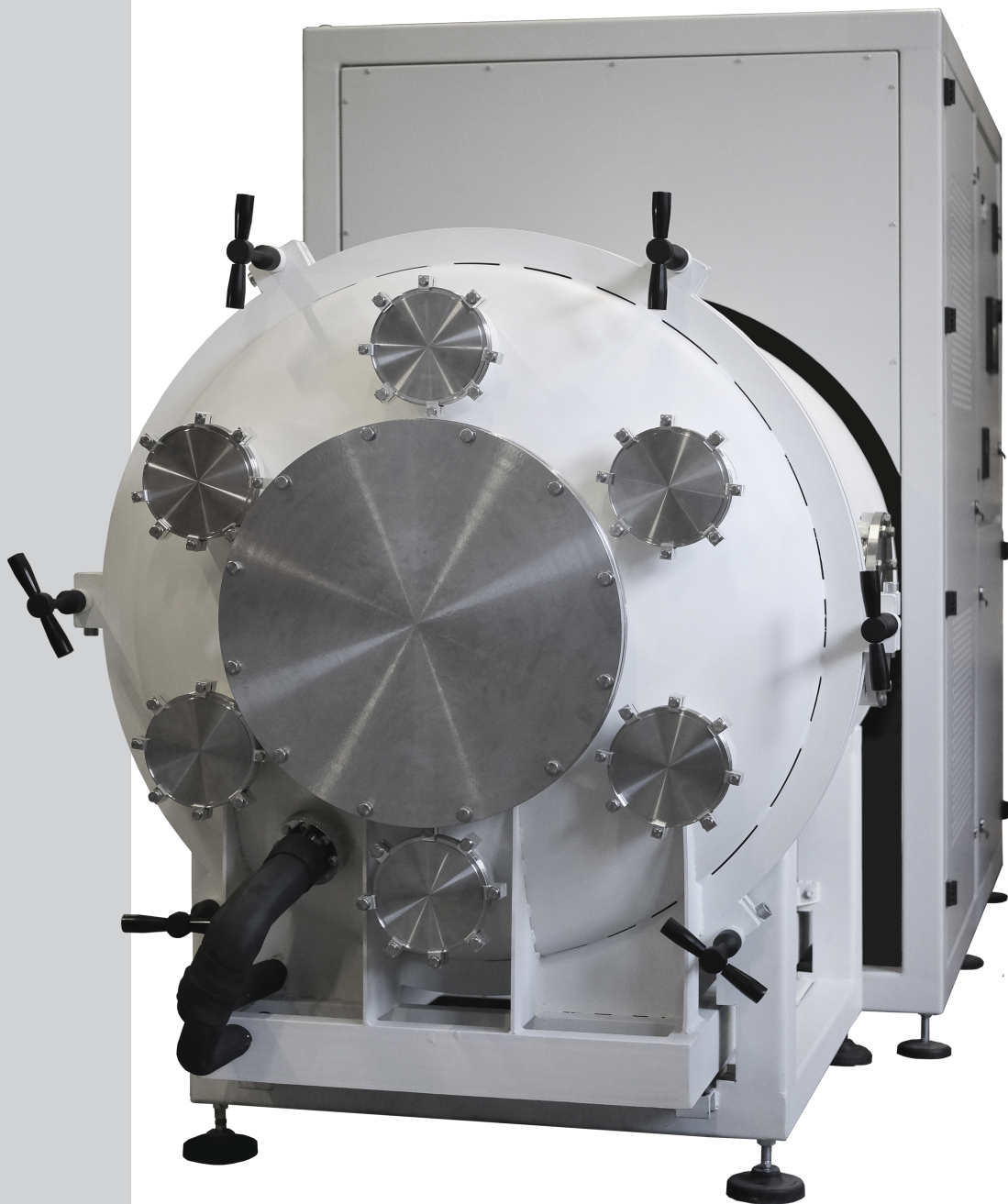




DEEPVAC

INTELLIGENT
THERMAL
VACUUM
CHAMBERS





Technical Description

The thermal vacuum chambers (models T and C) are intended for the testing and qualification of equipment and components designed to operate in space environment. The chambers simulate extreme temperatures and high vacuum typical of space, enabling qualification and verification testing of space equipment.

