C O N T E N T

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	Techical Director

International Scientific Products

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	Vice President

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Techical Director

Closed Joint-Stock Company
INERTEK
"International Energy Technologies"

INERTEK Founders:

- Russian Research Center "Kurchatov Institute", Moscow
- Central Design Bureau of Machine-Building, St.Petersburg
- Research Institute of Scientific and Industrial Association "Luch", Podolsk
- NIITP, Moscow
- Small Enterprise "Science-Intensive Products of Power Technologies" (NP Energotech), Moscow
- International Scientific Products (ISP), USA

Subject and Objectives of INERTEK Activities

INERTEK Closed Joint Stock Company is staged to develop science-intensive products, new technology and advanced materials and introduce them into the Russian economy and foreign markets, to produce and sell scientific and technological products and goods for the sake of meeting social demands and deriving profit.

The subject of INERTEK activities:

- R&D in the field of space power and engine-building for peaceful purposes
- R&D in the field of atomic and aerospace science and technology
- production and sale of the advanced science-intensive products, technology and materials, biomedicine and biotechnology
- production and sale of isotopes for medicine and other commercial purposes
- production of computer aids and their repair, development of special software, services on their exploitation
- development of data banks on the scientific and technological production and know-how and their exploitation
- patent and licensing activities
- organization of exhibitions, scientific conferences, seminars, symposia and schools
- production of consumer goods, commercial activities in the field of wholesale and retail trade

INERTEK

R & D and Production Activity Results

I Russian/American TOPAZ-2 Program

- American specialists in USA are trained to work with "TOPAZ-2" type thermionic nuclear systems
- The facility is built at NMERI (USA) for testing and investigation of the "TOPAZ-2" systems and components
- Demonstration tests of the "TOPAZ-2" system units I-71, Ya-21U and components performed at the TSET facility, NMERI, USA
- Delivery to the US of 4 "TOPAZ-2" units under the Flight Test Program
- Calculations and experiments in validation of safety of the "TOPAZ-2" system operation in space
- Performance of neutronics studies in validation of "TOPAZ-2" system nuclear safety
- Development and demonstration testing of SPD-100, SPD-160 electric thrusters at the US laboratories
- Return to Russia of six "TOPAZ-2" system units
- Termination of the Program

II Russian/American SPACE-R Program

- Calculational and experimental studies in validation of the SPACE-R system prototype
- Development of the "TOPAZ-3" TFE prototype
- Termination of the Program

II ATP Program (USA)

- Development of proposals on validaion of lifetime and safety of enhanced power TFE under the ATP Program

Investment Program

Areas:

- Research basis and production development
- Advancement of technologies available
- Innovative technologies, research and development
- Commerce
- Real estate and land
- Charity

Research Basis and Production

- Computers
- Communications
- Office facilities
- Technological equipment
- Electric thrusters production
- Computarization, modernization of critical assembly
- Development and manufacture of converter-reactor units and components
- Development and production of consumer goods' and equipment samples
- Feasibility study on establishment of new production (B-10, CFC-free refrigerants, beverage cans, etc.)

Advancement of Technologies Available

- 40 kW(e) thermionic space nuclear system
- Fuel to ensure extended lifetimes of thermionic space nuclear reactors
- TFE
- K-2. Test reactor for full-scale TFE testing
- Basic units and components of thermionic converter-reactor (working medium unit, automatic control drive, ionization chamber suspensions, etc.)
- ACS
- Experimental facilities (assessment)
- Power/propulsion systems based on developed TFE and NTP technologies

Innovative Technologies

- NEP using metal vapor
- Arc jet and resistojet electric rockets
- Non-CFC refrigeration
- Solar-wind power sources
- Sulfur-sodium storage batteries
- Close-spaced TEC
- Barogalvanic converters
- Fusion
- X-ray tubes

COMMERCE
REAL ESTATE AND LAND
DEPOSITS
CHARITY

TOPAZ TECHNOLOGIES

Russian NEPST Program
"TOPAZ-3" NPS
ENISSEY - Efficient Power Source for Space Applications
Atlas IIAS Launcher with Bimodal Power/Propulsion System
ACS (Automatic Conirol System)
Thermionic Fuel Elements (TFE)
Nuclear Fuel for Space Thermionic Systems
Nuclear Safety of SNPS
Sodium-Sulphur Storage Cells and Batteries
"TOPAZ-2" Space Nuclear Power System
"Baikal" Test Rig
TFE Test Rig
"RT-12" Rig

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Techhical Director

TOPAZ TECHNOLOGIES

Russian NEPST Program

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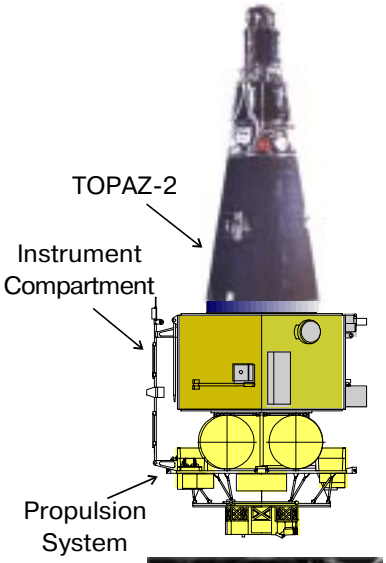
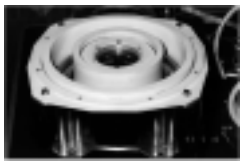
IKI, SPA MASH, CDBMB, NIITP,
NIIP





SPT

Hrunichev RRC
SPA MASH

Purpose:

- experimental verification of the "TOPAZ-2" NPS and NEP in actual space flight
- investigation of the S/C environment in the course of the experiment

Basis:

- "TOPAZ-2" NPS (Russia) + "PROTON" (Russia)

Benefits:

- employment of Russian technologies to launch the NEPSTP S/C with "TOPAZ-2" nuclear system
- hight reliability of the S/C orbital injection
- lower cost of the S/C launch
- evaluation of prospects for using the S/C with the NPS for the Earth monitoring and deep space exploration

Milestones:

- S/C development, fabrication and ground testing, two years from the beginning of the work
- ground testing and launch of the S/C , four years from the beginning of the work
- S/C flight testing

Main Features

S/C mass, kg	3700
"TOPAZ-2" NPS mass, including ACS, SB, kg	1250
Experiment mass, kg	127
NPS output electric power, kW	5
Reference orbit parameters:	
- altitude, km	5250
- inclination, degr.	28.5
- operating orbit altitude, km	5250-36000
- service life, years	3

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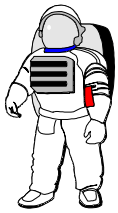
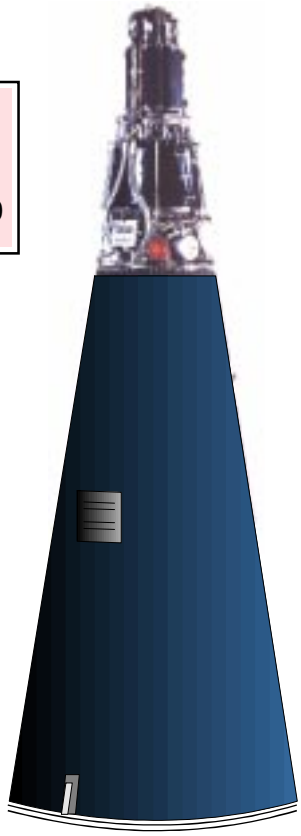
T O P A Z T E C H N O L O G I E S

”TOPAZ-3” NPS

”TOPAZ-2”		”TOPAZ-3”
About 6	Output Power, kW(e)	About 40
About 1000	Mass, kg	About 3000





Purpose:

- power source for space applications with power level of 40 kW(e) and more

Basis:

- ”TOPAZ-2” thermionic reactor (Russia) with increased number of single-cell TFEs

Benefits:

- upgraded efficiency and reliability of spacecraft power supply
- utilization of Russian and American experience and backlog on space power systems
- reduced program costs, time and risk

Tasks and milestones:

- NPS development
- development and testing of procedures providing for safe nuclear power in space
- testing with electric heating
- ground nuclear tests
- flight testing

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TOPAZ TECHNOLOGIES

ENISSEY - Efficient Power Source for Space

/Energy Integration Space Stirling-Emission Yoke/

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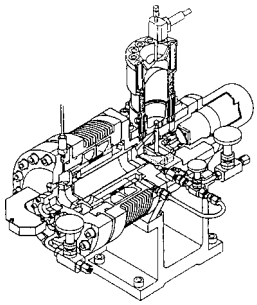
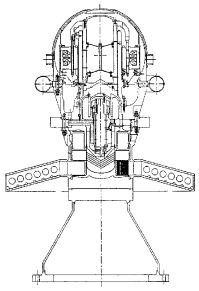
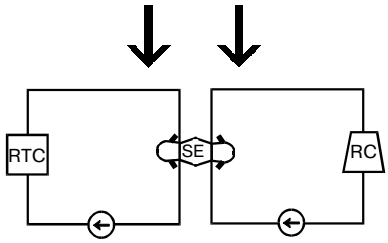
TOPAZ-2 (RTC)





Stirling Engine (SE)



ENISSEY Combined System

Purpose:

- hybrid power source for space applications with power level of 20-50 kW(e)

Basis:

- "TOPAZ-2" thermionic reactor (Russia) + Stirling engine = Hybrid system

Benefits:

- upgraded efficiency and reliability of spacecraft power supply
- utilization of Russian and American experience and backlog on space power systems
- reduced program costs

Tasks and milestones (four years from the beginning of the work):

- hybrid system development
- development and testing of procedures providing for safe nuclear power in space
- testing with electric heating on a thermal test stand
- ground nuclear tests
- flight testing

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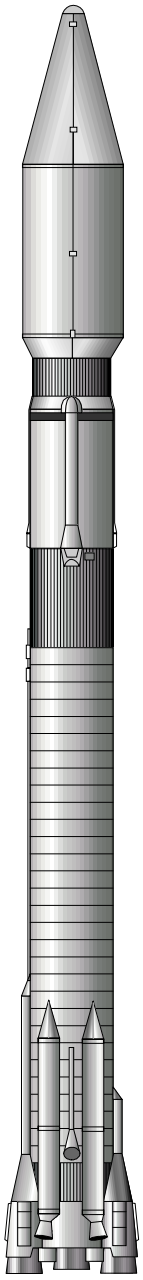
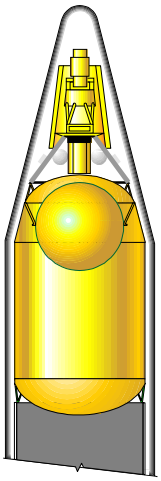
TOPAZ TECHNOLOGIES

Atlas IIAS Launcher with a Bimodal Power/Propulsion System





Atlas IIAS launcher:

Lifting capacity to LEO (H_{cir}=185 km) - 8600 kg
Total payload to GEO - 1050 kg
GEO payload with apogee engine - 1820 kg

Bimodal power and propulsion offers high performance, flexibility and responsiveness:

Thermal propulsion thrust	200 N	2200 N
Specific impulse	770 s	810 s
Useful electric power	10 kWe	10 kWe
Operational lifetime	10 yrs	10 yrs
Total payload to GEO	3823 kg 3866 kg*	4473 kg 4522 kg*
- including instrumental payload	1327 kg 1986 kg*	1916 kg 2621 kg*
Orbital transfer time	7 days	~1 day
Time of 180 ^{o} -repositioning in GEO	5 days 11..13 days*	5 days 11..13 days*

* Version with on-orbit maneuvering using electric propulsion

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TOPAZ TECHNOLOGIES

ACS



Basic Characteristics of the ACS Mockup (Automatic Conirol System)

Processor unit mass, kg	not over 5.5
Total mass, kg	20
Probability of no-failure operation over 3 years,	no less than 0.999
Maximum power consumption, W	not over 18
In the waiting mode, W	(0.5-0.8)
Design lifetime, years	no less than 10.5
Speed, ths. operations per second	200
Size of the working memory, Kb	12
ROM size, Kb	48
Number of analog data channels	48
Neutron radiation, energy < 0.1 MeV, n/cm^2	$8 \cdot 10^{12}$
Gamma radiation, rad	10^4

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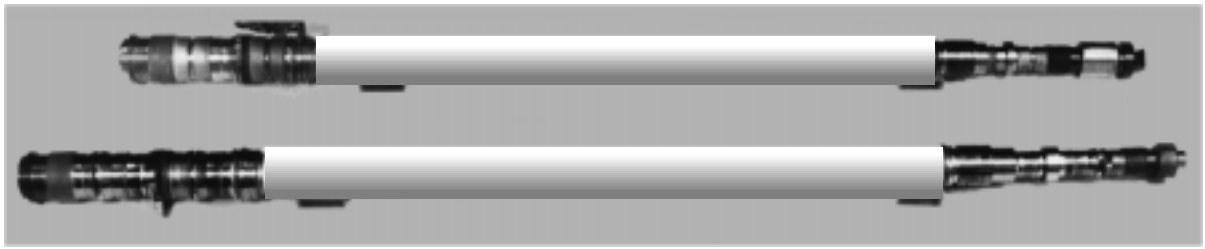
TOPAZ TECHNOLOGIES

Single-Cell Thermionic Fuel Elements (TFE)

1

2



1 TOPAZ-2 TFE			1 TOPAZ-3 TFE	
About	150	Output Power, W(e)	About	300...400
About	5	Efficiency, %	About	7,5
	3...5	Service life, years		7...10
	375, 23.7	Sizes (L_{fuel}, D_{TFE}), mm		400, 26.6

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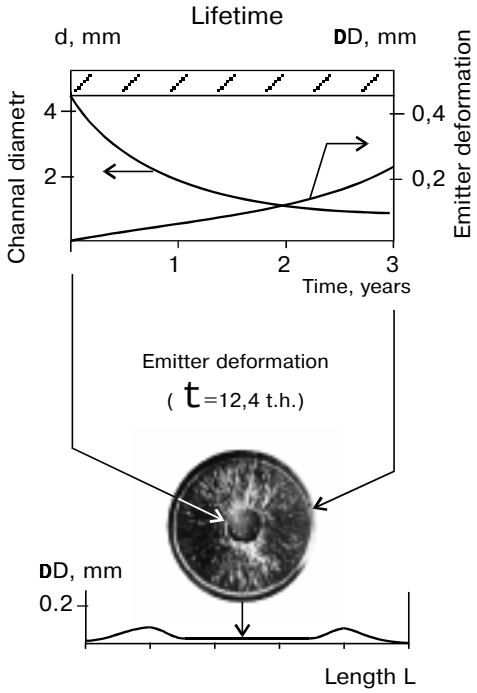
Nuclear Fuel for Space Thermionic Systems



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SIA "LUCH"

Purpose:

- development of nuclear fuel for different purpose space thermionic systems

Basis:

- UO_2 fuel for "TOPAZ-2" SNPS

Benefits:

- increased system lifetime due to non-swelling fuel
- enchanced power due to advanced refractory fuel compositions
- reduced program costs due to the available Russian experience in the manufacturing technology

Tasks and milestones (five years from the beginning of the work):

- fuel delivery (2 sets available):
- for "TOPAZ-2" safety demonstration
- for flight tests
- development of process for fuel rod fabrication of UN, UC and their compositions
- in-pile and ground nuclear tests of new fuels in systems
- PIE continuation

Characteristics

Fuel	UO_2
Enrichment, % in U_{235}	96
Density, %	95 TD
Stochiometry	2.000 + 0.005
Emitter temperature, ^{0}C :	
UO_2 fuel	below 1600
UN, UC, etc	above 1600

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TOPAZ TECHNOLOGIES

Nuclear Safety of SNPS

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SIA "LUCH", CDBMB

Nuclear safety investigations
on the critical assembly

Purpose:
- SNPS safety analysis and demonstration

Basis:
- "TOPAZ-2" termionic reactor
- critical facilities and equipment in Russia (RRC KI)

Benefits:
- demonstration of safe operation of SNPS in space
- investigation of the reactor operation impact on the Earth and near-Earth space environment

Tasks and milestones:
- development of procedures providing for safe employment of nuclear power in space
- development of agreed criteria of safety assessment
- probabilistic safety analysis for different missions using "TOPAZ-2" type reactors
- flight testing safety analysis

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TOPAZ TECHNOLOGIES

Sodium-Sulphur Storage Cells and Batteries

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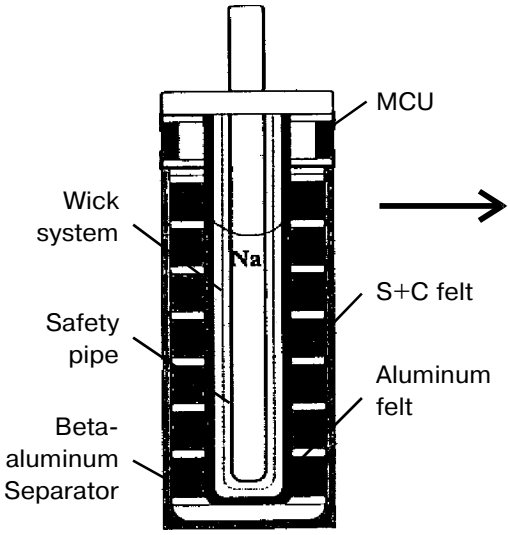
In comparison with traditional power supply sources (alkaline, acid, nickel-cadmium, nickel-hydrogen, etc.) SSB have higher characteristics, the reagents cost being low:

specific energy, Wh/kg	up to 140
specific power, W/kg	up to 180
efficiency, %	up to 90
lifetime, cycles	up to 1000
shelf life, years	up to 10

