

"International Energy Technologies"

**C1 OZONE-FRIENDLY
AZEOTROPIC
REFRIGERATING
MIXTURE**



JSC "INERTEK"

Inv. No. И/778

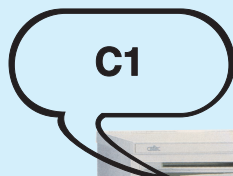
BOOKLET

**C1 OZONE-FRIENDLY AZEOTROPIC
REFRIGERATING MIXTURE**

**(Main results of properties investigations
and tests in refrigeration equipment)**

NOVELTY

**RUSSIAN
OZONE-FRIENDLY
REFRIGERANT C1- substitute
for R12 freon**



- Compares well with R12 in its indices.
- Can be used in refrigeration equipment designed for operation on R12 with no change to the equipment design.
- Pilot production is mastered
/TU-2412-040-00480689-94/.
- Protected by the RF patent and international priority under PCT.

Developed at M.V. Keldysh Research Center under the agreement with JSC "INERTEK".

Producer and supplier:

JSC "INERTEK"

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BRUSSELS EUREKA '94

43ème SALON MONDIAL DE L'INVENTION, DE LA RECHERCHE ET DE L'INNOVATION INDUSTRIELLE
43ste WERELDSALON VOOR UITVINDING, ONDERZOEK EN INDUSTRIELE VERNIEUWING
43rd SALON MUNDIAL DE LA INVENCION, INVESTIGACION E INNOVACION INDUSTRIAL
43rd WORLD EXHIBITION OF INVENTION, RESEARCH AND INDUSTRIAL INNOVATION
43. WELTMESSE FÜR ERFINDUNG, FORSCHUNG UND INDUSTRIELLE INNOVATION
43. SALONE MONDIALE DELL'INVENZIONE, DELLA RICERCA E DELL'INNOVAZIONE INDUSTRIALE

DIPLOMA

AO "JNERTEK"

POUR L'INVENTION Mélange frigorifique pour les machines frigorifiques.

Médaille de Bronze



BRUXELLES, 14/11/1994

LE RAPPORTEUR DU JURY

LE PRESIDENT DU COMITE
ORGANISATEUR DU SALON



РОССИЙСКАЯ ФЕДЕРАЦИЯ

КОМИТЕТ РОССИЙСКОЙ ФЕДЕРАЦИИ ПО ПАТЕНТАМ
И ТОВАРНЫМ ЗНАКАМ
(РОСПАТЕНТ)

ПАТЕНТ

№ 2088626

на ИЗОБРЕТЕНИЕ

"Рабочая смесь для холодильных машин"

Патентообладатель (ли): Акционерное общество "ИНЕРТЕК"

Автор (авторы): Барабанов Валерий Георгиевич, Беляев Андрей Юрьевич, Егоров Сергей Дмитриевич, Кондратьев Юрий Роальдович, Коротеев Анатолий Сазонович, Пономарев-Степной Николай Николаевич, Рувинский Генрих Яковлевич, Хмельнюк Михаил Георгиевич и Чикуров Сергей Константинович

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Заявка № 94015395

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реестре изобретений 27 августа 1997г.

ПРЕДСЕДАТЕЛЬ РОСПАТЕНТА





URZĄD PATENTOWY
RZECZYPOSPOLITEJ POLSKIEJ

Dokument patentowy

NA MOCY USTAWY Z DNIA 19 PAŹDZIERNIKA 1972 R.
O WYNAŁAZCZOŚCI (DZ. U. NR 26 Z 1993 R., POZ. 117)
ZOSTAŁ UDZIELONY NA RZECZ

SOVMESTNOE PREDPRIYATIE "INERTEK", Moskwa,
Federacja Rosyjska

PATENT

NR 178398

NA WYNAŁAZEK PT.
Mieszanka robocza dla urządzeń chłodniczych

PRZEDSTAWIONY W OPISIE PATENTOWYM
WŁĄCZONYM DO NINIEJSZEGO DOKUMENTU

PATENT TRWA OD DNIA 1994.08.15

WARSZAWA, DNIA 04 MAJ 2000

PREZES
z up. 
dr Zenobiusz Miklasinski
WICEPREZES

C1 Ozone-friendly Refrigerant.

