

GLASS PERFORMANCE DAYS 2025

CIRCULAR IGUs – STRATEGIES FOR THE TECHNICAL EVALUATION

Research Project:
Assessments for the Reuse
and Remanufacturing of
Reclaimed IGUs („Re-Use“)



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Piling Up Glass Waste

- 350 000 tons of post-consumer cullet per year due to demolition and modernization in Germany (ift Rosenheim, 2019)
- material cycle of flat glass is still mostly linear, cascading to lower quality products

Why does this happen if glass is in theory a 100% circular material?

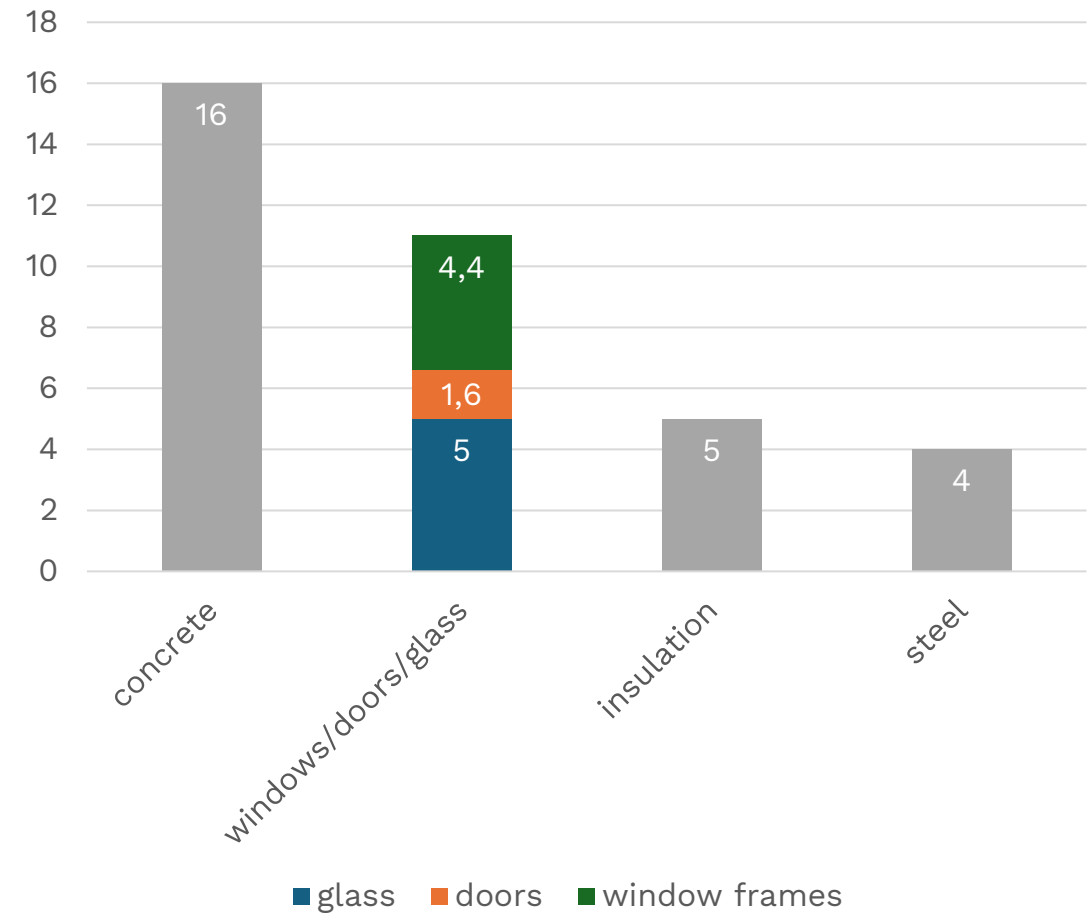


A Matter of Perspective

- architectural glass is **large contributor** to greenhouse gas emissions in building construction
- Much higher CO₂-footprint compared to other materials (~ 10x compared to concrete)

