



**TOGETHER**  
*for a sustainable future*

## OCCASION

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



**TOGETHER**  
*for a sustainable future*

## 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](mailto:publications@unido.org) for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at [www.unido.org](http://www.unido.org)

21117

# **FINAL REPORT**

according to UNIDO-Contrat Nr. 95/043



**Gesellschaft für Entwicklung  
und Projektmanagement mbH**

**dkk • August-Bebel-Straße 24 • D-09435 Scharfenstein**

**UNIDO  
P.O.Box 300  
A-1400 Vienna  
Austria**

**August-Bebel-Straße 24  
D-09435 Scharfenstein  
Telefon 03725/7076-0  
Telefax 03725/7076 21**

## **FINAL REPORT**

according to UNIDO-Contract Nr. 95/043

1. Declerations and shaping for the realized working plan of Iranian experts
2. Measurements on the refrigerator model AR08 according to DIN 8950
  - 2.1. Test on a continuous run
  - 2.2. Test on a cyclic run
3. Determination of the cabinet constant C on Model AR08 of Azmayesh Ind. Co.
4. Test on refrigerator models VC 52 AJG and NR 58 LAEG of Arj Co.
5. Summary of the test results
6. Evaluation of the test results and suggestions for further tests
7. Layouts

Scharfenstein, on 16.03.95

Wieszorek

Dr. Salem

## 1. Declarations and shaping for the realized working plan of Iranian experts

- 27.02.95 - Greeting and presentation of each firm
- 28.02.95 - Visit of the factory of Refrigerators manufacturing of FORON "Hausgeräte GmbH"
  - Carrying out of the test "continuous run" for the first refrigerator model
- 01.03.95 - Evaluation and discussion of the first test results and explanation of further steps
  - Seminar about Experience of FORON-Hausgeräte GmbH according to refrigerant change over from CFC 12 through HFC 134a to hydrocarbons
- 02.03.95 - Visit of the factory for washing machine manufacturing of FORON "Hausgeräte GmbH"
- 03.03.95 - Evaluation of present test results and explanation of further steps
  - Common check of Total Load calculations of Refrigerator models according to the given data for determining of refrigerating cycle components
- 06.03.95 - Evaluation of present test results
  - Description of the procedure for practical determining of cabinet constant C
- 07.03.95 - Visit of the factory for compressor manufacturing of FORON "Hausgeräte GmbH"
  - Evaluation of present test results
  - Theoretical view to thermodynamic refrigerating cycle
- 08.03.95 - Preparation of experimental tests for further refrigerator models
  - Seminar about using of FORON computer simulation program relative to calculation and selection of refrigerating cycle components
- 09.03.95 - Evaluation of present test results
  - Demonstration by video about KS-refrigerator manufacturing of FORON
- 10.03.95 - Evaluation of present test results
  - Evaluation and discussion of the provisional report
  - Seminar about experience of FORON in refrigerator service by using the different refrigerants CFC 12, HFC 134a and hydrocarbons

- 13.03.95 - Evaluation of present test results
  - Product load calculations and descriptions for further tests
- 14.03.95 - Evaluation of present test results
  - An additional Seminar to the same topic of 01.03.95
- 15.03.95 - Calculations for design of refrigerating devices
  - Visit of refrigerator production line and cyclopentane plant of FORON Co.
- 16.03.95 - Evaluation of present results
  - Evaluation and discussion of final report

## **2. Measurements on refrigerator model AR08 of Azmayesh Co., according to DIN 8950**

**This model AR08 was prepared for testing by joined activities of "dkk" and "Azmayesh" Firms.**

**The following preparatory work was carried out:**

- (1) According to the valid technical security in Germany the following activities were carried out:**
  - Connection of a new mains supply cable with protection**
  - Binding the refrigerator housing to the protected connection system**
  - Carrying out of technical test according to DIN 57700/ VDE 0700**
- (2) Arrangement of thermoelements for temperature recording according to DIN 8950**

## 2.1. Test on a continuous run for climate class T

Test conditions: - Proof test of power efficiency on continuous run  
(Thermostat adjustment at position 8)

- ambient temperature  $t_a = 43\text{ °C}$
- Distance condenser/Wall about 1 cm

### 2.1.1. Without test packages

Test results:

- Temperature in cooling compartments  $t_m$ : +4,9 °C
- two stars freezer compartment  $t^{**}$ : -11,4 °C
- celler compartment  $t_{cm}$ : +9,9 °C
- Power input  $P_1$ : 113 W
- voltage/ frequency: 220 V/ 50Hz

### 2.1.2. With test packages

Test results:

Parameter	actual value	rated value
- Temperature in cooling compartments, $t_m$	+6,4 °C	$\leq +5\text{ °C}$
- two stars freezer compartment, $t_{pw}$ (Temperature of the warmest test package)	-9,0 °C	$\leq -12\text{ °C}$
- celler compartment, $t_{cm}$	+11,4 °C	$+8\text{ °C} \leq t_{cm} \leq 14\text{ °C}$
- Power input, $P_1$	113 W	

## 2.2. Test on cyclic run

### 2.2.1 Ambient temperature $t_a = + 43 \text{ }^\circ\text{C}$

Test conditions: - Thermostat adjustment on position 3,5  
- Test package according to DIN 8950  
- Distance condenser/Wall 1 cm

Test results: - Temperature in cooling compartment  $t_m$ :  $+8,1 \text{ }^\circ\text{C}$   
- Temperature in the warmest test package  $t_{wp}$ :  $-6,8 \text{ }^\circ\text{C}$

Relative switch time  $\frac{\text{running time}}{\text{total measuring time}} \sim 85 \%$

Temperature difference between condenser (third turn) and Filter dryer  $\Delta t$ : 2,5 K

### 2.2.2 Ambient temperature $t_a = + 32 \text{ }^\circ\text{C}$

a) Thermostat adjustment at position 4.0  
Test conditions: - Test packages according to DIN 8950  
- Distance condenser/Wall about 5 cm

#### Test results

Parameter	Actual value	Rated value
Temp. in cooling compartments, $t_m$	6,1 $^\circ\text{C}$	5 $^\circ\text{C} \pm 0,5$
Temp. of the warmest test package $t_{wp}$	-5,2 $^\circ\text{C}$	$\leq -12 \text{ }^\circ\text{C}$
Celler compartment $t_{cm}$	9,2	$+8 \text{ }^\circ\text{C} \leq t_{cm} \leq 14 \text{ }^\circ\text{C}$
Energy consumption	1,1 kWh	-
Relative switch time	45 %	-

b) Thermostat adjustment at position 6.0  
Test conditions refer to a)

#### Test results

Parameter	Actual value	Rated value
Temp. in cooling compartments, $t_m$	4,6 $^\circ\text{C}$	5 $^\circ\text{C} \pm 0,5$
Temp. of the warmest test package $t_{wp}$	-7,4 $^\circ\text{C}$	$\leq -12 \text{ }^\circ\text{C}$
Celler compartment $t_{cm}$	9,2 $^\circ\text{C}$	$+8 \text{ }^\circ\text{C} \leq t_{cm} \leq 14 \text{ }^\circ\text{C}$
Energy consumption	1,17 kWh	-
Relative switch time	39,6 %	-



### 3. Determination of the cabinet constant C

Conditions:

- The refrigerator is standing in the air conditioned room at ( $t_a$ )
- Installation of electrical heater of ( $P$ ) inside the refrigerator cabinet for getting inside temperature ( $t_i$ )
- The difference ( $t_i - t_a$ ) should be equal  $\sim 20$  K

$$\text{Cabinet constant C: } C = \frac{P}{(t_i - t_a)}$$

$$P \text{ in W}$$
$$(t_i - t_a) \text{ in K}$$

Example: AR08

$$P = 20 \text{ W}$$
$$t_i = 37,86 \text{ }^\circ\text{C}$$
$$t_a = 25,43 \text{ }^\circ\text{C}$$

$$C = \frac{P}{(t_i - t_a)} = \frac{20 \text{ W}}{(37,86 - 25,43) \text{ K}} = 1,61 \text{ W/K}$$

The cabinet constant of refrigerator model AR08 is 1,61 W/K.