Na-S cell



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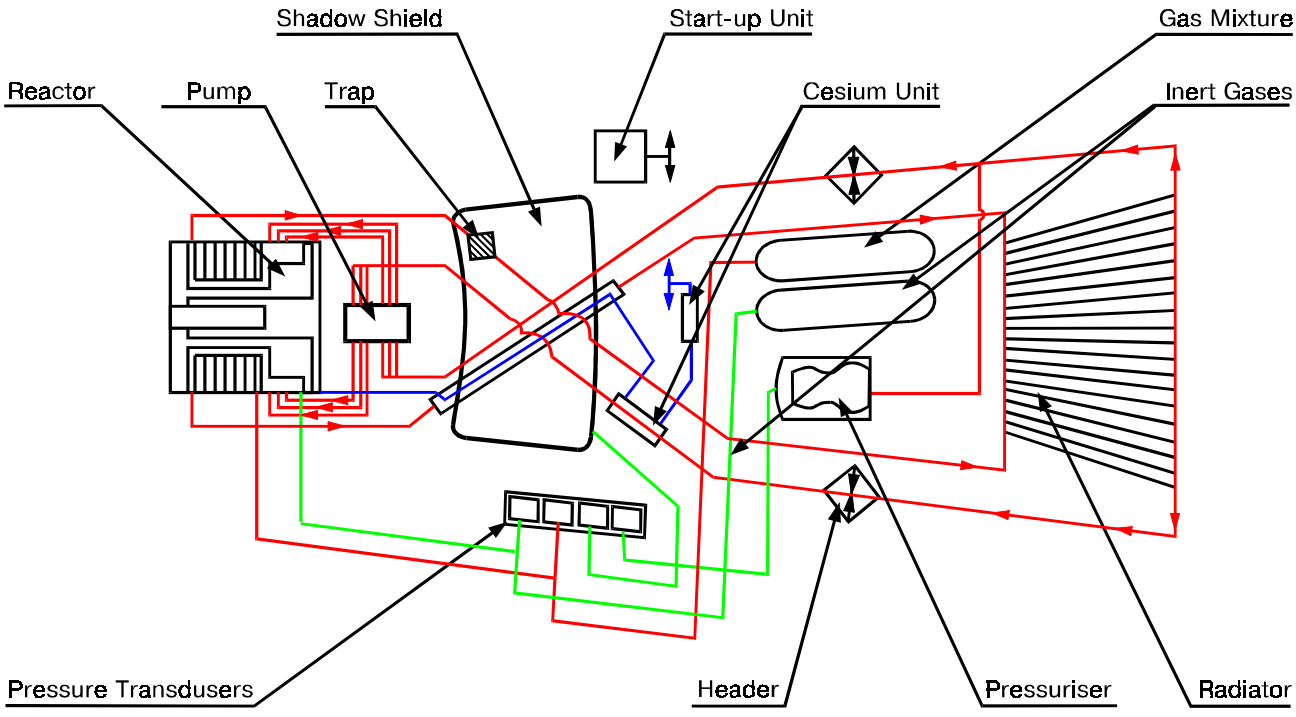
TOPAZ TECHNOLOGIES

"TOPAZ - 2" Space Nuclear Power System

"TOPAZ-2" Space Nuclear Power System capable of 6 kW electric power generation on the basis of a single-cell TFE reactor-thermionic converter is intended for use as an independent electric power source for multi-purpose instrumentation aboard spacecraft.

Designers

CDBMB St. Petersburg	- Central Design Bureau of Machine Building of RF Ministry of Atomic Energy
RRC "Kurchatov Institute", Moscow	- Russian Research Center "Kurchatov Institute".
SIA "LUCH" Moscow Region, Podolsk	- Scientific-Industrial Association "LUCH" of RF Ministry of Atomic Energy.



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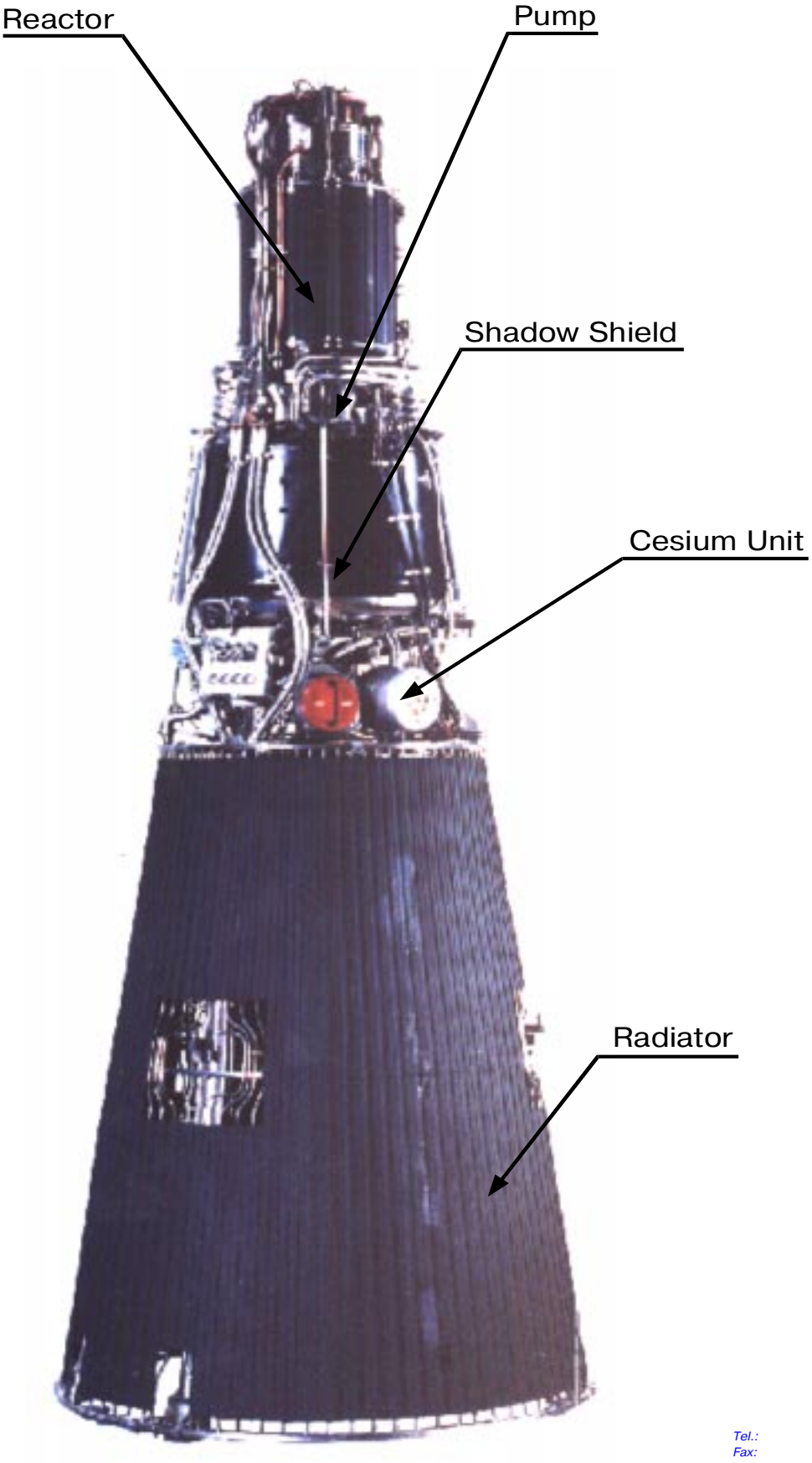
TOPAZ TECHNOLOGIES

"TOPAZ - 2" Space Nuclear Power System



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TOPAZ TECHNOLOGIES

"TOPAZ - 2" Space Nuclear Power System

The TOPAZ-2 nuclear power system on the basis of the single-cell TFE reactor

- provides a 6 kW continuous reliable power supply for space vehicles
- features a 3-5 year lifetime
- is safe for orbit injection because of the reactor deep subcriticality
- is compact
- exhibits good manoeuvrability
- can provide electric power for electric propulsion systems (EPS) to transfer a satellite from a reference to an operational orbit
- can provide electric power up to 30 kW when integrated with the Stirling engine

Main Features

Number of TFEs	37
TFE type	single-cell
Electric power, kW	6
Thermal power, kW	135
Voltage across the reactor terminals, V	28-30
Coolant temperature, ^{0}C	600
Length, m	3.9
Maximum diameter, m	1.4
Reactor mass, kg	290
Radiator mass, kg	50
Total mass, kg	1000

Possible areas of application

- satellite communications
- Earth surverillance satellites for atmospheric researsh, agriculture, and prospecting of mineral resources
- radar-equipped satellites to locate vessels, cars and space vehicles
- EPS power supply for orbital transfers
- bases on the Moon and other planets
- a support of long-term space missions to solar system planets, comets, asteroids, and return to the Earth

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TOPAZ TECHNOLOGIES

"Baikal" Test Rig

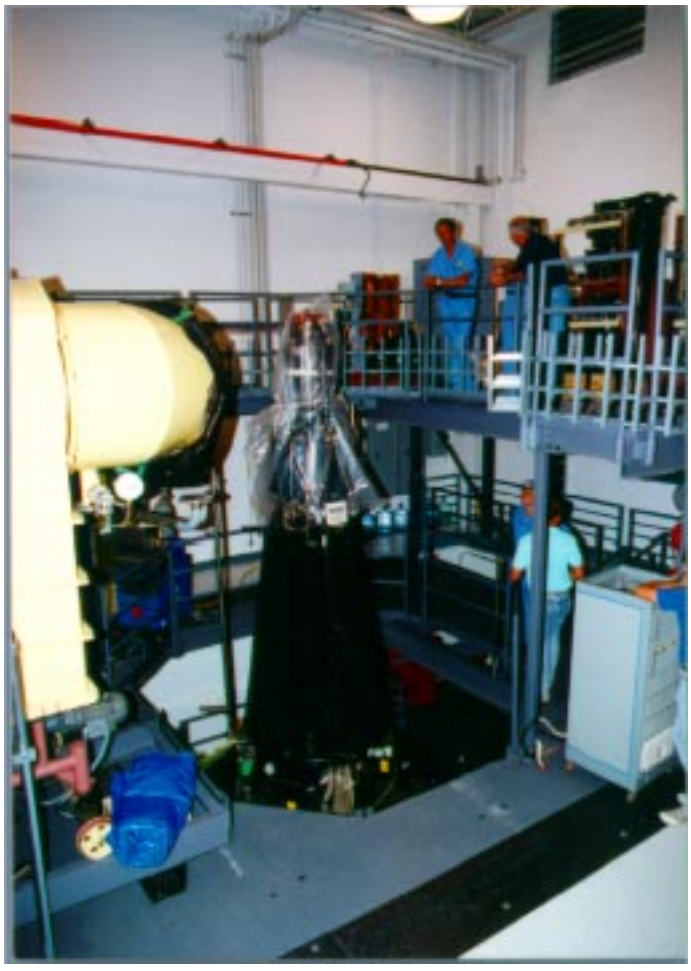
The "Baikal" test rig is intended to:

- outgas the "TOPAZ-2" system;
- fill the "TOPAZ-2" system with coolant (NaK) and gas mixtures;
- check the output characteristics using special electric heaters - thermal simulators of nuclear fuel (TISA) - for heating the reactor.