Modernizing facades is effective measure to **reduce operational emissions!**

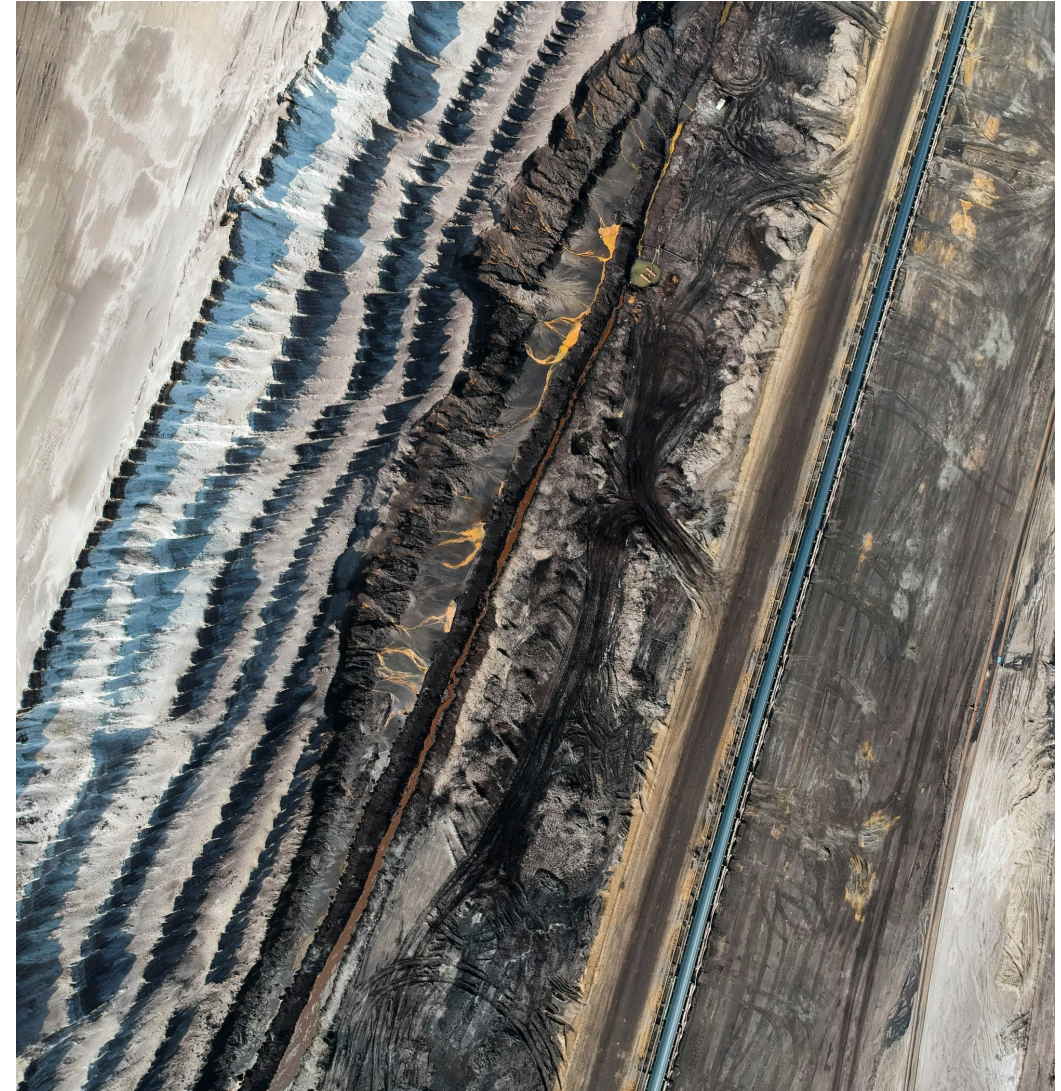
CO₂e in building construction in Germany in mio. tons (dena, 2022)



Material Hunger

- dependency on fossil fuels
- constant need for virgin material extraction
- loss of value along the supply chain:
cullet is worth much less than glass panes

It's not just an ecological but also becomes
an **economic issue!**



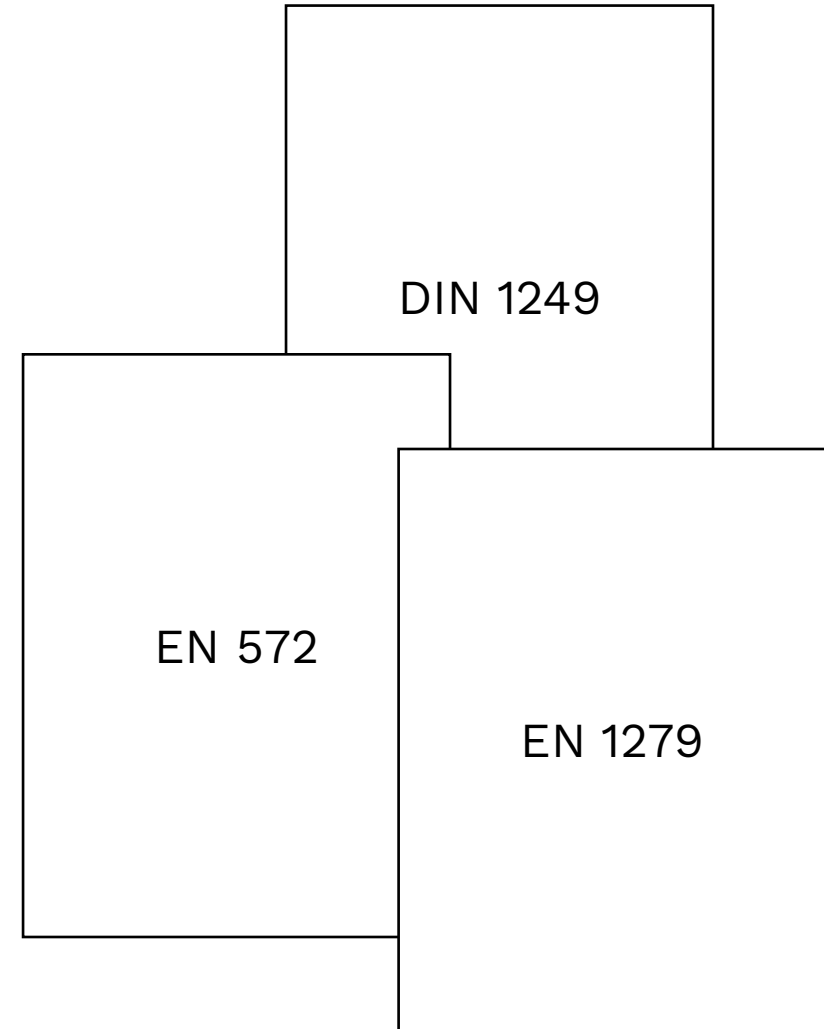


Research Objective

- Analysis of the **current building stock**
- **Analysis of standards** for float glass
- Definition of **testing requirements**
- **Experimental Testing** of reclaimed IGUs

How can collected data inform an **effective testing procedure** for reclaimed IGUs?