The practical overall heat transfer coefficient ( $K$ ) can be found from  $C$  as follows:

$$K = \frac{C}{A}$$

units for  $C$  in W/K and  $A$  in  $\text{m}^2$

$A$ : effective heat transmission area

Simple derivation for separate cabinet constant of freezer compartment and refrigerator compartment (cooling compartment enclosing celler compartment) can be found as follows:

$$C_1 = K * A_1 \quad A_1: \text{effective heat transfer area of two stars freezer compartment}$$

$$C_2 = K * A_2 \quad A_2: \text{effective heat transfer area of cooling compartment enclosing celler compartment}$$

Simple calculation of Transmission heat  $Q_T$

$Q_T = Q_{T1} + Q_{T2}$        $Q_{T1}$  = Transmission heat relative to two stars freezer compartment

$Q_{T1} = C_1 * \Delta t_1$        $Q_{T2}$  = Transmission heat relative to cooling compartment enclosing  
celler compartment

$Q_{T2} = C_2 * \Delta t_2$

$\Delta t_1 = t_a - t_{i1}$

$\Delta t_2 = t_a - t_{i2}$

$t_{i1} = -12 \text{ }^\circ\text{C}$

$t_{i2} = +5 \text{ }^\circ\text{C}$

$t_a = +43 \text{ }^\circ\text{C}$

#### 4. Test on refrigerator models VC 52 ATG and NR 58 LAEG of Arj co.

##### 4.1. Determination of cabinet constant

Determination of the constants is corresponding to the method explained in item no. 3

##### Results:

Model	Cabinet constant
VC 52 AJG	1,37 W/ K
NR 58 LAEG	1,56 W/ K

##### 4.2. Test on model VC 52 AJG

##### Test on continuous run

- Conditions:
- ambient temperature  $t_a = +43 \text{ }^\circ\text{C}$
  - Distance condenser/ wall is about 5 cm
  - without test packages
  - Voltage/ frequency: 220 V~/ 50 Hz

- Results:
- Temperature of the cooling compartment,  $t_m = -3,7 \text{ }^\circ\text{C}$
  - Temperature of two stars compartment,  $t^{**} = -19,7 \text{ }^\circ\text{C}$
  - Temperature of celler compartment,  $t_{cm} = +0,8 \text{ }^\circ\text{C}$

## 5. Summary of test results for climate class T

### 5.1. Model AR 08 of Azmayesh co.

Test	Parameter	actual value	rated value
- continuons run with test packages at $t_a = +43\text{ }^\circ\text{C}$	- Temperature in the cooling compartment, $t_m$	+6,4 °C	$\leq +5\text{ }^\circ\text{C}$
	- Temperature of the warmest test package, $t_{wp}$	-9,0 °C	$\leq -12\text{ }^\circ\text{C}$
	- Temperature of celler compartment $t_{cm}$	+11,4 °C	$+8\text{ }^\circ\text{C} \leq t_{cm} \leq 14\text{ }^\circ\text{C}$
- cyclic run at $t_a = +32\text{ }^\circ\text{C}$ Thermostat adjust- ment (Position 4.0) and distance condenser/wall of 5 cm	- Temperature in the cooling compartment, $t_m$	+6,1 °C	$+5\text{ }^\circ\text{C} \pm 5$
	- Temperature of the warmest package, $t_{wp}$	-5,2 °C	$\leq -12\text{ }^\circ\text{C}$
	- Temperature of celler compartment $t_{cm}$	+9,2 °C	$+8\text{ }^\circ\text{C} \leq t_{cm} \leq 14\text{ }^\circ\text{C}$
	- Energy consumption	1,1 kWh	-
	- relative switch time	45 %	-
- cyclic run at $t_a = +32\text{ }^\circ\text{C}$ Thermostat adjust- ment (Position 6.0) and distance condenser/wall of 5 cm	- Temperature in the cooling compartment, $t_m$	+4,6 °C	$+5\text{ }^\circ\text{C} \pm 5$
	- Temperature of the warmest package, $t_{wp}$	-7,4 °C	$\leq -12\text{ }^\circ\text{C}$
	- Temperature of celler compartment $t_{cm}$	+8,1 °C	$+8\text{ }^\circ\text{C} \leq t_{cm} \leq 14\text{ }^\circ\text{C}$
	- Energy consumption	1,17 kWh	-
	- relative switch time	40 %	-

### 5.2 Model VC 52 AIG working on CFC 12 of Arj co.

Test	Parameter	actual value	rated value
- continuons run without test packages at $t_a = +43\text{ }^\circ\text{C}$	- Temperature in the cooling compartment, $t_m$	-3,7 °C	-
	- Temperatur of two stars freezer compartment, $t^{**}$	-19,7 °C	-
	- Temperature of celler compartment $t_{cm}$	+0,8 °C	-

