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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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UNIDO Contract No. 97/001
UNIDO Project No. MP/CPR/96/087

Final Report

February 1999

Table of Content

1. Summary

The engineering part of the product conversion in the Dongbei Refrigaration Manufacture Group Co., Ltd. started with an in-depth analysis of the factory situation in spring 1997.

The engineering level, the production cleanliness and the standards of quality control altogether were already well advanced and state of the art, so that conversion process went very smoothly and straight forward. The R12 versions of the compressors were tested in dkk´s laboratory. The results confirmed Dongbei´s data sheets as the zero-line of the conversion target.

Conversion approach took into account

- reduction of death volume
- reduction of mechanical losses
- investigation of motor improvement
- implementation of plastic muffler
- usage of EC.

Concept was tested with QD 142 as the pilot case and confirmed in several steps.
After success of the pilot conversion the concept was applied to the other five models of the QD series selected by Dongbei.

Samples were built according to the new drawings and assembled with consideration of the new set of parameters and tolerances.

The target in

- cooling capacity
- performance in terms of COP
- noise level
- start up voltage

were achieved.

After successful training and final supervision the company started production in quantity for several pilot customers. All field tests and laboratory certificates were positive and confirmed:

Dongbei has successfully converted the former compressor line QD to highly efficient Isobutane compressors and Dongbei is ready and capable to produce the new line in quantity.

2. Work performed during the conversion project

2.1 Development of conversion concept

2.1.1 Analysis of existing status

At the beginning of the project the following status existed as found out in two factory visits.

2.1.1.1 Process technology

Process technology was state of the art besides cleaning equipment. Results of continuous monitoring of residual contamination and humidity proved adequacy also for R600a. No machine replacement or change required due to conversion to hydrocarbon.

2.1.1.2 Laboratory and test facility

Well equipped and properly handled. For R600a additional detectors and safety equipment required.

2.1.1.3 Quality

Continuous quality monitoring. ISO 9001 in place.

2.1.1.4 Product

The QD product line is of Tecumseh origin, from there sold to Aspera and licensed to Dongbei in 1988 with expiration date of 1995. Dongbei implemented already some major design changes on it's own, such as:

- reduction in height to fit into smaller compartments
- modification of oil pump for lower pressure pipes with spring to lower some of the frequencies
- reduction of oil volume by 50 mltr because of height reduction
- increase thickness of housing from 3 mm to 3,5 mm to reduce noise
- piston and valve plates are planned to be out of sinter instead of cast iron (for piston already 40 % implemented), valves are nor considered to be changed to sinter
- electrical module scheduled to use PTC relay

Electrical motors are purchased from outside without modifications known since production start.

2.1.1.5 Available data

All required data on design, production and measurement were available and immediately handed out apart from motor diagrams of electrical motor.

2.1.2 Conversion target

Dongbei decided to focus conversion on

- QD70 to become DB140 with Isobutane (working name)
- QD90 to become DB160 with Isobutane
- QD98 to become DB180 with Isobutane
- QD120 to become DB200 with Isobutane

where the numbers indicate the cooling capacity according to ASHRAE. As the QD90/DB160 is most important model, all modifications first had to be verified with this model.

Major target was COP not less than 1.3. All other performance data should at least match the present product data with special attention on

- start up voltage not higher than 165 V
- noise according to EN not more than 39 dB.

On the Chinese market displacement volume is an issue, therefore attention had to be paid to reach performance goals with lowest possible displacement at least in the second step.

Cost efficiency was of increasing importance. Design modifications for performance improvement should take into account the resulting cost implications and be presented to Dongbei for acceptance or revision of goals.

2.1.3 Conversion approach

Conversion had to be accomplished in several subsequent steps as the modifications are partly interdependent from each other.

The results of each step was the basis for further refinement.

As far as larger displacement for Isobutane was required (about two times of R12) for DB140 and DB160 the existing parts defining displacement of larger QD-types should be used.

2.1.3.1 Reduction of death volume

Reduction of death volume is crucial for COP and of special importance at lower evaporation temperature such as for freezer.

New drawings were provided for

- crankcase
- crankshaft
- piston
- piston cold pressure extrusion part
- seal valve plate-cylinder
- valve plate
- suction valve plate
- gasket cylinder head

Piston and cylinder had less chamfer. Piston design had to be simplified: no oil way and cross boring.

Suction valve had to be of integrated design (out of seal valve plate). Seal valve plate had to be of sinter to reduce thickness.

For DB180 and 200 new cylinder head had to be designed for larger displacement, not only through increase of stroke from 61 mm to 65 mm. Increase only through diameter will lead to an increase of death volume which not even through additional plastic muffler can be compensated.

2.1.3.2 Reduction of mechanical losses

Utilisation of oils with lower viscosity.
After results of computer simulation, new allocation of clearance pairs were expected. For this measurement data of statistical significance were required from Dongbei.

A new design of connecting road shall lead to lower losses. The losses in the piston were reduced by avoiding the groove which Aspera was using.

2.1.3.3 Improvement of motor efficiency

The motor diagram was available only for the set point of the motor. Dkk defined in it's own laboratory the missing motor characteristic to assess the efficiency of the motor.

After first tests with the pilot Isobutane compressors new allocation of motor with compressor were tuning the efficiency,

EC motor were considered and evaluated afterwards.

2.1.3.4 Plastic muffler

Utilisation of plastic muffler is very common in the Chinese market and was expected to lead to an efficiency increase of more than 10 % by the counterpart' engineers.

According to dkk´s experience this is only true for R134a, whereas to the lower temperature at the suction side with Isobutane of app. 15 to 20 ^{0}C and due to the lower dependency on temperature the gain of COP through plastic muffler is not more than 5 % for Isobutane. With the additional costs of plastic muffler of about 1 to 2 US$ this had to be a change only in the second step. The importance also is partly eaten up by some of the changes in 2.1.3.1.

2.2 Establishing of Zero line

Dongbei has sent to dkk samples out of production:

- eight compressors, design R12, four types
  - 2 pieces QD90
  - 2 pieces QD98
  - 2 pieces QD120
  - 2 pieces QD142
- complete Compressor parts for ten QD142, except the suction valve plate and the cylinder gasket (as agreed)

Laboratory test dkk confirmed the Dongbei data sheet for R12.

For detailed data see first interim report.

2.3 Pilot conversion for QD142

The QD142 was modified in steps to verify the conversion approach.

The calorimeter results with refrigerant R12 and R600a of the original design are shown the tables 2 – 9 of first interim report.

The original design of the QD142–R600a reached a COP of 1,08 W/W. This is the base point for the measuring R600a. dkk has tested the influence of:

- motor MAF694
- DI - internal discharge tube
- oil – WE5452
- plastic muffler
- new parts: piston, integrated suction valve plate, crankshaft, crankcase, gasket cylinder, optimised tolerances

The version with the motor MAF694, DI 1,77 and new oil reached a COP 1,28 W/W. This was a visible progress compared to the base point, but the target value was not yet reached.

With the new parts a COP of 1,32 W/W has been reached. The next versions had been performed with the same motor, internal discharge tube and oil. The difference was the plastic muffler and the original suction inlet. The best result of the COP was 1,39 W/W.

The reduction of the death volume was a very important point. The losses could have been reduced through the new piston, valve plate (death volume) and the smaller groove. The volumetric efficiency has been improved and therefore the cooling capacity too. The influence of the plastic muffler was low. According to dkk´s experience this is valid for refrigerant with high temperatures as R134a, R12 and similar.

Additional major changes were due to the noise-level reduction.

The original design, special shell and cover of the DB180-R600a reached a level about 44 dB(A). This is a very bad value for R600a. The main reason were the Shell, suction tract and fixing of the compressor block.