The tests on the "Baikal" rig are ***absolutely clean*** from the radiation safety veiwpoint.

Characteristics

Area occupied, m^2	about 150
Floor-to-crane hook height, m	about 12
Crane load-lifting capacity required, t	5
Vacuum chamber inside diameter, m	2,5
Vacuum chamber inside height, m	5,4
Vacuum chamber mass , t	16
Cooling water flow rate, m^3 / hour	7
Power demand (380 V, 50 Hz), kW	250



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INERTEK TOPAZ TECHNOLOGIES

"Baikal" Test Rig

RIG COMPONENTS

The water supply system is intended to provide the prescribed temperature conditions for the "Baikal" test rig and "TOPAZ-2" system equipment during the tests

The evacuation system is intended to:

- produce a pressure of $1 \cdot 10^{-5}$ mm Hg required for tests in the vacuum chamber
- provide for pre-rarefication of high-vacuum systems
- remove outgassing and evacuation products after leak checks, cavity filling, etc.

The reactor evacuation unit and cesium unit are intended to:

- produce the required pressure of $1 \cdot 10^{-6}$ mm Hg in the cesium cavities of the rig and "TOPAZ-2" system
- remove outgassing products out of the indicated cavities
- perform Helium purification, spectral analysis, and filling of the "TOPAZ-2" Cesium system

The filling system is intended to:

- Produce a pressure of $1 \cdot 10^{-3}$ mm Hg required for tests in the NaK cavities
- Fill the "TOPAZ-2" system with NaK
- Clean NaK of oxides and check NaK for purity

The gas supply system is intended to:

- produce a pressure of $1 \cdot 10^{-3}$ mm Hg required for tests in the gas cavities
- prepare necessary gas mixtures
- fill the cavities with the gases or their mixtures

The EM pump control system is intended to control and monitor the EM pump parameters, as well as to provide for the NaK circulation over 30 s at the rig power cutoff by means of an independant power source. This is necessary to avoid dramatic temperature fluctuations in case of inadvertant TISA switch-off.

The TISA power supply system is intended for a smooth TISA voltage regulation, as well as for monitoring of parameters and TISA protection against overloads.

The work section load is intended to remove the power generated in the "TOPAZ-2" system during its functioning. It provides for the "TOPAZ-2" system output voltage regulation and stabilization, as well as monitoring of the work section parameters .

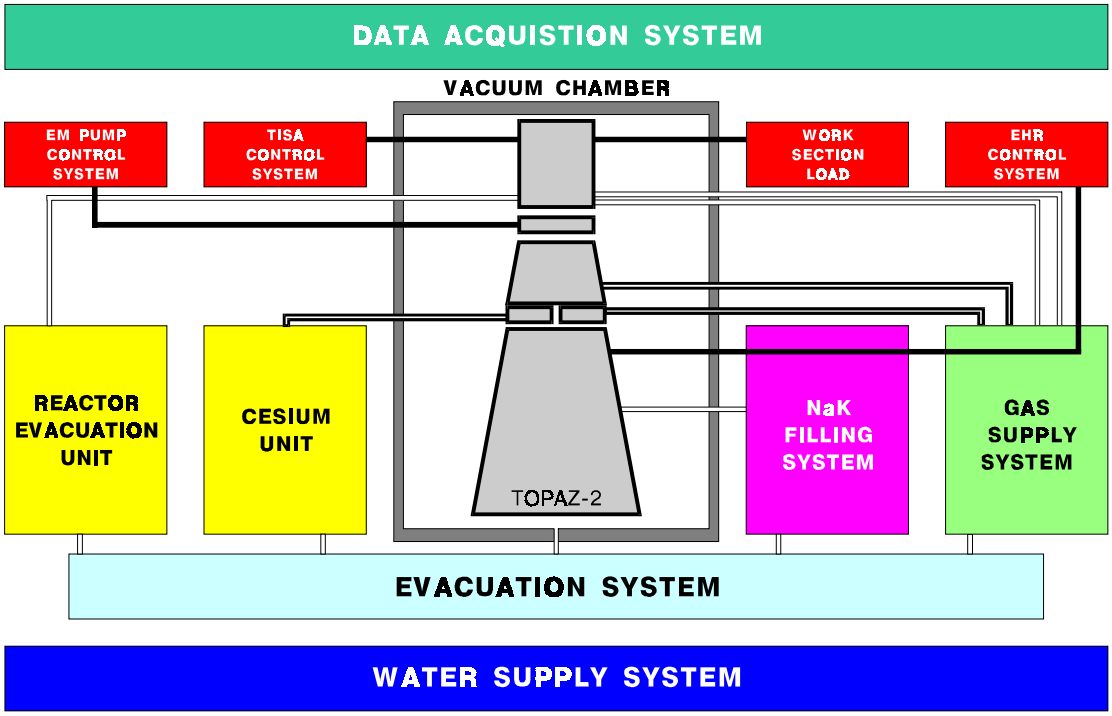
The EHR control system is intended for control and parameter monitoring of the electric heater used to heat up the "TOPAZ-2" system radiator during its outgassing and filling with NaK.

The automatic data acquisition system is intended to monitor the "Baikal" rig and "TOPAZ-2" system parameters during tests, process the information obtained and represent it in the form suitable for storage and perception by the operating personnel.

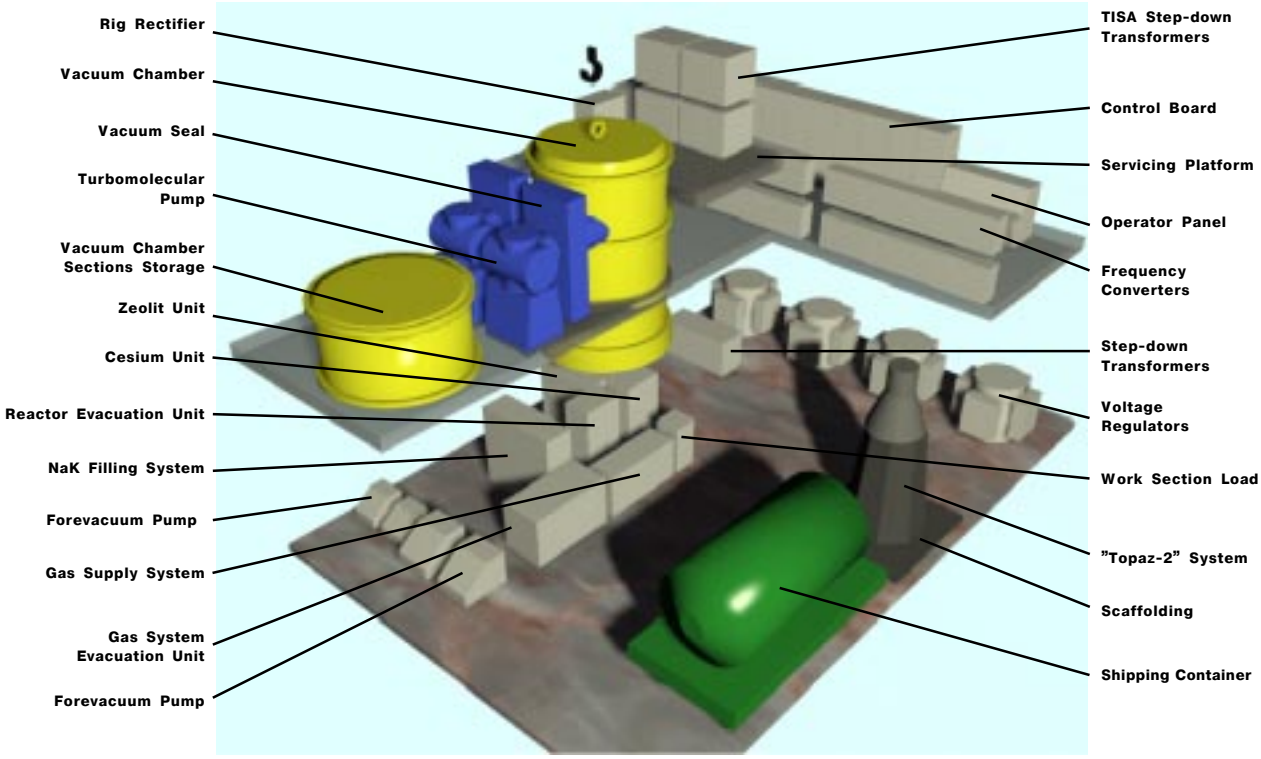
TOPAZ TECHNOLOGIES

"Baikal" Test Rig

BLOCK DIAGRAM



BAIKAL RIG EQUIPMENT LAYOUT



* Equipment disposition can be changed depending on available area.

