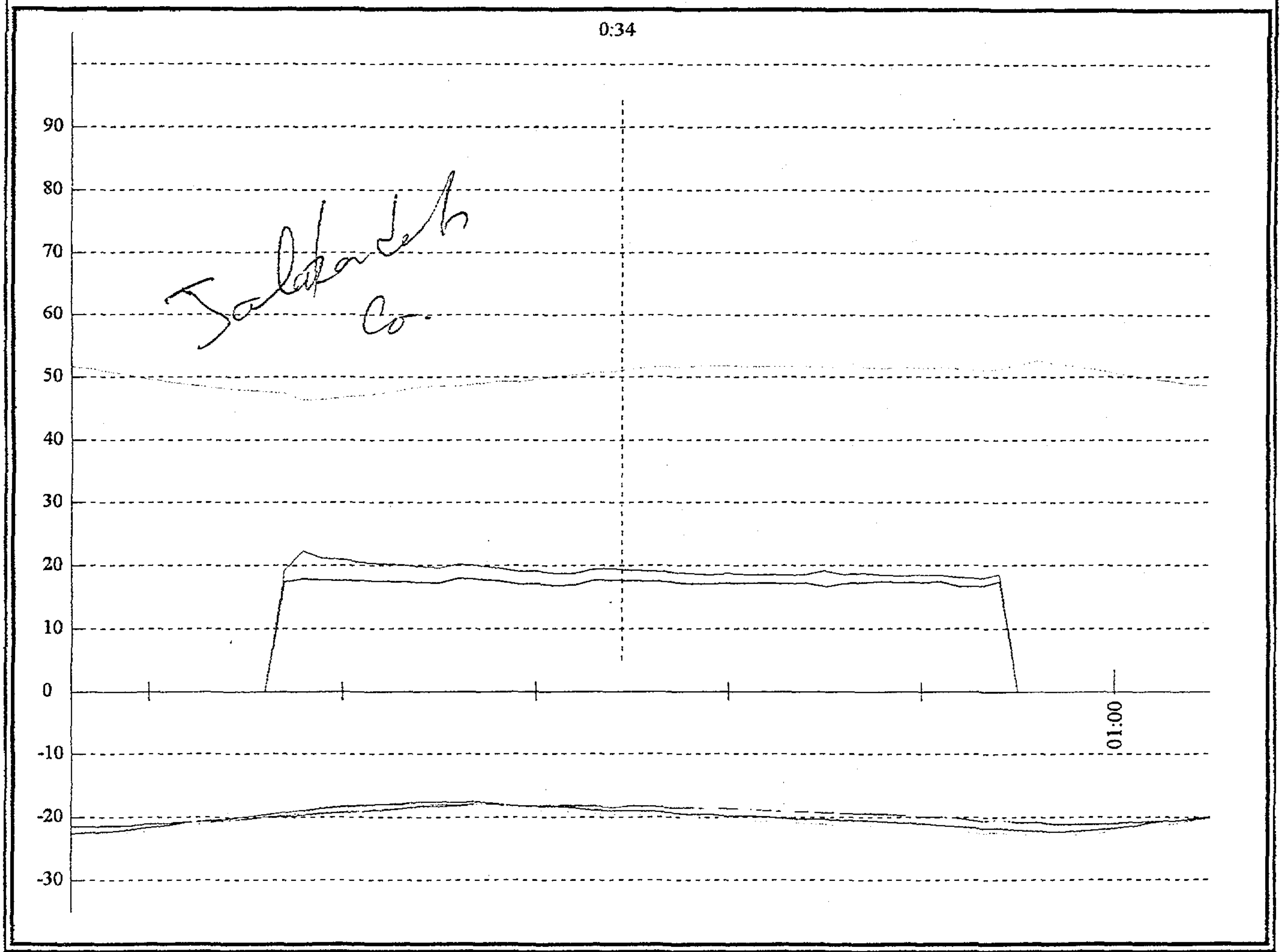
TestDate: **IC/RC/TE ST:1** Report No.: ( ) - Page 1