Advantages:

- has a zero ozone depletion potential (ODP = 0) and a rather low global warming potential (GWP);
- does not require major modifications to compressors and domestic refrigeration equipment designed for operation with R12, can be used with mineral and synthetic oil;
- ensures the minimum power consumption of refrigeration equipment as compared to R12 and R134a.

Areas of application:

- domestic refrigeration equipment, shop equipment, automobile air conditioners with a leak-proof refrigerant circuit.

Level of readiness:

- established pilot production of C1 with annual output of up to 100 t;
- demonstrated favorable results of testing at virtually all of the Russian domestic refrigeration equipment factories, in USA, Slovakia, Poland, China, Korea, Singapore;
- the Krasnoyarsk Refrigerator Works released for sale a pilot lot of freezers. No claims have been made since 1995;
- based on sufficient scope of performed tests, high performance and relative simplicity of production process, C1 was recommended for use as refrigerant in domestic refrigeration equipment by the Science and Technology Council at the RF Ministry of Environment Protection and Natural Resources (Resolution of 14.09.94).

Protection:

- the Russian patent № 2088626 is obtained, specifications and sanitary certificate are issued;
- the Polish patent №178398 of 15.08.94, registered on 04.05.2000 is obtained;
- patenting is underway with EPO (France, Italy, Germany, Spain, UK), Finland, Hungary, Ukraine.

Commercialization proposals:

- delivery of the refrigerant for Russian and foreign refrigeration equipment in amounts of up to 100 t/y. If larger amounts are required, production of up to 3000 t/y can be established in the near future at Caustic Co., Volgograd, Russia;
- sale of a license for production of C1, for production equipment and technical documentation, fabrication and delivery of equipment.

Contact information: tel. (095)196-71-64, fax (095)196-89-71

JSC INERTEK

Veniamin A. USOV, Deputy General Director

The Scope of Performed Investigations of C1 Properties.

No.	Description	Main results	Note
1.	Power consumption of domestic refrigeration equipment were studied to substantiate patentability of C1.	JSC INERTEK obtained the RF patent № 2088626 of 27.04.94 and Polish patent № 178398. Patenting is underway with EPO (France, Italy, Germany, Spain, UK), Finland, Hungary, Ukraine. PCT/RU94/00191 of 27.04.94. JSC INERTEK was awarded by a Certificate and a Medal of the 43 rd International Exhibition of Inventions in Brussels for C1.	
2.	Thermodynamic and physical properties of C1 were studied over the temperature range of - 50 ÷ +175°C	The pressure-enthalpy chart was built for the temperature range of - 30°C ÷ + 70°C. P, ρ _o , H, S, Cp, Cv, phase composition, steam content were studied as a function of temperature.	Results of the studies are presented in the Booklet on C1. JSC INERTEK № AO-2/04.96 1996
3.	Corrosion resistance of metal materials and endurance of electric insulation materials in C1 refrigerant were studied.	Data on the corrosion rate and pattern at + 100°C were obtained for 500 hour tests.	- “ -
4.	Flammability characteristics of C1 were studied.	Data were obtained on the lower flammability concentration limit - 3,15 % by volume, permissible charges of domestic refrigeration equipment for different volume rooms (the safe C1 concentration in the closed room air is 18 g/m ³); ignition temperature (t ≥ 450 °C)	- “ -

The Scope of Performed Investigations of C1 Properties. (continued)