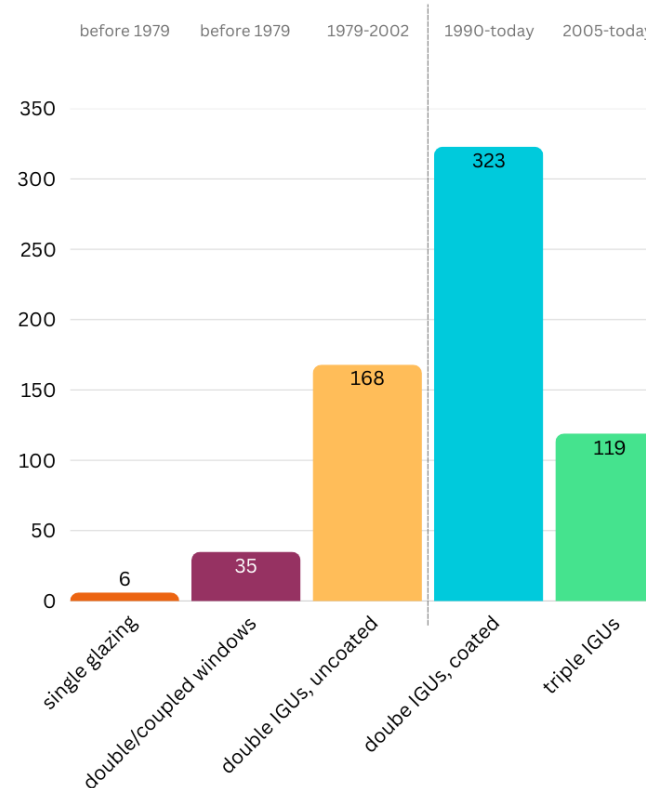
Which **circular strategies** apply for certain configurations?



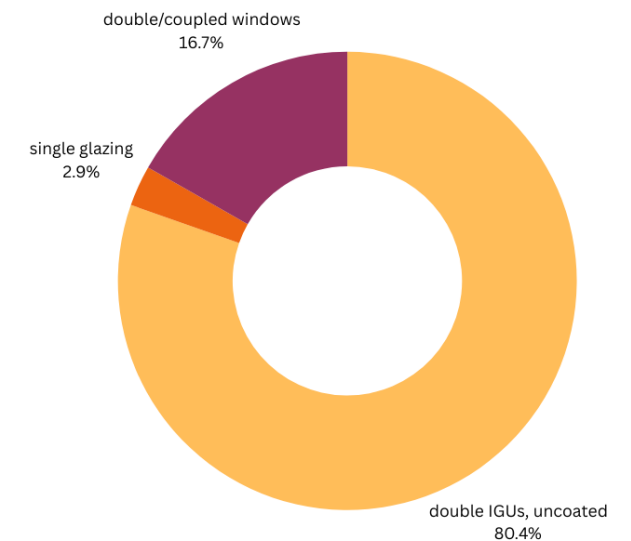
Utilizing Existing Potentials

- key word: **urban mining**
-> buildings are units for material storage
- Effective application of **circular strategies** to the value chain of float glass

Window types in current building stock (2023)



Ratio: Window types worth renovating (2023)



until 1978:
**single glazing &
double/coupled windows**
(U-value: 2.8-5.8 W/m²K)

1979-1989:
double IGU, non-coated
(U-value: 2.8 W/m²K)

1990-today:
double IGU, coated
(U-value: 1.1-1.4 W/m²K)

2005-today:
triple IGU, coated
(U-value: 0.5-0.7 W/m²K)

1977:
THERMAL PROTECTION ORDINANCE
(WärmeschutzV)

1959:
Introduction of FLOAT PROCESS,
Development of MODERN IGU

2002:
ENERGY CONSERVATION
REGULATION (EnEV)

2020:
BUILDINGS ENERGY ACT (GEG)

possible **asbestos contamination** in firm glazing putty (until 1993)

Use of **SF6 fill gas** for sound insulation (1975-2002)

1930

DIN 1249

“window glass”

4 QL's
thicknesses &
tolerances

1952

DIN 1249

“sheet glass”

information on
density, same
thickness
tolerance as
today

1973

DIN 1249(draft)

“window glass”

additional
thicknesses,
tolerances for
cut sizes &
shape

1980

DIN 1249-3

“float glass”

start of
splitting
standard in
several parts

1988

DIN 1249-10

“chemical and
physical
properties”

1994

EN 572
Part 1-7

“glass in
building”

European
Harmonization

2004

EN 572
Part 8+9

“supplied and
final cut sizes”

“product
standard”