PageTestName: **Energy Consumtion** ReportDate: /01/1999 13:20

Page Result :

1 - Page Test Time	*1 Hours*
2 - Working Percent	*64 %On*
3 - Energy (Accord to page)	*1,944 kwh*
4 - Zoom Time	*0:34 Hour*
5 - Compr Current	*1,77 Amp*
6 - Evaprator Mean Temp	*-18,7 C*
7 - Cabin Mean Temp	*29,7 C*
8 - Crisp Temp	*29,5 C*
9 - Compr Temp	*50,9 C*
10- Condensor In Temp	*32,7 C*
11- Condensor Out Temp	*36,7 C*
12- Condition	*30,5 C 30 %H*
13- Volt	*Max=216 Mean=215 Min=204*
14-	
15-	
16-	
17-	





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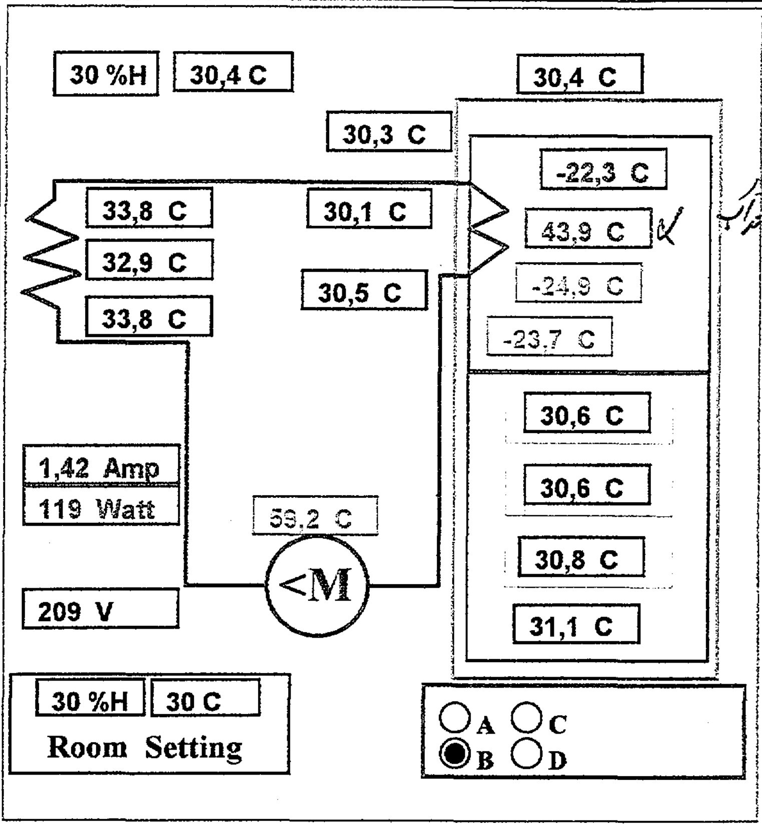