The improvement of the noise level from 44,5 to 36 dB(A) and lower had been reached by following changes:

- shell, fastening the compressor with compression springs
- new cover
- suction gas duct, suction valve plate 0,2 mm
- design of the valve
- crankshaft oil bores 3,5 mm
- plastic muffler
- valve plate, suction and pressure bores
- drive device (crankshaft, piston)

The compressor block had to be put on four compression springs. The fastening of the springs was reached with two mounting plates (left, right).

The cover form had been changed to reduce the noise.

The suction gas duct had been designed with a plastic muffler to the inlet suction bore.

The thickness of the suction valve plate had been reduced to 0,2 mm.

The piston had been redesigned with oil groove.

The oil bores in the crankshaft have been reduced.

Drawings were prepared for all types according to the verified approach for the pilot model.

Subsequently further refinements were implemented by Dongbei based on extensive testing.

2.4 Production process

2.4.1 Part production

Part production was kept, as the required parameter for precision, cleanliness and humidity were already in place.

All changes as far as parts, parameters and tolerances of existing machines and changes of material specifications are concerned were handed over in form of individual tables per part.

2.4.2 Assembly line

The assembly required more a precise system for leak detection.
Specification had been provided to UNIDO.

2.4.3 Test equipment

Additional test equipment had been discussed during the study trip together with UNIDO.

Additional supervision and alarm system was required for calorimeter test-area together with improved exhaust system.

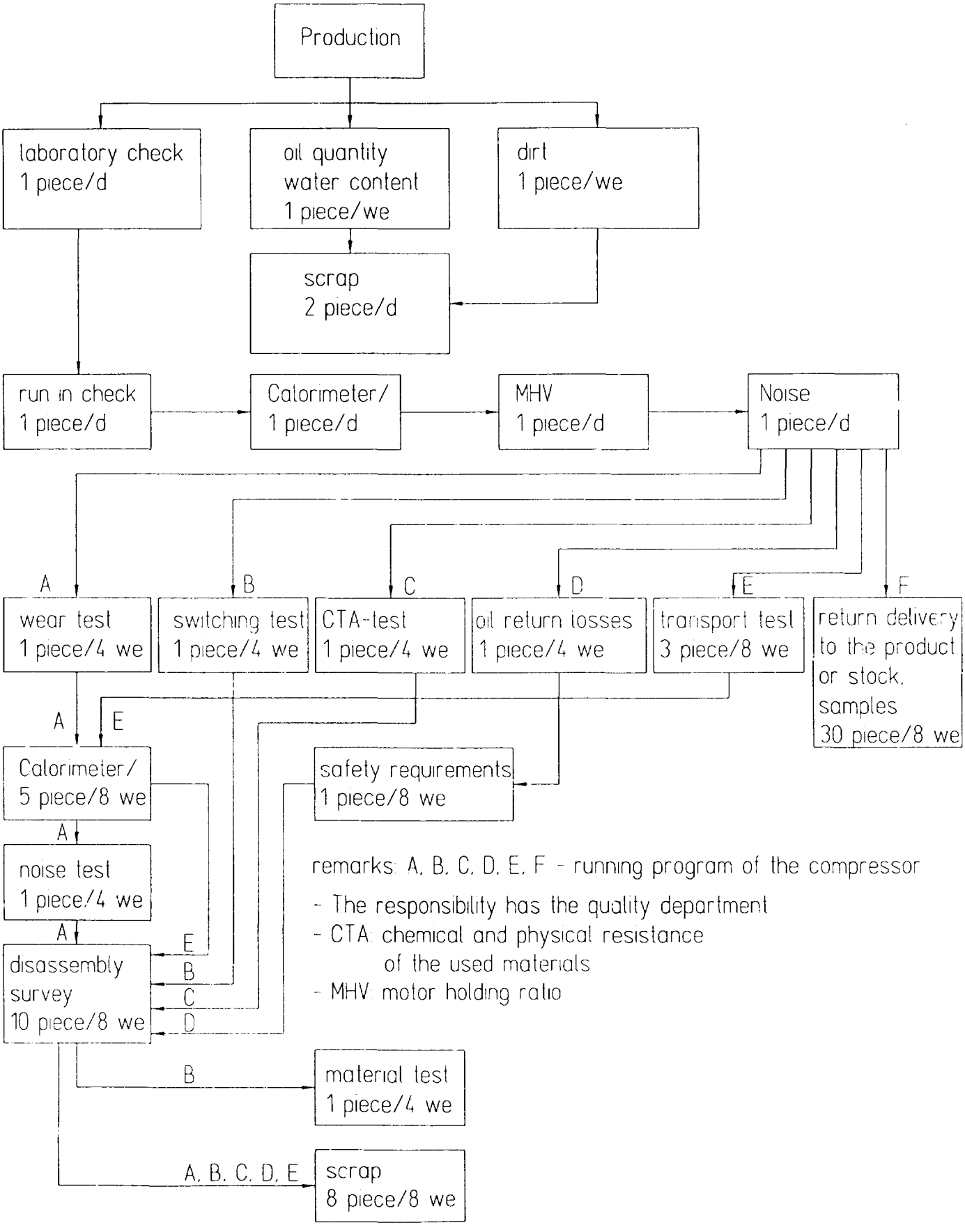
Specification was supplied to UNIDO.

2.4.4 Quality Assurance

Proven standards for quality data and flow chart of quality assurance were provided and explained for local adaptation.

Dongbei

Compressor series check in the laboratory



2.5 Study trip

At the end of the pilot conversion a study trip in Europe was organised to enlarge the perception of hydrocarbon compressors production by

- factory training
- visit to compressor factories in Germany and Poland
- visit to compressor motor plant
- visit to independent certification institute
- visit to leak detection manufacturer
- visit to electric motor equipment manufacturer.

2.6 Training and supervision

Senior factory engineers were trained on a specific program with the following headlines:

1.	training for laboratory staff
1.1	conversion of the test stands
1.2	standards
1.3	refrigerants
1.4	compressor test R600a
1.5	explosion limit
1.6	leak detector
1.7	instruction of staff
2.	training of production staff
2.1	adjustment dead volume
2.2	co-ordination of the parts – according to the drawing
2.3	co-ordination of motor – compressor
2.4	check and supervision of the precondition values
2.5	oil

Final supervision confirmed readiness of factory, product and people to produce Isobutane compressors.

3. Work performed after start-up of modified plant

The modified plant started quantity production in November for selected pilot customers.
For marketing purpose the modified products were renamed.

3.1 Haier

1000 compressors of QD88Y and more than 1000 pieces of QD100Y were delivered to Haier in Qindao, first part already in September.

More than 2000 pieces of QD123Y were also shipped to Haier

Laboratory and field tests of Haier were successful.

3.2 Wanbao

Samples of all models were delivered to Wanbao factory in Guangzhou for qualification. Positive test results were confirmed in laboratory test reports by Wanbao.

3.3 dkk

Samples from first production month were shipped to dkk to cross-check the test data obtained from Chinese Standard Test Centre.

Results fully confirmed the previous measurement data – see attachment.

Test – Report

Measuring Calorimeter – R600a

Compressors: QD69Y, QD81Y, QD100Y, QD135Y

performed by dkk

UNIDO Project: Dongbei

Date: 1999-01-20

1. **Design**

Hermetic compressor for household refrigerators
Refrigerant: R600a
220V/50Hz
Climate class: N
Application: LST

QD68Y to QD100Y with run capacitor
QD135 without run capacitor

2. **Conditions**

ASHRAE conditions:

to -25 °C, -23,3 °C, -15 °C

$t_a = t_{gl} = 32{,}2$ °C

$t_f = 54{,}5$ °C $t_{fl} = 32{,}2$ °C

static ventilation

220V/ 50Hz

3. **Conversion target**

I. Cooling Capacity R600a corresponds the range of 100 to 200 W

II. COP not less than 1,3 W/W [ASHRAE rated point -23,3 °C]

4 **Results**

4.1 **Calorimeter**

The data of the calorimeter measuring are summarized in the tables QD69Y to QD135Y.
Furthermore all values are shown in the protocols of calorimeter measuring.