2012

EN 572

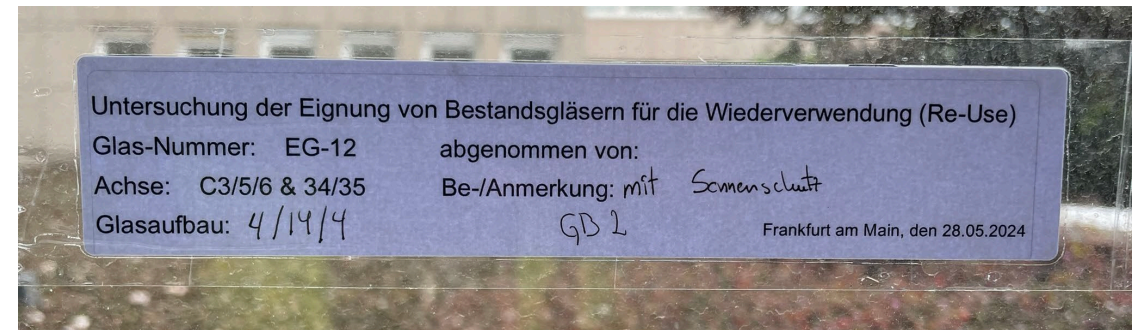
Editorial
changes

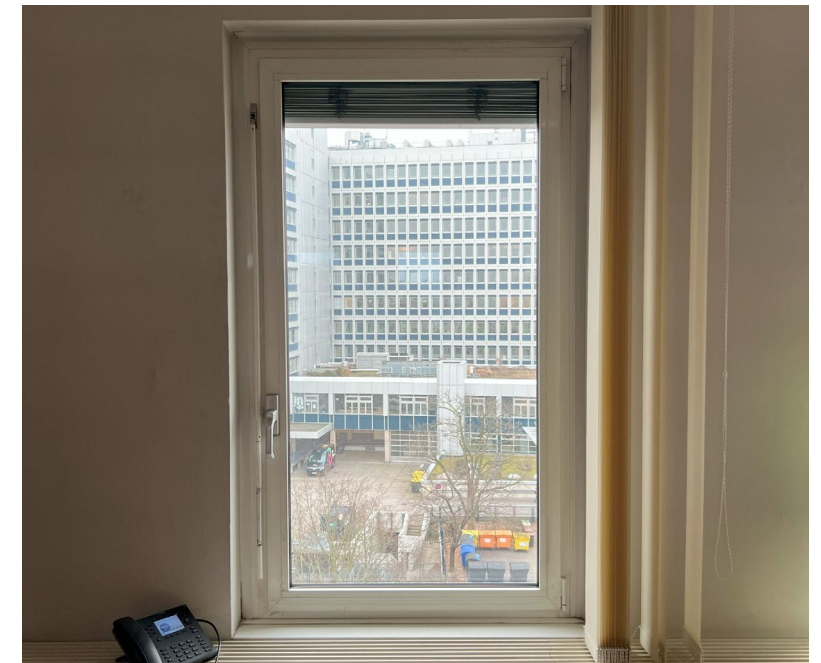
2016

EN 572

chart on
chemical
composition is
updated to
elementary
components

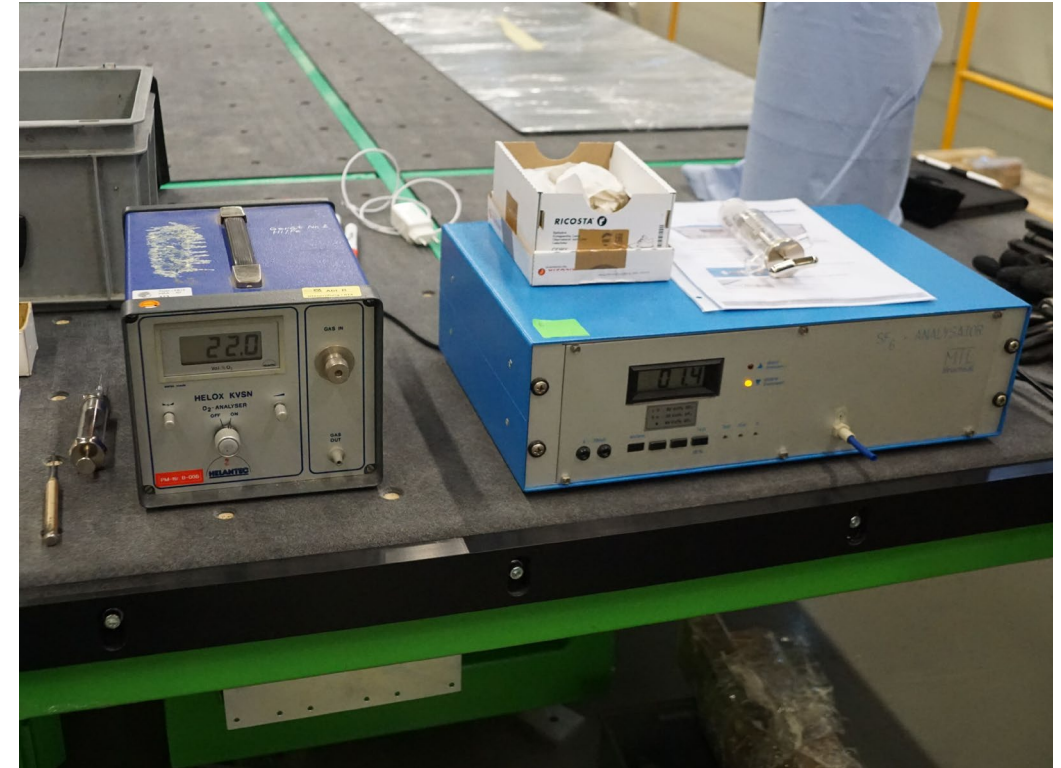
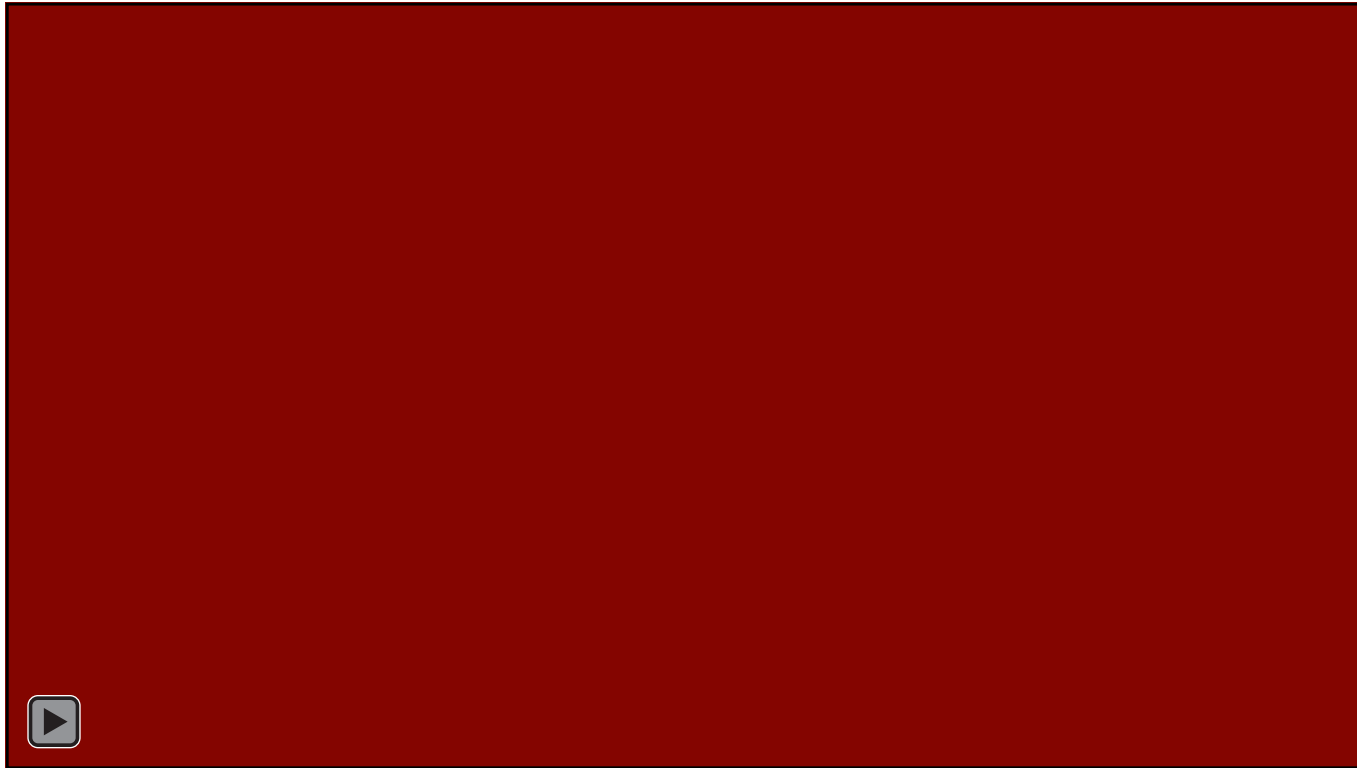
Sourcing





