

Why using graphite as gasket material?

Following the substitution of asbestos, no technically reliable solutions were available initially for gasket applications in higher temperature ranges. Rubber-bonded gasket materials have a natural maximum temperature limit. There was a particular need for better solutions for media that are hot, dangerous and have creep properties, such as steam or heat transfer oils. This was the reason for the tremendous success of gaskets made from expanded graphite.

Properties of novaphit® gaskets made from expanded graphite

- Suitable for temperatures between -200 °C and 550 °C
- Insensitive to changing loads
- Maximum adaptability to flange unevenness
- High flexibility when sealing surfaces are unfavourable/faulty
- Practically no hot creep
- Universal chemical resistance
- Maximum sealing performance in the flange
- Use possible at internal pressure levels of up to 250 bar

Consistent product quality thanks to process control system

Frenzelit is involved throughout the manufacturing process of the novaphit® product family, from obtainment of the graphite raw material to the finished gasket. All the parameters that affect quality are monitored via a process control system. This guarantees consistent maintenance of the highest product quality. Reliable production processes lead to reliable sealing in the user's operations and thus to just as reliable processes at his plant.

Sealing system design

Frenzelit produces the data needed to calculate the design parameters for gasket applications in its own laboratory. A large number of different tests that are relevant to gasket materials are carried out in-house on an ongoing basis. The test range from media resistance tests to mechanical/thermal tests and determination of sealing parameters on state-of-the-art AMTEC test rigs. Both the quality assurance department and the development department take frequent advantage of these laboratory services. Customer-specific tests are made as well, in order to ensure that the user's assignment is carried out as well as possible.



The production process from the mine to the finished product



Graphite ore from the mine

High-quality graphite gaskets made from high-quality graphite

novaphit® gaskets made from expanded pure graphite are suitable for high chemical, thermal and mechanical stresses. They do their job reliably even when there are extreme fluctuations in conditions. novaphit® gaskets do not contain any binders, incidentally.

There can be substantial differences in the quality of expanded graphite. An explanation is given below of how expanded graphite is made and what criteria need to be met as quality features.

Where does graphite come from?

Graphite is obtained in both open-cast and underground mines. The choice of the mine already decides the subsequent quality level. The grinding and cleaning operations that follow are just as important.

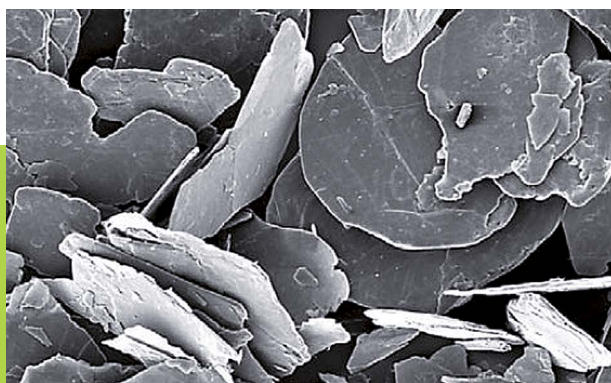
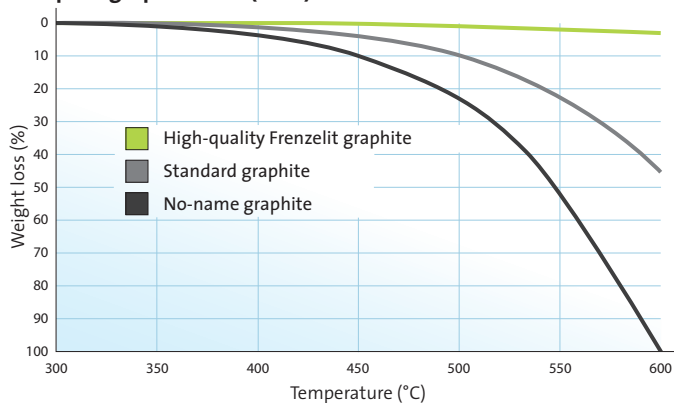
What happens in the expanding process?

The ground basic graphite is expanded in a thermal process, in which the volume of the graphite is increased many times over. A flexible and soft graphite film is produced from a "brittle" graphite powder.

