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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

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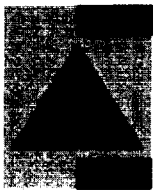

FOOD REFRIGERATION
AND PROCESS
ENGINEERING
RESEARCH
CENTRE

UNIDO PROJECT MP/EGY/95/038

THE REDESIGN OF DOMESTIC REFRIGERATOR COOLING CIRCUITS FROM R12 TO R134A, EGYPT.

FINAL REPORT

ANDREW GIGIEL

7 April, 1999

UNIVERSITY OF BRISTOL

Food Refrigeration and Process Engineering Research Centre,
Churchill Building, Langford, Bristol, BS18 7DY, UK.

Tel +44 (0)117 928 9239
Fax +44 (0)117 928 9314
e-mail frperc-bris@bristol.ac.uk

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Summary

Introduction

Domestic refrigerator manufactures in Egypt have installed equipment for charging refrigerant R134A and new development facilities.
This project concerns assistance to convert their current refrigerators from operating on R12 to R134A, to produce environmentally sound refrigerators and freezers.
The aim was to transfer the experience of The Food Refrigeration and Process Engineering Research Centre in the design and optimisation of refrigeration units to the Egyptian manufacturers.

Program of Work

The program of work was in accordance with the Terms of Reference issued by UNIDO.

1. A workshop in Egypt for manufactures on the necessary skills and information needed in order to redesign refrigeration circuits for R12 to R134A.

2. Separate meetings with each manufacturer in order to prepare individual conversion programs.

3. Support to assist the manufactures in carrying out these programs.

4. Revisit each factory at the end of the project to make a critical appraisal of the designs and to give advice on any further problems that may have arisen.

Workshop and meetings with manufacturers

A full report on the work was submitted to UNIDO on 7th May 1998. It contained the Workshop notes, supplementary material on the development and testing of small refrigerator circuits and an agreed program for conversion with each manufacturer.
Most of the time at each factory was spent showing the development engineers how to improve and interpret test data for use in development . Methods of communication between the manufactures and FRPERC by fax, phone and e-mail were agreed. The manufacturers conversion programs are summarised in the following Table 1.

Manufacturer	Start of 1st conversion	Finish of 1st conversion	Finish all conversions
International Company for Refrigeration Appliances (Iberna)	11 March 98	12June 98	11March 99
Siltal	All refrigerators already converted		
Helwan Company, Factory 360	16 March 98	16 May 98	16 March 99
Superbosch	No program agreed		
Mondial Refrigeration Industries	18 March 98	18 April 98	18 September 98
SAE (Alaska)			
Neeasae (Phillips)	19 March 98	30 April 98	30 September 98

Table 1 Agreed conversion program for each manufacturer

Support during conversions

Test data has been received from 2 manufactures and a revised program from a further one. I have no knowledge of progress made by the other manufactures. Faxes have been sent to all the manufactures on 2 occasions requesting progress and test data.

Helwan Company, Factory 360

Test data was received on 30 June 98 for 3 pulldown tests on their 300l refrigerator. This test data is summarised in Table 2.

Refrigerant	R12	R134a					
Capillary length (mm)	3650	3900		4000		4100	
Charge(gm)	205	190	210	190	210	190	210
Comp suction (T1)	46	46	44	46.5	44	45.5	40.6
Comp discharge (T2)	133	110.8	114.5	109	109	114	112
Condenser Temp (T3)	54	54.3	55.7	54	50	54	55.7
Condenser Exit(T4)	53.5	52.6	55.2	53	49.9	54	55.2
Evaporator Temp (T5)	-14.3	-12.3	-9.8	-14.7	-15	-13.8	-12
Evaporator Exit(T6)	-14.2	-12.2	-9.8	-14.5	-14.8	-13.7	11.5
Ref air Temp (T7)	8.8	8.2	9.7	7.5	4.65	6.0	6.0
Power (watts)	158	188	194	184	174	172	191

Table 2 Test data for the 300l refrigerator from Helwan

The following advice was sent to the manufacturer who has not responded since.

1. With the exception of one result (3900 mm length, 210 g charge) the refrigerator temperature with R134a was colder than with R12.

2. In all tests the superheat at the outlet from the evaporator was approximately zero. This implies that there was sufficient charge in all systems.

3. The condensing temperature was approximately the same in all tests.

4. The temperature of the compressor suction decreased with increasing charge of R134a. This, together with the zero superheat at the end of the evaporator, indicates that the amount of liquid entering the suction line capillary tube heat exchanger increased with increasing charge.

5. The compressor fitted in the R134a refrigerator was larger and used more power when run continuously than the R12 compressor. This is consistent with the colder temperatures in the refrigerator obtained with R134a under continuous running compared to R12. If operating on a thermostat it is likely that the run time for the R134a refrigerator will be reduced and therefore that the energy consumption over 24 hours will be the same or less.

Overall it is likely that the charge of 190 and 210 g of R134a is actually larger than needed. I suggest trying a smaller charge, say 170 g. The capillary tube fitted on this machine, at 4 m, is very long. It is unlikely that the small differences of 100 mm in the length will make a significant differences to the performance of the system. The similarity in the condensing and evaporating temperatures implies that the resistance is satisfactory. A bigger change will be needed to see if a shorter length will be required, say a length of 3000 mm.

In conclusion the performance of the R134a refrigerator is probably very close to optimum and the small changes made to both charge and capillary tube length are within the sensitivity of these two perameters and therefore the results show little difference. An energy consumption test at 25°C comparing the R134a and R12 refrigerators could well show that a successful conversion has been made in that the refrigeration temperature is correct and the same amount of energy is used to obtain it.