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TOPAZ TECHNOLOGIES

TFE Test Rig

The TFE Test Rig is intended for:

- TFE outgassing and leak-checks;
- checks of the TFE output parameters with the use of special "TISA" electric heaters (thermal simulators of nuclear fuel) to heat up the TFE;
- TFE investigations and lifetime tests.

Characteristics

Area occupied, m^2	about 30
Floor-to-crane hook height, m	about 6
Crane load-lifting capacity required, t	5
Vacuum chamber diameter, m	0.6
Vacuum chamber height, m	1.2
Pressure of residual gases in VC, Pa	$1 \cdot 10^{-3}$
Pressure of residual gases in VCsS, Pa	$1 \cdot 10^{-4}$
Cooling water flow rate, m^3/h	1.0
Power demand (380V, 50Hz), kW	50
Liquid nitrogen consumption, l/day	40

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INERTEK TOPAZ TECHNOLOGIES

TFE Test Rig

RIG COMPONENTS

The Vacuum Chamber (VC) is designed to:

- accommodate a working section with TFE and a TISA thermal simulator
- bring out service lines and connect them to the rig systems
- maintain a required pressure within the VC.

The Working Section (WS) is a thermal channel intended to remove waste heat from the TFE and to maintain required thermal and gas-vacuum parameters during the TFE operation.

The Evacuation System is designed to:

- produce a pressure of $1 \cdot 10^{-5}$ mm Hg required for tests in the vacuum chamber
- produce pre-rarefaction in high-vacuum systems
- remove outgassing products and residual gases after leak-checks, gas-fills, etc.

The Vacuum-Cesium System (VCsS) is designed to:

- produce a required pressure of $1 \cdot 10^{-6}$ mm Hg in VCsS and TFE
- remove outgassing products out of the cavities mentioned
- maintain prescribed cesium vapour pressure in TFE interelectrode gap (IEG)

The Load System provides for recording I-V characteristics and serves as TFE electric load.

The Gas Supply System is designed to:

- produce a required for tests pressure of $1 \cdot 10^{-3}$ in gas cavities
- prepare required gas mixtures
- fill the TFE and WS with gases or gas mixtures

The TISA Power Supply System is intended for smooth TISA voltage regulation, monitoring of parameters, TISA protection against overloads.

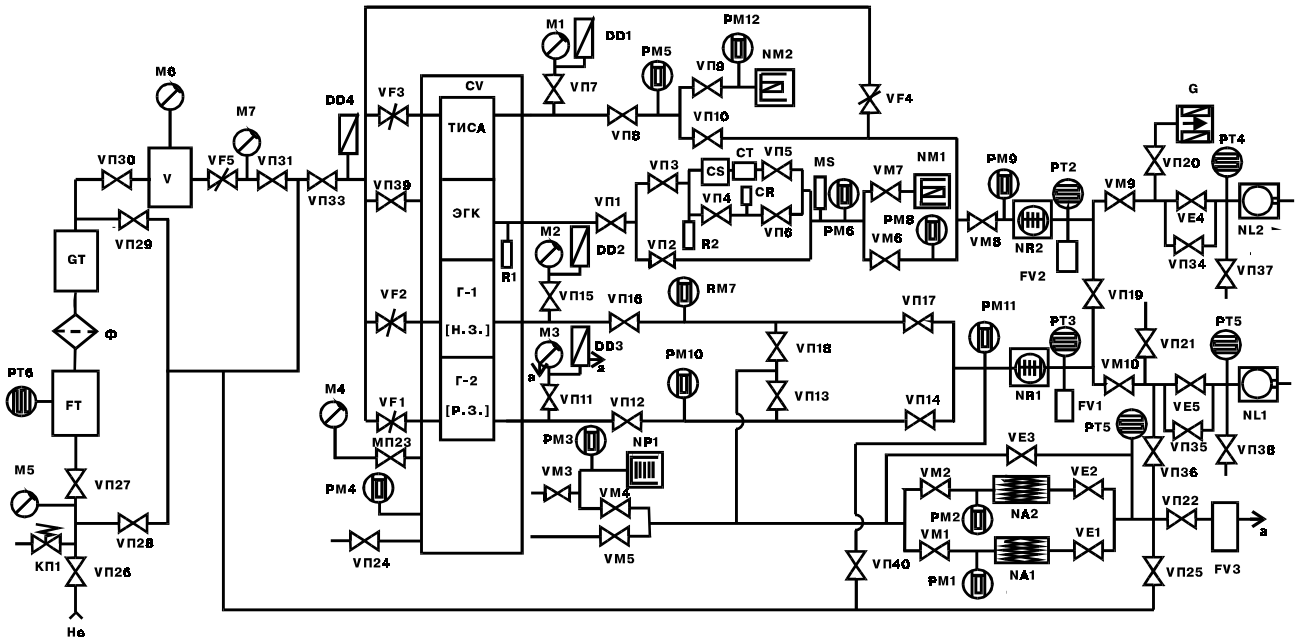
The Automatic Data Acquisition System is designed for monitoring of the TFE and TFE Test Rig parameters during testing, incoming data processing and presentation in the form suitable for storage and perception by personnel.

The Water Supply System is intended to maintain required temperature conditions of the rig and TFE during the tests.

TOPAZ TECHNOLOGIES

TFE Test Rig

DESIGN SCHEMATIC



NOMENCLATURE

NL1, NL2 - rotary vacuum pumps;
NR1, NR2 - turbo-molecular vacuum pumps;
NA1, NA2 - sorption vacuum pumps;
NM1, NM2 - high-vacuum magnetic pumps;
NP1 - НСВМГ- type combined magnetic, getter ion high vacuum pump of АСВМГ aggregate;
PT1...PT6 - thermo-electric manometric converter;
PM1...PM12 - magnetic manometric converter;
M1...M6 - diaphragm pressure gauge;
ДД1...ДД4 - inductive pressure transducer;
VF1...VF5 - vacuum valves for fine adjustment;
VE1...VE5 - vacuum valves with electromagnetic drive;
VM1...VM1 - vacuum valves with electromechanical drive;
VП1...VП40 - vacuum valves with hand drive;
MS - mass-spectrometer sensor;
FV1...FV3 - forevacuum cylinders;
CS - Cs separator;
CT - Cs trap;
R1, R2 - Cs reservoirs;
CR - container with a Cs ampoule;
КП1 - safety valve;
FT - freezing trap;
Ф - filter;
GT - titanium getter;
V - accumulator of purified gas;
CV - vacuum chamber;
ТИСА - working section chamber for TISA accommodation;
ЭГК - inter-electrode gap cavity of TIC;
Г-1 - working section cavity with uncontrollable He-pressure;
Г-2 - working section cavity with controllable He-pressure;
He - pipe connection to a He source.

TOPAZ TECHNOLOGIES

"RT-12" Rig

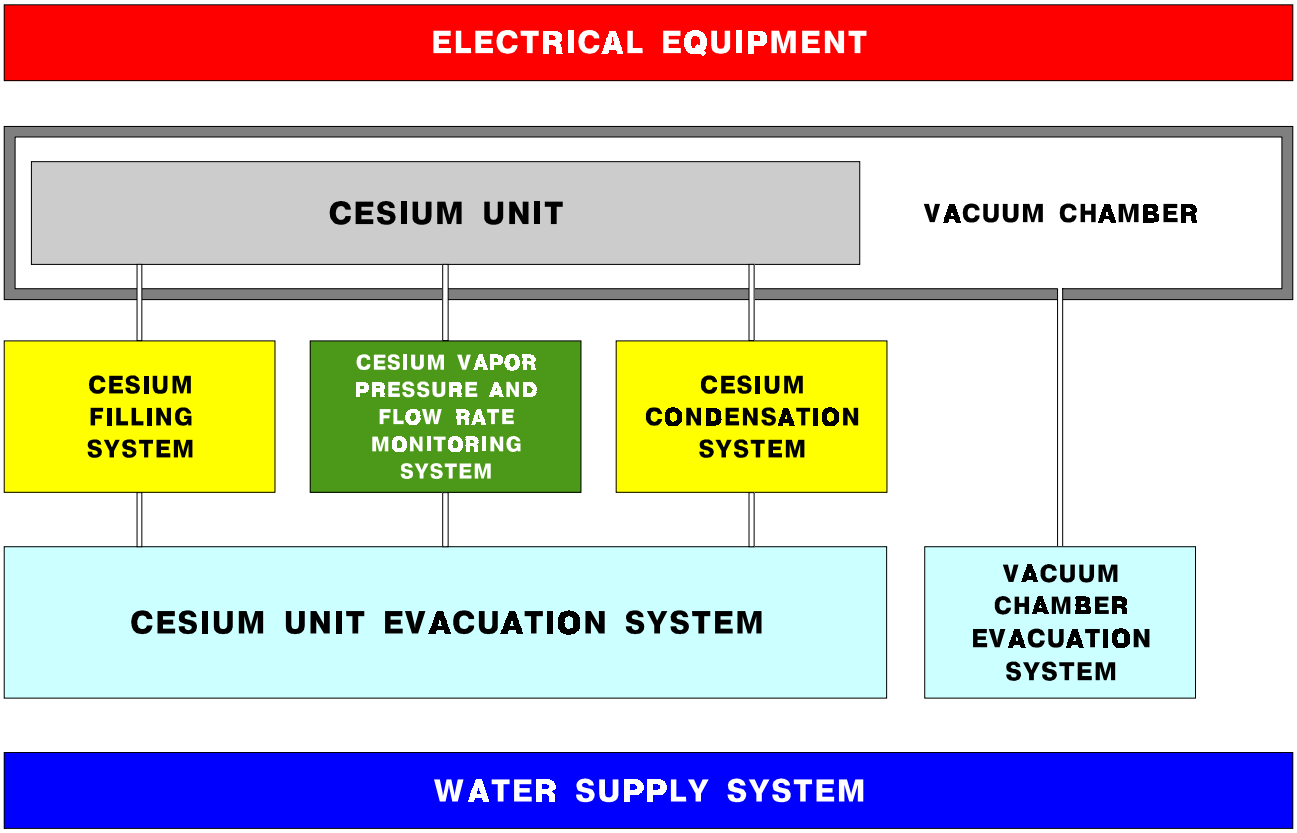
FOR CESIUM UNIT FILLING AND LIFETIME TESTING

The "RT-12" rig is intended for filling the cesium unit, experimental defining its technical data and performing life-time testing.