The cooling capacity is between 100 W and 200W. The designed target has been reached and even exceeded.

The compressor QD135Y was not delivered with run capacitor. The other models have the run capacitor with 3 µF whereby the input power will be decreased. This improvement is to be seen in conjunction with an adjustment of the motor. The high efficiency motor improves therefore also the COP.

The COP values moves in a range from 1,35 W/W to 1,47 W/W at the ASHRAE rated point.

The conversion has been performed successfull of all models.

Proposal for the rated values Qo [W], P_1 [W], COP [W/W]

	Qo [W]	P_1 [W]	COP [W/W]
QD69Y	102	79	1,29
QD81Y	125	95	1,31
QD100Y	165	115	1,43
QD135Y	200	145	1,38

The QD88Y and the QD123Y have been rated in a former report. (see behind)
Meanwhile Dongbei has improved the performance data of QD 88Y by adding a run capacitor.

4.2 **Start test**

The start of the compressors have been rated in conjunction with the measuring of the sweep voltage.

The sweep voltage is the measuring value where the compressor motor is just before he stop.

The compressor has constant and stable conditions of temperature and pressure.

	Uk [V]
QD69Y	95
QD81Y	115
QD100Y	112
QD135Y	113

All compressors have a large reserve to the rated voltage and therefore the start reaction is sure.

Date 27.01.1999

dkk
Gesellschaft für Entwicklung
und Projektmanagement mbH
August-Bebel-Straße 24
D/09435 Scharfenstein
Tel. 0 37 25 / 7 07 60 · Fax 0 37 25 / 70 76 21

Protocol 1

Compressor data — collected on 15.01.99

Compressor type	: QD69Y	Compressor No. :	981686
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		
Recording	: qd69y dongbei 0199		

Calorimeter Data

Conditions						
				Measuring date	15.01.1999	
				Worker	we	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
3. Evaporating temperature	[°C]	:	-23,3	R cold	[Ohm]	: 13,25
Cooling capacity	[W]	:	86,0	R warm	[Ohm]	: 15,95
Input power	[W]	:	77,5	Constant heating V	[V]	: 0
COP	[W/W]	:	1,11	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	95	Constant heating P	[W]	: 25
Current	[A]	:	0,465	Switch heating start	[time]	: 9.59
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 11.02
Winding temperature	[°C]	:	86,4	Switch heating duration	[s]	: 3808
Discharge pipe temperature	[°C]	:	58	Real power counter start	[KWh]	: 5,3982
Temperature behind elec. casing	[°C]	:	65,5	Real power counter end	[KWh]	: 5,4825
Temperatur casing top	[°C]	:	61,5	Energy consumption	[KWh]	: 0,0843
Temperature casing bottom	[°C]	:	64,0	Energy consumption	[Ws]	: 303480
Revolution per minute	[1/s]	:	49,3	Heating power	[W]	: 79,695
Heating power total	[W]	:	104,7	factor	[-]	: 0,8215
Heating power total	[kcal/h]	:	90,04	Viscosity	[cSt]	: -

Compressor data — collected on 15.01.99

Compressor type	: QD69Y	Compressor No. :	981686
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		
Recording	: qd69y dongbei 0199		

Conditions	like above listed					
				Measuring date	15.01.1999	
				Worker	we	
2. Evaporating temperature	[°C]	:	-25,0	R cold	[Ohm]	: 13,25
Cooling capacity	[W]	:	79,4	R warm	[Ohm]	: 15,9
Input power	[W]	:	74,2	Constant heating V	[V]	: 0
COP	[W/W]	:	1,07	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	92	Constant heating P	[W]	: 20
Current	[A]	:	0,455	Switch heating start	[time]	: 15.00
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 16.02
Winding temperature	[°C]	:	85,4	Switch heating duration	[s]	: 3655
Discharge pipe temperature	[°C]	:	57,5	Real power counter start	[KWh]	: 5,779
Temperature behind elec. casing	[°C]	:	64,5	Real power counter end	[KWh]	: 5,8568
Temperatur casing top	[°C]	:	60,5	Energy consumption	[KWh]	: 0,0778
Temperature casing bottom	[°C]	:	64,0	Energy consumption	[Ws]	: 280080
Revolution per minute	[1/s]	:	49,3	Heating power	[W]	: 76,629
Heating power total	[W]	:	96,63	factor	[-]	: 0,8216
Heating power total	[kcal/h]	:	83,1	Viscosity	[cSt]	: -

Protocol 2

Compressor data collected on 15.01.99

Compressor type	: QD69Y	Compressor No. :	981686
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		
Recording	: qd69y dongbei 0199		

Calorimeter Data

Conditions						
				Measuring date	15.01.1999	
				Worker	we	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
3. Evaporating temperature	[°C]	:	-15,0	R cold	[Ohm]	: 13,05
Cooling capacity	[W]	:	170,9	R warm	[Ohm]	: 16,1
Input power	[W]	:	115,2	Constant heating V	[V]	: 0
COP	[W/W]	:	1,48	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	128	Constant heating P	[W]	: 25
Current	[A]	:	0,63	Switch heating start	[time]	: 9.59
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 11.02
Winding temperature	[°C]	:	94,4	Switch heating duration	[s]	: 3808
Discharge pipe temperature	[°C]	:	76,3	Real power counter start	[KWh]	: 5,3982
Temperature behind elec. casing	[°C]	:	65,5	Real power counter end	[KWh]	: 5,4825
Temperatur casing top	[°C]	:	63,0	Energy consumption	[KWh]	: 0,0843
Temperature casing bottom	[°C]	:	59,0	Energy consumption	[Ws]	: 303480
Revolution per minute	[1/s]	:	48,9	Heating power	[W]	: 79,695
Heating power total	[W]	:	208,14	factor	[-]	: 0,8215
Heating power total	[kcal/h]	:	179	Viscosity	[cSt]	: -

Protocol 3

Compressor data collected on 14.01.99

Compressor type	: QD81Y	Compressor No. :	981068
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		

Recording : qd81y dongbei 0199

Calorimeter Data

Conditions

			Measuring date	14.01.1999		
			Worker	we		
Operating Current	[V]	: 220,0	Ventilation	static		
Condensing temperature	[°C]	: 55,0	Frequency	[Hz]	:	50
Ambient temperature	[°C]	: 32,0	Liquid subcooled to	[°C]	:	55
tg2 Outlet calorimeter	[°C]	: 32,0	tg1 Suction pipe	[°C]	:	32
			tf2 on valve	[°C]	:	32
1. Evaporating temperature	[°C]	: -23,3	R cold	[Ohm]	:	13,05
Cooling capacity	[W]	: 105,6	R warm	[Ohm]	:	16,2
Input power	[W]	: 94,5	Constant heating V	[V]	:	0
COP	[W/W]	: 1,12	Constant heating C	[A]	:	0
Sweep voltage	[V]	: 115	Constant heating P	[W]	:	56,5
Current	[A]	: 0,54	Switch heating start	[time]	:	10. 33
Vol. Cooling Capacity	[W/cm³]	:	Switch heating end	[time]	:	11. 34
Winding temperature	[°C]	: 96,4	Switch heating duration	[s]	:	3687
Discharge pipe temperature	[°C]	: 67,1	Real power counter start	[KWh]	:	4,8318
Temperature behind elec. casing	[°C]	: 64,0	Real power counter end	[KWh]	:	4,9056
Temperatur casing top	[°C]	: 62,0	Energy consumption	[KWh]	:	0,0738
Temperature casing bottom	[°C]	: 60,0	Energy consumption	[Ws]	:	265680
Revolution per minute	[1/s]	: 49,1	Heating power	[W]	:	72,059
Heating power total	[W]	: 128,56	factor	[-]	:	0,8215
Heating power total	[kcal/h]	: 110,56	Viscosity	[cSt]	:	-

Compressor data

Compressor type	: QD81Y	Compressor No. :	981068
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		