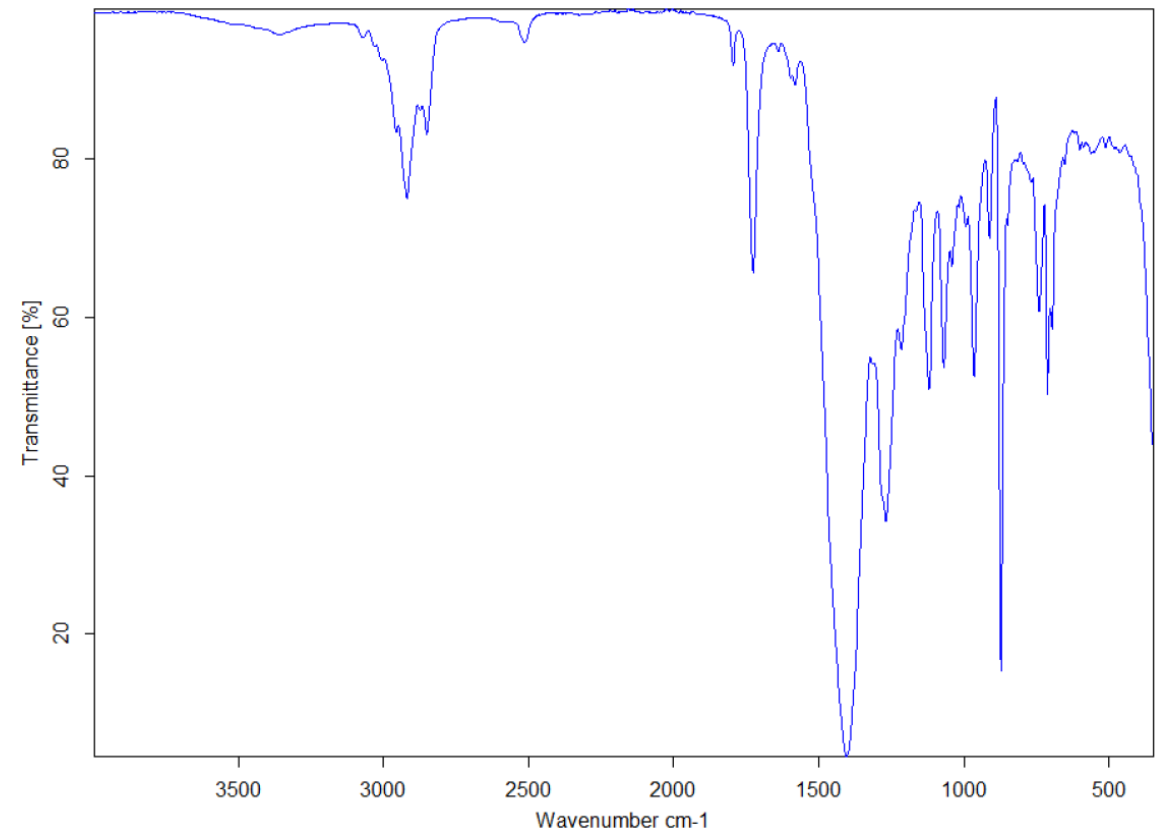
Gas Fill & Dew Point

- Measuring Argon content and presence of SF₆



Secondary Sealant

- Separation of IGUs and IR-Spectroscopy of Sealant Material -> Polysulfide (PS)