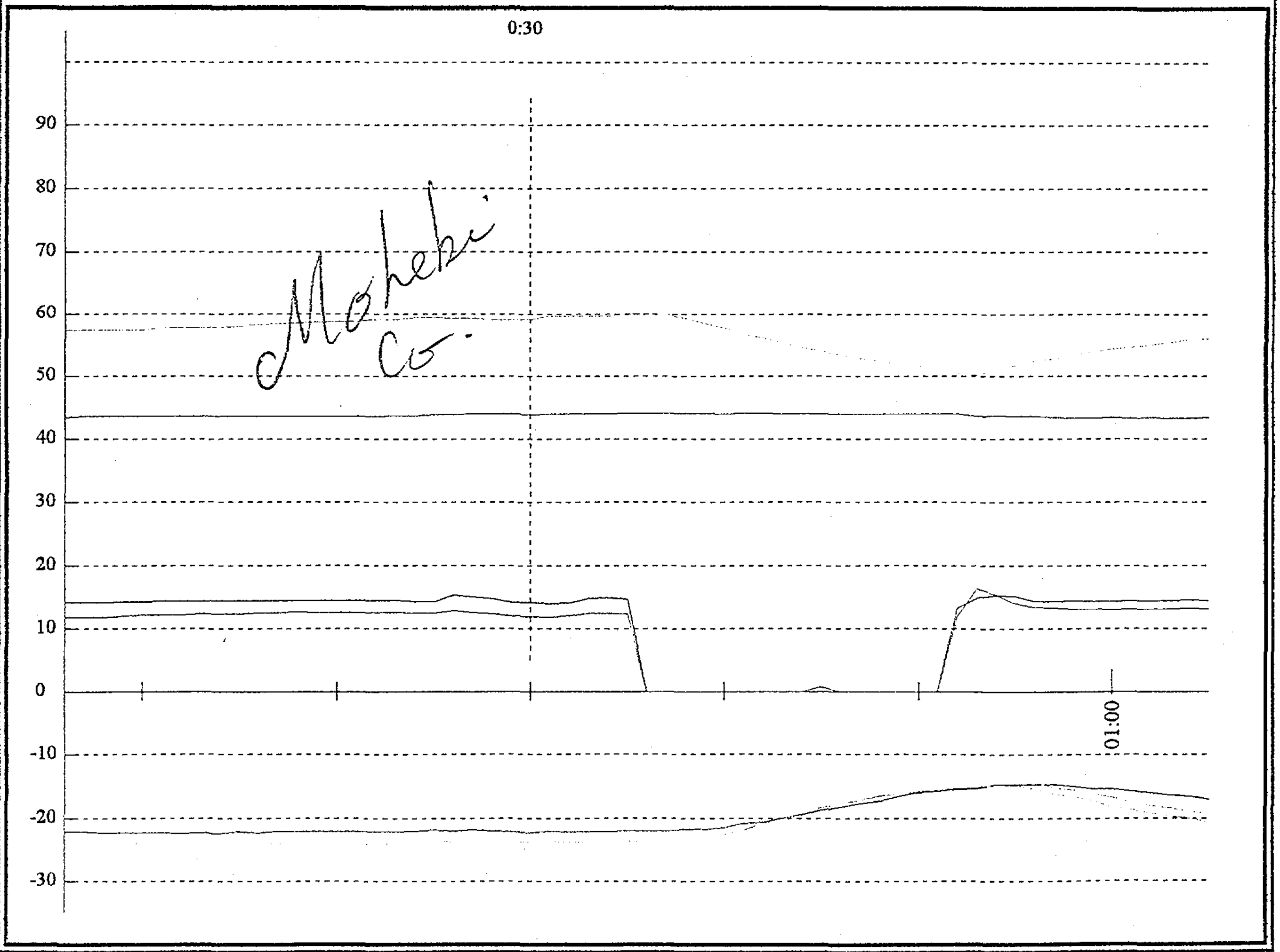
TestDate: **IC/RC/TE ST:1** Report No.: ( ) - Page 1

PageTestName: **Energy Consumtion** ReportDate: /01/1999 13:09

Page Result :

1 - Page Test Time	1 Hours
2 - Working Percent	74 %On
3 - Energy (Accord to page)	2,071 kwh
4 - Zoom Time	0:30 Hour
5 - Compr Current	1,42 Amp
6 - Evaprator Mean Temp	-6,7 C
7 - Cabin Mean Temp	30,6 C
8 - Crisp Temp	31,1 C
9 - Compr Temp	59,2 C
10- Condensor In Temp	33,8 C
11- Condensor Out Temp	33,8 C
12- Condition	30,4 C 30 %H
13- Volt	Max=216 Mean=215 Min=204
14-	
15-	
16-	
17-	





