Beyond Gravity Austria GmbH | Stachegasse 13 | 1120 Vienna | Austria
Phone +43 1 80199 0 | cryo.at@beyondgravity.com

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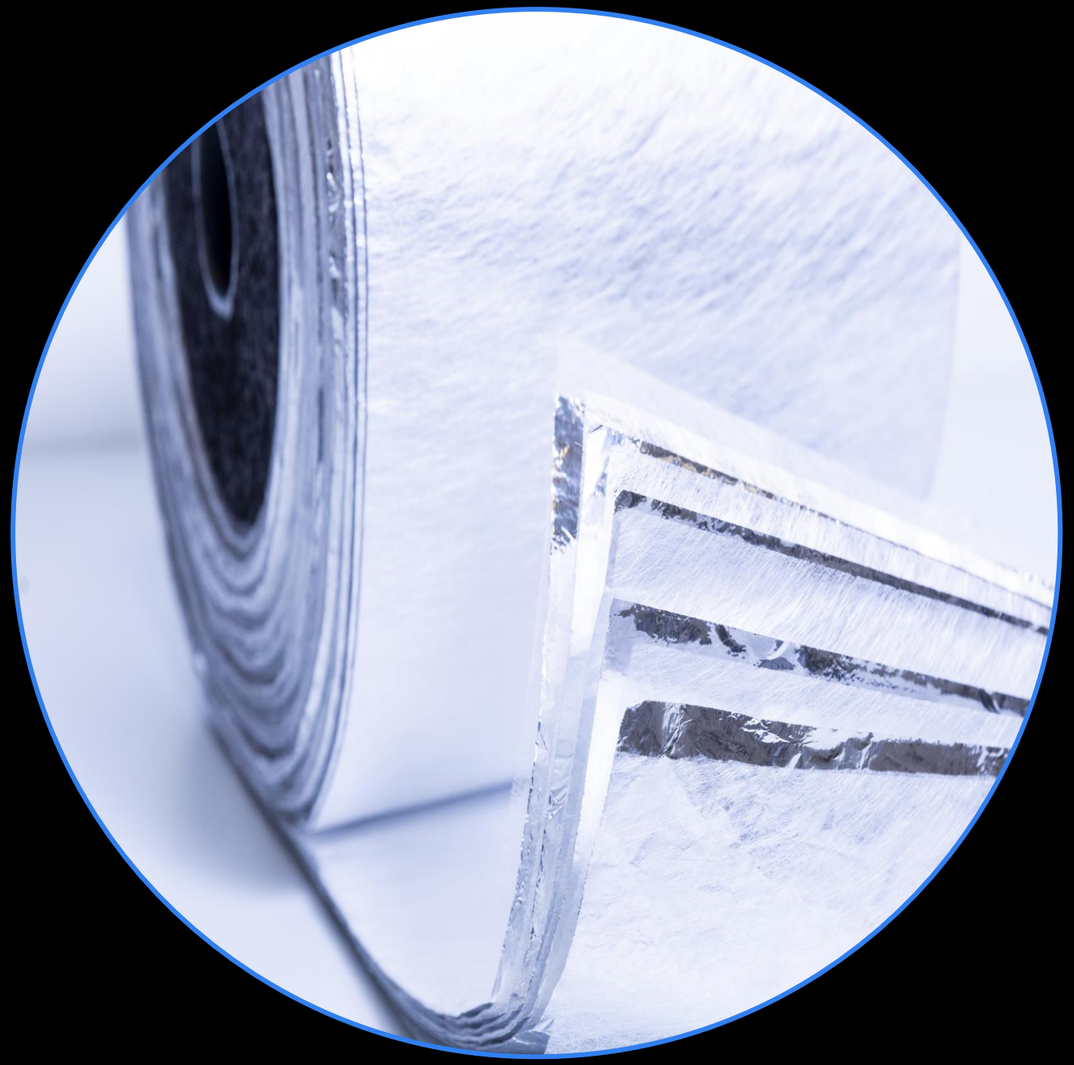
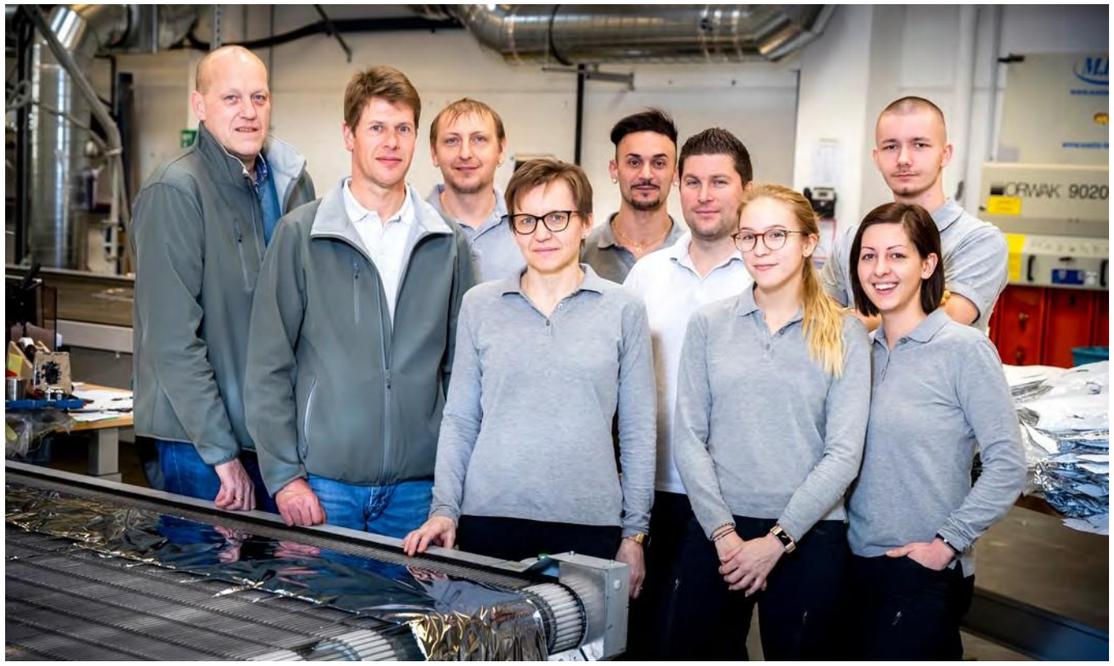