International Company for Refrigeration Appliances (Iberna)

Iberna sent data on a pulldown and continuous run test and a storage temperature test on the 21 September 98. The data is shown in Table 3.

Channel			R12		R134a	
No	Lable	Unit	Charge 180g		Charge 150g	
			Cap 0.66x3000 mm		Cap 0.66x3400 mm	
			After 24h	Stabilised	After 24h	Stabilised
1	Ambient	C	43.24	41.83	45.34	44.67
2	In Evap	C	-23.4	-23.8	-25.44	-25.4
3	Ambient	C	-22.99	-23.26	-25.71	-24.99.
4	Temp.Air 1	C	-12.49	-13.03	-13.59	-14.76
5	Temp. Air2	C	-16.67	-17.07	-19.24	-18.68
6	Temp. Air 3	C	-17.47	-18.01	-20.19	-19.75
7	Temp. Air4	C	-19.48	-19.76	-21.40	-20.83
8	Temp. Air5	C	-11.94	-12.35	-21.94	-21.37
9	Temp. Air6	C	-18.27	-19.22	-2.07	-21.64
10	In Cond	C	63.40	63.84	62.82	63.84

11	Out Cond.	C	53.36	54.17	53.45	52.78
12	In O.C.	C	56.65	56.64	56~27	55.37
13	Out O.C.	C	98.94	97,76	70.49	70.97
14	Suction line	C	23.07	22.18	34.29	33.27
15	Discharge	C	103.08	102.43	89.84	91.19
16	Voltage	Volt	227.50	232,00	226.90	220.6
22	Power	kW	0.179	0.180	0.170	0.167
33	Current	Amp	1.122	1.13	1.293	1.266

Table 3 Pulldown and continuous run data for the Iberna V22 refrigerator

Channel			R12		R134a	
No	Lable	Unit	Charge 180g		Charge 150g	
			Cap 0.66x3000 mm		Cap 0.66x3400 mm	
			After 24h	Stabilised	After 24h	Stabilised
1	Ambient	C	42.82	40.18	43.26	43.09
2	in.Evap	C	-24.55	-25.56	-25.40	-25.99
3	Out Evap.	C	-24.16	-25.17	-24.99	-25.45
4	Ml	C	-16.62	-16.95	-14.49	-15.22
5	M2	C	-19.02	-19.38	-19.61	-20.74
6	M3	C	-19.59	-19.92	-19,88	-21.14
7	M4	C	-21,07	-21.26	-20.95	-22.22
8	MS	C	-20,13	-20.72	-18.93	-19,79
9	M6	C	-18.64	-19.11	-18.93	-19.93
10	In Cond.	C	64.22	59.93	66.86	62.02
11	Out Cond.	C	57.04	54.87	56.42	50.38
12	In OC.	C	58.1.0	55.93	57.83	52.73
13	Out OC	C	96.84	92.34	73.64	70.48
14	Suction 1ine	C	25.74	22.80	33.97	31.54
15	Discharge	C	101.94	97.01	94.69	89.83
16	1 Mains	volts	202.90	2i0.10	224.30	221.90
22	Power	kW	0.178	0.177	0.170	0.164
33	Current	Amp	1.125	1.135	1.167	1.077

Table 4 Storage data for the Iberna V22 refrigerator

The following advice was given.

Thank you for your prompt reply in your fax of the 21st September 1998 and the attached information. I have one or two questions on this. First of all what does In O.C. and Out O.C. indicate ? Secondly where in the freezer were the air temperatures measured ? Finally I am not completely clear about the difference between 24 hour and stabilised results. Am I right in assuming that 24 hours is 24 hours after the commencement of the pull down test and stabilised means after an additional period of perhaps one or two days when the temperatures have reached their final steady values ?

Also you measured the inlet and outlet temperatures to the condenser. From these numbers it would appear that at the inlet to the condenser the gas is still super heated and the outlet is almost certainly sub cooled. Do you know what the condensing temperature was, or alternatively what the condensing pressure was ? Condensing temperature can be measured by attaching a thermocouple, in good thermal contact, to the condenser approximately half way along its length and then thoroughly insulating this from the environment in order to obtain an accurate reading of the condensing temperature at that point. Alternatively pressure tappings in the discharge from the condenser connected to a pressure transducer will give a reading of the pressure at the discharge which will be close to that of the condenser.

Overall I agree with you that the conversion from R12 to R134a appears to be successful, with reduced energy consumption and at least as good food temperatures. I assume that in climate class T (tropical) this freezer is rated as a two star (warmest temperature -12°C) as –18°C is not achieved in the warmest pack. This is true for both the original R12 freezer and the newly converted R134a freezer. My question to you is does this suit the market you are aiming for ? If it does then all well and good, if on the other hand your competitors are selling three star freezers, still rated at climate class T, then maybe you should consider improving the temperature of the warmest packs at the top of the freezer in order to rate your freezer as a three star. If it is only to be rated as two star then your warmest pack for R134a, and indeed for R12, is 2.5°C warmer than it needs to be. You can therefore adjust the thermostat to reduce this temperature to –12°C for the energy consumption test.

I shall be pleased to receive further test results when they are available and in the meantime if I can be of any assistance with help or advice please let me know.

Mondial Refrigeration Industries SAE (Alaska)

Alaska faxed on the 22 September 98 that they had "not conducted a lot of testing up till now". They expected to "finish the major model testing by the end of the year", when they will send an update.

Siltal

Siltal said that they have already converted all their refrigerators at the time of the workshop and have not requested any assistance

No further information has been received from any of the manufactures.

Final position

The position as known on the 1 November 1998 is summarised in Table 4. At this time UNIDO requested the final report as sufficient time had been allowed for the conversions.