Industrial Control Research Center HotRoom Ver 5

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TERMOSTAT	-	-	-	-	+	+	-	-	+	+	-	-	-	+	+	-	-	-

TIME	15:08	15:15	15:20	15:30	15:45	16:00	16:15	16:18	16:30	16:35	16:45	16:51	17:00	17:15	17:18	17:31	17:45	18:00
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EXTERNAL TEMPERATURE	19	20	20	20.5	25	20	18	18	16	16	16	16	15	15.5	15.5	15.5	18	21
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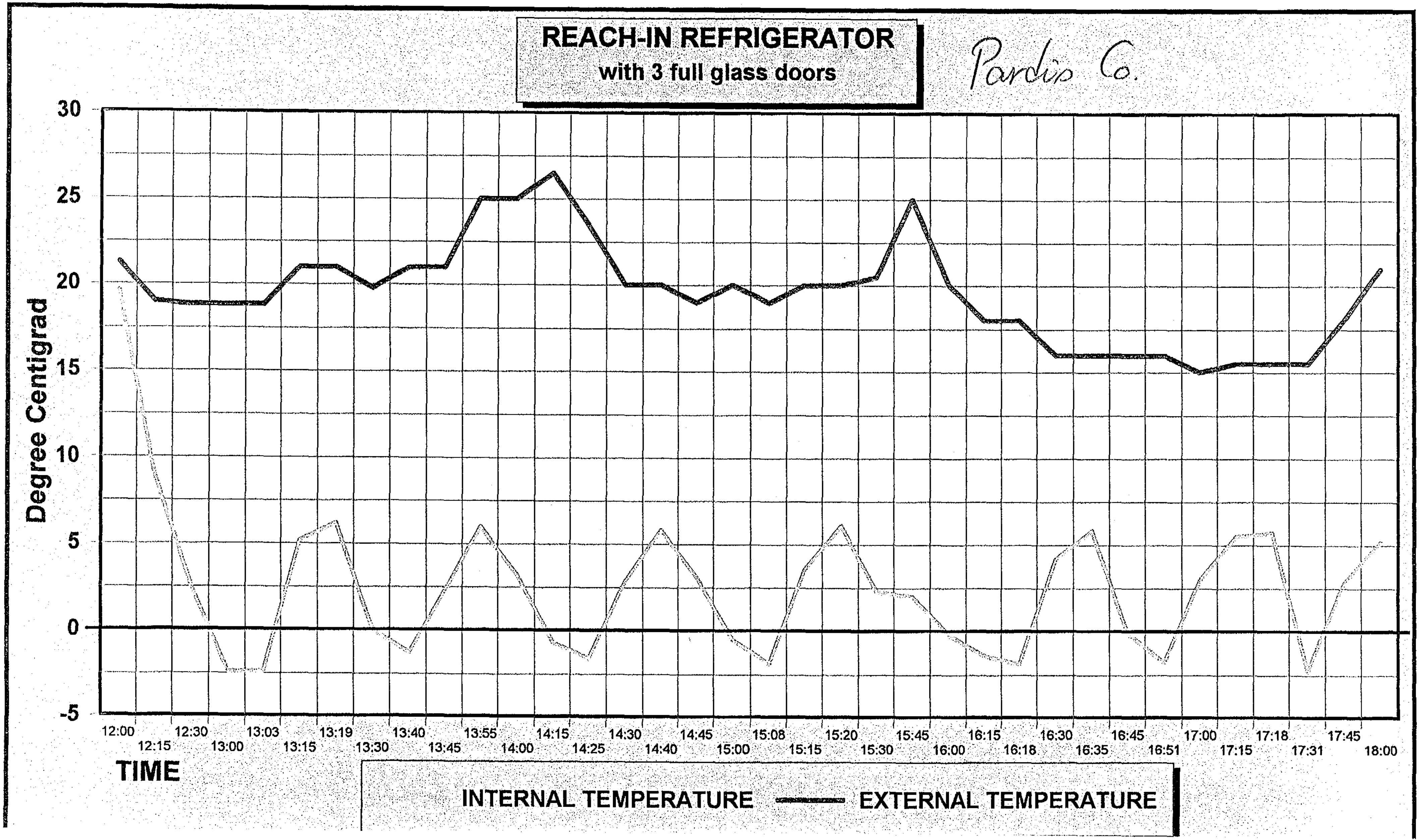

