

***ESG-HF – a construction product from
a third-party monitored manufacturer***

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1.0 Introduction: Spirit and purpose of the guide

In accordance with the German Building Code there are three product types of toughened safety glass: TSG according to EN 12150, heat soaked TSG according to EN 14179 and heat soaked TSG according to EN 14179 with reliability class RC2 according to DIN EN 1990. Delimitation of these three products is not always clear in practice. This guide is intended to provide all groups involved such as:

- fabricators
- users
- planners
- insulating glass manufacturers and
- installers

with a clear picture of the definition of these products and the associated requirements.

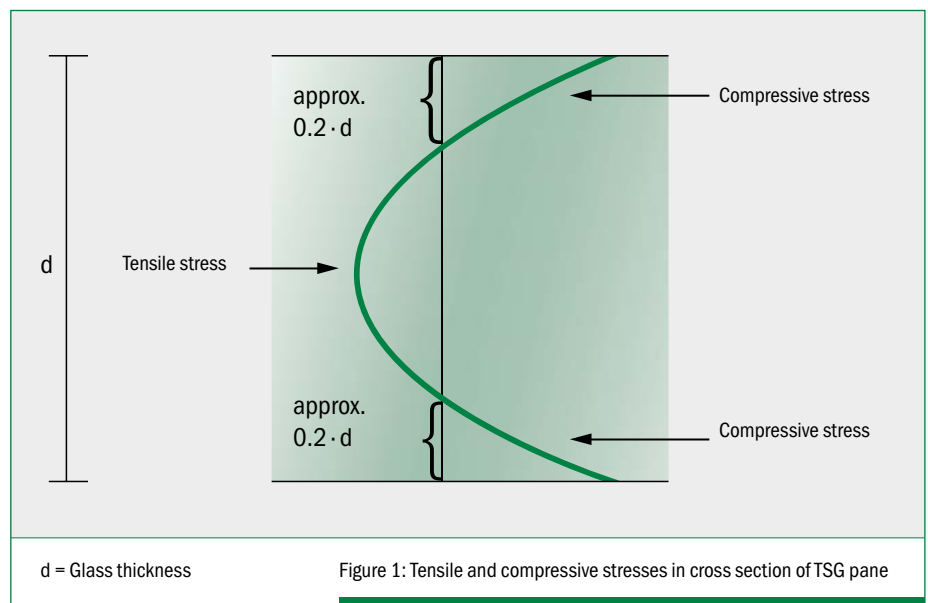
2.0 The product and its manufacture

Toughened safety glass

Toughened safety glass (TSG) is a thermally toughened float or patterned glass which exhibits residual stress characteristics resulting from a special thermal treatment of the glass. Unlike normally cooled glass, this thermal toughening process considerably increases the toughness of the glass.

This is achieved by heating the glass uniformly in a “toughening furnace” to approx. 620 °C within a defined time period and then cooling it rapidly. This generates compressive stress on both surfaces (each in an area of approx. 20 % of the glass thickness) and tensile stress in the core.

In the edge areas this area corresponds approximately to the glass thickness, in the corner areas to 2.5 times the glass thickness and in the area around holes also to the glass thickness.



The compressive and tensile stresses are in equilibrium. Subsequent glass working is not permitted.

Compared to untoughened glass, TSG has a greater bending tensile strength and resistance to thermal shock as well as a fine crumb-like fragmentation pattern, which gives the product its safety features.

TSG spontaneous fracture induced by NiS-inclusions

During the manufacture of float glass, it is impossible to prevent nickel contamination of the molten glass despite taking the greatest care. As a result, nickel sulphide inclusions may occur in the glass. They may increase in volume over time due to phase transformation. This process is accelerated by exposure to temperature. This phenomenon does not present a problem in normally cooled glass. If, however, there is an inclusion of this type in the tensile stress area in the core of a toughened safety glass, the resulting additional

stresses may lead to a sudden failure of the pane. An effective measure to counter this spontaneous fracture is another thermal treatment of this TSG using the “heat soak test”.

Heat soaking of toughened safety glass

In the heat soak test, the previously thermally toughened TSG is subjected to an additional temperature process. The thermally toughened glass is heated under defined conditions in a calibrated furnace specially provided for this purpose. After reaching the specified temperature it is stored for a defined period. During this process, any nickel sulphide inclusions present increase in size. If they are inside the tension zone and are above a minimum size, they cause fracture of the TSG. Current knowledge indicates that this process, if properly applied, can be used to increase the reliability of the glazing construction to the minimum level specified by the German states building authorities for installation heights greater than 4 m.