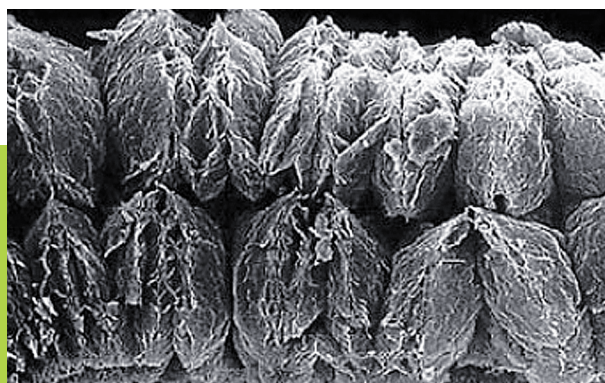
Oxidation resistance is the most important quality feature of graphite gaskets

The efficiency of the graphite is defined essentially by its oxidation resistance. The common assumption that graphite quality is determined solely by a specific degree of purity is not correct. On the contrary: it is essential to determine the oxidation properties of the graphite exactly, because even graphite films of the highest purity level may not be resistant enough to oxidation. Thanks to careful selection of the basic graphite and 100% incoming goods checks of this and other properties, only high-quality graphite is used in the novaphit® SSTC, novaphit® SSTC^{TA-L} and novaphit® MST production process.

Weight loss as an indication of the oxidation resistance of pure graphite film (99%)



Flake graphite Source: Graphit Kropfmühl AG



Expanded graphite Source: Graphit Kropfmühl AG

Environmental protection optimised by gaskets of maximum quality throughout the company

High-quality gaskets make a major contribution to protection of the environment. Rules like the German Clean Air Act ("TA Luft") specify demanding sealing criteria. It is particularly important that these criteria are met in applications involving media that endanger the environment and are harmful to health.

Demonstration of the high quality of novaphit® MST and novaphit® SSTC^{TA-L} (according to TA Luft) in component testing

The component test involves leakage measurement following 48 hours of exposure to a temperature of 300 °C. The leakage limit is $1 \cdot 10^{-4}$ mbar · l / (s · m). Up to now, this has been the most important criterion for determining the quality of a gasket material.

Many years of practical experience with gaskets have, however, shown that the quality of the gasket material depends on other criteria too. They include mechanical properties as well as long-term temperature resistance at the same time as effective sealing for a long period of time. It is apparent from this that excellent gasket material performance is determined by the combination of several different properties.

Focus on the entire sealing system: VDI 2290

There are more detailed regulations that are designed to make sure the requirements of TA Luft are satisfied more specifically. The quality of the overall gasket connection is influenced not only by the properties of the gasket material but also by the installation situation. The current VDI directive 2290 is based to a particularly large extent on a comprehensive approach to the creation of a sealing system. The importance of expert installation is stressed just as much as the need for accurate design calculations.

Gasket design in accordance with DIN EN 1591

DIN EN 1591-1 is explicitly recommended for the design and calculation of gasket systems. Attention is also drawn to use of the design sealing class $L_{0,01}$ in VDI 2290.

Thanks to their optimum performance, novaphit® MST and novaphit® SSTC^{TA-L} enable gasket connections to be established that meet the strict criteria of TA Luft and VDI 2290. By supplying novaphit® MST and novaphit® SSTC^{TA-L}, Frenzelit creates the basis for carrying out company-wide standardisation at a maximum quality level.

If you have any application engineering questions, we will be delighted to answer them. Just contact:

gaskets@frenzelit.com

XP technology

Higher efficiency thanks to new technology

Frenzelit carries out constant research into innovations that improve products even when they have proved successful for decades. The XP technology for novaphit® was developed in the course of this process. Graphite has natural properties that have in the past been considered unchangeable and therefore had to be accepted by users. The new XP technology for novaphit® is now eliminating these restrictions.

Non-stick properties without any temperature restrictions

Up to now, one of the standard properties of graphite has been that gasket residue almost always adheres to the sealing surface and has needed to be removed in laborious and time-consuming operations when gaskets have been replaced. Conventional non-stick coatings on an organic basis weaken such properties of the graphite as its sealing efficiency or stability at high temperatures – which are otherwise very impressive. Non-stick properties that remain stable for long periods of time over the entire application temperature range of the graphite cannot be achieved with these systems.

This problem has been solved successfully for the first time with the innovative inorganic XP technology.