No.	Description	Main results	Note
5.	Environmental impact parameters of C1 were obtained as compared to other refrigerants.	ODP = 0 GWP = 98 (relative to CO ₂ =1.0)	- “ -
6.	Phase equilibrium states and volume ratios in the freon 152a - isobutane system were studied over the temperature range of 0-20°C	The presence of positive azeotrope in the system with the freon 152a mole fraction of 0,64-0,65 was demonstrated	- “ -
7.	Mutual solubility of C1 refrigerant and mineral oil was studied.	Solubility of C1 in mineral oil was demonstrated (oil content in wt. % and stratification temperatures, °C were determined)	- “ -
8.	Comparison studies of domestic refrigeration equipment using C1, R12 and R134a were performed	C1 was demonstrated to compare well with R12 and to surpass R134a in power consumption, refrigerating capacity, coefficient of performance.	- “ -
9.	Results of the investigations were used in development of Specifications for C1 production, Safety Certificate, and Sanitary Certificate.	Specifications TY 2412-040-00480689-94. Safety Certificate № 07544401.24.03650, 1998 Sanitary Certificate № 78 ЧП06241ТО4235*98 of 16.03.1998	- “ -

Table 1

**Comparison between Parameters of C1 and Parameters of Other
Ozone-friendly Refrigerants and R12
Used for Domestic Refrigeration Equipment.**

No.	<u>Refrigerant Parameter</u>	R12	C1	R134a	R600a	Hydro carbon mixture R290/ R600a, CARE30
1.	ODP (relative to R11)	1	0	0	0	0
2.	GWP (relative to CO ₂)	8500	98	1300	3	3
3.	Optimum charge, relative to R12	1	0,35 - 0,45	0,9	0,41	0,41
4.	COP	1	+10 %	lower than for R12	+10 %	+10 %
5.	Volumetric refrigerating capacity (relative to R12)	-	higher	similar	much lower	similar
6.	Flammability: <ul style="list-style-type: none"> • lower flammability concentration limit when mixed with air, % by volume/ g/m³ (LFCL); • upper limit, % by volume/ g/m³; • safe limit of concentration in air in a closed room, g/m³ (20% of LFCL) 	No - - -	Yes <u>3,15</u> 90 <u>16,5</u> 500 18	No * - - -	Yes <u>1,85</u> 48 <u>8,5</u> 220 10	Yes <u>1,95</u> 35 <u>9,1</u> 165 8
7.	Ignition temperature, ° C	-	450-520	-	460	430
8.	Substance	azeotrope	azeotrope	azeotrope	azeotrope	zeotrope
9.	Maximum permissible concentration for inhalation in the working area; mg/m ³ .	1000ppm	2200 (3000 for R152a 300 for R-600a)	3000ppm	300	300
10.	Possibility to use existing compressors designed for R12		possible	impossible	impossible	possible
11.	Possibility to use mineral oil used in compressors designed for R12		possible	impossible **	possible	possible

* When compressed by air, R134a may produce an inflammable mixture.

** Requires the use of more expensive synthetic oil that is sensitive to moisture.

The Scope of Testing C1 in Domestic Refrigeration Equipment of Different Types.

No.	Description	Main results	Note
1.	Testing of domestic refrigeration equipment produced by the Krasnoyarsk Refrigerator Works, RF: "Birusa-14" freezer, "Birusa-22", "Birusa-19" refrigerators	The tests have demonstrated positive results. The equipment complies with State Standards and Specifications in power consumption and temperature conditions. The Krasnoyarsk Refrigerator Works produced the pilot lot of "Birusa-14" freezers in 1995. No claims have been made since that time.	Test results are presented in a paper for the "Compressors-99" International Conference, Slovakia, 1999.
2.	Testing of D...XL1Z series compressors and SCV-130 freezer produced by Novy Calex, Slovakia	The tests have demonstrated positive results. Compressors with C1 demonstrate better refrigerating capacity and COP as compared to R12 and R134a (see Figs.1,2). Power consumption of SCV-130 with C1 is lower by 7÷13%	- " -
3.	Testing of domestic refrigeration equipment produced by Atlant Co., Byelorussia: MIII-154 freezer and KIIIД-152 refrigerator	The tests have demonstrated positive results. Further optimization for refrigerant charge and capillary tube throughput will allow improving performance of the domestic refrigeration equipment using C1.	- " -
4.	Testing of domestic refrigeration equipment produced by ZIL, RF: ZIL-64 refrigerator with V792R compressor using C1, CM1 and R12 refrigerating mixtures	C1 shows the least power consumption as compared to CM1, R12 refrigerants	- " -
5.	Testing of domestic refrigeration equipment produced by AKMA company, Singapore with R12 and C1 refrigerants.	For AK807 make of the refrigeration equipment, C1 shows power consumption by 16,9% lower than R12, and for AR716 make – by 5,6% lower than R12.	- " -
6.	Comparison tests of "Orsk-112" and "Orsk-115" refrigerators produced by Orsk Refrigerator Machine Works with R12 and C1.	The test results are encouraging. Optimization is required for C1 charge and capillary tube throughput, which will allow performance improvements when using C1.	Ormez Co. Ref. 49/25 of 02.12.96