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TERMOSTAT	-	-	-	-	+	-	+	-	+	-	-	+	-	+	-	-	+	-

TIME	12:00	12:08	12:12	12:30	12:39	12:45	13:00	13:10	13:20	13:30	13:37	14:00	14:07	14:15	14:35	14:41	14:58	15:04
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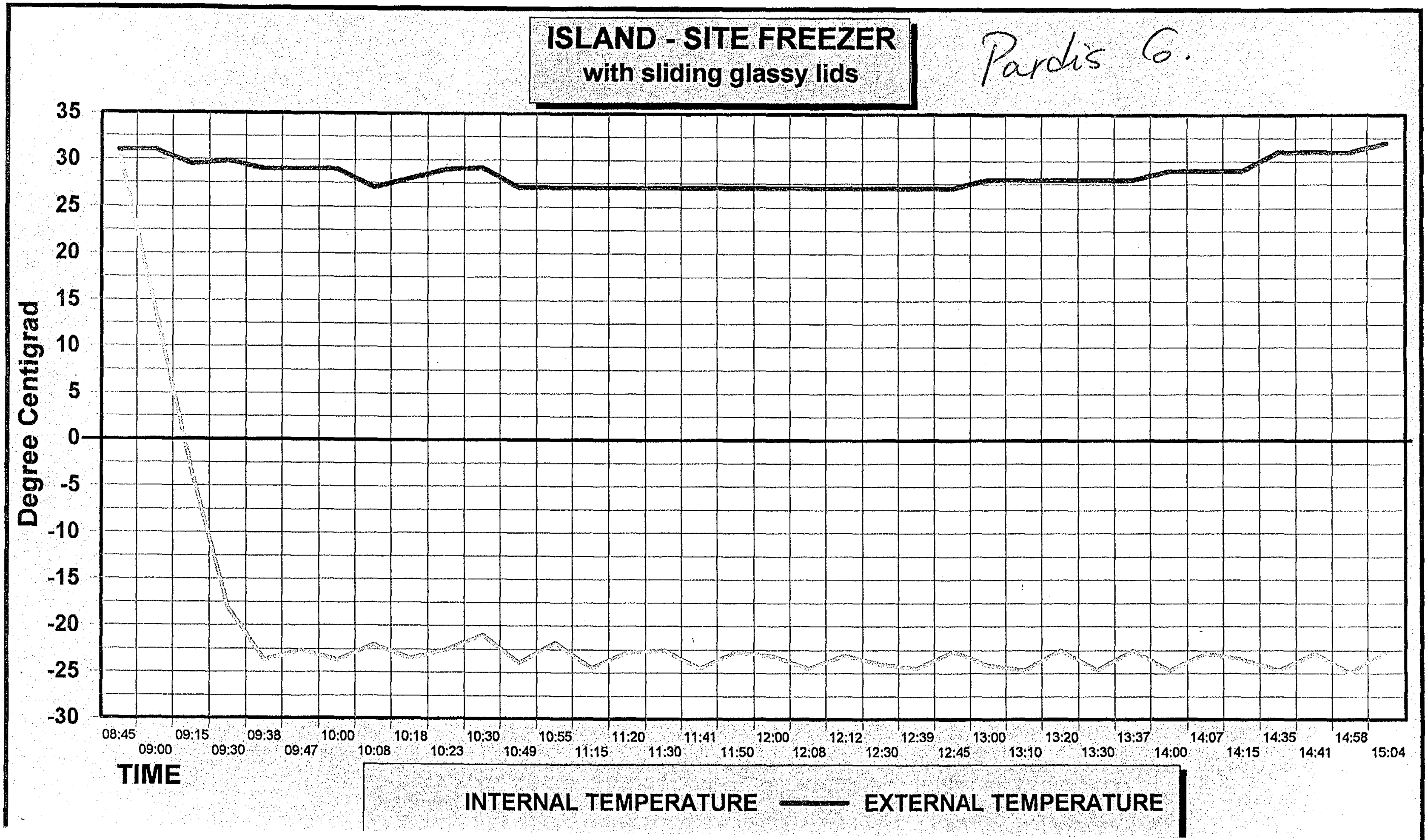
EXTERNAL TEMPERATURE	27	27	27	27	27	27	28	28	28	28	28	29	29	29	31	31	31	32
TERMOSTAT	-	+	-	-	+	-	-	+	-	+	-	+	-	-	+	-	+	-