Increase in oxidation resistance

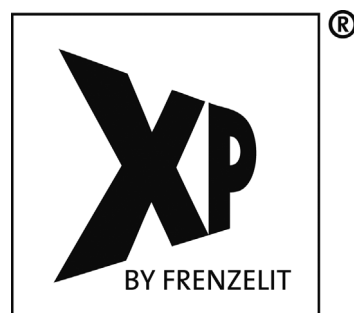
Even high-quality graphite films that incorporate oxidation inhibitors are subject to oxidation as of a certain temperature. With the XP technology for novaphit®, deep passivation of the graphite is carried out, which slows down the oxidation process significantly. This leads to a substantial increase in long-term resistance.

Inorganic active substance

The XP technology for novaphit® involves purely inorganic treatment of the graphite. In this process, homogeneously distributed nanoparticles throughout the entire cross-section of the material provide compact protection for the graphite. The active substance is chemically inert and supports the excellent media resistance of the graphite.

Advantages at a glance:

- Non-stick properties: fast gasket replacement – tremendous potential for saving time
- Minimised risk of flange damage
- Inorganic basis guarantees long-term effectiveness and media stability – at temperatures above 250 °C too
- Increase in oxidation resistance – better long-term performance
- Mass loss < 3 %/h at 670 °C
- Higher plant reliability / availability



XP = eXtended Performance

XP technology facilitates gasket replacement

XP technology provides novaphit® flat gaskets with non-stick properties that have not been achieved before with graphite.

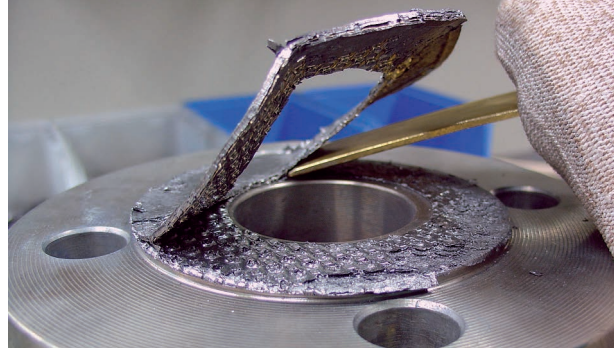
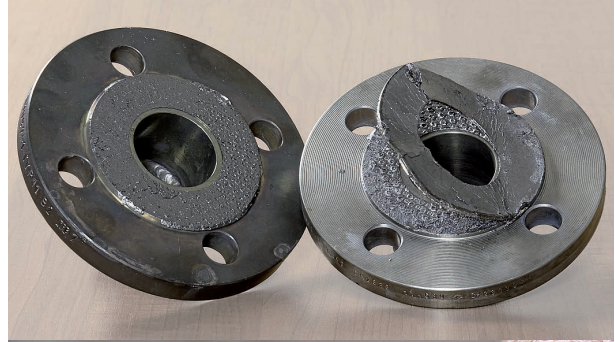


With XP technology

The non-stick function of novaphit® with XP technology is fully effective over the entire application temperature range of a graphite gasket. Due to the inorganic, inert basic structure of the XP technology, there are no functional restrictions with respect to chemical media resistance.

The XP technology for novaphit® materials reduces the common graphite deposits on the sealing surfaces and facilitates gasket removal and the time-consuming cleaning of the flanges. This represents an impressive improvement in the performance of graphite gaskets.

The XP technology leads to tremendous economic benefits. They are attributable to the simpler removal of the gaskets, the considerable simplification or elimination of flange cleaning and the time saving that is associated



Without XP technology

with this. The sealing surfaces are protected at the same time, so that they remain intact for a longer period of time. Tongue-and-groove flange connections are a particularly tough challenge, when the residue of old gaskets needs to be removed.

Investigations carried out by plant operators also show that it is not unusual for leakage problems to be attributable to incomplete removal of old gasket residue. In this respect, the use of XP technology is a major contribution to process reliability.

See for yourself!