The Scope of Testing C1 in Domestic Refrigeration Equipment of Different Types. (continued)

No.	Description	Main results	USA
7.	Testing of Sears Roebuck refrigerator and Ford Explorer automobile air conditioner at the Case Consulting Lab., USA	The tests have demonstrated positive results. For the optimized charge, power consumption of the refrigerator with C1 is lower by 10%.	Report of the Case Consulting Lab., USA № 00497-001
8.	Comparison tests of "Polar-138" refrigerator with SH-0,63E compressor produced by EDA company, Poland	The tests for power consumption, noise level and resistance of materials to C1 at required temperature conditions have demonstrated that C1 compares favorably with R12.	Report 40, EDA, 1996
9.	Bench tests of BC 500 (2) refrigeration unit and IIX-0,6 M2 cabinet at the Refrigeration Equipment Center, St.-Petersburg.	C1 shows the same refrigerating capacity as R12. Power consumption per unit of refrigeration is lower by ~ 10 % for C1.	Report of the Refrigeration Equipment Center, 1998

Efficiency of C1

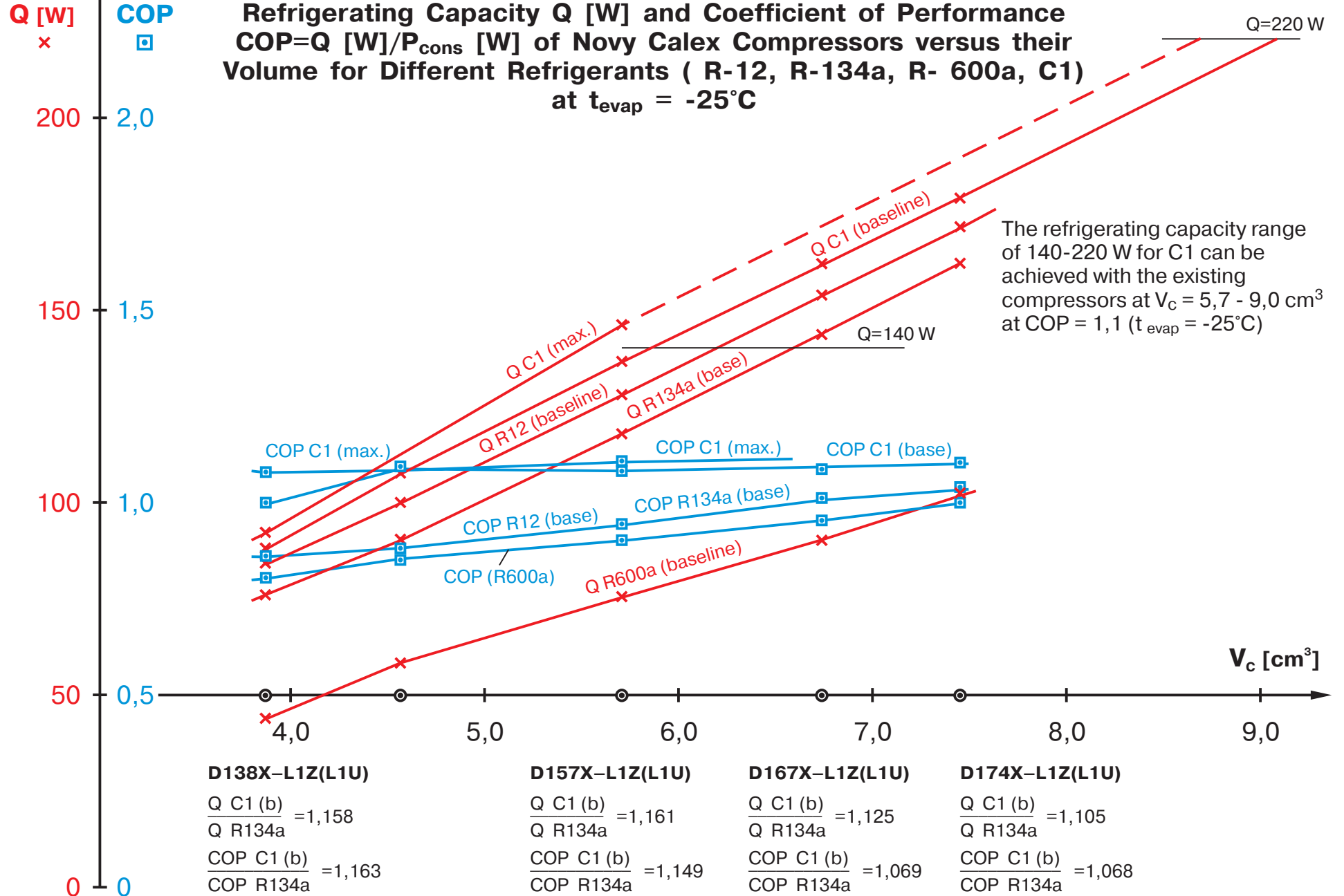


Fig. 1.

Refrigerating Capacity Q [W] and Coefficient of Performance $COP=Q$ [W]/ P_{cons} [W] of C1 Refrigerant versus Evaporation Temperature /at $t_{evap} = \text{Var}(\text{from } -5 \text{ to } -35^\circ\text{C})$,
 $t_{cond} = +55^\circ\text{C}$, $t_{amb} = +32^\circ\text{C}$, $t_{gas\ suction} = t_{overcool} = +32^\circ\text{C}$ /
 for D157X-L1U Novy Calex Compressor