Visual Surface Quality

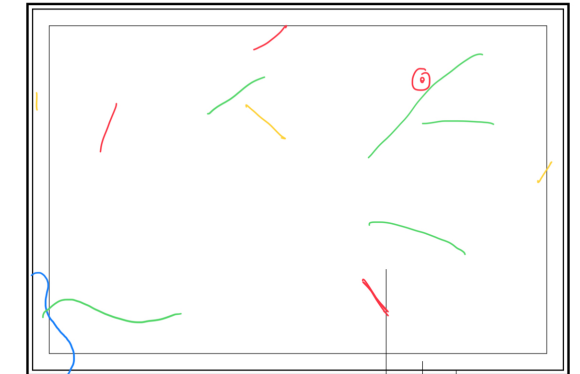


Bewertung: ISO-Glas nach EN 572-8 und EN 1279-1 (bzw. Hadamar-Richtlinie)

Glas-ID: EG-6 - GB-7

Prüfungsablauf EN 1279-1/Hadamar: Senkrechte Positionierung ohne Hintergrund;
diffuse Lichtquelle; 1m Abstand und senkrechte Betrachtung; 1 Minute pro m² Betrachtungszeit

Prüfungsablauf EN 572-8: Senkrechte Positionierung vor mattschwarzem Hintergrund;
diffuse Lichtquelle; 2m Abstand und senkrechte Betrachtung; 1 Minute pro m² Betrachtungszeit



Scheibenformat: 1600mm x 1100mm (1,76 m²)

bzw. 1600mm x 900mm (1,44m²), 2-fach ISO

R = Falzzone (15mm)

E = Randzone (50mm)

M = Hauptzone

Farbeinteilung Markierungen:

-  Prüfung nach EN 1279-1
(BF-Richtlinie 006/2019)
-  Prüfungsablauf EN 572-8
(Floatglas)

Fehlertypen:

-  Punktförmige Fehler
-  Rückstände - Punkte u. Flecken
-  Lineare/Langgestreckte Fehler

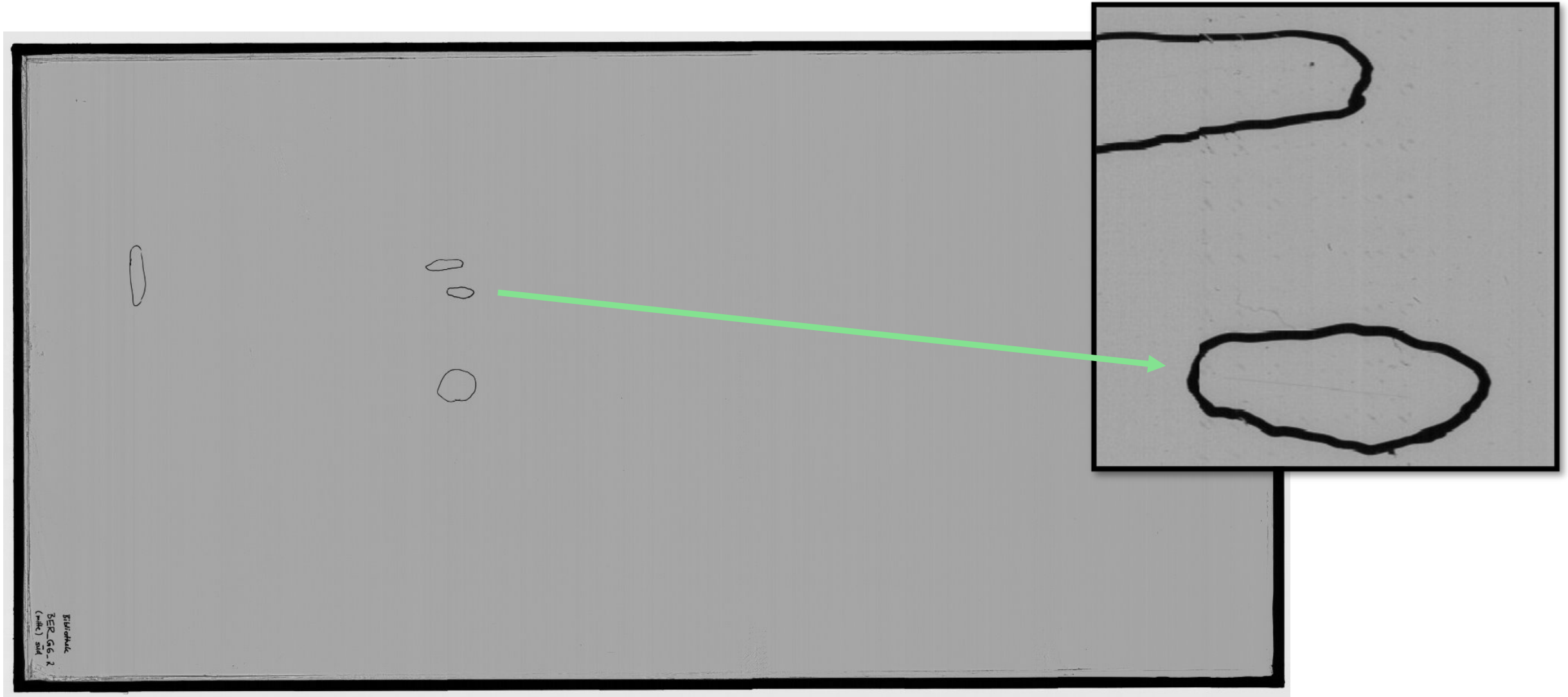
Notizen: *Glasränder bei der Versuchseinrichtung geissen*
nachträglich geprüft | Geeignet für Sanen Vproun

