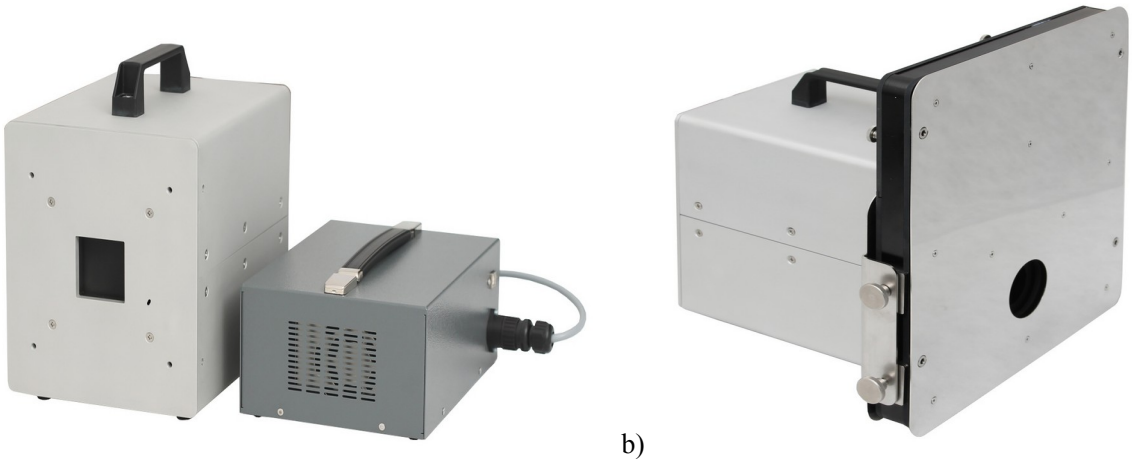
VB

Vacuum blackbodies



a) b)

Fig.1. Photo of VB-TCB-2D blackbody set: a) VB-TCB-2D blackbody head and VDC power supply, b) VB blackbody head integrated with VRW-8 rotary wheel

1 Basic information

Testing infrared systems to be sent into space missions is typically done using blackbodies located in cooled vacuum chambers that simulate space conditions. Design of required blackbodies is a technological challenge due to a set of special requirements: ability to work in vacuum conditions, ability to withstand extremely low temperatures, precision regulation of temperature of blackbody emitter, and remote control of the blackbody located in the vacuum chamber from the control center located outside the chamber. It should be also notes that vacuum temperature chambers used in space industry vary a lot due to different dimensions, temperature of internal surface and design of thermal shroud.

Blackbodies located at vacuum chambers are typically used to simulate uniform target that imitates Earth o temperature in range from about -40ºC to about +150ºC (233K-423K). Sometimes blackbodies of expanded range from about -100ºC to about +250ºC are needed to simulate both Earth, cold deep space objects and hot Earth targets (173K-423K).

2 Inframet typical blackbodies

Temperature ranges needed by vacuum blackbodies partially overlap temperature ranges of two blackbodies manufactured by Inframet (Table 1):

1. TCB blackbodies: https://www.inframet.com/Data_sheets/TCB.pdf,
2. MTB blackbodies: https://www.inframet.com/Data_sheets/MTB.pdf.

Table 1. Temperature ranges of TCB and MTB blackbodies

Blackbody type	Absolute temperature range (at ambient 20ºC)	Differential temperature range (at ambient 20ºC)
TCB	0ºC to +100ºC option: -15ºC to +150ºC	-20ºC to about +80ºC option: -35ºC to +130ºC
MTB	+25˚C to +550˚C	+5˚C to +530˚C

It should be also noted that Table 1 presents temperature ranges of TCB/MTB blackbodies working at typical laboratory temperature equal to 20ºC when abient temperature inside typical vacuum temperature chambers vary at least from -100ºC to +30˚C. Such situation shows potential to design vacuum chamber blackbodies of desired temperature range (basic version: -40ºC to +150ºC ; expanded version: -100ºC to about +250ºC) by simple modification of typical TCB/MTB blackbodies: making electronics capable to work at vacuum. However, practically TCB/MTB blackbodies after such minor modification shall not work properly in vacuum chambers.

TCB/MTB blackbodies enable regulation of absolute temperature of their emitter. However, from designer point of view these blackbodies regulate differential temperature of blackbody emitter: difference between temperature of blackbody emitter and temperature of the thermal base block. Temperature of the latter block is kept similar to

ambient room temperature using air cooling. This type of cooling cannot be used vacuum blackbodies because there is no air in vacuum chambers.