Recording : qd81y dongbei 0199

Calorimeter Data

Conditions like above listed

			Measuring date	14.01.1999		
			Worker	we		
2. Evaporating temperature	[°C]	: -25,0	R cold	[Ohm]	:	13,05
Cooling capacity	[W]	: 93,9	R warm	[Ohm]	:	16,25
Input power	[W]	: 88,3	Constant heating V	[V]	:	0
COP	[W/W]	: 1,06	Constant heating C	[A]	:	0
Sweep voltage	[V]	: 100	Constant heating P	[W]	:	39
Current	[A]	: 0,52	Switch heating start	[time]	:	14 .24
Vol. Cooling Capacity	[W/cm³]	:	Switch heating end	[time]	:	15 .25
Winding temperature	[°C]	: 97,5	Switch heating duration	[s]	:	3686
Discharge pipe temperature	[°C]	: 63,5	Real power counter start	[KWh]	:	5,1154
Temperature behind elec. casing	[°C]	: 64,0	Real power counter end	[KWh]	:	5,1925
Temperatur casing top	[°C]	: 61,5	Energy consumption	[KWh]	:	0,0771
Temperature casing bottom	[°C]	: 62,0	Energy consumption	[Ws]	:	277560
Revolution per minute	[1/s]	: 49,1	Heating power	[W]	:	75,301
Heating power total	[W]	: 114,3	factor	[-]	:	0,8216
Heating power total	[kcal/h]	: 98,3	Viscosity	[cSt]	:	-

Protocol 4

Compressor data collected on 14.01.99

Compressor type	: QD81Y	Compressor No. :	981068
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		

Recording : qd81y dongbei 0199

Calorimeter Data

Conditions

				Measuring date	14.01.1999	
				Worker	we	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
3. Evaporating temperature	[°C]	:	-15,0	R cold	[Ohm]	: 13,05
Cooling capacity	[W]	:	170,9	R warm	[Ohm]	: 16,1
Input power	[W]	:	115,2	Constant heating V	[V]	: 0
COP	[W/W]	:	1,48	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	128	Constant heating P	[W]	: 134
Current	[A]	:	0,63	Switch heating start	[time]	: 12.38
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 13.38
Winding temperature	[°C]	:	94,4	Switch heating duration	[s]	: 3632
Discharge pipe temperature	[°C]	:	76,3	Real power counter start	[KWh]	: 4,9823
Temperature behind elec. casing	[°C]	:	65,5	Real power counter end	[KWh]	: 5,0571
Temperatur casing top	[°C]	:	63,0	Energy consumption	[KWh]	: 0,0748
Temperature casing bottom	[°C]	:	59,0	Energy consumption	[Ws]	: 269280
Revolution per minute	[1/s]	:	48,9	Heating power	[W]	: 74,141
Heating power total	[W]	:	208,14	factor	[-]	: 0,8212
Heating power total	[kcal/h]	:	179	Viscosity	[cSt]	: -

Protocol 5

Compressor data collected on 18.01.99

Compressor type	: QD100Y	Compressor No. :	981684
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		

Recording : qd100y dongbei 0199

Calorimeter Data

Conditions				Measuring date	18.01.1999	
				Worker	wc	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
3. Evaporating temperature	[°C]	:	-23,3	R cold	[Ohm]	: 13,15
Cooling capacity	[W]	:	137,0	R warm	[Ohm]	: 16,1
Input power	[W]	:	113,8	Constant heating V	[V]	: 0
COP	[W/W]	:	1,20	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	112	Constant heating P	[W]	: 90
Current	[A]	:	0,6	Switch heating start	[time]	: 10.07
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 11.09
Winding temperature	[°C]	:	91,9	Switch heating duration	[s]	: 3712
Discharge pipe temperature	[°C]	:	72,7	Real power counter start	[KWh]	: 6,0409
Temperature behind elec. casing	[°C]	:	68,5	Real power counter end	[KWh]	: 6,1201
Temperatur casing top	[°C]	:	65,5	Energy consumption	[KWh]	: 0,0792
Temperature casing bottom	[°C]	:	63,5	Energy consumption	[Ws]	: 285120
Revolution per minute	[1/s]	:	48,9	Heating power	[W]	: 76,81
Heating power total	[W]	:	166,81	factor	[-]	: 0,8215
Heating power total	[kcal/h]	:	143,46	Viscosity	[cSt]	: -

Compressor data collected on 18.01.99

Compressor type	: QD100Y	Compressor No. :	981684
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		

Recording : qd100y dongbei 0199

Conditions like above listed				Measuring date	18.01.1999	
				Worker	wc	
2. Evaporating temperature	[°C]	:	-25,0	R cold	[Ohm]	: 13,15
Cooling capacity	[W]	:	127,3	R warm	[Ohm]	: 16,05
Input power	[W]	:	108,0	Constant heating V	[V]	: 0
COP	[W/W]	:	1,18	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	110	Constant heating P	[W]	: 72,5
Current	[A]	:	0,58	Switch heating start	[time]	: 14.29
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 15.35
Winding temperature	[°C]	:	90,9	Switch heating duration	[s]	: 3946
Discharge pipe temperature	[°C]	:	70,8	Real power counter start	[KWh]	: 6,3942
Temperature behind elec. casing	[°C]	:	66,6	Real power counter end	[KWh]	: 6,4846
Temperatur casing top	[°C]	:	65,5	Energy consumption	[KWh]	: 0,0904
Temperature casing bottom	[°C]	:	65,0	Energy consumption	[Ws]	: 325440
Revolution per minute	[1/s]	:	48,9	Heating power	[W]	: 82,473
Heating power total	[W]	:	154,97	factor	[-]	: 0,8216
Heating power total	[kcal/h]	:	133,27	Viscosity	[cSt]	: -

Protocol 6

Compressor data collected on 18.01.99

Compressor type	: QD100Y	Compressor No. :	981684
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: with run capacitor		

Recording : qd100y dongbei 0199

Calorimeter Data

Conditions						
				Measuring date	18.01.1999	
				Worker	we	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
3. Evaporating temperature	[°C]	:	-15,0	R cold	[Ohm]	: 13,15
Cooling capacity	[W]	:	222,2	R warm	[Ohm]	: 15,9
Input power	[W]	:	145,5	Constant heating V	[V]	: 0
COP	[W/W]	:	1,53	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	128	Constant heating P	[W]	: 195
Current	[A]	:	0,74	Switch heating start	[time]	: 12.41
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 13.41
Winding temperature	[°C]	:	87,8	Switch heating duration	[s]	: 3603
Discharge pipe temperature	[°C]	:	80,7	Real power counter start	[KWh]	: 6,2627
Temperature behind elec. casing	[°C]	:	63,0	Real power counter end	[KWh]	: 6,3384
Temperatur casing top	[°C]	:	67,0	Energy consumption	[KWh]	: 0,0757
Temperature casing bottom	[°C]	:	62,0	Energy consumption	[Ws]	: 272520
Revolution per minute	[1/s]	:	48,6	Heating power	[W]	: 75,637
Heating power total	[W]	:	270,64	factor	[-]	: 0,8212
Heating power total	[kcal/h]	:	232,75	Viscosity	[cSt]	: -

Protocol 7

Compressor data collected on 13.01.99

Compressor type	: QD135Y	Compressor No. :	981688
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: without run capacitor		
Recording	: qd135y dongbei 0199		