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TERMOSTAT	-	-	-	-	+	-	+	-	+	-	-	+	-	+	-	-	+	-

TIME	12:00	12:08	12:12	12:30	12:39	12:45	13:00	13:10	13:20	13:30	13:37	14:00	14:07	14:15	14:35	14:41	14:58	15:04
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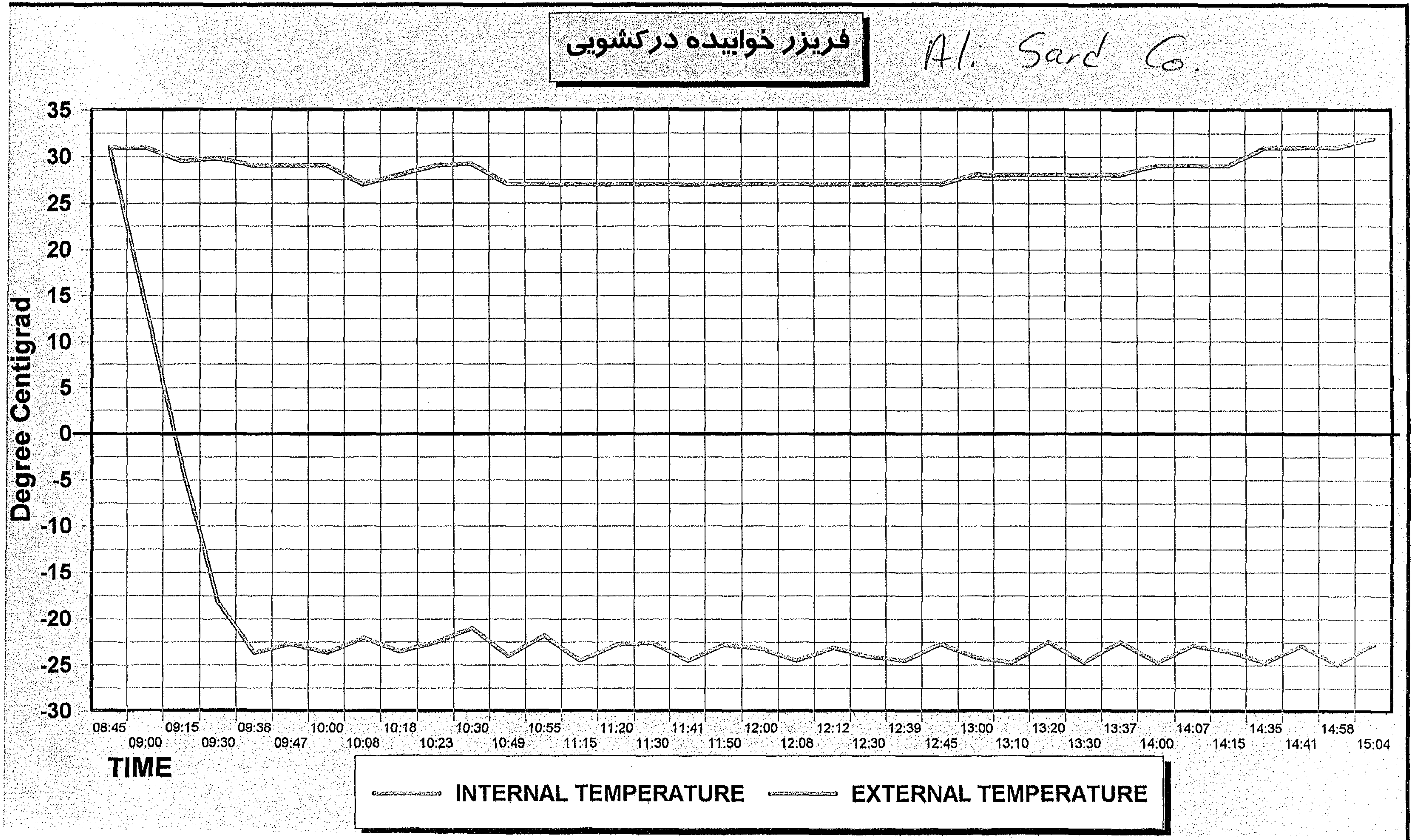
EXTERNAL TEMPERATURE	27	27	27	27	27	27	28	28	28	28	28	29	29	29	31	31	31	32
TERMOSTAT	-	+	-	-	+	-	-	+	-	+	-	+	-	-	+	-	+	-