3.0 Building code regulations

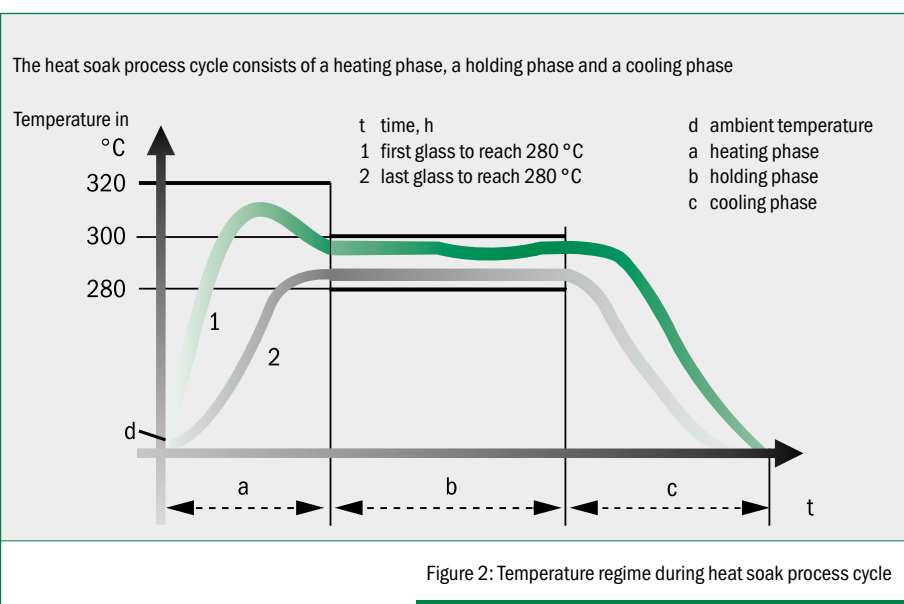
A distinction is made between product-related (use) and applications-related requirements.

3.1 Product-related requirements

To ensure safety of structures, Germany distinguishes three types of TSG products in DIN 18008-2:2020-05:

- “Thermally toughened soda lime silicate safety glass” according to EN 12150, referred to in the following as “TSG”;
- “Heat soaked thermally toughened soda lime silicate safety glass” according to EN 14179, referred to in the following as “heat soaked TSG”.
- “Heat soaked thermally toughened soda lime silicate safety glass” according to EN 14179 with reliability class RC2 according to DIN EN 1990, referred to in the following as heat soaked TSG with third-party monitoring (e.g. ESG-HF according to RAL-GZ 525).

The table on pages 4 and 5 shows the differences between these three products.



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Criterion	TSG (according to EN 12150)	Heat soaked TSG (according to EN 14179:2005-09)	Heat soaked TSG with third-party monitoring (e.g. ESG-HF according to RAL-GZ 525)
End of heating phase	-	Attainment of 280 °C surface temperature for last glass sample, (EN 14179-1 Clause 5.3.2)	
Maximum glass temperature during heating phase	-	320 °C, (EN 14179-1 Clause 5.3.2)	
Holding time	-	2 h (EN 14179-1 Clause 5.3.3)	2 h (EN 14179-1 Clause 5.3.3)
Maximum glass temperature during holding time	-	300 °C, (EN 14179-1 Clause 5.3.3)	
Recording HS process cycle	-	Temperature/time regime Number of panels broken during the process (EN 14179-2 Annex A.3.2)	
Initial test of HS oven	-	Yes, factory responsibility (EN 14179-1 Clause 6.5 and Annex A)	Yes, third-party monitoring by a testing and surveillance body
Routine monitoring of HS oven	-	1 year after initial test; then every 5 years, factory responsibility (EN 14179-2 Annex A.3.2)	1 year after initial test; then every 5 years, via third-party monitoring (EN 14179-2 Annex A.3.2)
Basic glass	<ul style="list-style-type: none"> ■ Float glass according to EN 572-2 ■ Drawn sheet glass according to EN 572-4 ■ Patterned glass according to EN 572-5 ■ Coated glass according to EN 1096-1 		
Enamelling permitted	Yes, according to EN 14179-1 Clause 3.4 and EN 14179-2 Clause 4.3.1.2		
Minimum value of characteristic bending tensile strength, see EN 14179-1, Clause 11.4, Table 6	<ul style="list-style-type: none"> ■ Basic product: Clear, body tinted and coated float glass = 120 N/mm² ■ Basic product: Enamelled float glass (enamel in tensile zone) = 75 N/mm² ■ Patterned glass, drawn sheet glass = 90 N/mm² 		