3 What are VB blackbodies?

VB blackbodies are customized versions of typical blackbodies TCB/MTB (or others) capable to work in vacuum chambers. This capabilities have been achieved after a series of design modifications:

1. Typical blackbody in form of integrated blackbody head with electronic controller is replaced by blackbody in form of two separate blocks: 1)blackbody head, 2) electronic controller. Only the first block is to be inserted to vacuum chamber.
2. Blackbody head is manufactured using parts that are compatible with vacuum chamber,
3. Typical cooling method using air fans is replaced by one of three types of cooling: 1) thermal base block is cooled using mix of ethylene and glycol as cooling fluid, 2) thermal base block is cooled using LN2 as cooling fluid.

The first design modification enables to use typical electronic parts to design electronic controller that is located outside vacuum chamber.
The second modification enables to keep low gas contamination of vacuum chamber when blackbody is inserted.
The third modification enables to regulate temperature of blackbody emitter by electronic controller in the same way as it is carried out in typical blackbodies.
The first way of cooling is applied to modify TCB blackbody that uses Peltier element to heat/cool blackbody emitter. It enables design of new vacuum compatible VB-TCB blackbody.
The second way of cooling is applied to modify MTB blackbody that uses heating ceramic element to heat blackbody emitter. It enables design of new vacuum compatible VB-MTB blackbody.
In both cases the thermal base block of the blackbody is connected with chiller using flexible pipes that go through wall of the chamber via an interface in the wall. Similar interface in chamber wall is also needed for electrical cable to connect blackbody head inside chamber and electronic controller outside chamber.

4 Technical specifications

Table 2. Technical specifications of VB-TCB series blackbodies

	VB-TCB-2D	VB-TCB-4D	VB-TCB-8D	VB-TCB-12D
Emitter area	50x50mm	100x100mm	200x200mm	300x300mm
Emissivity	0.98	0.98	0.98	0.98
Absolute temperature range	-40ºC to +150ºC (233K-423K)	-40ºC to +150ºC (233K-423K)	-30ºC to +150ºC (233K-423K)	-20ºC to +150ºC (233K-423K)
Temperature resolution	1mK	1mK	1mK	1mK
Temperature stability	3mK	3mK	3mK	3mK
Heating/cooling time (from min to max temperature)	<30 min	<50 min	<200 min	<600min
Optimal radiative temperature range of vacuum chamber	-20°C to +20°C	-20°C to +20°C	-20°C to +20°C	-20°C to +20°C

5 Table 2. Technical specifications of VB-MTB series blackbodies

	VB-MTB-2D	VB-MTB-4D	VB-MTB-12D	VB-MTB-12D
Emitter area	50x50mm	100x100mm	200x200mm	300x300mm
Emissivity	0.98	0.98	0.98	0.98
Absolute temperature range	-100ºC to +250ºC (173K-423K)	-100ºC to +250ºC (173K-423K)	-100ºC to +250ºC (173K-423K)	-100ºC to +250ºC (173K-423K)
Temperature resolution	1mK	1mK	1mK	1mK
Temperature stability	3mK	3mK	3mK	3mK
Cooling time from 293K to minimum temperature	<1 h	<2 h	<3 h	<4h
Optimal radiative temperature of vacuum chamber	-100°C to +20°C	-100°C to +20°C	-100°C to +20°C	-100°C to +20°C

6 Customization

VB series blackbodies are offered as customized products that are optimized for specific chamber and desired performance parameters (emitter size, temperature range). Customer is expected to choose preferable model listed in Tables 2-3 and deliver detail technical specifications of the vacuum chamber. Customer is responsible to have chamber with proper interfaces for cooling liquid and electrical cables. He is also responsible to deliver liquid LN2 (if needed).

7 Options

Some vaccum chambers are equipped special mechanism capable to cool (dissepate heat) of heat sources inside chamber. Thermal shroud or cold fingers are commonly used for such applications.

If vaccum chamber is equipped with such mechanism then it can be used to cool thermal base block. Cooling using liquid pipes is not needed and Inframet can deliver cheaper VB blackbody.

8 Summary

VB are ultra precision blackbodies that can work at vacuum chambers and enable to carry out test of space thermal imagers in near real work conditions. Desigh of VB blackbodies is based on mature TCB/MTB series blackbodies.

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