Watch the film: www.frenzelit.com/XP_e

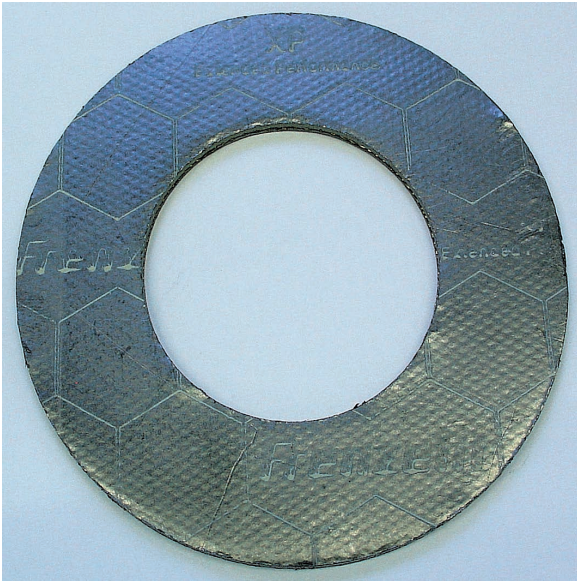


XP technology increases oxidation resistance

When an oxidant, such as atmospheric oxygen, is present, graphite gaskets are subject to oxidation at higher temperatures. Graphite turns (among other things) into CO₂ as a result. This leads to a loss of graphite mass, the consequence of which is an increase in leakage from the gasket seal, and even to total failure of the gasket.

Impact of the difference in oxidation resistance

Test temperature: 670 °C/4 h, atmosphere: air



novaphit® with XP technology



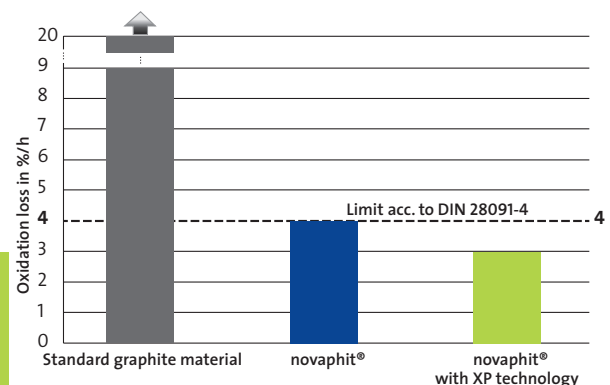
Standard graphite gasket

The quality requirements on the oxidation resistance of flat graphite gaskets are specified in DIN 28091-4 to be a maximum of 4 % oxidation loss per hour and a dwell time of 4 h at a temperature of 670 °C. The exacting demands of specifications from the oil processing industry have been incorporated in the DIN standard here.

The XP technology for novaphit® materials leads to a significant improvement in the oxidation resistance of the graphite. The XP technology makes novaphit® so inert that a maximum mass loss of 3 %/h occurs due to oxidation, i.e. considerably lower than the requirements of the current standard.

The following chart shows the results of thermogravimetric analysis (TGA in accordance with DIN 28090-2) of a proven novaphit® gasket – which is already inherently oxidation-resistant – with and without XP finishing. The effect of the XP technology is to make sure that the oxidation loss does not exceed 3 %/h. The increase in efficiency helps to keep seals stable for a longer period of time and thus improves both process reliability and plant availability.

Mass loss due to oxidation acc. to DIN 28090-2, TGA at 670 °C/4 h



Material profile of novaphit® SSTC / novaphit® SSTC^{TA-L}

Advantages of the expanded metal insert used

Gasket material made from expanded graphite (purity level > 99 %) with internal impregnation and an acid-resistant expanded metal insert made from chrome-nickel steel (material no. 1.4404 / AISI 316L).

Expanded metal made from acid-resistant stainless steel
Corrosion- and acid-resistant material (AISI 316L).

Thickness of the expanded metal insert used

Stretching the stainless steel film used (original thickness 0.15 mm) leads to a three-dimensional structure with a projected height of about 0.4 mm, as a result of which chambering of the gasket core is achieved.

Geometry of the stainless steel insert

- Better exploitation of the surface pressure available to compact the graphite, because no “crowns” need to be levelled. Installation of the gasket is completed faster.
- No undercutting in the insert material. The graphite film encloses the insert completely.
- Optimised surface pressure distribution by comparison with other insert concepts. This is demonstrated impressively by the self-contained lines of higher surface pressure (see the Fuji Film photo of novaphit® SSTC^{TA-L} with expanded metal).
- Favourable grid geometry (diamond dimension = 3.0 mm) makes it possible to produce gaskets with very narrow widths reliably.
- Easy cuttability. Handling benefits in manual and in-house finishing.
- Considerably lower risk of layer separation when bending occurs. Even in such a case, the graphite film is pressed around the insert again completely when pressure is