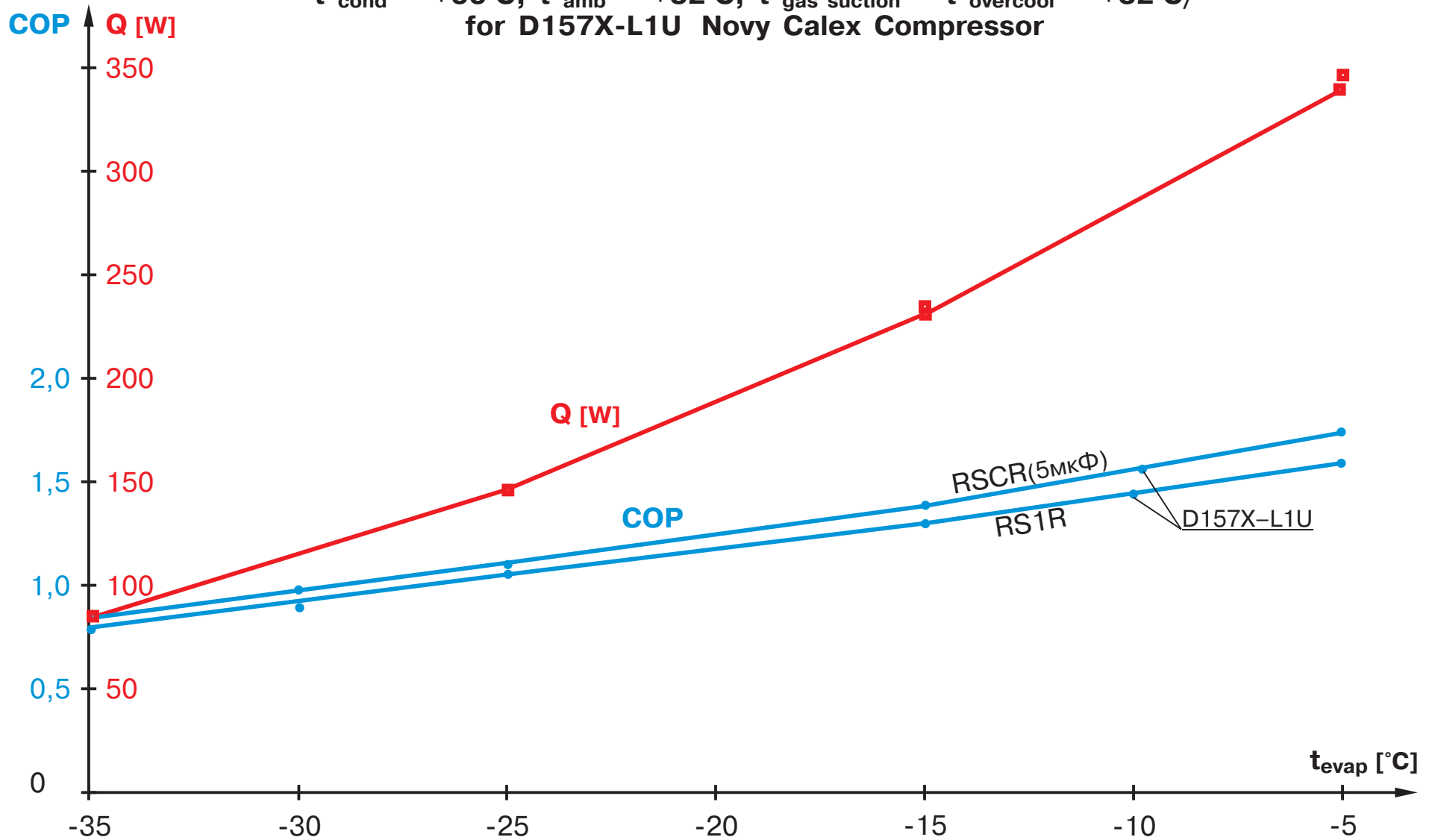


Fig. 2.

Results of Testing “Birusa” Refrigerators with C1 Mixture

I. Tests of the “Birusa-19” Refrigerator.

1. **Purpose of the tests:** determine the charge of C1 mixture and establish refrigerator compliance with requirements of Specifications, State Standard GOST 16317-87 for temperature and power parameters.
2. **Test object:** «Birusa-19» refrigerator, volume – 150 liters, without low temperature compartment.
3. **Test results:**

Tamb, °C	Charge, g	Average temperature in the chamber, °C	Cycle times	Operating time coefficient	Electric power consumption, kW·hr/day
25	35	4,36	Operation-5 min Idle time-25 min	0,166	0,6
32	35	4,5	Operation - 9 min Idle time-22 min	0,29	0,97

4. Conclusions:

- The «Birusa-19» refrigerator charged with C1 mixture ensures average temperatures over the cabinet of 0-5°C with the power consumption of 0,6 kW·hr/day which complies with requirements of the State Standard GOST 16317-87 and Specifications TU 92-01.02.028-88 for temperature and power parameters.
- The recommended charge is 35⁺³ g.
Note: the normal charge of R12 is 60 g.

Results of Testing “Biriusa” Refrigerators with C1 Mixture

II. Comparison Tests of the “Biriusa-22” Refrigerator and “Biriusa-14” Freezer.

1. Purpose of the tests: Determination of characteristics of «Biriusa» refrigerators of different types and their compliance with the State Standard GOST 16317-87 in terms of thermal and power parameters.

2. Test objects:

- «Biriusa-22» refrigerator – two-compartment, total volume - 255 liters, volume of the refrigerating chamber - 170 liters, volume of the low-temperature chamber - 85 liters;
- «Biriusa-14», volume -120 liters.