Criterion	TSG (according to EN 12150)	Heat soaked TSG (according to EN 14179)	Heat soaked TSG with third-party monitoring (e.g. ESG-HF according to RAL-GZ 525)
Requirements for fragmentation patterns	See EN 12150-1, Clause 8, Dimensions of test specimen 360 x 1100 mm; Compliance with all producible dimensions	See EN 14179-1, Clause 10, Test specimen size 360 x 1100 mm	
Third-party monitoring	No		Yes, according to VTB (Administrative Regulation - Technical Rules for Works), Annex A 1.2.7/2 No. 2 or according to DIN 18008-2:2020-05 Annex C using a procedure according to DIN EN 1990/NA:2010-12, Table NA.B.2, line "IL2 in combination with RC2", as detailed in, e.g. RAL-GZ 525, Clause 3.2.
Max. permissible depth of edge damage	According to DIN 18008-1 max. 15 % of glass thickness		Only for ESG-HF according to RAL-GZ 525: max. 5 % of glass thickness
Edge working, drill holes ¹⁾ , openings, cut-outs	Permissible according to EN 12150-1, Clause 7	Permissible according to EN 14179-1, Clause 9	
Initial test of the product	Required according to EN 12150-2, Clause 5.2.2	Required according to EN 14179-2 Clause 5.2	Required, e.g. according to RAL-GZ 525
Factory production control incl. documentation	Required according to EN 12150-2, Clause 5.3	Required according to EN 14179-2 Clauses 5.3 to 5.5	Required, e.g. according to RAL-GZ 525
Marking	According to EN 12150-1 Clause 10: Name or trademark of manufacturer Number of the European standard: "EN 12150"	According to EN 14179-1, Clause 12: Name or trademark of manufacturer Number of the European standard: "EN 14179-1"	Required, e.g. according to RAL-GZ 525, Clause 4
Requirements for verification	System 3 EN 12150-2 Annex ZA.2	System 3 EN 14179-2 Annex ZA.2.1	E.g. RAL quality mark certificate RAL-GZ 525
Monitoring the installation	Point-supported and ventilated wall claddings made of toughened safety glass are governed by special rules in many German states.		
¹⁾ Applications-related technical rules (DIN 18008) specify additional restrictions, e.g. distance between drill holes and glass edge.			

Table 1: Distinguishing characteristics of TSG products

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3.2 Applications-related requirements

The applications-related requirements for the three TSG products are governed by the relevant Administrative Regulations – Technical Rules for Works (VV TB) of the corresponding German state and by DIN 18008.

Accordingly, monolithic single glass or external monolithic IGUs

- made of TSG and of heat soaked TSG can be installed only if their upper edge is located a maximum of 4 m above circulation areas.
- made of heat soaked TSG with third-party monitoring (e.g. ESG-HF according to RAL-GZ 525) can be installed without restrictions on the installation height.

Furthermore, Section 8.0 must be taken into consideration.

4.0 Factory production control (FPC) and third-party monitoring

Documentation of the manufacturing processes, in particular of the heat soak test, and ensuring the mandatory product characteristics are essential for the production of heat soaked TSG and heat soaked TSG with third-party monitoring (e.g. ESG-HF according to RAL-GZ 525).

The documentation provides verification of the proper implementation of the heat soak test in the context of factory production control and third-party monitoring.

At the request of the customer, distribution can be agreed separately with the manufacturer.

The documentation should include at least the following information:

- Manufacturing plant and designation of oven, where more than one oven is involved
- Order number / item
- Date of heat soak test
- Holding time and temperature during the holding phase
- Signature of person responsible

There may be additional data provided on factory production control.

For manufacture of ESG-HF according to RAL-GZ 525, third-party monitoring by a testing and inspection body nominated by the “Gütegemeinschaft Flachglas” is also required.

5.0 Marking and documentation

Both EN 14179-1 and the quality and inspection regulations of RAL-GZ 525 ESG-HF specify requirements for the marking of products to ensure identification of the manufacturer (see Table 1).

The marking should always be visible in the built-in condition.

This is necessary to ensure that it is always clear to everyone that the product is a toughened safety glass with special characteristics.