Projekt ZukunftBAU: Untersuchung der Eignung von Bestandsgläsern für die Wiederverwendung (Re-Use)

Visual Surface Quality



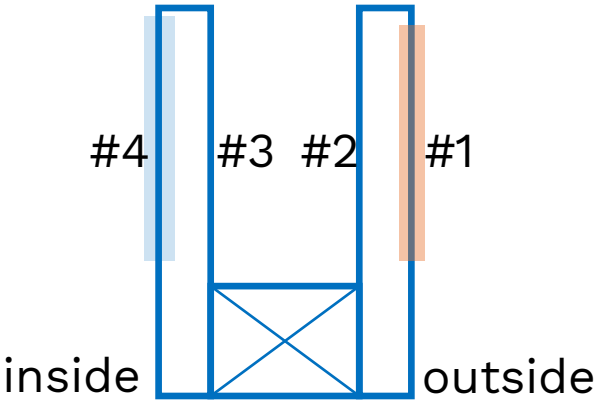
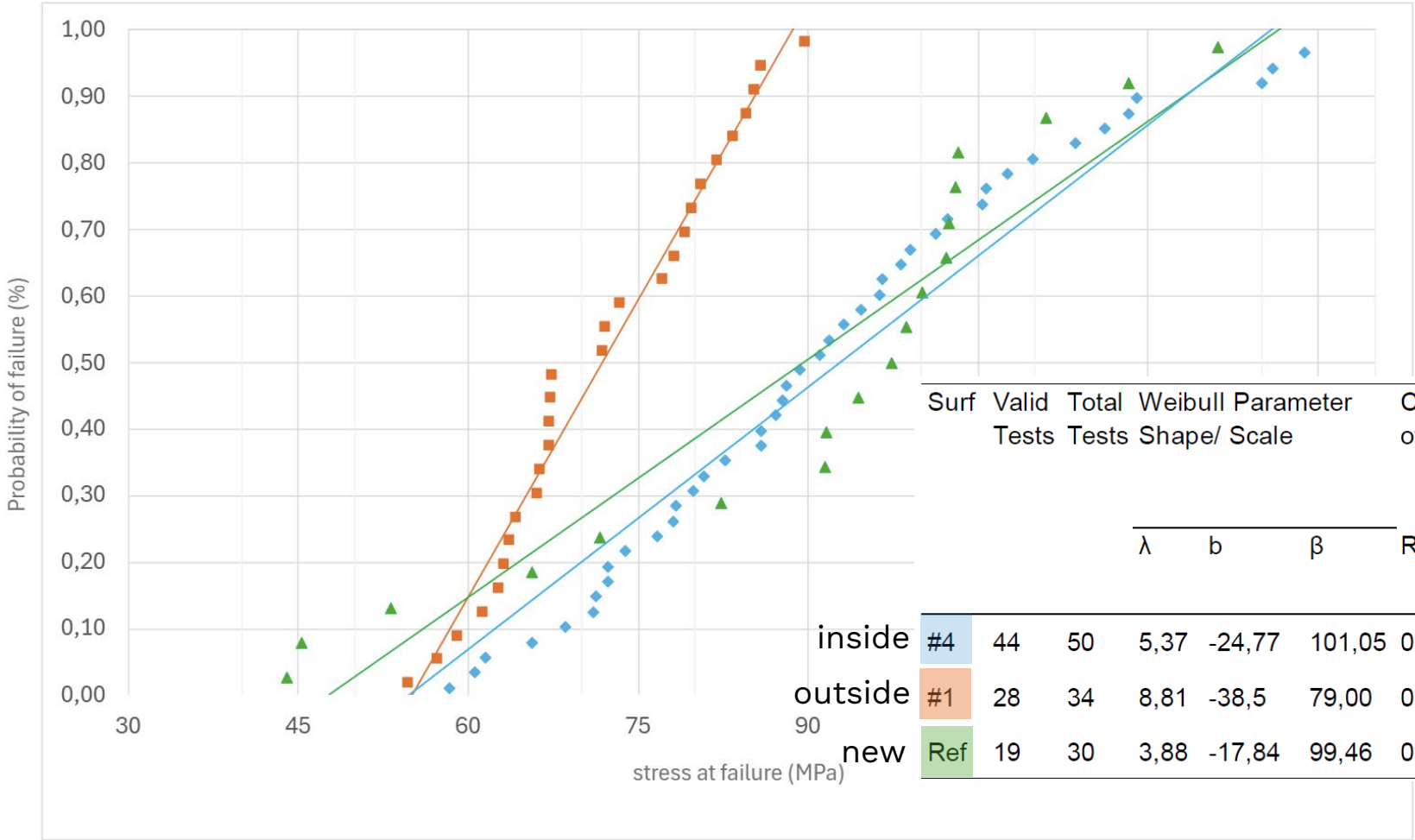
Visual Surface Quality