Common Technical Characteristics

Series T and C (volume)	65	125	250	500	1000	2000
Measurement and control characteristics						
Temperature range on the thermal plate, °C	direct LN2 injection cooling with surface-mounted heaters: -180 °C to +150 °C					
	GN2 closed-circuit circulation control; GN2 conditioning via LN2 heat exchanger: -180 °C to +150 °C					
	mechanical cooling: -70 °C to +125 °C					
	flooded LN2 heat exchanger in two-phase boiling mode: down to approximately -190 °C					
Temperature uniformity, K	± 2					
Temperature stability (steady-state), K	± 0,5					
Temperature change rate, K/min	heating ≥ 1 cooling ≥ 1					
Working pressure, mbar	≤ 1 × 10 ⁻⁶					
Type of temperature sensor	Pt100					
Vacuum pumping system						
Turbomolecular pump pumping speed, L/s (nominal)	300	450	500	900	1200	2200
Pumping speed of the backing vacuum pump (nominal value), m³/h	16	16	25	40	63	100
Control system						
Type	freely programmable controller (PLC-based)					
Setpoint resolution	0.1 °C					
Control panel	7-inch color touchscreen					
Data storage on USB storage devices	available (storage of actual and setpoint parameters; service parameters of the refrigeration system or cryosubsystem)					
Data export: available	available (CSV, TXT, XLS)					
Connection to a PC	control via PC software					
Constructions						
Internal chamber material	AISI 304 stainless steel, walls with polished surface					
Power supply	220 V ± 10% / 50 Hz, single-phase			380 V ± 10 % / 50 Hz, three-phase		
Standard process ports	ISO-K 100 (1 pc.), alternatively any flanges and connections			ISO-K 160 (1 pc.), alternatively any flanges and connections		
Other characteristics						
Operating conditions	ambient temperature: +10 °C to +35 °C					
Automatic emergency protection functions	available					
Overtemperature and undertemperature protection	available					



Design Features – Model T

The T series thermal vacuum chamber is a vacuum-tight rectangular construction made of stainless steel. The chamber is equipped with a front door with a manual locking mechanism, which allows convenient access to the work area. There are vacuum and diagnostic connections according to ISO-K, CF, or KF standards on the housing, to which pumping systems, sensors, thermocouples and technological inputs can be connected (type and number are agreed with the customer). Inside the chamber is an aluminum thermal plate for temperature control of the test specimen. A heating plate made of copper or stainless steel can be supplied on request. The chamber is mounted on a sturdy frame that allows for transport and vibration isolation.

The surfaces inside the chamber are polished to minimize outgassing and ensure a high vacuum.

The system is supplied as a modular design that includes a vacuum chamber with an integrated pumping system and pneumatic valves, as well as a separate low-temperature chiller or nitrogen cooling system. The vacuum-tight chamber housing and pump-out system are mounted on a common metal frame that distributes the load evenly across the floor.



T Series – Dimensions & Weight

Model	T64	T125	T250	T500	T1000	T2000
Internal usable volume, L	65	125	250	500	1000	2000
Internal usable dimensions (W × H × L), mm	400 ×	500 ×	630 ×	800 ×	1000 ×	1260 ×
	400 ×	500 ×	630 ×	800 ×	1000 ×	1260 ×
	400	500	630	800	1000	1260
External dimensions (W × H × L), mm	600 ×	700 ×	830 ×	1000 ×	1150 ×	1400 ×
	1800 ×	1900 ×	1900 ×	1900 ×	1900 ×	2100 ×
	900	1000	1130	1300	1500	1760
Thermal plate dimensions W × L, mm	380 ×	480 ×	610 ×	780 ×	980 ×	1120 ×
	350	450	580	750	940	1120
Weight, kg	450	650	950	1400	2200	3200



Design Features – Model C

The Model C thermal vacuum chamber (TVAC-C) is a hermetically sealed cylindrical stainless-steel chamber, designed for testing under high vacuum and controlled temperature conditions. The chamber is equipped with technological flanges and ports for the installation of vacuum pumping equipment, temperature and pressure sensors, and electrical feedthroughs.