If the marking is completely missing, the use of the toughened safety glass as a construction product under the meaning of the European Construction Products Regulation (CPR) is not permitted.

In the event of complaints or building market surveillance measures, the documentation of the manufacturing process and the product marking with RAL-GZ 525 ESG-HF are important instruments for verifying the correct application of the heat soak test.

6.0 Level of safety

All building materials are subject to high reliability requirements.

Minimum values for the reliability index β are defined to ensure this.

According to EN 1990 “Eurocode: Basis of structural design”, Annex B, the mandatory minimum reliability of building components whose failure causes danger to life and limb is 99.9999 % per year (reliability class RC2 with reliability index $\beta \geq 4.7$ for a reference period of 1 year).

According to DIN EN 1990/NA:2010-12, Table NA.B.2, line “IL2 in combination with RC2”, this reliability is complied with by third-party monitoring.

7.0 Causes of fracture in toughened safety glass

Due to the thermal toughening process, toughened safety glass is more resistant than untoughened glass in many respects. As a brittle material, it can nevertheless fracture when exposed to excess loads or handled incorrectly, often with no obvious cause.

In this case it is often prematurely assumed that nickel-sulphide inclusions have caused the fracture.

However, fractures can be caused by a number of possible factors such as:

- edge damage
- incorrect block setting
- unplanned restraints during installation
- exceeding thermal shock resistance
- structural settling
- contact of glass with hard materials
- subsequent glass working
- manual burglary attack
- vandalism

Indications of a fracture-inducing nickel sulphide inclusion can be:

- butterfly fracture pattern at the fracture origin (only visible if the pane remains inside the frame or if large connected pane fragments are found)
- spherical, usually metallic shiny inclusion on the fracture mirror of the fracture origin
- characteristic rough surface structure (“elephant skin”/ crazing effect) and brass colour of the inclusion seen in the incident light microscope.
- diameter of inclusion approx. 0.05 to 0.5 mm
- position of inclusion in tensile stress area of the pane cross section
- The final verification of a nickel sulphide inclusion is the verification of the characteristic composition of nickel and sulphur, e.g. by EDX (Energy-Dispersive X-ray spectroscopy)

8.0 Information on placing and handling orders

The customer and manufacturer should clearly agree on whether TSG, heat soaked TSG or third-party monitored, heat soaked TSG (e.g. ESG-HF according to RAL-GZ 525) in accordance with the definitions set out in this guideline, is the subject of the contract. In cases of doubt, it must be clarified which requirements apply to the product to be supplied (level of safety, installation location, etc.). The manufacturers’ instructions must be followed.

If the customer wishes to pass on the documentation of the manufacturing processes, in particular of the heat soak test, this must be agreed separately (see Section 4).

In view of the current legislation, the manufacturers sometimes feel obliged to point out the technically unavoidable residual risk of glass breakage – including for orders of heat soaked TSG and third-party monitored heat soaked TSG (e.g. ESG-HF according to RAL-GZ 525).

In the event of complaints about alleged spontaneous fractures, the numerous other possible causes of damage (see Section 7) should be considered.

9.0 Literature / Applicable documents

DIN 18008: Glass in Building –
Design and construction rules

EN 1990: Eurocode: Basis of
structural design.

EN 1990/NA, National Annex –
Nationally defined parameters –
Euro-code: Basis of structural design

EN 12150, Glass in building –
Thermally toughened soda lime silicate
safety glass

EN 14179, Glass in building –
Heat soaked thermally toughened soda
lime silicate safety glass

Technical Guideline No. 3:
“Block setting of glazing units” and No.
17 “Glazing of insulating glass”
by Glaserhandwerk (glazier trade), Techni-
sches Kompetenzzentrum des Glaserhand-
werks, (Technical Competence Centre of
the Glazier Trade), Hadamar

VFF Guidance Sheet V.05: Recommendati-
ons for use of safety glass in building, Ver-
band Fenster und Fassade e. V. (Window
and Façade Manufacturers Association) ,
Frankfurt a. M.

Heat soaked thermally toughened safety
glass (ESG-HF) Gütesicherung RAL-GZ 525
(Quality Assurance) , Issue March 2019,
RAL Deutsches Institut für Gütesicherung
und Kennzeichnung e.V., Bonn

VV TB, Verwaltungsvorschriften Technische
Baubestimmungen der Bundesländer (Ad-
ministrative Regulations for Technical Rules
for Works of the German States)

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