3. Refrigerant charge:

R12 freon: «Biriusa-22»-120 g, «Biriusa-14» - 82 g.

C1 mixture: «Biriusa-22» - 56 g, «Biriusa-14” - 28 g.

4. Test results: The electric power consumption was found to be as follows:

Make	For R12 freon		For C1 mixture	
	Power consumption kW·hr/day at Tamb=25°C	Power consumption kW·hr/day at Tamb=32°C	Power consumption kW·hr/day at Tamb=25°C	Power consumption kW·hr/day at Tamb=32°C
Biriusa-14	1,37	1,8	1,25	1,7
Biriusa-22	1,64	2,2	1,6	2,23

5. Conclusion: The power consumption of «Biriusa» refrigerators using C1 mixture and R12 freon is virtually identical. The refrigerators comply with the State Standard GOST 16317-87.

Results of Testing “Birusa” Refrigerators with C1 Mixture

III. Testing of the «Birusa-14» Freezer to Determine the Optimum Throughput of the Capillary Tube and Optimum Charge of C1 Mixture.

1. **Purpose of the tests:** selection of the optimum combination of the charge of C1 mixture and throughput of the refrigeration unit capillary tube.
2. **Test object:** the tests were performed with the «Birusa-14» production-line freezer having the normal capillary tube throughput of 3,5 l/min. The throughput was further increased to 4,0 l/min and to 4,5 l/min. The C1 charge was varied from 30 g to 50 g in 5-g steps for each value of the throughput in order to determine the optimum value. Based on results of the previous tests, the thermostat bellows tube was moved from the lower shelf to the upper one. The other assemblies were standard.
3. **Test results:**