Cryogenic insulation products



For enquiries for cryogenic materials, please contact:
cryo.at@beyondgravity.com

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Vacuum thermal insulation thermal components

Beyond Gravity is the leading European supplier of Multi-Layer Insulation for spacecraft and global market leader of superinsulation for cryogenic medical systems. The experience we have gained in more than almost three decades of thermal design and production enables us to increase your competitiveness with Beyond Gravity's leading edge technology solutions.

Our vision is to be the leading competence center for vacuum thermal insulation solutions for space and terrestrial applications.

Our mission is the development and production of Multi-Layer Insulation for the space and cryogenic industry to support our customers in increasing their competitiveness. To achieve this mission we focus on first-class products and reliable and long-standing partnerships with our clients.

Beyond Gravity activities to develop and produce Multi-Layer Insulation for space applications (satellites and instruments) started in 1991. Since then we have proven our competencies and skills in more than 80 projects to become the leading European supplier of Multi-Layer Insulation for spacecraft.

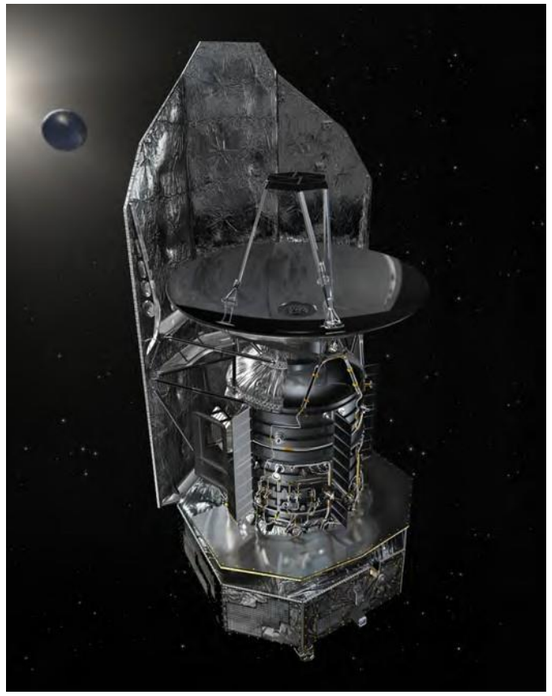
Moreover, Beyond Gravity has gained great expertise in the field of cryogenic insulation. Today Beyond Gravity also offers the development and the production of cryogenic superinsulation for various applications such as Helium liquefiers or superconducting magnets, liquid gas tanks and infrastructure.

Our development and production process comprises of:

- Thermal and mechanical engineering
- Layout and design
- Production and integration

Our value creating chain includes:

- CAD design (3-D and 2-D)
- Prototyping, support during first installation
- Production (standard and tailor-made products and also build to print)



Artist impression of Herschel Spacecraft courtesy of ESA

We also produce superinsulation based on customer drawings and we accept the definition of blanket shapes in DXF, IGES or STEP format.

Beyond Gravity GmbH is certified to ISO 9001, ISO 14001 and EN 9100 by DNV.

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Cryogenic insulation (COOLCAT line)

Our product family COOLCAT comprises of standard insulation and tailor made insulation. Our insulation is composed of aluminized polyester foils interleaved with polyester spacer materials or made of aluminium foils interleaved with glass spacer materials. In addition, we supply, amongst other things, welding protection materials and tapes.