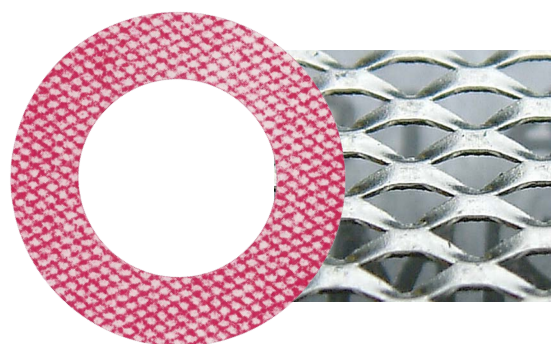
applied to the gasket during installation in the flange. This results in a greater tolerance in case of incorrect handling.

- Repeated bending of the insert is irreversible because of strain hardening, i.e. the insert recovers and is actively involved in the sealing operation! This guarantees greater security in the gasket connection, particularly at higher surface pressure levels.
- Another advantage of novaphit® SSTC and novaphit® SSTC^{TA-L} in direct comparison with smooth metal inserts is their open insert design principle. This means that not merely the outer graphite layer but rather that a considerably thicker layer is available to compensate for flange damage.

Fuji Film photos

Sensitivity: medium
Gasket thickness: 2.0 mm
Surface pressure: 30 N/mm²

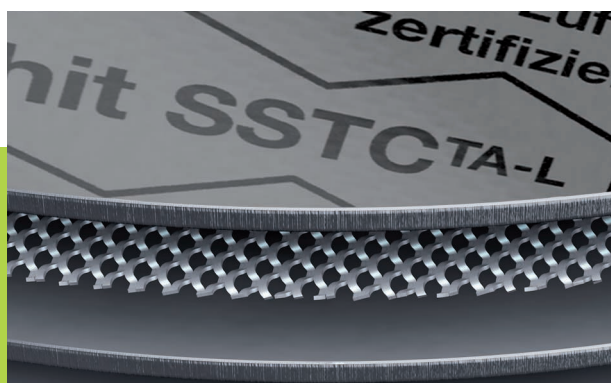
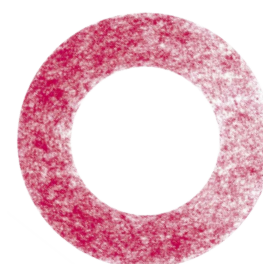
**Frenzelit graphite gasket
novaphit® SSTC^{TA-L} with expanded metal**



**Graphite gasket
with tanged metal**



**Graphite gasket
with smooth metal**



Material profile of novaphit® MST with XP technology

Advantages of the unique combination of expanded metal and smooth metal inserts

Multilayer gasket material made from expanded graphite (purity level 99.5%*) with several expanded metal and flat metal inserts made from stainless steel (material no. 1.4404 / AISI 316L) and intelligent internal impregnation.

XP technology as standard

novaphit® MST, the flagship of the novaphit® product family, features all advantages of the XP technology as standard.

Outstanding adaptability

The logical arrangement of the stainless steel inserts is the special feature of novaphit® MST. Graphite foils of 0.5 mm thickness alternate with stainless steel 1.4404. Expanded metal is, however, chosen for the outer layers on each side. The open structure of the expanded metal makes the gasket more adaptable, because the two outer graphite layers on each side can be used to compensate for flange unevenness.

New dimension in internal impregnation performance

Systematic improvement in the effectiveness of the internal impregnation has made it possible to use graphite films with optimised initial density. The sealing properties are at the same time increased as a result, while adaptability is significantly better.

Gasket deformation of about 43 % is achieved with surface pressure of only 20 MPa. Compared with standard multilayer laminates, which reach only about 23 %, this means that adaptability is 87 % higher.