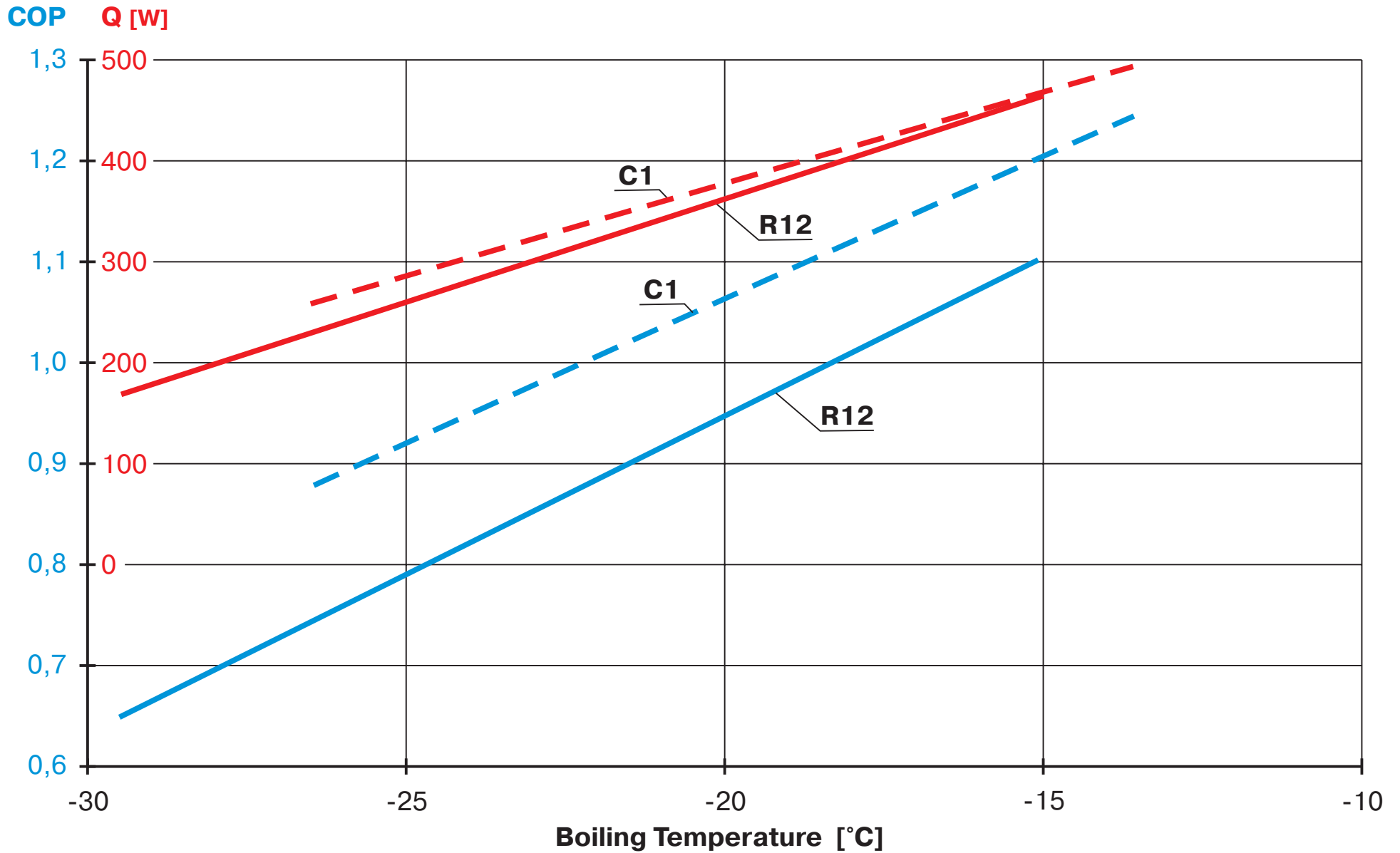
The best temperature and power parameters of the «Birusa-14» freezer at $T_{amb}=25\text{ }^{\circ}\text{C}$ were obtained, as is seen from the graph, with the capillary tube throughput of 4,0 l/min and C1 charge of 40 g. At the highest ambient temperature, the freezer provided the temperature of minus 18,4 $^{\circ}\text{C}$ with the power consumption of 1,20 kW·hr/day and operating time coefficient of 0,52. According to Specifications TU 92-01.02.030-8, power consumption shall not exceed 1,26 kW·hr/day. The boiling temperature of C1 mixture for the above mentioned parameters of the refrigeration unit at the steady-state conditions is minus 27,4 $^{\circ}\text{C}$, and the temperature of C1 condensation in the condenser is +40,5 $^{\circ}\text{C}$. The power consumption in the cycle is 120/95 W. At the suction pipe section where it goes from under the flange, the temperature does not fall below +21,0 $^{\circ}\text{C}$ at $T_{amb}=25^{\circ}\text{C}$ which indicates that the suction pipe is protected against condensate precipitation at relative humidity no higher than 73 %. The permissible temperature at the suction pipe is no lower than +18,5 $^{\circ}\text{C}$.