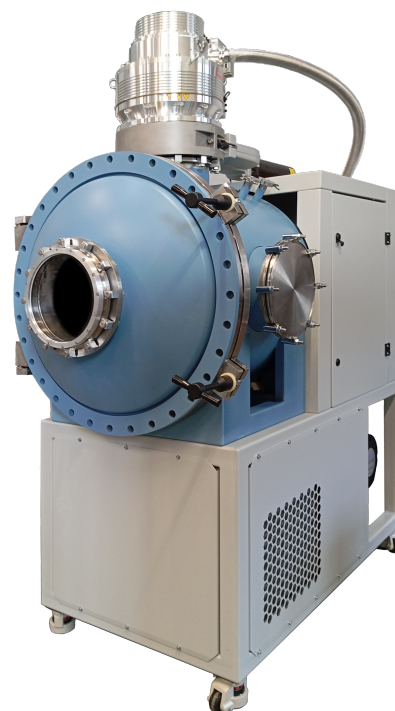
TVAC-C Configurations by Access Type

Front-Hinged Door Configuration

The chamber is equipped with a front-mounted hinged door featuring a manual or quick-acting locking mechanism, providing convenient access to the working volume for specimen installation and maintenance. The door is fitted with a vacuum-rated sealing system.

Roll-Out Trolley Configuration (Sliding Platform)

The chamber is manufactured with a roll-out trolley (sliding platform) for mounting test fixtures and specimens. Loading is performed by pulling the trolley out of the chamber body, simplifying handling of large or heavy test articles and reducing test preparation time. After loading, the trolley is inserted into the working volume and the chamber is sealed.



C Series – Dimensions & Weight

Model	C64	CS125	C250	C500	C1000	C2000
Internal usable volume, L	65	125	250	500	1000	2000
Internal usable dimensions (D × L), mm	Ø500× 350	Ø600× 420	Ø800× 490	Ø1000× 700	Ø1250× 880	Ø1500× 1200
External Dimensions (W × H × L), mm	600× 1800× 900	700× 1900× 1000	900× 1900× 1130	1100× 1900× 1300	1400× 1900× 1500	1700× 2100× 1860
Thermal plate dimensions W × L, mm	330× 350	400× 420	460× 500	660× 700	840× 880	1140× 1200
Weight, kg	500	620	750	1100	1600	2500



Thermal control system

The thermal control system is used to specify, maintain and program temperature profiles in the thermal vacuum chamber (TVAC). It includes the following main components:

- Thermal Plate with Heat Transfer and Heat Exchanger Assemblies
- Heating elements (integrated or surface-mounted) for heating operation and compensation of heat inputs
- Refrigeration or cryosubsystem (depending on the version)

Measurement and control system (temperature sensors, controllers, protective circuits)

The thermal plate is designed with threaded holes for fastening the test specimen. To ensure high temperature uniformity, optimized heat transfer structures and coordinated control algorithms for heating and cooling are used.

Depending on the required temperature range and available infrastructure, the following versions are available:

■ Direct liquid nitrogen injection with surface-mounted heaters

Temperature range: -180 °C to +150 °C.

Cooling is provided by metered liquid nitrogen (LN2) injection into the heat exchanger of the thermal plate. Heating and precise temperature adjustment are carried out via surface heaters. This design allows for high cooling rates and a wide temperature range if an LN2 supply is available.

■ Gaseous nitrogen control

Temperature range: -180 °C to +150 °C.

Cooling is achieved by circulating gaseous nitrogen (GN2) in a closed circuit, with cooling provided by an LN2 heat exchanger or an equivalent cooling source. In combination with heaters, stable temperature maintenance and thermal cycles are possible. This design is recommended when a nitrogen infrastructure is available and particularly gentle cooling is required.

■ Mechanical Refrigeration

Temperature range: -70 °C to +125 °C.

Cooling is provided by a vapor-compression refrigeration system. Heat is dissipated via the heat transfer circuit of the thermal plate. Optionally, a circulating flow of a refrigerant or heat transfer medium can be used to increase the temperature uniformity over the plate. The refrigeration system is equipped with hermetic compressors and is designed for industrial operation.

■ Flooded Liquid Nitrogen (flooded LN2 heat exchanger, two-phase boiling mode)

Minimum temperature: down to -190 °C.