Laser cutting

Polyester superinsulation blankets are cut to shape using our numerically controlled (NC) cutting machines. Polyester superinsulation is laser cut whereas aluminium/glass insulation is cold cut. The laser cutting process assembles the multi-layered package around its cutting edges. Bridges of molten polyester hold the edges together.

However, laser cut edges are open for edge pumping (see picture below). In the comparative calorimeter test between Multi-Layer Insulation with cold cutting and laser cutting, no significant difference in thermal performance was found: Laser cutting does not increase edge effects!

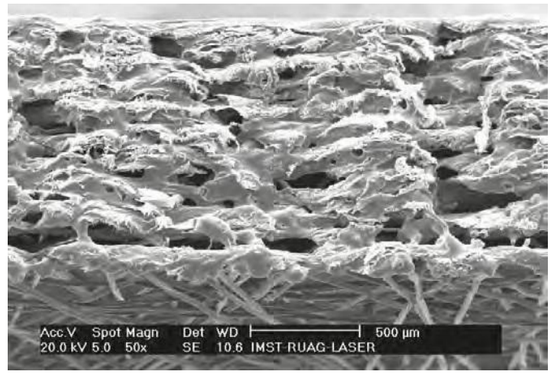
We can NC laser cut to a maximum width of 2.7 m. The length of the cutting area is 3.0 m, which does not limit the length of individual superinsulation blankets, as the superinsulation is fed into the cutting machine on a conveyor, forwarding the material band when needed.

This method of producing polyester superinsulation has proven to be very efficient, because no additional assembly of the layers (pins, staples, welding points or similar) is required to attain a robust blanket with very good handling properties. The thermal performance is optimized by minimizing thermal shortcuts through assembly elements.

When compared to cold cut blankets, where cracks could start from the edge of each single reflector foil, laser cut/welded blankets combine the strength of several thin layers. The tear strength of laser cut edges is 20–30 % higher than the tear strength of cold cut edges. No crack stopper holes are needed at the end of laser cuts or inside corners (<180° C).

During the evacuation of the vacuum space, the air and outgassing products enclosed within the multi-layer package of the insulation can be pumped at the open edges (edge pumping) and through perforation holes of the reflector foils (broadside pumping). Most of our COOLCAT superinsulation is made of perforated foils to allow broadside pumping. Thus, the insulation gap can be evacuated more quickly and the residual vacuum pressures are lower than for edge pumping only.

We supply standard sheets and rolls of polyester superinsulation such as COOLCAT 2 NW. COOLCAT 1 and COOLCAT 2 have been replaced by superior insulation. Please request our recommendations for your technical solution. These standard superinsulation products are held together by a grid of ultrasonic spot welds. The standard pitch of these welds is 0.3x0.3 m. Which assemble the multilayered package and ensure that the different foils and spacers will not fall apart when our customers cut their own shapes using scissors, scalpels or similar.



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COOLCAT B-R50 tape is recommended for closing super- insulation blanket joints. Depending on the configuration of the cryostat it may be possible to completely enclose the cold parts to be insulated with a shell of insulation blankets. In this case, the taping of superinsulation joints may be sufficient to hold the insulation in place. In other cases, it may be necessary to use additional fixation elements such as plastic pins.