Characteristics

Pressure in vacuum chamber, mm Hg	$1 \cdot 10^{-4}$
Pressure in forevacuum lines, mm Hg	$1 \cdot 10^{-2}$
Pressure in high-vacuum lines, mm Hg	$1 \cdot 10^{-6}$
Temperature in cesium unit, °C	400...500
Temperature in operating lines, °C	350...550
Cesium vapor pressure, mm Hg	0...5
Power demand (380 V, 50 Hz),kW	4
Mass, kg	2000
Area occupied, m^2	15

BLOK DIAGRAM



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INERTEK TOPAZ TECHNOLOGIES

"RT-12" Rig

FOR CESIUM UNIT FILLING AND LIFETIME TESTING

The vacuum chamber is designed to accommodate the cesium unit and simulate the cesium unit operational environment.

The cesium unit evacuation system is designed to perform evacuation and maintain a required pressure in the cesium unit inner cavities and their associated pipelines. It incorporates the oil-free evacuation equipment (turbomolecular and ion pumps), pipelines and fittings.

The vacuum chamber evacuation system is intended for its evacuation to a specified pressure. It incorporates turbomolecular and forevacuum pumps with liquid nitrogen traps, pipelines and fittings.

The cesium unit filling system is intended for cesium purification, purity checking, and filling into the cesium unit. It incorporates a reservoir with cesium, a vessel to remove gaseous impurities and to check the amount of cesium being filled, a cesium trap, pipelines and high-temperature fittings.

The cesium vapor pressure and flow rate monitoring system is intended to record the above parameters and to assess the cesium unit serviceability. It incorporates a cesium vapor pressure transducer, "Topaz-2" system reactor simulator, pipelines and high-temperature fittings.

The cesium vapor condensation system is intended for collecting the cesium vapor generated by the cesium unit. It incorporated a reservoir for collecting cesium, a cesium trap, pipelines and high-temperature fittings.

The water supply system is designed to ensure temperature conditions required for the rig equipment in the process of testing. It incorporates pipelines and fittings.

The electrical equipment is intended for :

- heating and maintaining the required temperature in the cesium unit and high-temperature pipelines;
- monitoring of the rig and the cesium unit parameters during the tests;
- control over the rig equipment (pumps, etc.).

It incorporates a control panel, electric heaters, sensors and auxiliary devices, cable system, etc.

HIGH TECHNOLOGIES

Refrigerant C1 - Substitute for Freon-12

Innovations in Medicine

Metal-ceramic Rotating Anode X-ray Tube

Synthetic Corundum (leucosapphire) and Its Final Products

Address: 1, Kurchatov sq., Moscow, 123182, RUSSIA

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Contact: Boris S. Stepennov
Techical Director

NOVELTY

RUSSIAN OZONE-FRIENDLY REFRIGERANT C1- substitute for R12 freon

- Compares well with R12 in its quality.
- 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 № 2088626 of 04.27.94 and international priority under the Patent Cooperation Treaty - PCT/RU94/00191 of 04.27.94.

- JSC ”INERTEK” was awarded a diploma and bronze medal for C1 at the 43rd World Exhibition of Invention, Research and Innovation.

Patent holder, producer and supplier:

JSC ”INERTEK” Kurchatov Square 1, Moscow 123182 Russia
Tel. : (095)196-71-64
Fax : (095)196-89-71

REFRIGERANT C1- SUBSTITUTE FOR FREON-12

1. Refrigerant Description.

In accordance with the Montreal (1987) Protocol on substances that destroy the ozone layer, and decisions of subsequent meetings of the Parties to the Montreal Protocol, manufacture of freon-12 and its use in newly produced refrigeration equipment is prohibited beginning in 1996.

Refilling of refrigeration equipment after repair becomes a serious problem, as ozone-friendly refrigerants proposed as alternatives to freon-12, such as freon-134a and hydrocarbon-based refrigerants (propane + isobutane, pure isobutane), require major retrofitting of the refrigeration equipment, and, therefore, involve sizable costs.

Ozone-friendly refrigerant C1 has been developed at M.V. Keldysh Research Center under the agreement with JSC "INERTEK" and with financial support by the latter, which refrigerant substitutes for freon-12 in refrigeration equipment without the necessity to modify the equipment design and change oil for another.

Refrigerant C1 represents a binary azeotropic mixture of ozone-friendly substances R-152a and R-600a. It can be used in domestic refrigerators, automobile and household air conditioners, in shop refrigeration facilities with leak-proof refrigeration systems and compressors.

Refrigerant C1 is thermodynamically close to freon-12:

- boiling point at atmospheric pressure - 29.5 ^{o}C;
- condensation pressure 1.44 MPa at the condensation temperature $T_{cond.}$ = 55 ^{o} C;
- compatible with mineral oil used with freon-12 (ХФ12-16), structural and electric insulation materials of refrigeration equipment.

Refrigerant C1 is a chemically inert gas, non-toxic and ozone-friendly, it features low global warming potential (GWP 0.015) and zero ozone depletion potential (ODP).

Refrigerant C1 received a sanitary certificate № 2685 of 12.02.94, attesting to its compliance with standards established by the Russian sanitary legislation, and is permitted for manufacture and employment in refrigeration equipment.

Refrigerant C1 is protected by a Russian patent № 2088626 of 04.27.94, and by the international priority under the Patent Cooperation Treaty - PCT/RU94/00191 of 04.27.94. The patent holder for C1 is JSC "INERTEK".

JSC "INERTEK" was awarded a diploma and bronze medal for C1 at the 43rd World Exhibition of Invention, Research and Innovation.

Thermodynamic and physical properties of C1 are presented in Figs. 1, 2, and in Attachment 3.

Indices of environmental hazards associated with refrigerant C1 as compared to other refrigerants are presented in Attachment 2.

Attachment 4 presents results of studies on phase equilibrium states and volumetric ratios in the system of freon 152a and isobutane, and Attachment 5 presents results of studies on mutual solubility of refrigerant C1 and mineral oil.

Comparison of key parameters for cooling agents C1, R12 and R134a is given in Table 1.