**Comparison Tests of AMO ZIL Domestic Refrigeration Equipment
 (“ZIL-64” Refrigerator with V792R Type Compressor)
 with Refrigerants C1, R12 and CM-1**

Refrigerant charge	T_{amb}, °C	Setpoint	P_w/hr	Power consumption kW·hr/day	Average T in the refrigerating chamber °C	Average T in the low-temperature chamber °C
C1 50 g	25	4	80	0,924	4,28	-17,9
R12 105 g	24,6	5	80	1,515	5,5	-18,5
CM-1 90 g	25,7	5	75	1,017	5,05	-18,7

Note: with the low-temperature chamber loaded by acaroid of mass 13,5 kg.

Refrigerating Capacity Q and Coefficient of Performance COP versus Boiling Temperature Curves
Obtained from Testing BC500(2) Unit with R12 and C1



The Possibilities for Production of C1 in Russia.

C1 components are produced:

R152a - «Caustic» Works, Volgograd

Isobutane (R600a) - Novokuibyshev Petrochemical Combine; VNIIGAS, Moscow.

C1 is produced:

- At the Keldysh Center/INERTEK pilot plant, Moscow, with an output of up to 100t/yr.
- At the Caustic Co., Volgograd, with an output of up to 3000 t/yr (under the license issued by INERTEK).