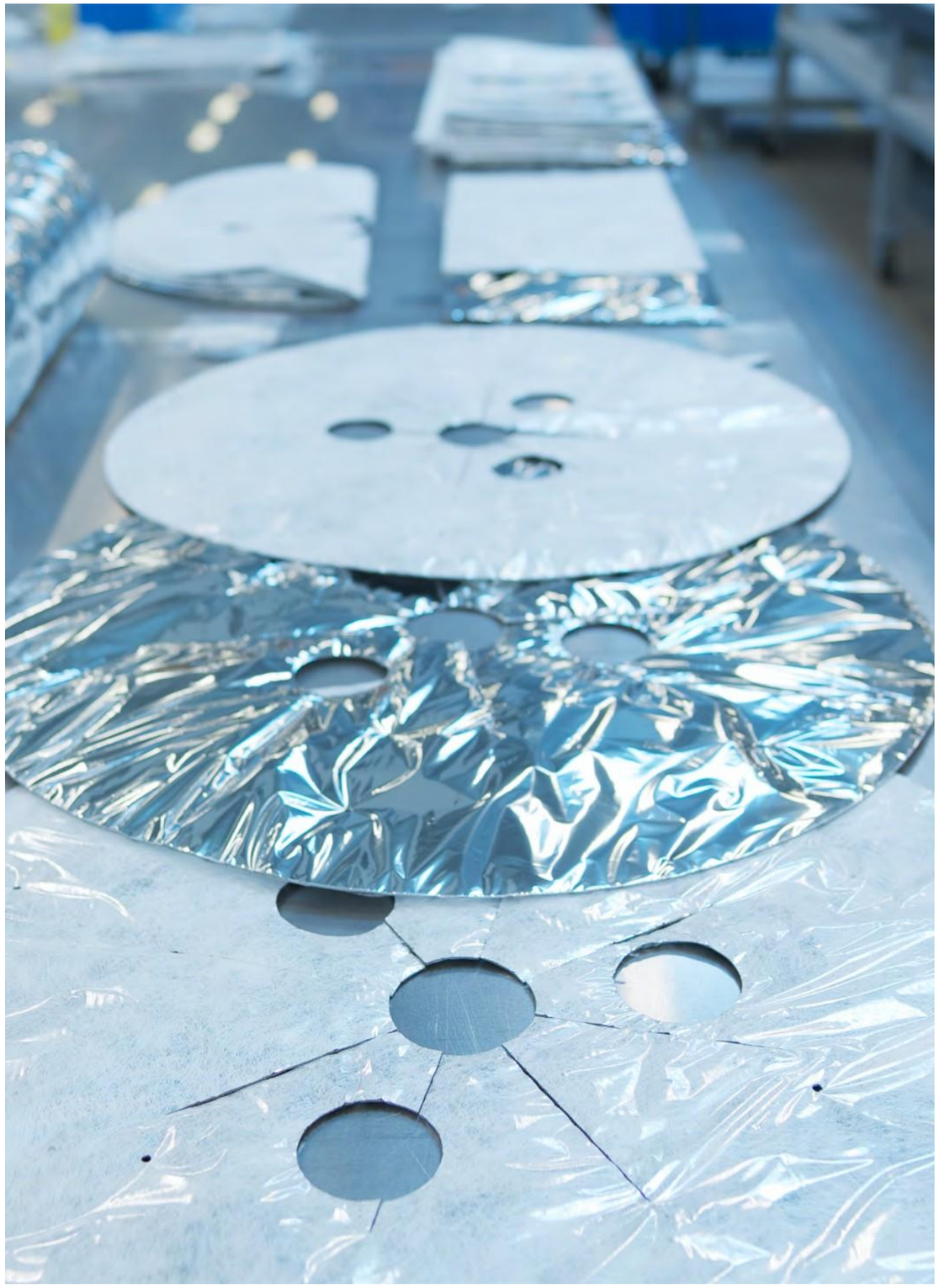
Superinsulation types such as COOLCAT 2 NF, COOL-CAT 2 LOX and COOLCAT H, which are not made of polyester but contain other materials such as aluminium foil or glass-fibre fleece are cold cut on our NC cutting machines using oscillating knives. This process does not assemble the multi-layer package and so we use tag pins to hold the blanket together. We offer NC cold cutting up to a blanket size of 3.0 x 0.95 m but we cold cut larger blankets by hand if required.

The superior performance of COOLCAT insulation is based on:

- High quality polyester film, 6 or 12 µm thick, double-sided aluminized at minimum 40 nm (400 Angstrom).
- Reflector foils are separated with pure polyester spacer material.
- 10 layers of foil and 10 layers of spacer are combined as a semi-finished insulation lay-up, ready for cutting.
- The insulation is perforated for perfect evacuation of the vacuum chamber.
- Beyond Gravity thermal insulation is designed based on CAD models and is cut accurately on the numerically controlled laser cutting machine.
- The insulation is easy to handle due to the laser cut edges.
- The insulation performance is long term stable, no degradation of insulation due to the spacer material, no flattening, limited gravitational compression, no severe compression effect over edges.
- The reproducibility of performance in a serial production is very high.

Storage conditions:
In our workshop COOLCAT superinsulation is packaged into polyethylene bags with desiccant. These bags are pumped and sealed to prevent the insulation from moving inside the bags during transport. Then the goods are packed into sturdy cardboard or wooden boxes.

We recommend to store COOLCAT products at room temperature and a relative humidity of 40 – 60 %. Direct exposure to salt atmosphere must be avoided.



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COOLCAT 2 NW

Common usage: MRI and NMR systems

COOLCAT 2 NW is a spacered superinsulation composed of 10 layers of polyester foil, double-sided aluminized, perforated and interleaved with 10 layers of non-woven polyester spacer material.

Due to its high thermal performance and good handling properties, it is used in serial production of MRI, NMR and accelerator cryostats at an industrial scale.

Spacered superinsulation offers more robust thermal performance than crinkled superinsulation (for example at corners and under compression).

Non-woven spacers are dimensionally stable and therefore, COOLCAT 2 NW offers easier handling and more efficient installation than insulation with knit-woven spacer.

COOLCAT 2 NW has a nominal compressed thickness of 1.4 mm per 10 layers. For a good thermal performance, compression of the superinsulation should be avoided. It is recommended to allow a minimum insulation gap thickness of 3 mm per 10 layers and to install the insulation in a loose way.

All polyester reflector foils are aluminized to provide a specific surface resistance of < 0.8 ohms per square (coating thickness > 40 nm).