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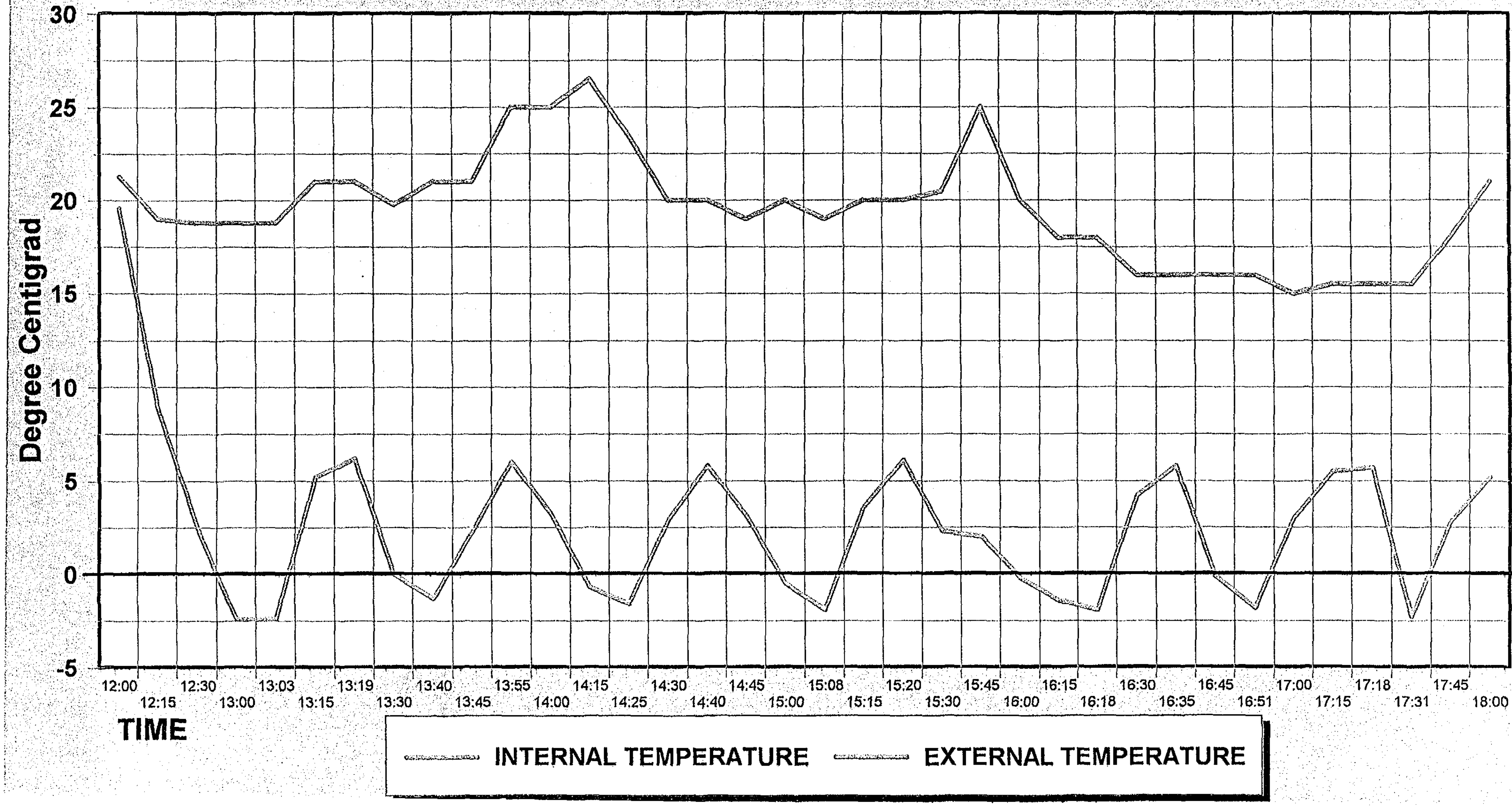
EXTERNAL TEMPERATURE	21.3	19	18.8	18.8	18.8	21	21	19.8	21	21	25	25	26.5	23.5	20	20	19	20
TERMOSTAT	-	-	-	-	+	+	-	-	+	+	-	-	-	+	+	-	-	-