* typical value

Excellent handling

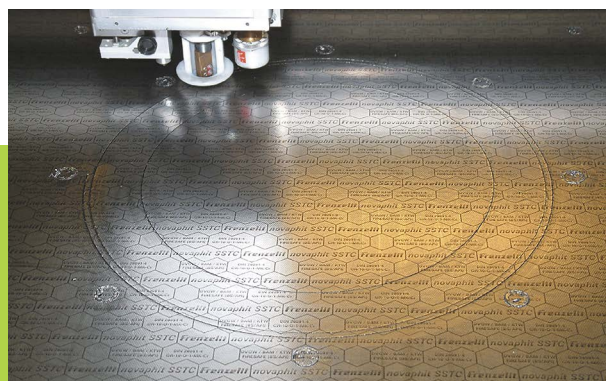
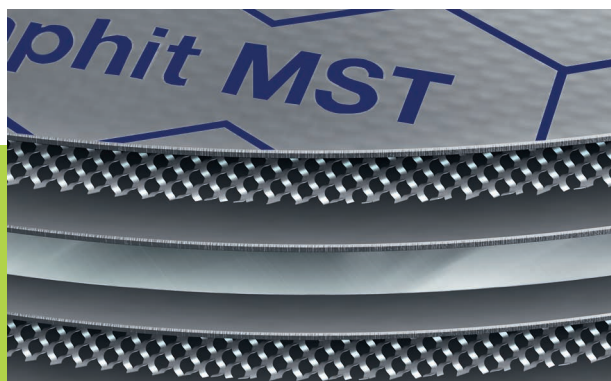
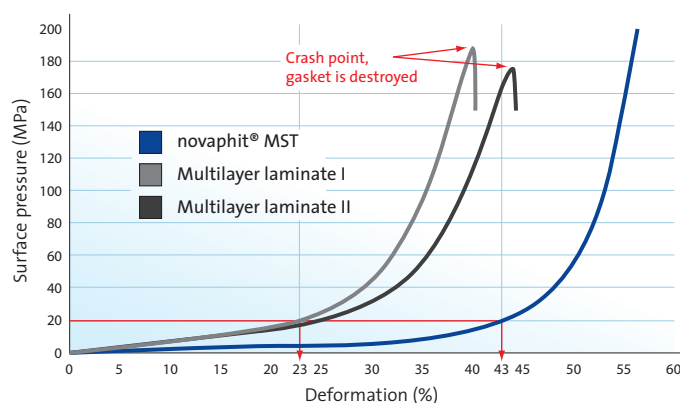
Thanks to the multilayer structure, gaskets made from novaphit® MST have extremely good dimensional stability properties and do not buckle. This can be an advantage over single-layer, reinforced graphite gaskets.

Very simple processing

The thickness of the individual stainless steel inserts (0.05 mm) has been chosen carefully to make sure that extremely reliable and simple processing is possible by all standard methods:

- Punching
- Plotting
- Water jet cutting
- Cutting with circular saws
- Cutting with metal shears
- Cutting with scissors

Compression chart according to DIN 28090-1

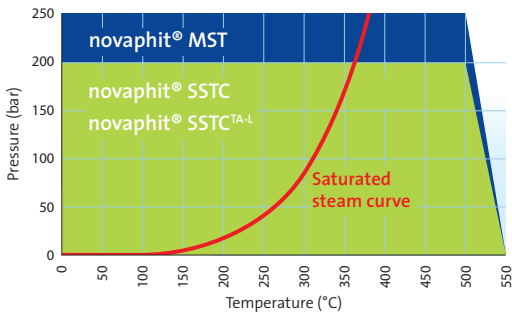


Technical information

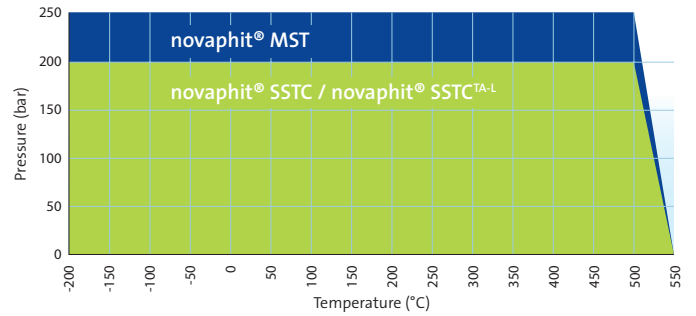
Application recommendations, depending on the pressure and temperature

The application recommendations for different temperature and pressure levels in the graphs apply to gaskets 2.0 mm thick that are used with raised face flanges. Higher limits are possible when thinner gaskets are used!