For low outgassing, COOLCAT 2 NW contains 100 % polyester spacer without binder. For short pumping times all double-sided aluminized polyester foils are perforated at an open area of 0.05 to 0.1 %.
Maximum baking temperature: 423 K

Temperature range [K]	Number of layers	Heat flux [W/m²] *
300 to 77	10 foils + 10 spacers	> 1.00
	20 foils + 20 spacers	> 0.75
	30 foils + 30 spacers	> 0.60
	40 foils + 40 spacers	> 0.55
77 to 4	10 foils + 10 spacers	> 0.02

* Heat flux values measured under laboratory conditions at good vacuum (< 1 E-3 Pa); for the sizing of superinsulation for real applications it is recommended to multiply these heat flux values with a factor of 1.3–1.5. This is assuming adequate design, installation and vacuum conditions.

Standard rolls available up to 1.9 m wide, wider rolls available on request:

Articel no.	Dimensions [m]	Foil thickness [µm]	Nominal area weight for 10 layers [kg/m²]
PL100297	3 x 1.5	6	0.224
PL100045	50 x 1.5	6	0.224
PL100047	50 x 1.9	12	0.308

The grid of ultrasonic spot welding points on standard material is 0.3 x 0.3 m, details see page 4.

Narrow rolls are available to custom dimensions, for example:

3 foils + 3 spacers: min. 100 mm wide x 200 m long;
5 foils + 5 spacers: min. 100 mm wide x 50 m long;
10 foils + 10 spacers: min. 100 mm wide x 50 m long.

The minimum width of narrow rolls is 25 mm. Narrow Multi-Layer Insulation bands with widths between 25 mm and 100 mm are wound on one common core.

Starting from a width of 100 mm each individual roll has its own plastic core.

Please note: polyester superinsulation is flammable and suitable welding protection is required (we recommend the use of COOLCAT H). COOLCAT 2NF and COOLCAT 2 LOX are our only two COOLCAT products in this catalogue which are liquid oxygen compatible. For all applications, a separate risk assessment is required to confirm the use of polyester superinsulation.

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COOLCAT 2 NF

Common usage: hydrogen, LNG- & LOX-systems

COOLCAT 2 NF is a spacered superinsulation composed of multiple layers of glass fibre fleece spacer interleaved with multiple layers of 9 µm pure aluminium foil.

COOLCAT 2 NF is high temperature tolerant and non-flammable. COOLCAT 2 NF was tested to and successfully met the requirements of ISO 21010 Cryogenic vessels – Gas/materials compatibility, Section 4.4.4 Insulation Test, which is based on EN 1797. COOLCAT 2 NF does not sustain combustion when touched with a glowing platinum wire in a 100 % oxygen atmosphere at 1 bar absolute pressure. It is therefore considered suitable for the insulation of liquid oxygen equipment. For example it has been used for the thermal insulation of automotive cryogenic hydrogen storage tanks.

Glass fibre diameter: 16 µm (non-respirable).

COOLCAT 2 NF sheets consist of 11 layers of glass fibre fleece spacer and 10 layers of 9 µm pure aluminum foil, which are provisionally held together by PEEK tag pins along their short ends at a pitch of 0.2 m (nylon tag pins are available on request).

COOLCAT 2 NF rolls consist of 6 layers of glass fibre fleece spacer and 5 layers of 9 µm pure aluminium foil, which are co-wound on plastic core. The layers are not assembled.

Max. layer offset: 10 mm
Max. finished roll width: 1.02 m

COOLCAT 2 NF has a nominal compressed thickness of 5.0mm per 10 layers. For good thermal performance, compression of the superinsulation should be avoided. It is recommended to allow a minimum insulation gap thickness of 7mm per 10 layers and to install the insulation in a loose way.

Maximum baking temperature: 503 K.

It is highly recommended to execute a risk analysis for the intended usage regarding non-flammability requirements. Alternatively, COOLCAT 2 LOX shall be considered.

Temperature range [K]	Number of layers	Heat flux [W/m²] *
300 to 77	20 foils + 20 spacers	> 1.25

* Heat flux values measured under laboratory conditions at good vacuum (< 1 E-3 Pa); For the sizing of superinsulation for real applications it is recommended to multiply these heat flux values with a factor of 1.5–2. This is assuming adequate design, installation and vacuum conditions. The thermal conductance of aluminium foils is much higher than the one of aluminized polyester foils and therefore thermal edge effects are more severe.