TIME	15:08	15:15	15:20	15:30	15:45	16:00	16:15	16:18	16:30	16:35	16:45	16:51	17:00	17:15	17:18	17:31	17:45	18:00
INTERNAL TEMPERATURE	-1.9	3.6	6.1	2.3	2	-0.2	-1.4	-1.9	4.2	5.8	-0.1	-1.8	3	5.5	5.7	-2.3	2.8	5.2
EXTERNAL TEMPERATURE	19	20	20	20.5	25	20	18	18	16	16	16	16	15	15.5	15.5	15.5	18	21
TERMOSTAT	+	+	-	-	-	-	-	+	+	-	-	+	+	-	-	+	+	+

یخچال ایستاده سه در سوپری

Ali Saed Co.



TIME	09:00	09:12	09:30	09:46	10:00	10:10	10:24	10:32	10:45	10:59	11:10	11:32	11:40	11:50	12:05	12:15	12:26	12:45
INTERNAL TEMPERATURE	29	13	-3.5	-15	-23	-22	-23	-24	-23	-24	-21	-24	-21.8	-23	-25	-22.6	-24	-25
EXTERNAL TEMPERATURE	29	29	29.5	29	30	30	29	29	29	30	30	30	31	30	30	31	31	31
TERMOSTAT	-	-	-	-	+	-	-	+	-	+	-	+	-	-	+	-	-	+

TIME	12:58	13:10	13:25	13:35	13:50	14:10	14:15	14:40	14:55	15:10	15:18	15:36	15:55	16:12	16:25	16:40	16:55	17:05
INTERNAL TEMPERATURE	-23.2	-24.5	-23.1	-24.1	-24.5	-22.7	-24.2	-24.7	-22.6	-24.7	-22.5	-24.7	-22.9	-25	-24	-25	-22	-22
EXTERNAL TEMPERATURE	32	32	32	33	33	33	33	33	32	32	33	32	32	31	32	32	32	32
TERMOSTAT	-	+	-	-	+	-	-	+	-	+	-	+	-	+	-	+	-	-

فریزر صندوقی - یخچال سازی میبدتگرگ