Calorimeter Data

Conditions

				Measuring date	13.01.1999	
				Worker	we	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
1. Evaporating temperature	[°C]	:	-23,3	R cold	[Ohm]	: 9,7
Cooling capacity	[W]	:	167,5	R warm	[Ohm]	: 11,8
Input power	[W]	:	145,0	Constant heating V	[V]	: 0
COP	[W/W]	:	1,15	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	120	Constant heating P	[W]	: 125,5
Current	[A]	:	0,98	Switch heating start	[time]	: 10 :05
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 11 :06
Winding temperature	[°C]	:	89,8	Switch heating duration	[s]	: 3662
Discharge pipe temperature	[°C]	:	84,2	Real power counter start	[KWh]	: 4,1191
Temperature behind elec. casing	[°C]	:	71,0	Real power counter end	[KWh]	: 4,1989
Temperatur casing top	[°C]	:	69,0	Energy consumption	[KWh]	: 0,0798
Temperature casing bottom	[°C]	:	64,0	Energy consumption	[Ws]	: 287280
Revolution per minute	[1/s]	:	48,6	Heating power	[W]	: 78,449
Heating power total	[W]	:	203,95	factor	[-]	: 0,8212
Heating power total	[kcal/h]	:	175,4	Viscosity	[cSt]	: -

Compressor data

Compressor type	: QD135Y	Compressor No. :	981688
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: without run capacitor		
Recording	: qd135y dongbei 0199		

Calorimeter Data

Conditions like above listed

				Measuring date	13.01.1999	
				Worker	we	
2. Evaporating temperature	[°C]	:	-25,0	R cold	[Ohm]	: 9,7
Cooling capacity	[W]	:	153,6	R warm	[Ohm]	: 11,9
Input power	[W]	:	139,0	Constant heating V	[V]	: 0
COP	[W/W]	:	1,11	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	113	Constant heating P	[W]	: 112
Current	[A]	:	0,955	Switch heating start	[time]	: 15,00
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 16,02
Winding temperature	[°C]	:	92,6	Switch heating duration	[s]	: 3693
Discharge pipe temperature	[°C]	:	83,3	Real power counter start	[KWh]	: 4,517
Temperature behind elec. casing	[°C]	:	71,0	Real power counter end	[KWh]	: 4,5939
Temperatur casing top	[°C]	:	68,0	Energy consumption	[KWh]	: 0,0769
Temperature casing bottom	[°C]	:	60,0	Energy consumption	[Ws]	: 276840
Revolution per minute	[1/s]	:	48,7	Heating power	[W]	: 74,963
Heating power total	[W]	:	186,96	factor	[-]	: 0,8216
Heating power total	[kcal/h]	:	160,79	Viscosity	[cSt]	: -

Protocol 8

Compressor data collected on 13.01.99

Compressor type	: QD135Y	Compressor No. :	981688
Variant	: sample Dongbei		
Design	: R600a		
Remarks	: without run capacitor		

Recording : qd135y dongbei 0199

Calorimeter Data

Conditions						
				Measuring date	13.01.1999	
				Worker	we	
Operating Current	[V]	:	220,0	Ventilation	static	
Condensing temperature	[°C]	:	55,0	Frequency	[Hz]	: 50
Ambient temperature	[°C]	:	32,0	Liquid subcooled to	[°C]	: 55
tg2 Outlet calorimeter	[°C]	:	32,0	tg1 Suction pipe	[°C]	: 32
				tf2 on valve	[°C]	: 32
3. Evaporating temperature	[°C]	:	-15,0	R cold	[Ohm]	: 9,7
Cooling capacity	[W]	:	266,1	R warm	[Ohm]	: 11,7
Input power	[W]	:	187,0	Constant heating V	[V]	: 0
COP	[W/W]	:	1,42	Constant heating C	[A]	: 0
Sweep voltage	[V]	:	135	Constant heating P	[W]	: 245
Current	[A]	:	1,13	Switch heating start	[time]	: 12.51
Vol. Cooling Capacity	[W/cm³]	:		Switch heating end	[time]	: 13.54
Winding temperature	[°C]	:	87,1	Switch heating duration	[s]	: 3760
Discharge pipe temperature	[°C]	:	91,1	Real power counter start	[KWh]	: 4,3575
Temperature behind elec. casing	[°C]	:	70,5	Real power counter end	[KWh]	: 4,4401
Temperatur casing top	[°C]	:	68,5	Energy consumption	[KWh]	: 0,0826
Temperature casing bottom	[°C]	:	61,5	Energy consumption	[Ws]	: 297360
Revolution per minute	[1/s]	:	48,1	Heating power	[W]	: 79,085
Heating power total	[W]	:	324,09	factor	[-]	: 0,8216
Heating power total	[kcal/h]	:	278,72	Viscosity	[cSt]	: -

Calorimeter Data

Date: 1999-01-19

Q/Ri

TYPE:	QD 69Y
Design:	run capacitor,R600a
Refrigerant:	R600a
Recording:	qd69y dongbei 0199
Start:	0199

Conditions: 220V/50Hz ASHRAE

Compr.No.	to	Ventilation	Qo	P1	COP	Uk	I_1	Qvol	tw	tg_3	tsch	tko	tku	n	remarks
	°C		W	W	W/W	V	A	W/cm³	°C	°C	°C	°C	°C	1/s	
981686	-25	static	96,3	74,2	1,30	92	0,45	-	85,4	57,5	64,5	60,5	64,0	49,3	
981686	-23,3	static	104,7	77,5	1,35	95	0,46	-	86,4	58,0	65,5	61,5	64,0	49,3	
981686	-15	static	179,5	97,5	1,84	105	0,55	-	84,4	69,0	66,0	62,0	63,0	49	

Calorimeter Data

Date: 1999-01-19

Q/Ri

TYPE:	QD 81Y
Design:	run capacitor,R600a
Conditions:	220V/50Hz
Refrigerant:	R600a
	ASHRAE
Recording:	qd81y dongbei 0199
Start:	0199

Compr.No.	to	Ventilation	Qo	P1	COP	Uk	I_1	Qvol	tw	tg_3	tsch	tko	tku	n	remarks
	°C		W	W	W/W	V	A	W/cm³	°C	°C	°C	°C	°C	1/s	
981068	-25	static	114,3	88,3	1,29	100	0,52	-	97,5	63,5	64,0	61,5	62,0	49,1	
981068	-23,3	static	128,6	94,5	1,36	115	0,54	-	96,4	67,1	64,0	62,0	60,0	49,1	
981068	-15	static	208,1	115,2	1,81	128	0,63	-	94,4	76,3	65,5	63,0	59,0	48,9	

Calorimeter Data

Date: 1999-01-19

Q/Ri

TYPE:	QD 100Y
Design:	run capacitor,R600a
Refrigerant:	R600a
Recording:	qd100y dongbei 0199
Start:	0199
Conditions:	220V/50Hz
	ASHRAE

Compr.No.	to	Ventilation	Qo	P1	COP	Uk	I_1	Qvol	tw	tg_3	tsch	tko	tku	n	remarks
	°C		W	W	W/W	V	A	W/cm³	°C	°C	°C	°C	°C	1/s	
981684	-25	static	155,0	108,0	1,43	110	0,58	-	90,9	70,8	66,6	65,5	65,0	48,9	
981684	-23,3	static	166,8	113,8	1,47	112	0,6	-	91,9	72,7	68,5	65,5	63,5	48,9	
981684	-15	static	270,6	145,5	1,86	128	0,74	-	87,8	80,7	63,0	67,0	62,0	48,6	