COOLCAT 2 NF is available in standard sheets and rolls:

Articel no.	Dimensions [m]	Number of layers	Nominal area weight for 10 or 5 layers [kg/m²]
PL110206	3 x 1	10	0.540
PL113127	45 x 1	5	0.284

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COOLCAT 2 LOX

Common usage: liquid oxygen systems

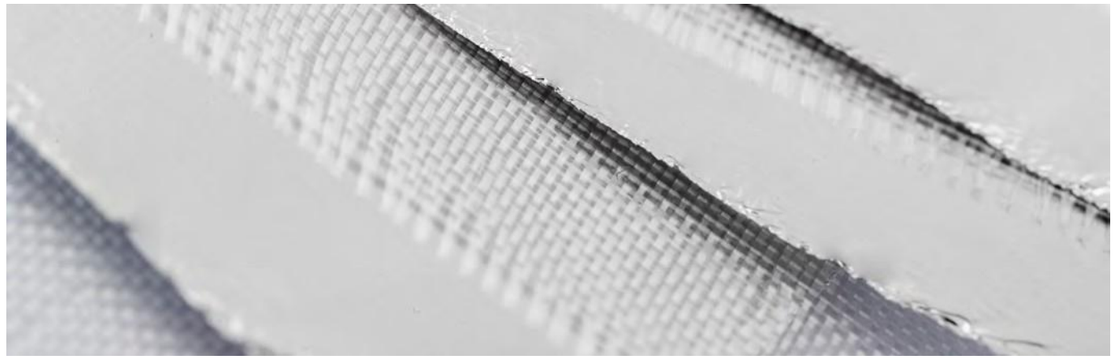
COOLCAT 2 LOX is a spacered superinsulation composed of 5 layers of pure aluminium foil interleaved with 5 layers of glass fibre cloth spacer.

COOLCAT 2 LOX is high temperature tolerant and liquid oxygen compatible: COOLCAT 2 LOX was tested to and successfully met the requirements of ISO 21010 Cryogenic vessels – Gas/materials compatibility, Section 4.4.4 Insulation Test, which is based on EN 1797. COOLCAT 2 LOX does not sustain combustion when touched with a glowing platinum wire in a 100 % oxygen atmosphere at 1 bar absolute pressure. It is therefore considered suitable for the insulation of liquid oxygen equipment. The glass fibre spacer has been de-sized and heat cleaned. The insulation is free of organic constituents. Glass fibre diameter: 5 µm (non-respirable).

COOLCAT 2 LOX sheets are provisionally held together by PEEK tag pins along one short end at a pitch of 0.2 m (Nylon tag pins available on request).

COOLCAT 2 LOX has a nominal compressed thickness of only 0.4 mm per 10 layers. For good thermal performance, compression of the superinsulation should be avoided. It is recommended to allow a minimum insulation gap thickness of 1 mm per 10 layers and to install the insulation in a loose way.

Maximum baking temperature: 623 K.



Temperature range [K]	Number of layers	Heat flux [W/m²] *
300 to 77	10 foils + 10 spacers	> 4.41
	20 foils + 20 spacers	> 3.35

* Heat flux values measured under laboratory conditions at good vacuum (< 1 E-3 Pa); for the sizing of superinsulation for real applications it is recommended to multiply these heat flux values with a factor of 1.2–1.5. This is assuming adequate design, installation and vacuum conditions. The thermal conductance of aluminium foils is much higher than the one of aluminized polyester foils and therefore thermal edge effects are more severe.

COOLCAT 2 LOX is available in standard sheets:

Articel no.	Dimensions [m]	Foil thickness [µm]	Nominal area weight for 5 layers [kg/m²]
PL110205	3 x 1	9	0.247

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COOLCAT 2 NI

Common usage: SQUIDS and superconducting machines

COOLCAT 2 NI is a spacered superinsulation composed of 10 layers of polyester foil, single-sided aluminized in squares of 10 mm x 10 mm or double-sided aluminized in squares of 20 mm x 20 mm, interleaved with 10 layers of non-woven polyester spacer material.

COOLCAT 2 NI minimizes eddy currents and still offers a high thermal performance. It has been developed for applications where the insulation is exposed to varying magnetic fields:

- SQUID sensors: reduction of magnetic thermal noise
- Superconducting machines (fault current limiters, motors, generators etc): Reduction of heat dissipated in the superinsulation coatings

COOLCAT 2 NI has a nominal compressed thickness of 1.4 mm per 10 layers. For good thermal performance, compression of the superinsulation should be avoided. It is recommended to allow a minimum insulation gap thickness of 3mm per 10 layers and to install the insulation in a loose way.

For low outgassing COOLCAT 2 NI contains 100 % polyester spacer without binder. COOLCAT 2 NI is not perforated.

Maximum baking temperature: 423 K.

Magnetic thermal noise measurements were performed with 20 layers on a sample size of 100 mm x 100 mm.

Frequency [Hz]	Noise spectral density for 0.8 Ω per square [fT/√Hz] 10 x 10 mm	1.6 Ω per square [fT/√Hz] 10 x 10 mm	0.8 Ω double sided per square [fT/√Hz] 20 x 20 mm
30	0.61	0.41	1.71
100	0.91	0.89	1.85
500	0.79	0.66	1.81
1000	0.76	0.62	1.79
10000	0.73	0.61	1.82

Temperature range [K]	Squares	Number of layers	Heat flux [W/m²]*	Number of layers	Heat flux [W/m²]*
300 to 77	10 x 10 mm	10 foils + 10 spacers	> 4.60	20 foils + 20 spacers 20 foils + 20 spacers	> 3.40
	20 x 20 mm	10 foils + 10 spacers	> 1.54		> 1.38

* Heat flux values measured under laboratory conditions at good vacuum (< 1 E–3 Pa); for the sizing of superinsulation for real applications it is recommended to multiply these heat flux values with a factor of 1.3–1.5. This is assuming adequate design, installation and vacuum conditions.