## 6. Evaluation of results and suggestions for further tests

### 6.1. Model AR 08 of Azmayesh co.

- With the present construction the demands will not be attainable for climate class T according to DIN 8950.
- On consideration of the calculated total load of 107 W and the selected compressor of Aspera, type BP 1084 with a capacity ( $Q_0$ ) of 77 W at evaporating temperature ( $t_0$ ) of -25 °C the demands will not be fulfilled according to DIN 8950.
- With the present mounted compressor the following temperature measurements (according to item 2.2.2. b) were recorded:
  - warmest test package,  $t_{wp} = -7,4$  °C
  - temperature in cooling compartment,  $t_m = +4,6$  °C
- It is necessary to have a suitable compressor with a higher capacity to achieve the minimal required temperature of the warmest test package ( $t_{wp}$ ) of -12 °C.  
On the one hand the attainable cooling capacity at this replaceable compressor can insure the required minimal temperature ( $t_{wp}$ ), on the other hand the temperature in the cooling compartment ( $t_m$ ) will decrease down to non-valid temperatures.

Following suggestions for further steps:

1. Application of a compressor with a minimal cooling capacity  $Q_0$  of 107 W at evaporating temperature  $t_0$  of -25 °C
2. Optimization of the refrigerant charge
3. Test according to DIN 8950
4. An improvement of coordination between two stars compartment and cooling compartment to ensure the required temperatures of the warmest test package ( $t_{wp}$ ) and of the cooling compartment ( $t_m$ ).
5. At further negative test results optimization of refrigerating cycle components should start
6. An improvement of energy levels according to EU-guideline 92/75/EWG is available by an improvement of the cabinet insulation.

## **6.2. Model VC 52 AJG**

The recorded results from the test on continuous run without test packages at an ambient temperature  $t_a = +43$  °C show, that the present cooling capacity should be available for further classification.

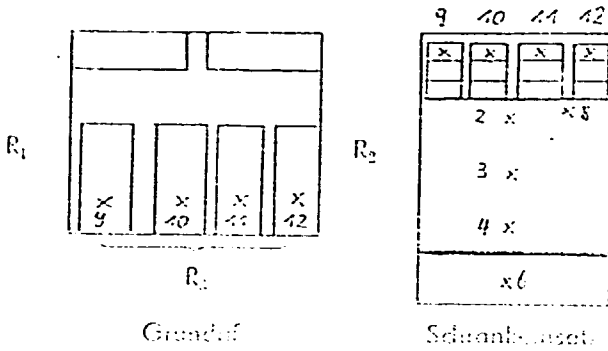
Following suggestions for further steps:

- Optimization of the refrigerant charge
- Carrying out of the test according to DIN 8950 (ISO/ DIS 7371)
- Evaluation of energy levels according to EU-guideline 92/75/EWG
- Preparation of suggestions to improve energy levels on base of their actual values

## **7. Layouts**

- Test reports

Anordnung der Temperaturmeßstellen



Prüfung Nr.	
Schranktype	
Schrank Nr.	
Brutto-Inhalt	230 l
Netto-Inhalt	
Eri. Heizbel.	
Aggregat Typ	Aspera BP1084Z
Aggregat Nr.	
Motor Typ	
Verdichter Typ	
Verdichter Nr.	
Kältemittel	R134a / 110g
Thermostat Typ	
Isolierung	PIR
geprüft am	
Durch	

Lüftemitteltemperatur  $t_{L1}$  43°C  
 $t_{L2}$   
 $t_{L3}$  Schreiber

Schreiber für Schranktemperatur: Nr.

Klassifizierung

Klimo Klasse T  
 Dauerlauf

Bezeichnung

3

... ..

... ..

... .. 24

... .. 24 (Standard)

... .. 100%

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

Bemerkung

10. 3. 95

*[Signature]*

Anlage 2

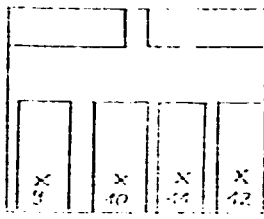
DIN 8950

Leistungsprüfung

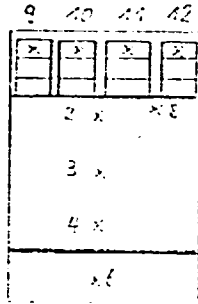
2.2.2. a)

Anordnung der Temperaturmessstellen

R<sub>1</sub>



R<sub>2</sub>



Schreibweise

Prüfnummer

R<sub>1</sub>  
R<sub>2</sub>  
R<sub>3</sub>

32°C

Schreiber 2  
H.