Calorimeter Data

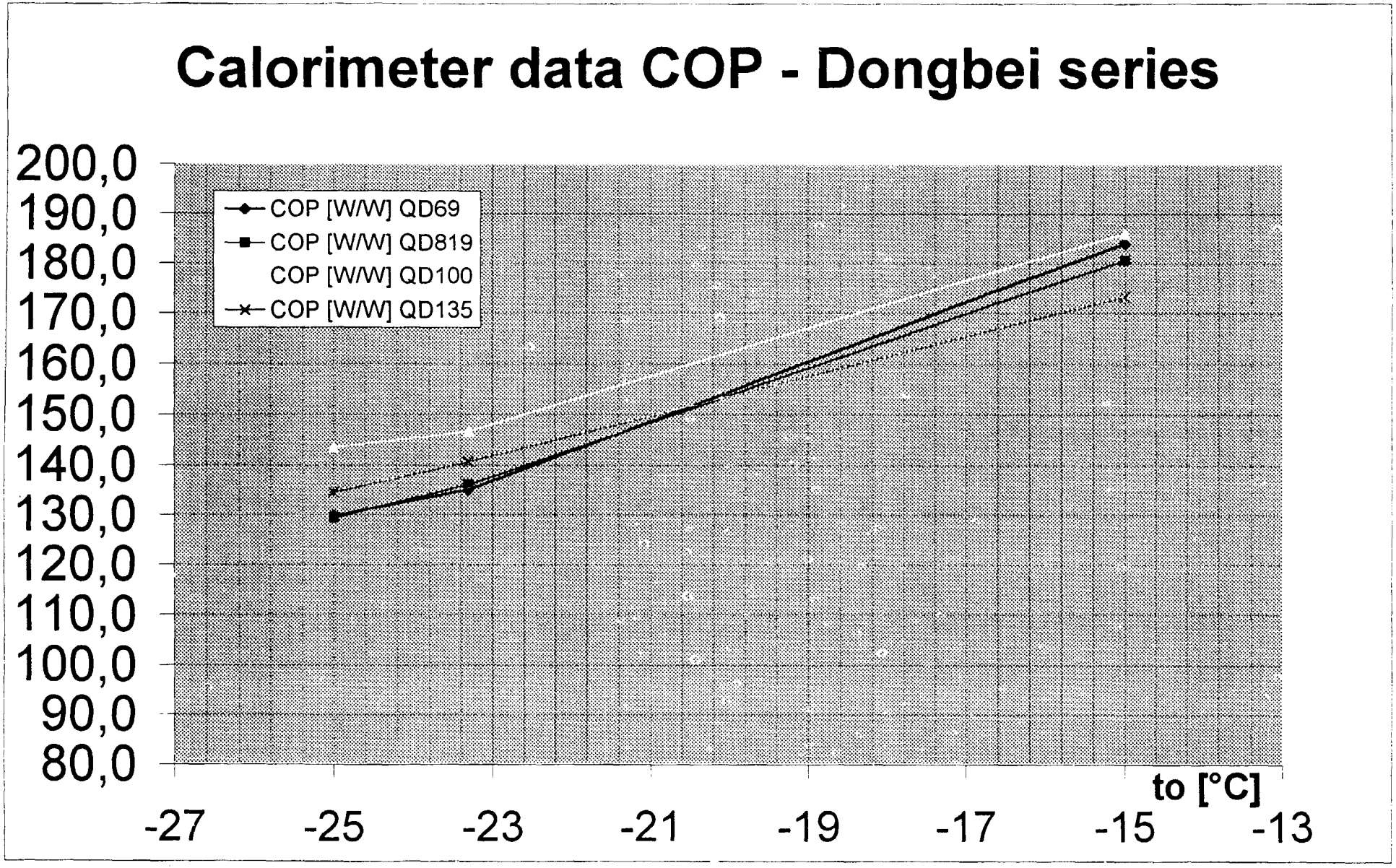
Date: 1999-01-19

Q/Ri

TYPE:	QD 135Y
Design:	without run capacitor,R600a
Refrigerant:	R600a
Recording:	qd135y dongbei 0199
Start:	0199