COOLCAT 2 NI is laser cut, which assembles the layers along the edges. COOLCAT 2 NI is available in sheets of 3 m long and 0.75 m wide, other sizes on request:

Articel no.	Squares [mm]	Electrical surface resistance [Ohms per square]	Dimensions [m]	Foil thickness [µm]	Nominal area weight for 10 layers [kg/m²] *
PL101416	10 x 10	0.8	3 x 0.75	12	0.308
PL101417	10 x 10	1.6	3 x 0.75	12	0.308
PL102015	20 x 20	0.8	3 x 0.75	12	0.308

* Squares are aluminized to this surface resistance. These squares are electrically insulated from each other by uncoated lines, which are typically 0.1 mm wide.
Caution Notes: Polyester superinsulation is flammable and suitable welding protection is required (we recommend the use of COOLCAT H).

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COOLCAT H

Common usage: welding protection for polyester insulation

Article no.	Thickness [mm]	Nominal area weight for 1 layer [kg/m^2]
PL100782	0.9	0.68

COOLCAT H is a welding protection made of aluminium foil and fiber-glass cloth.

It is recommended for the protection of polyester super-insulation against welding heat. This welding protection is needed because the polyester superinsulation is flammable and melts at 250 degrees Celsius (523 K).

COOLCAT H insulates by reflecting the welding heat at its aluminium surface and by featuring the low conductivity of fiberglass cloth in air under ambient pressure.

The maximum service temperature of the E-Glass cloth is at 500 degrees Celsius (773 K). The adhesive of the laminate fails above 150 degrees Celsius (423 K). Welding trials are recommended to confirm if one layer of COOL-CAT H is sufficient for the customer application.

COOLCAT H was tested to and successfully met the requirements of ISO 21010 cryogenic vessels – gas/materials compatibility, section 4.4.4 Insulation Test, which is based on EN 1797. COOLCAT H does not sustain combustion when touched with a glowing platinum wire in a 100 % oxygen atmosphere at 1 bar absolute pressure. It is therefore considered suitable for the insulation of liquid oxygen equipment.

The glass fibres have a diameter of larger than 6 µm and are not respirable.

COOLCAT H is available in rolls of 150 mm wide and 50 m long.

We offer customized COOLCAT H sheets to a maximum width of 1 m. These sheets are cut to customer specification using our cost efficient automated NC cutting machine.

COOLCAT H is also used as a robust cover layer of large liquid oxygen or liquefied natural gas tank insulation.

COOLCAT 4K

Common usage: liquid helium vessel surface

COOLCAT 4K is a low absorptance helium vessel laminate for thermal insulation of cold masses at 4K.

It is a laminate of a 6 µm pure aluminium foil and a 12 µm polyester foil, double-side aluminized.

COOLCAT 4K laminate combines the very low absorptance of a pure aluminium foil with the good handling properties of a polyester foil.

As a superconducting magnet thermal insulation, the small aluminium foil thickness offers lower heat dissipation at 4K (incurred by eddy currents) and lower Lorentz forces at quench.

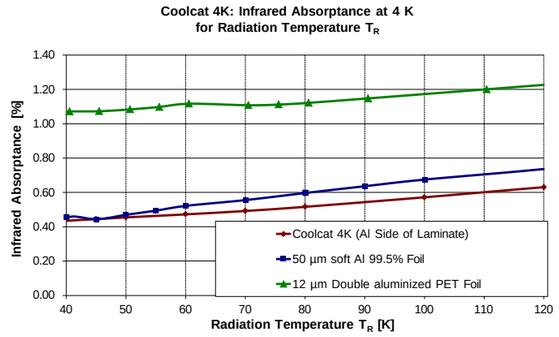
COOLCAT 4K does not crinkle and tear the way aluminium foils do. At room temperature, it has the higher tear resistance of a laminate. This makes the installation of the insulation easier and saves labour costs.

COOLCAT 4K is available at a maximum width of 1.83 m. We offer customized COOLCAT 4 K sheets to a maximum width of 1.75 m. These sheets are cut to customer specification using our cost efficient automated NC laser-cutting machine.

According to cryogenic tests COOLCAT 4K contracts by 0.44 % at 4K.

In order to prevent cracking of COOLCAT 4K at cryogenic temperatures, stress concentrations must be avoided or appropriate local reinforcement of the laminate must be provided.

Installation: The mat (dull) side of the foil is the aluminium foil side and shall be used for thermal insulation. The shiny side is the aluminized polyester side and shall face the cold surface. An adhesive transfer film can be applied to the aluminium coating of the shiny side of the laminate for its attachment to the cold helium vessel surface.