Cooling is provided by a flooded LN2 heat exchanger in two-phase boiling mode, which allows very low temperatures and a high cooling capacity to be achieved. Operation is controlled by regulating LN2 inflow and boiling behavior as well as by the heaters (for stabilization and for the generation of step-shaped temperature profiles).

The system is equipped with independent protective circuits that prevent overheating, undertemperature and operation beyond permissible limits:

- Hardware and software temperature limits
- Thermostats or sensors for emergency protection
- Monitoring of the parameters of the refrigeration or cryogenic subsystems (depending on the selected version)

In versions with mechanical refrigeration, the condenser and compressor(s) are air-cooled as standard. When installed in enclosed or poorly ventilated rooms, supply and exhaust air ducting is recommended in order to reliably dissipate heat from the refrigeration system. The heat input depends on the current test mode, in particular the set temperature and thermocycle frequency.

On request, the system can be retrofitted with water cooling, which is particularly relevant for integration into enclosed areas or noise-sensitive production environments.



Thermal control with cryogenic shrouds and infrared heaters (optional)

To generate thermal vacuum conditions and to control the radiative heat transfer in the test volume, the chamber can be equipped with a system of cryogenic shrouds and infrared heaters.

Cryoscreens are shield panels that are arranged around the installation area of the test specimen and cooled by the selected cryogenic or refrigeration subsystem, for example by liquid nitrogen or a mechanical refrigeration system. Cryogenic shrouds reduce radiative heat input to the test specimen and allow the required effective ambient temperature (cryogenic shroud temperature) to be set in the working area.

The cooling of the cryoscreens is carried out via integrated heat transfer channels; the temperature operation is regulated by the chamber control.

To improve temperature uniformity, the cryoscreens are divided into zones with independent measurement and control.

The design of the cryoscreens minimizes thermal bridges and reduces parasitic heat input.

Infrared heaters are used to simulate external heat effects and to heat the test specimen in a vacuum via radiation. IR heaters can be used to implement temperature profiles and thermal cycles, as well as to simulate solar flux and localized heat fluxes, depending on the configuration.

- The heaters are positioned on the cryoscreens or on the test setup and generate the required radiant load on the test specimen.
- Capacity control is carried out in a closed loop on the basis of temperature sensors and predefined profiles; zonal regulation is possible.
- Independent overtemperature protection functions are provided (hardware and/or software limitations, emergency thermostats).

The interaction of cryoshields and IR heaters enables the specification of a defined radiation environment, a high repeatability of the thermal test conditions and a reduction in the influence of heat input via the chamber walls.

Vacuum Pumping System

The vacuum system is used to generate and maintain the specified vacuum level in the working volume during the tests. The design is based on the required pressure range, the chamber volume, the gas load (desorption, leaks, outgassing of the test specimen) and the requirements for the purity of the vacuum atmosphere.

The vacuum section includes:

- Pump group (backing stage and high vacuum stage if required)
- Vacuum fittings (gate valves, isolation valves, check valves, throttling, and control valves)
- Vacuum measuring equipment (pressure sensors for the respective measuring ranges)
- Control and protection system (interlocks, operational monitoring, emergency algorithms)

The pump group has a modular design and can contain:

- Pre-pumping stage: dry scroll pump, screw pump or rotary vane pump, depending on purity requirements and operating costs
- Performance increase in the pre-vacuum: Roots Booster according to pumping time requirements
- High Vacuum Stage: Turbomolecular Pump for High Vacuum Operation
- Additional solutions: cryoelements, traps or filters depending on the task, e.g. to reduce backflow, protect the high vacuum pump and improve vacuum purity.

At the customer's request, the pump group can be equipped with components from different manufacturers or equivalent products, e.g. Pfeiffer Vacuum, Leybold, Edwards or ULVAC.

Pressure measurement is carried out by sensors that cover all operating states. A typical configuration includes:

- Sensor for the pre-vacuum range (thermoconductive, Pirani)
- Sensor for medium and high vacuum (cold cathode or ionization sensor, depending on measuring range and requirements)
- Optional capacitive sensor for high-precision measurement in a defined range, with low dependence on the gas mixture
- The vacuum system is equipped with fittings and protective functions:
 - Check valves to prevent backflow
 - Control elements such as throttles if smooth pressure control or defined pumping speed is required
- Interlocks and Control logic: release of the high-vacuum stage only after reaching pre-vacuum, monitoring of valves and sensors, emergency shutdown in case of limit violations.