Application recommendation for water/steam

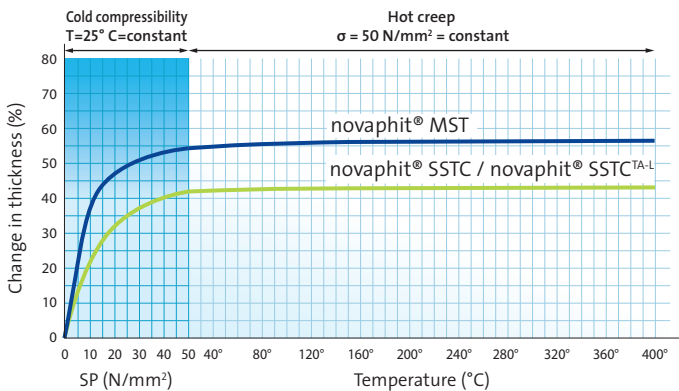


Application recommendation for other media*

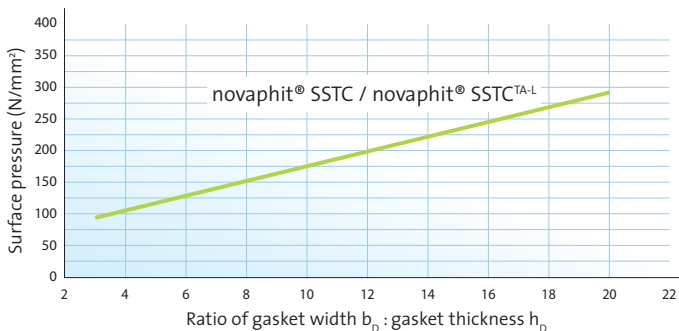


* Example for the most common other media. Exact data about individual cases can be obtained via the Frenzeli novaDISC program or from our application engineering staff.

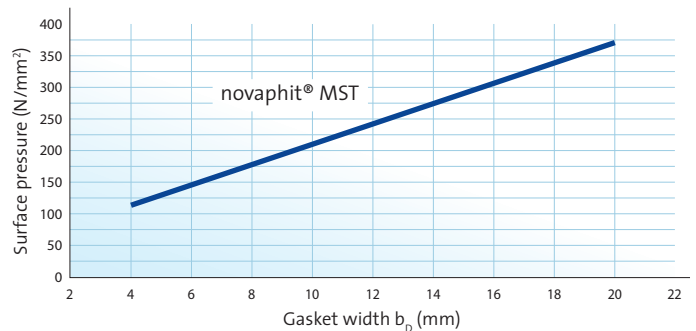
Compression set - Temp-Test up to 50 N/mm² and 400 °C



Maximum surface pressure after installation, with raised faces



The maximum surface pressure can be increased by a factor of approximately 1.5 in the case of tongue and groove flanges



The multilayer structure of novaphit® MST means that the gasket thickness does not play a role

Explanatory notes about the temperature test (Temp-Test):

The purpose of the temperature test is to determine how the gasket deforms under certain conditions. It is a special Frenzeli development that represents what is effectively a "fingerprint" of major gasket properties. The compression set of the gasket at room temperature is determined in the first part of the test. This curve indicates the adaptability of the gasket during installation.

In the second part of the test, the temperature is increased at a specified speed, while the surface pressure level reached in the first part is maintained consistently. I.e. the system is not allowed to "relax" as a result of gasket compression. This is overly critical – the strain on the gasket would be lower in a real sealing situation – but it unsparingly reveals the character of the gasket.

Material data

General information		novaphit® SSTC	novaphit® SSTC ^{TA-L}	novaphit® MST
Binders		none	none	none
Approvals and tests	DVGW VP401 TA Luft Blow out safety test according to VDI 2200 BAM for gaseous O ₂ (200 °C / 130 bar) and liquid O ₂ Firesafe (DIN EN ISO 10497, API607, BS6755) Germanischer Lloyd (GL)	✓ - - - ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓ ✓ ✓	✓ - ✓ ✓ ✓ ✓ ✓
Colour		graphite grey	graphite grey	graphite grey
Printing colour		black	black	blue