Conditions: 220V/50Hz ASHRAE

Compr.No.	to	Ventilation	Qo	P1	COP	Uk	I_1	Qvol	tw	tg_3	tsch	tko	tku	n	remarks
	°C		W	W	W/W	V	A	W/cm³	°C	°C	°C	°C	°C	1/s	
981688	-25	static	187,0	139,0	1,35	113	0,95	-	92,6	83,3	71,0	68,0	60,0	48,7	
981688	-23,3	static	204,0	145,0	1,41	120	0,98	-	89,8	84,2	71,0	69,0	64,0	48,6	
981688	-15	static	324,1	187	1,73	135	1,13	-	87,1	91,1	70,5	68,5	61,5	48,1	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100,0
90,0
80,0
COP [W/W] QD69
COP [W/W] QD819
COP [W/W] QD100
COP [W/W] QD135
to [°C]
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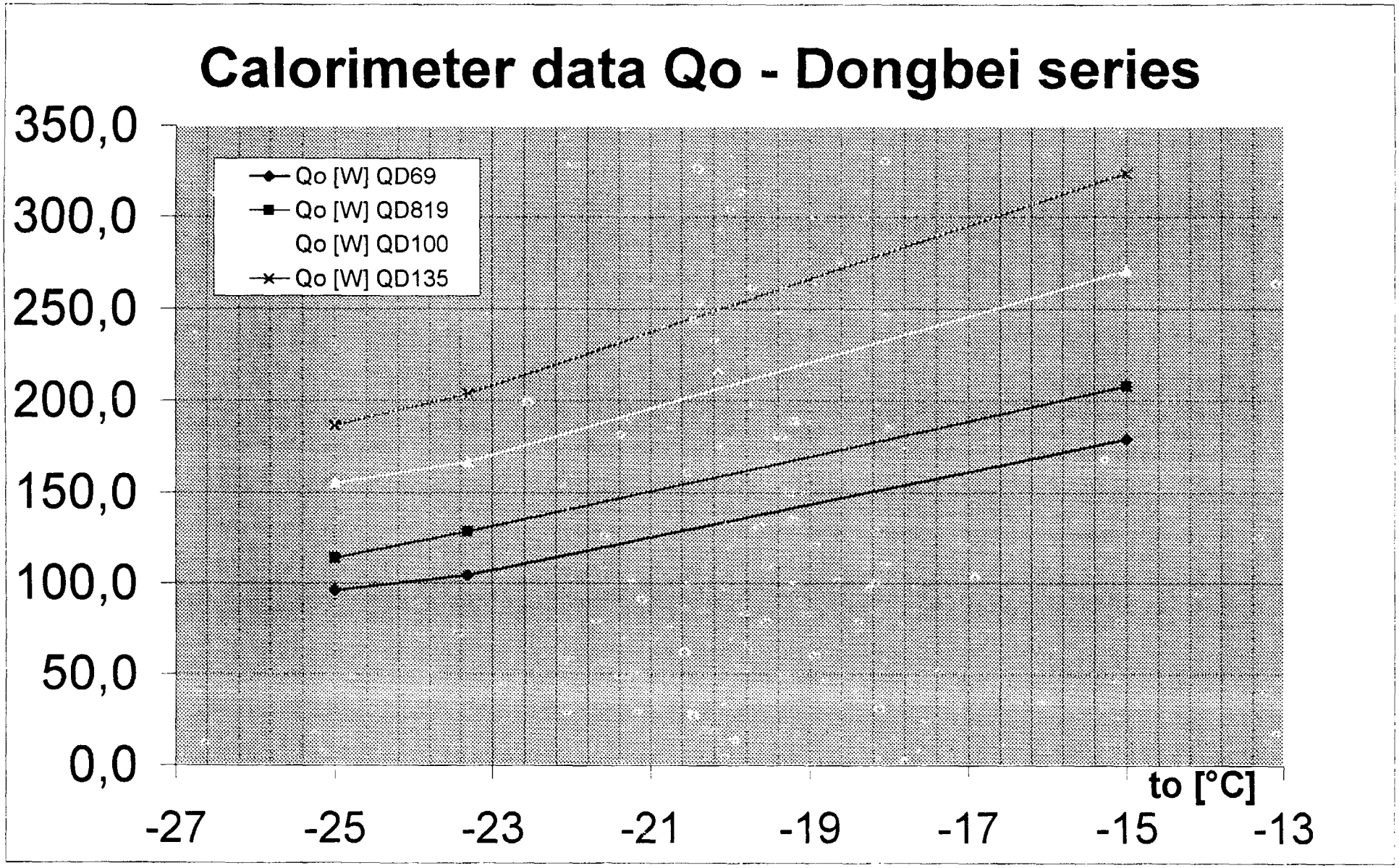
-25
-23
-21
-19
-17
-15
-13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Qo [W] QD819
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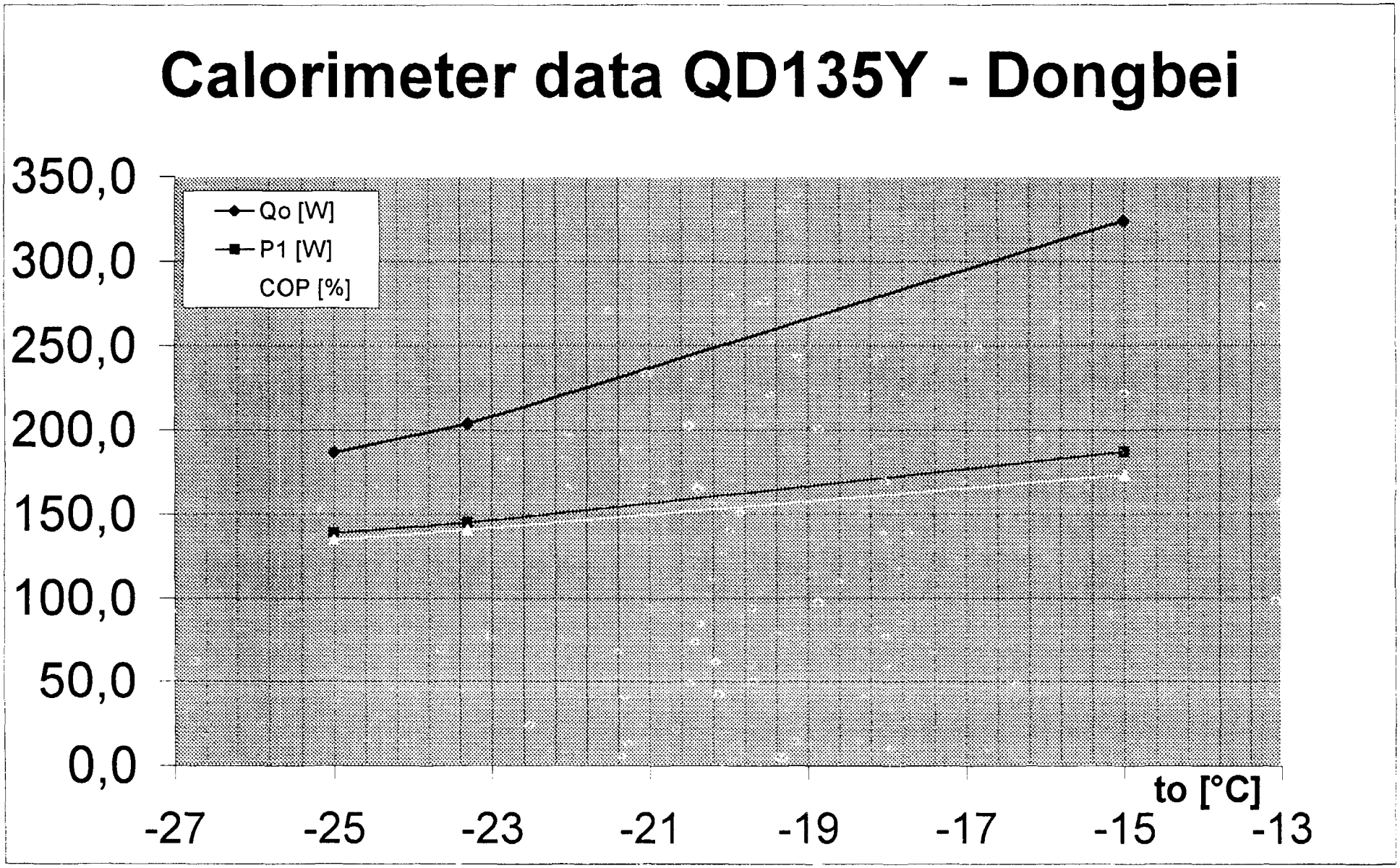