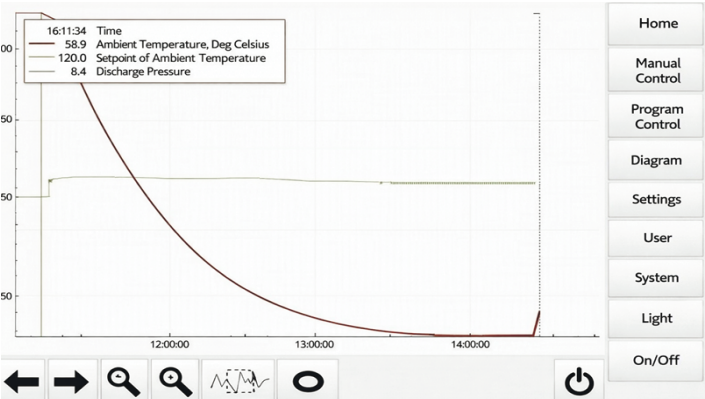


Control system

The chamber is equipped with a control system designed to meet the requirements of the testing equipment and operating personnel. A user interface with a 7-inch color touch display supports operation, routine operation, and monitoring. The system supports setup, monitoring and programming of test workflows, including automation and remote access.

Core features of the control system:

- Complete user interface, tailored to the requirements of the operating personnel
- Graphical program creation with up to 999 steps and clear visualization
- Manual and automatic setting of temperature setpoints, including ramp or approach speed adjustment
- Resolution: 0.1 °C
- Access to sensor calibration via the touch panel
- Display of current process values and device statuses to support maintenance and service
- Delayed start and event log with archive
- Data storage on USB data carriers
- Control of a single chamber or a group of systems from a computer
- Remote access via:
 - Ethernet (LAN) for network access
 - Modbus TCP for integration into industrial controls
 - OPC UA for connection to SCADA, MES and other automation systems



Thanks to the modular architecture, the control system can be adapted to special tasks and expanded with the further development of the test system.

The chambers are designed as a series system, and the technical solutions used have been tested in the company and verified on the production side. The company has a design and development department, which allows us to develop customized solutions according to the customer's requirements.

Optional features

Option	Purpose	Benefits
Solar simulator	Replication of radiant heat loads	Simulation of solar heat, extension of test scenarios
Viewing window (vacuum), optional ZnSe for thermography	Observation of the test specimen; ZnSe for IR transmission through the chamber wall	Visual inspection without ventilation; Thermography, hotspots and defects
Heated chamber walls (bake-out)	Heating of the inner surfaces to accelerate degassing	Reduction of pumping time, improvement of vacuum purity
Infrared Heater	Additional radiant heat load	Faster temperature rises, simulation of radiant heating
Cryogenic traps	Condensation of water vapor and other condensable gases	Improvement of vacuum purity and pressure stability
Additional temperature sensors	Increasing the measuring points	Improving temperature mapping
Additional process connections	Vacuum entries for current, signals, sensors	Simplified integration
Automatic venting and rinsing with dry nitrogen	Controlled filling and rinsing	Reduction of contamination risk, faster sample changes
Accelerated pumping module	Installing a Roots Booster	Reduction of pumping time
Fully oil-free vacuum pumping	Equipped with dry pumps	Minimizing hydrocarbon contamination
Residual gas analysis (RGA)	Control of the residual gas composition	Greater significance of the tests
Helium leak test preparation	Connections for leak testing	Acceleration of acceptance
QCM control	Monitoring of condensation and contamination	Quantitative assessment of contamination
Viewing windows, optical connections	Visual inspection, optical measurements	Advanced diagnostics without opening
Interior camera	Video control of the test specimen	Increased operational reliability
Additional temperature control zones	Independent regulation of areas	Better uniformity, more complex profiles
Vibration isolation	Mechanical decoupling of pumps	Reduction of vibrations on the test specimen
Remote monitoring and advanced data logging	Network transfer and export	Traceability, simplified evaluation
Water cooling	Heat dissipation via water cooling	Reduced heat emission and noise level

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