Schreiber für Lufttemperatur R<sub>1</sub>

Klassifizierung  
4,0

Klimaklasse T

Belegstellen

Prüfraumtemperatur (R<sub>1</sub>)

Prüfraumtemperatur (R<sub>2</sub>)

Prüfraumtemperatur (R<sub>3</sub>)

Prüfraumtemperatur (R<sub>4</sub>)

Prüfraumtemperatur (R<sub>1</sub>)

Prüfraumtemperatur (R<sub>1</sub>)

Prüfraumtemperatur (R<sub>1</sub>)

6,6 5,5 5,2 3,2 -5,8 -5,7 -5,9 -7,0

Bemerkung

10.3.95

Prüfung Nr.

Schranktype

Schrank Nr.

Brutto-Inhalt

230 l

Netto-Inhalt

Erf. Heizbel.

Aggregat Typ

Aspera BP4084Z

Aggregat Nr.

Motor Typ

Verdichtungsart

Verdichtungs Nr.

Kältemittel

R234a / R1202

Thermosicht Typ

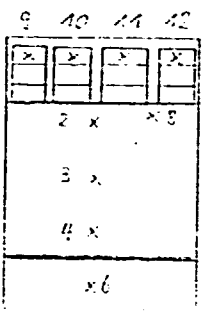
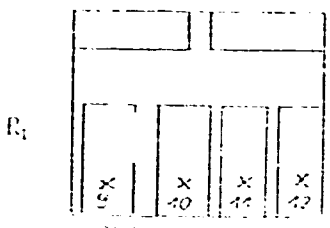
Isolierung

PUR

geprüft am  
durch



Anordnung der Temperaturstellen



Prüfung Nr.	
Schranktype	
Schrank Nr.	
Brutto-Inhalt	230 l
Netto-Inhalt	
Erf. Heizbel.	
Aggregat Typ	Aspera BP10847
Aggregat Nr.	
Küster Typ	
Verdichter Typ	
Verdichter Nr.	
Haltezeit I	R2544 1000g
Thermostat Typ	
Isolierung	PUR
geprüft am	
durch	

Prof. Nr. 3200  
 Anzahl: 2  
 ...

Schreiber für Behälternummer Nr.

Klassifizierung 60 Klimaklasse T

Hersteller

8541

21,57

~ 40%

1,05

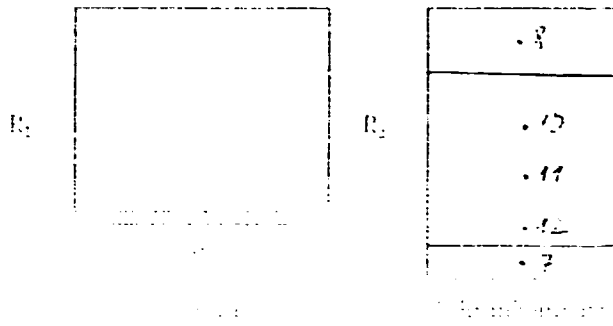
1,17

54 40 30 80 -79 -75 -80 -88

Bemerkung

10. 3. 95

Anordnung der Temperaturmessstellen



Temperaturmessstelle:  $43^{\circ}\text{C}$

Prüfung für:  
 Schranktyp:  
 Schrank Nr.:  
 Brutto-Inhalt:  
 Netto-Inhalt:  
 Erf. Heizbel.:  
 Äquivalenttyp:  
 Äquivalent Nr.:  
 Belüftung:  
 Isolierung:  
 Verschlussart:  
 Kältemittel:  
 Dämmstofftyp:  
 Isolierung:  
 geprüft von:  
 durch:

VC52 ATG

280 L

R12

PUR

Klimaklasse T

Dauerlauf ohne Testpackung

Prüfungsnr.: 8

24

24

100%

100-11.2

40-3.3-2.9

Bemerkung

16.3.95 *Joy Müll*