Qo [W] QD135
to [°C]
-27
-25
-23
-21
-19
-17
-15
-13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COP [%]
to [°C]
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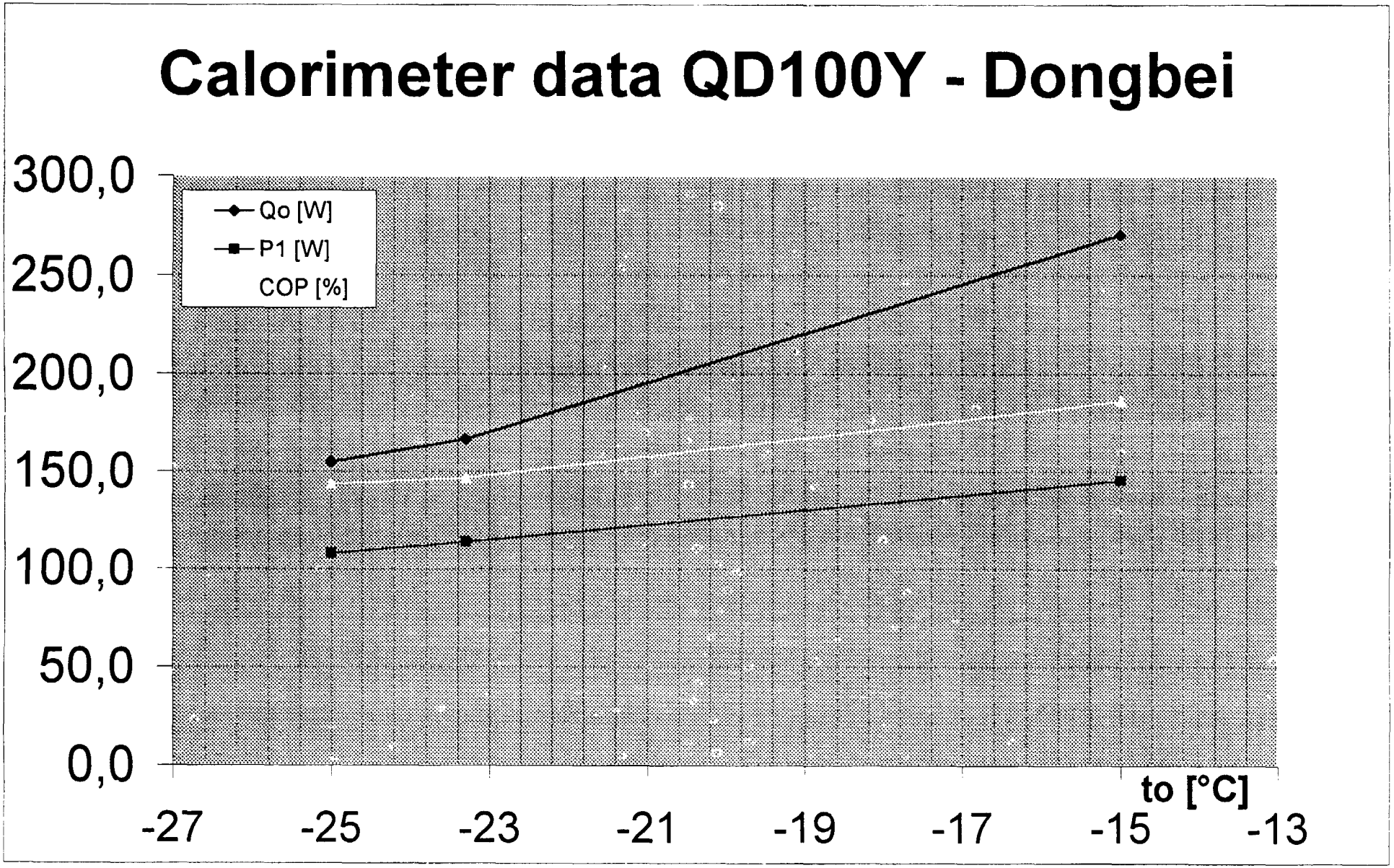
-25
-23
-21
-19
-17
-15
-13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COP [%]
to [°C]
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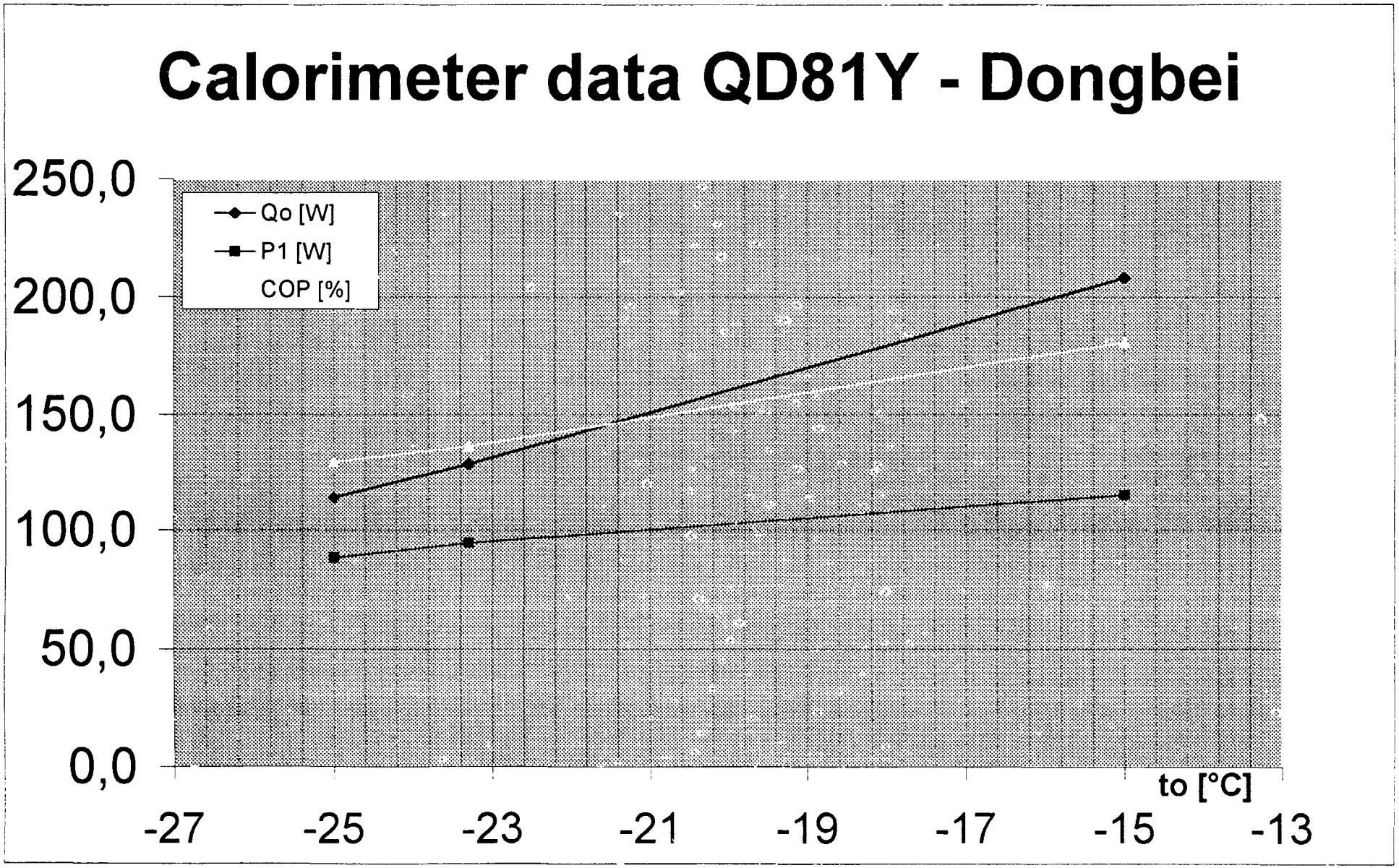
-21
-19
-17
-15
-13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COP [%]
to [°C]
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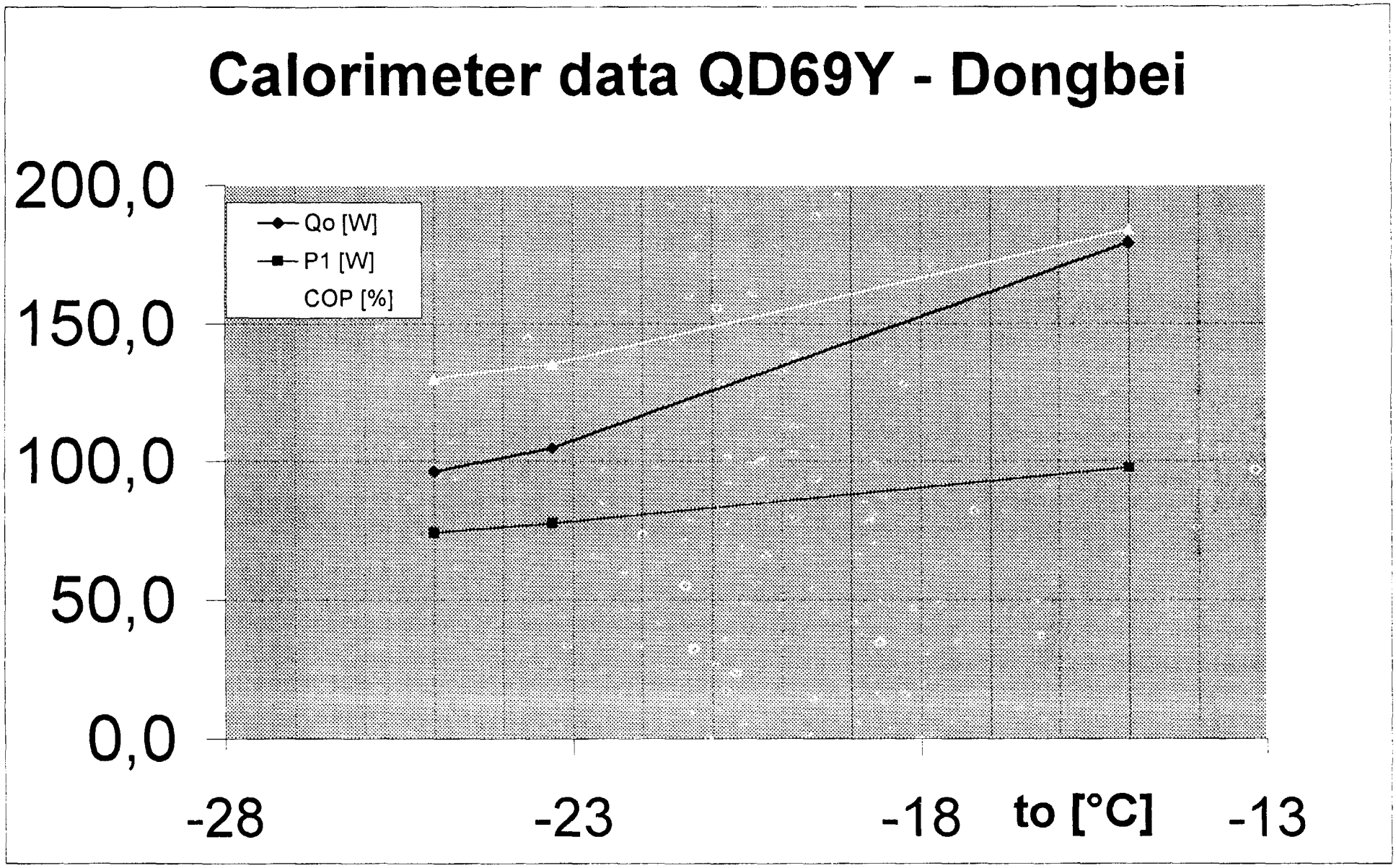
-25
-23
-21
-19
-17
-15
-13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0,0
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P1 [W]
COP [%]
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-23
-18
to [°C]
-13