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COOLCAT 1050

Common usage: liquid helium vessel surface, applications at 4K

COOLCAT 1050 is a high purity, low absorptivity aluminum tape for use in cryogenic applications. COOLCAT 1050 is applied directly onto 4K surfaces to provide lowest absorption of thermal radiation.

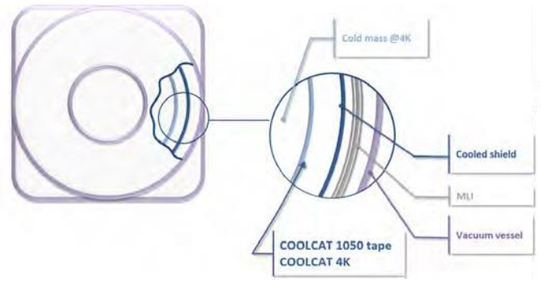
COOLCAT 1050 is composed of an 80 µm high purity (99.5 %) aluminum foil carrier and a pressure sensitive acrylic adhesive.

Due to its very high reflection COOLCAT 1050 offers excellent insulation quality.

COOLCAT 1050 is most recommended for covering surfaces with high absorptivity of thermal radiation like stainless steel or aluminium in a cryogenic environment such as helium vessels of superconducting magnets or any other cold mass.

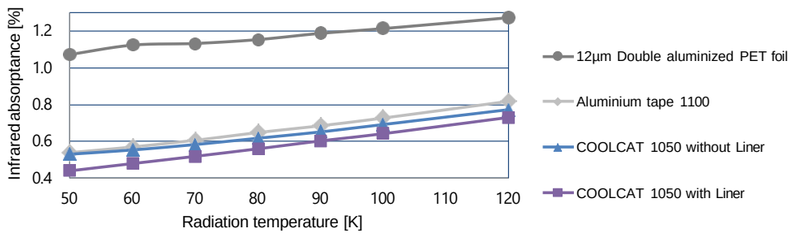
COOLCAT 1050 was especially developed for and tested at a temperature of 4K.

Article no.	Dimensions [m]	Packing unit [rolls]	Liner
PL108430	50 x 0.05	18	no
PL108431	50 x 0.05	18	yes
PL108432	50 x 0.10	6	yes



Holding strength / substrate	Peel strength [N/(12mm width)]	Shear strength [N/144 mm^2]
Stainless steel	2.9	104.0
Aluminium	3.7	99.8
Glass fibre reinforced epoxy (cleaned with acetone)	4.5	71.0

Infrared absorptance at 4 K for radiaton temperature (low value required for good radiative insulation)



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COOLCAT B-R50

Common usage: fixation of polyester insulation

COOLCAT B-R50 is a low emissivity adhesive tape optimized for use under cryogenic environment. It is composed of a 25 µm polyester foil carrier, double-sided aluminized and a high purity pressure sensitive acrylic adhesive.

COOLCAT B-R50 cryogenic adhesive tape has been developed specifically for thermal insulation in cryogenic applications, to provide lowest infrared emittance on its outer surface. This tape has been developed to replace tapes, which have a shiny appearance, but are second surface mirrors only.

It is most recommended for the closing of superinsulation joints e.g. for COOLCAT 2 NW layups. Bonding strength at room temperature:

- Peel strength: min. 16 N / 25 mm width (AFERA 5001)
- Shear strength: min. 60 N / 625 mm (AFERA 5012)

Tested bonding strength to stainless steel at 4K:

- Peel strength: 3 N / 12 mm width
- Shear strength: 47 N / 144 mm

The procedure for cryogenic tests follows AFERA as far as possible and is adapted to cryogenic temperatures as necessary.

The tape meets the standard outgassing requirements for satellites of the European Space Agency ESA.

The adhesive of the tape is protected by a release liner.

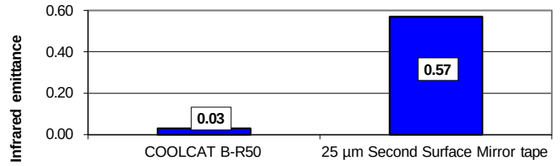
The tape is available 25 mm (1 inch) or 50 mm (2 inches) wide. It is delivered on plastic core. The minimum order quantity is one roll, but it is more economic to order complete packing units:

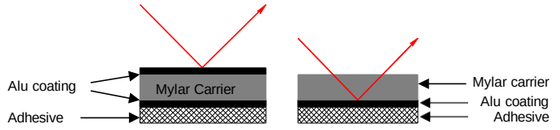
Article no.	Dimensions [m]	Packing unit [rolls]	Liner
PL100134	50 x 0.025	32	yes
PL100138	50 x 0.050	16	yes

Shelf life: 2 years from date of production

Please note: Polyester superinsulation is flammable and suitable welding protection is required (we recommend the use of COOLCAT H).

Emittance of aluminized tapes (Low value required for good radiative insulation)





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