REFRIGERANT C1- SUBSTITUTE FOR FREON-12

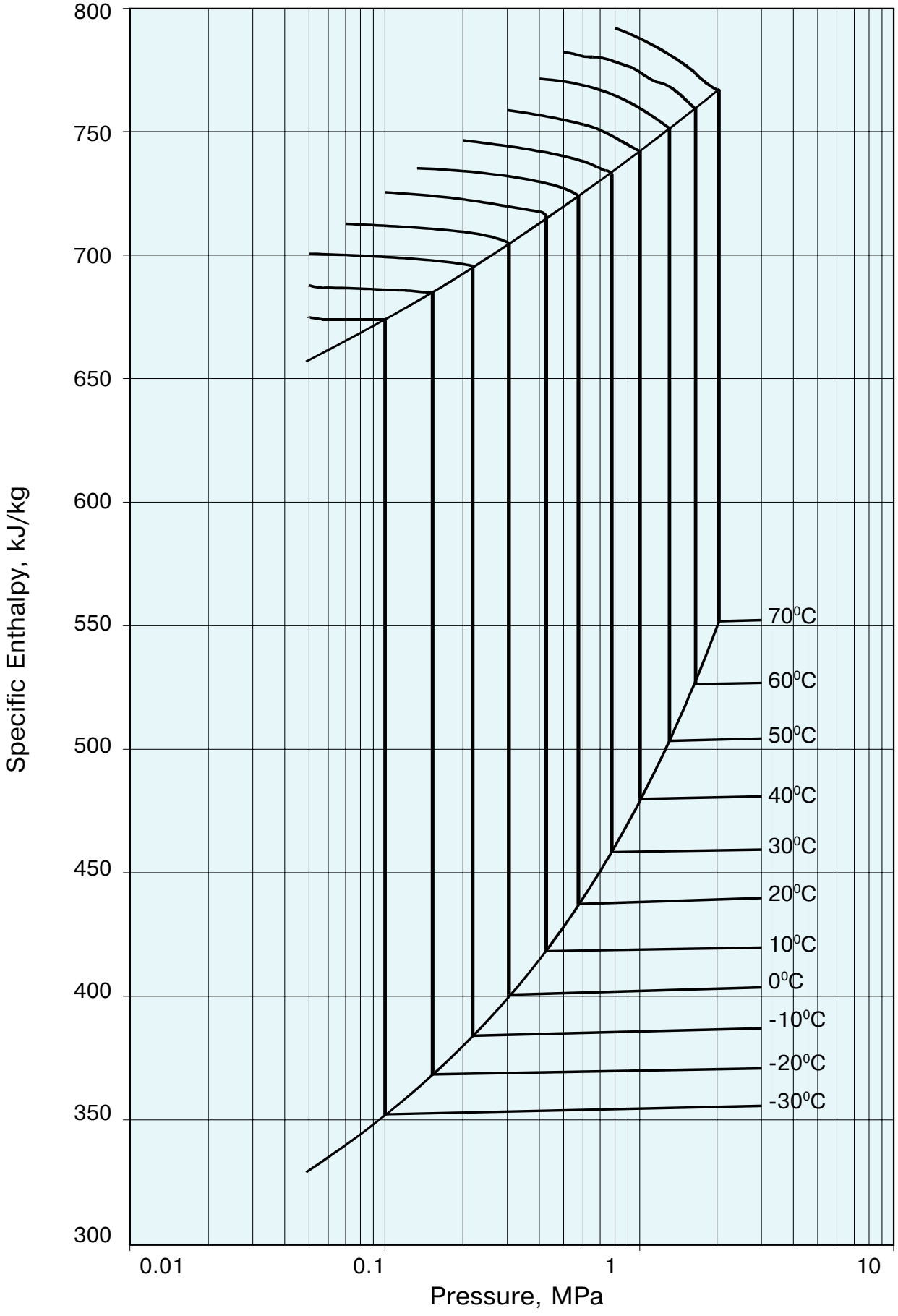

Fig. 1 Pressure-Enthalpy Diagram for C1

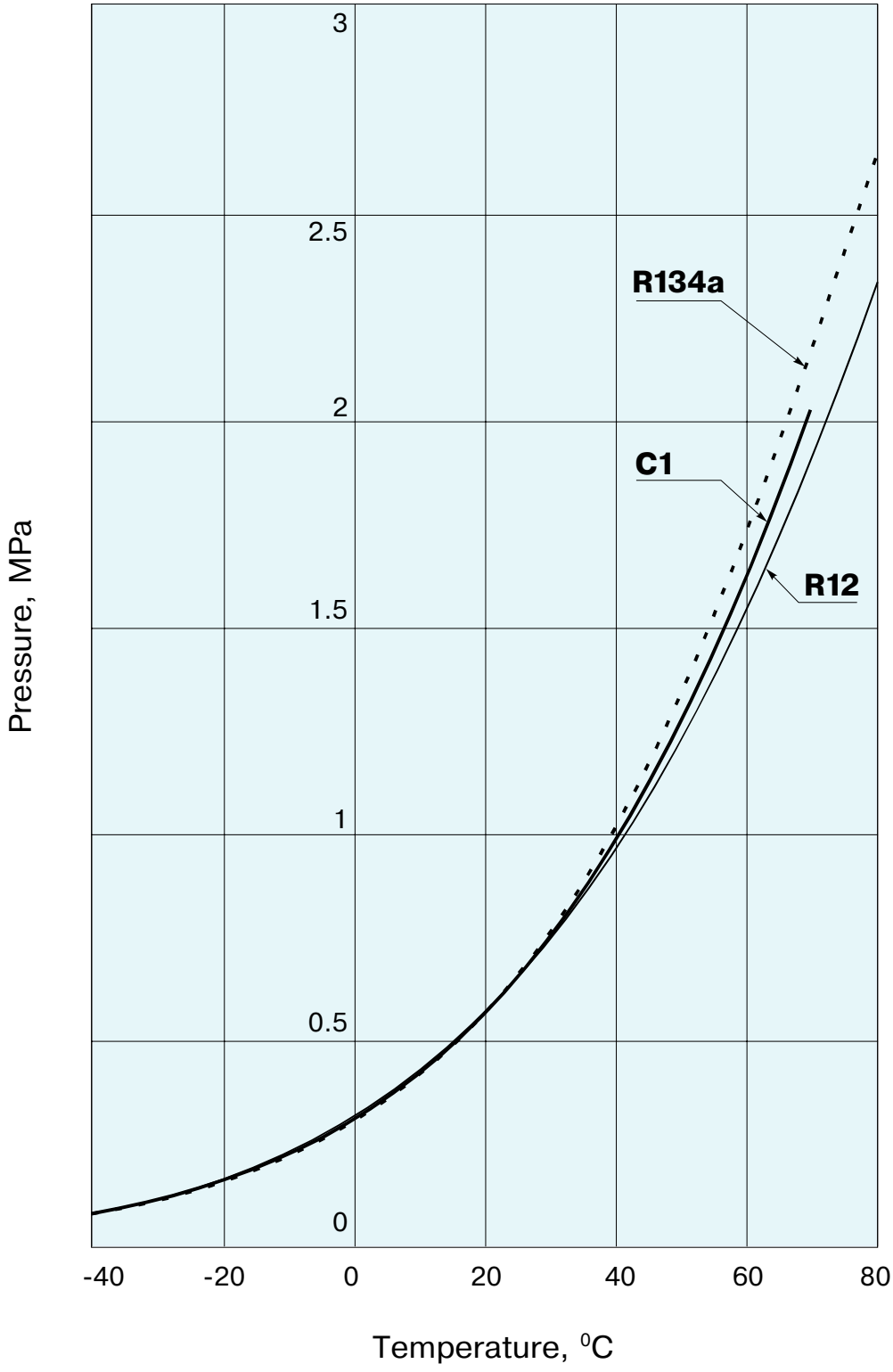

Fig. 2 Pressure in Liquid/Vapor Equilibrium Line

Table 1

Comparison of Key Parameters for Cooling Agents C1, R12 and R134a

	C1	R12	R134a
Compatibility with mineral oils	Yes	Yes	No
Refirigeration capacity, %*	100	96	89
Cooling efficiency, %*	100	101	95
Energy consumption, %*	100	101	108

* All values expressed relative to compund C1 as a reference (100%). Results are from R12 based compressor with boiling point of - 25^{0}C.

2. Compatibility with Refrigeration Equipment Materials.

Studies performed to determine performance of refrigerant C1 in combination with mineral oil demonstrated high corrosion resistance and chemical stability of metallic and electric insulation materials (Attachment 1).

3. Characterization of Flammability.

Refrigerant C1 is a flammable substance:

Lower explosive limit (LEL) in air is ~ 3.15 % by volume.

However, performed assessments indicate that fire-hazardous concentration is not produced within the volume of rooms wherein domestic refrigeration equipment can be installed, even in case of complete loss of the cooling agent.

Room volume, m^3	C1 weight at which fire-hazardous concentration is achieved in the room, kg	Maximum allowable charge of C1 in refrigeration equipment (with ten-fold fire-hazardous concentration margin), kg
8	0.714	0.070
27	2.4	0.240
64	5.7	0.570
125	11.2	1.100

Nevertheless, additional safety measures, for example, installation of plenum-exhaust ventilation, refrigerant leak detectors, fire-safe concentration gas analyzers, shall be provided for rooms wherein refrigeration equipment charged with rather large amount (500 g and above) of refrigerant C1, such as conditioners or shop refrigerators, will be installed.

Russian Institute of Fire Protection gave a positive opinion as to the possibility to use refrigerant C1 in domestic refrigerators.

4. Tests of the Refrigerant.

The refrigerant passed numerous tests at research centers in Russia, at major Russian refrigeration equipment works in Krasnoyarsk, Murom, Yuriuzan, Zelenodolsk, Saratov, Orsk, as well as in USA, Korea, China, Singapore, Poland. All the tests confirmed high power and technological properties of C1.

5. Manufacture of the Refrigerant.

Specifications (TU № 2412-040-00480689-94) are developed and issued for refrigerant C1, which guarantee quality of the manufactured product. Pilot production of C1 is established with an annual capacity of 30 to 100 tones. Design is developed for a larger-scale production of C1 with the output of up to 300 t/y. By agreement with a customer, the refrigerant can be shipped in cylinders of various volume ranging from 3 to 25,000 liters.

Cost of C1 at the pilot production stage - up to 15 $/kg (including VAT).

6. Proposals on Cooperation.

The possibilities for cooperation include:

- Delivery of the finished product;
- Sale of a license for manufacture of the refrigerant, and for relevant technical documentation;
- Sale of a license for equipment and technical documentation for a production division on C1 manufacture;
- Fabrication and delivery of equipment for a production division on C1 manufacture.

Any requests or questions concerning cooperation in the use and manufacture of C1 shall be addressed to:

JSC "INERTEK", Kurchatov Square 1, Moscow 123182 Russia.

Contact phone numbers in Moscow: (095) 196-71-64,
(095) 196-17-08,
fax: (095) 196-89-71

E-mail: vau@atis.kiae.su

Indices of Ecological Safety of Refrigerant C1 as Compared to Other Refrigerants

Refrigerant C1 is a chemically inert, colourless gas, it is non-toxic and ozone-friendly. It features low global warming potential (GWP 0.015), and zero ozone depletion potential (ODP = 0). Impact of refrigerant C1 on the environment in comparison with other refrigerants is shown in Fig. 3.