Physical properties	Test standard	Unit	Value		
			Mode (typical value)		
Gasket thickness 2.0 mm					
Graphite purity	DIN 51 903	[%]	> 99	> 99	99.5
Density	DIN 28 090-2	[g/cm ³]	1.35	1.37	1.20
Residual stress at 300 °C	DIN 52 913	[N/mm ²]	≥ 45	≥ 45	≥ 45
Compressibility	ASTM F 36 J	[%]	37	37	50
Recovery	ASTM F 36 J	[%]	15	17	10
Cold compressibility ϵ_{KSW}	DIN 28 090-2	[%]	35	36	45
Cold recovery ϵ_{KRW}	DIN 28 090-2	[%]	4	5	4
Hot creep $\epsilon_{WSW/300}$	DIN 28 090-2	[%]	2	3	3
Hot recovery $\epsilon_{WRW/300}$	DIN 28 090-2	[%]	2	4	3
Specific leakage rate	DIN 3535-6	[mg/(s·m)]	0.07	≤ 0.01	≤ 0.01
Oxidation value with XP technology	DIN 28090-2	[%/h]	≤ 3	≤ 3	≤ 3
Oxidation value without XP technology	DIN 28090-2	[%/h]	≤ 4	≤ 4	-
Tensile strength transverse	DIN 52 910	[N/mm ²]	8	8	16
Total chloride content	DIN 28 090-2	[ppm]	≤ 50	≤ 50	≤ 50
Leachable chloride content	PV 01605	[ppm]	≤ 20	≤ 20	≤ 20
Total fluoride content	DIN 51 723	[ppm]	≤ 50	≤ 50	≤ 50

Product data (tolerances acc. to DIN 28091-1)				
Dimensions	[mm]	1000 x 1000 1500 x 1500 2000 x 1000	1000 x 1000 1500 x 1500 2000 x 1000	1000 x 1000 1500 x 1500
Thicknesses	[mm]	1.0 / 1.5 / 2.0 / 3.0	1.0 / 1.6 / 2.0 / 3.0	1.0 / 1.5 / 2.0 / 3.0 / 4.0

Warranty disclaimer

In view of the variety of different installation and operation conditions and applications and processing engineering options, the information given in this prospectus can only provide approximate guidance and cannot be used as the basis for warranty claims.

Explanatory notes about the recommendations for use

The temperature and pressure recommendations in the graphs apply to gaskets 2.0 mm thick that are used with raised face flanges. Higher stresses are possible when thinner gaskets are used! The information provided must therefore be considered as estimates that are on the safe side rather than as specific operational limits.

Good for people and the environment.

From research and development to our manufacturing operations and use of the product by the customer: quality assurance and a responsible approach to resources and the environment are a firm commitment we observe in everything we do throughout the life cycle of all products.

The Frenzelit gasket division has obtained certification that the company complies with the requirements of ISO 9001, ISO 14001 and ISO 50001. This means complete transparency in all areas and therefore provides a high degree of security – for the benefit of our employees, the environment and our customers.

Installation instructions

- Clean the surfaces that being sealed and remove traces of old gaskets without damaging the flange surface.
- Check the flange surfaces for parallelity and unevenness; make adjustments if necessary.
- Before installing them, check gaskets that have been stored in dry conditions for cracks, surface damage, dimensional accuracy and - in the case of gaskets with bolt holes - congruence of the bolting pattern with the flange.
- Do not use any sealing agents! Fit gaskets dry and grease-free!
- Check the condition of the bolts before fitting them and use new bolts if necessary.
- Install the gaskets consistently and carefully by hand first. (Import note: never tighten the first bolt too securely!).
- Tighten the bolts with a suitable tool. Apply the specified torque diagonally in several stages.

The novaphit® product family

Product name	Brief description	XP technology
novaphit® MST	Multilayer gasket with expanded and flat metal inserts for highest mechanical stability, fulfilling TA Luft requirements	as standard
novaphit® SSTC ^{TA-L}	With expanded metal insert, fulfilling TA Luft requirements	optionally
novaphit® SSTC	With proven expanded metal insert	optionally
novaphit® SSTC ^{TRD 401}	The TÜV-certified solution for oval closure lid gaskets	optionally
novaphit® 400	Reinforced with flat metal insert, for filigree geometries and thin gasket thicknesses	-
novaphit® VS	Pre-compressed graphite sheet without metal reinforcement	optionally
novaphit® M	Graphite foil with density 1.0 g/cm ³	optionally

Quality management

ISO 9001

Environment management

ISO 14001

Energy management

ISO 50001

GASKETS

TECHNICAL TEXTILES

EXPANSION JOINTS

INSULATION

NEW MATERIALS

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 **Frenzelit**
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