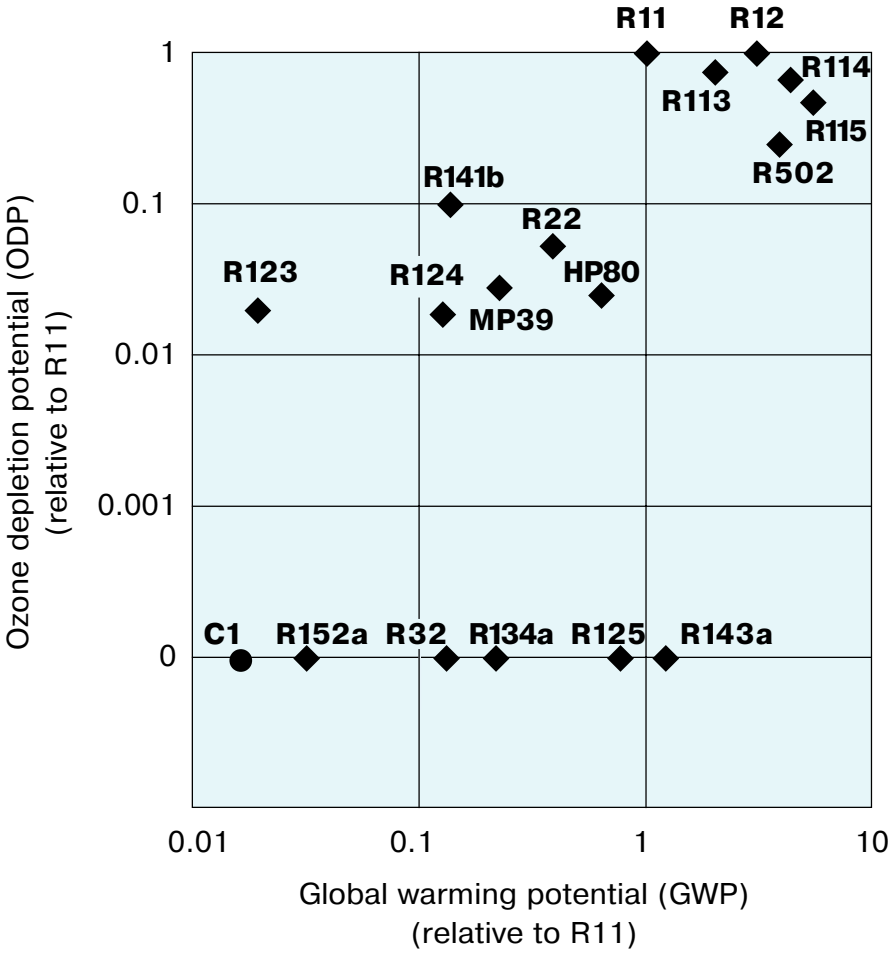

Fig. 3 Impact of Refrigerant C1 on the Environment in Comparison with Other Refrigerants

HIGH TECHNOLOGIES

Innovations in Medicine

Mirazh-MB40 Device (liquid microsprayer)
A set of medicine-containing polymeric coatings

Purpose:

- first aid at burns;
- wound cleaning from microbes;
- wound protection from contagion;
- dosed introduction of remedies into the wound;
- stimulation of the wound healing.

Advantages:

- the structure created over the wound is permeable to air but impermeable to microorganisms and harmful dust;
- possibility to restore the skin.

Areas of application:

medicine, veterinary medicine, cosmetology, agriculture, food industry.

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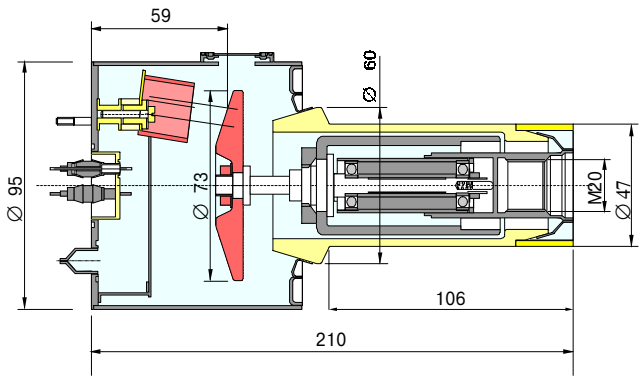
HIGH TECHNOLOGIES

Metal-ceramic Rotating Anode X-ray Tube



Purpose

- for employment in medical computer tomographs and mammographs

Advantages over analogues

- cleanness of X-ray radiation spectrum
- significantly smaller effect of afocal X-ray radiation
- acceptable price

High energy and operating characteristics are achieved by the use of metal-ceramic single-crystal materials previously used in nuclear space power.

Characteristics

Nominal voltage, kV	150
Focal spot size, mm	0.6
Anode diameter, mm	no less than 150
Anode material	W-Re-C, W-Re-Mo
Anode heat accumulator capacity, kJ	up to 1300
Speed of anode rotation, RPM	up to 9000

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INERTEK

HIGH TECHNOLOGIES

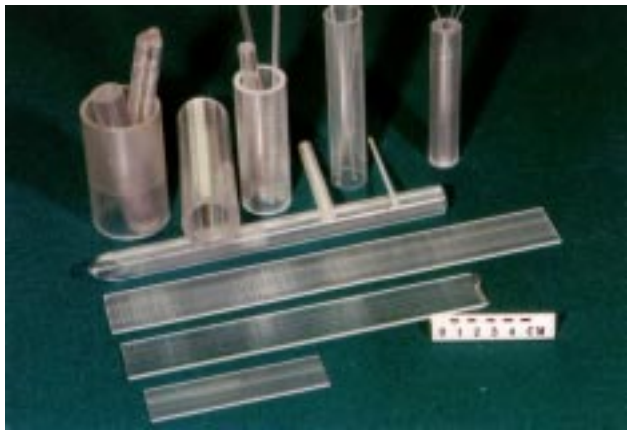
Synthetic Corundum (Leucosapphire) and Its Final Products

Consumer properties:

- shape perfection and stable properties;
- high mechanical strength, hardness and wear resistance;
- high heat resistance, radiation strength, dielectric characteristics, inertness in aggressive media;
- high melting point (2327 K) and operating temperature, vacuum tightness;
- optical transparency in a wide range of wave lengths;
- biological compatibility.

Finished and polished products

Shaped crystals



Main fields of application:

- watch industry (glasses, jewels);
- optics, lighting engineering (lenses, windows, light pipes);
- precise engineering industry (guides, sliding bearings, wear-resistant tips of measurement tools);
- electric and vacuum engineering (insulators, metal-ceramic assemblies);
- medicine (tips for laser systems, implants);
- microelectronics (bases for Si on Sapphire);
- chemical industry (spray nozzles, dies).

Range and geometry of products:

- shaped crystals with untreated surface up to 600 mm in length
  - tubes 5-40 mm in outer diameter, 1910 mm in wall thickness and 1 mm minimal inner diameter;
  - rods 1-10 mm in diameter;
  - plates up to 40 mm in width and 1-15 mm in thickness;
- products manufactured by the use of diamond instruments for processing and polishing
  - tubes, rods, plates;
  - machining accuracy is 0.05 mm;
  - surface finish Rz= 0.63 - 0.05 mm;
- the possibility of product manufacturing with the shape and sizes different from the above mentioned.

Metal-ceramic assemblies with leucosapphire insulators

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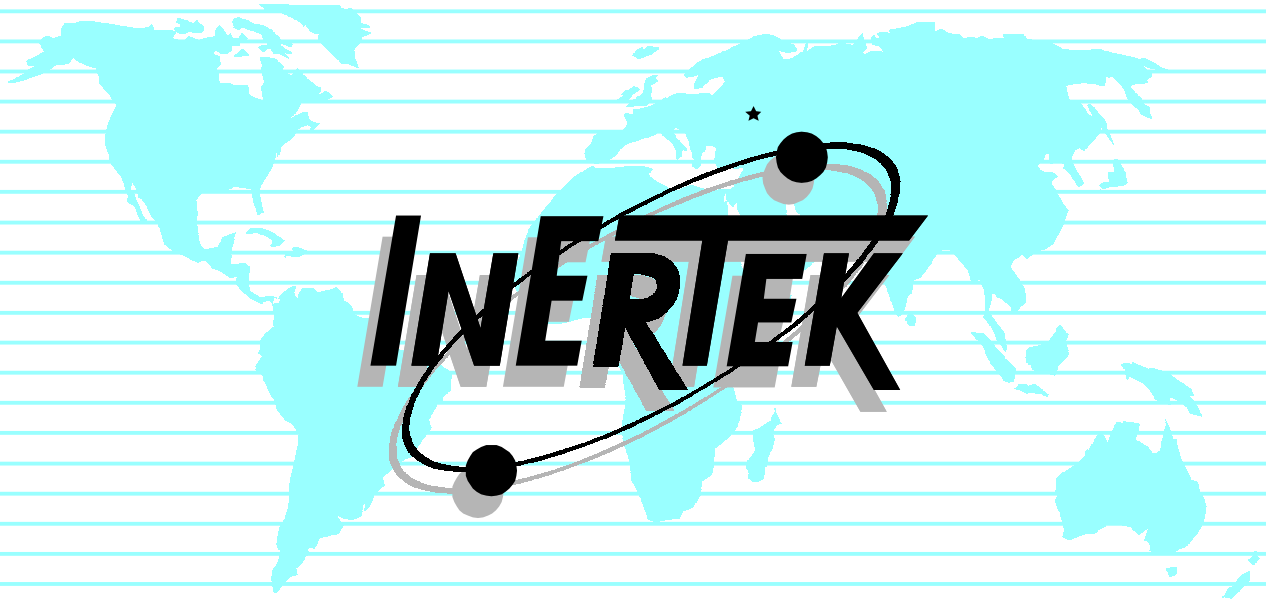

"International Energy Technologies"