Surface Strength

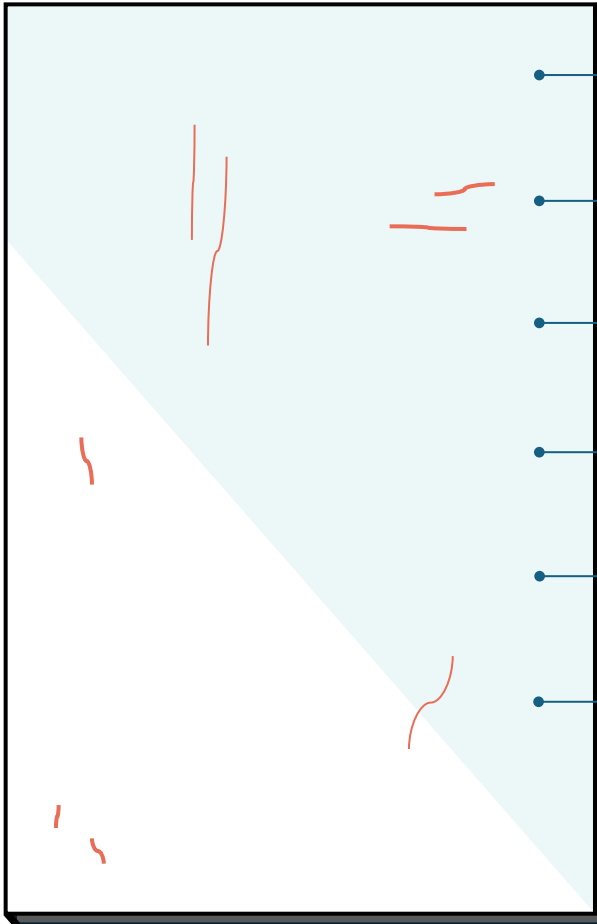


Surface Strength



Surf	Valid Tests	Total Tests	Weibull Parameter			Coeff. of det	Min	Max	Mean	5% Fractile	5% Fractile, 95% conf	Stand. Dev	Coeff. of var %
			λ	b	β								
						R^2	$\sigma_{f,min}$ MPa	$\sigma_{f,max}$ MPa	X MPa	$\sigma_k,5\%$ MPa	$\sigma_k,5\%$ MPa	σ_x MPa	
#4	44	50	5,37	-24,77	101,05	0,93	58,36	155,07	92,81	58,10	57,14	21,44	23,10%
#1	28	34	8,81	-38,5	79,00	0,92	54,69	89,64	71,76	56,40	55,71	9,76	13,60%
Ref	19	30	3,88	-17,84	99,46	0,93	44,00	126,16	89,55	46,25	43,83	23,46	26,19%

IGU from Frankfurt



manufactured in 1992-1993
“CLIMALIT IGW 2/92”

IGU configuration
4 mm FLOAT-14-4 mm FLOAT

several visual defects on at least one surface
(not accepted according to standard)

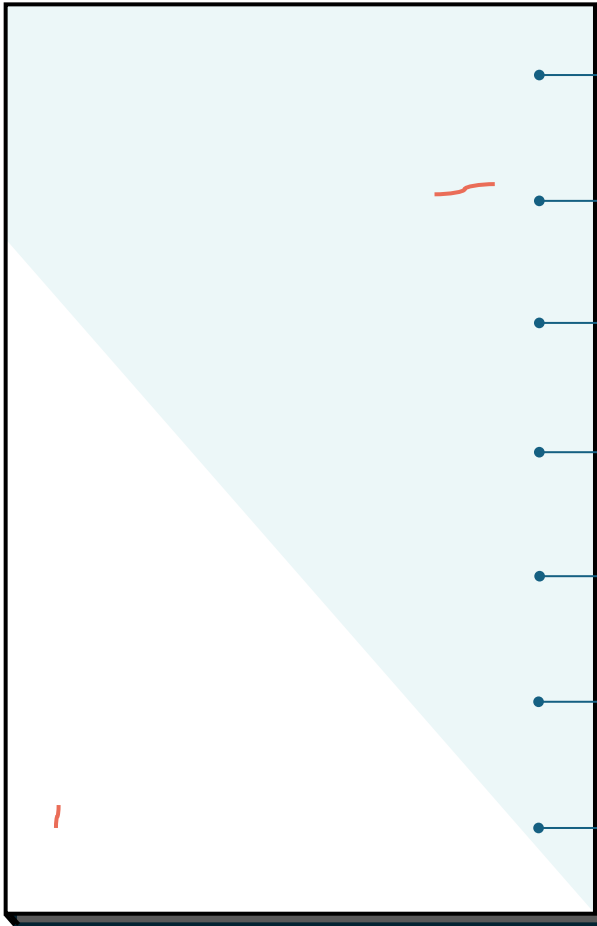
no gas fill detected,
dew point not measured

U-value $\sim 2.8 \text{ W/m}^2\text{K}$

Polysulfide as Secondary Sealant



qualifies for Remanufacturing or Repurpose



manufactured in 1993
“14 CLIMALIT 10360 4/93”

IGU configuration
4mm FLOAT (coated)-14-6mm FLOAT

minor visual defects
(acceptable according to standard)

96,6% Argon content
dew point of -60°C

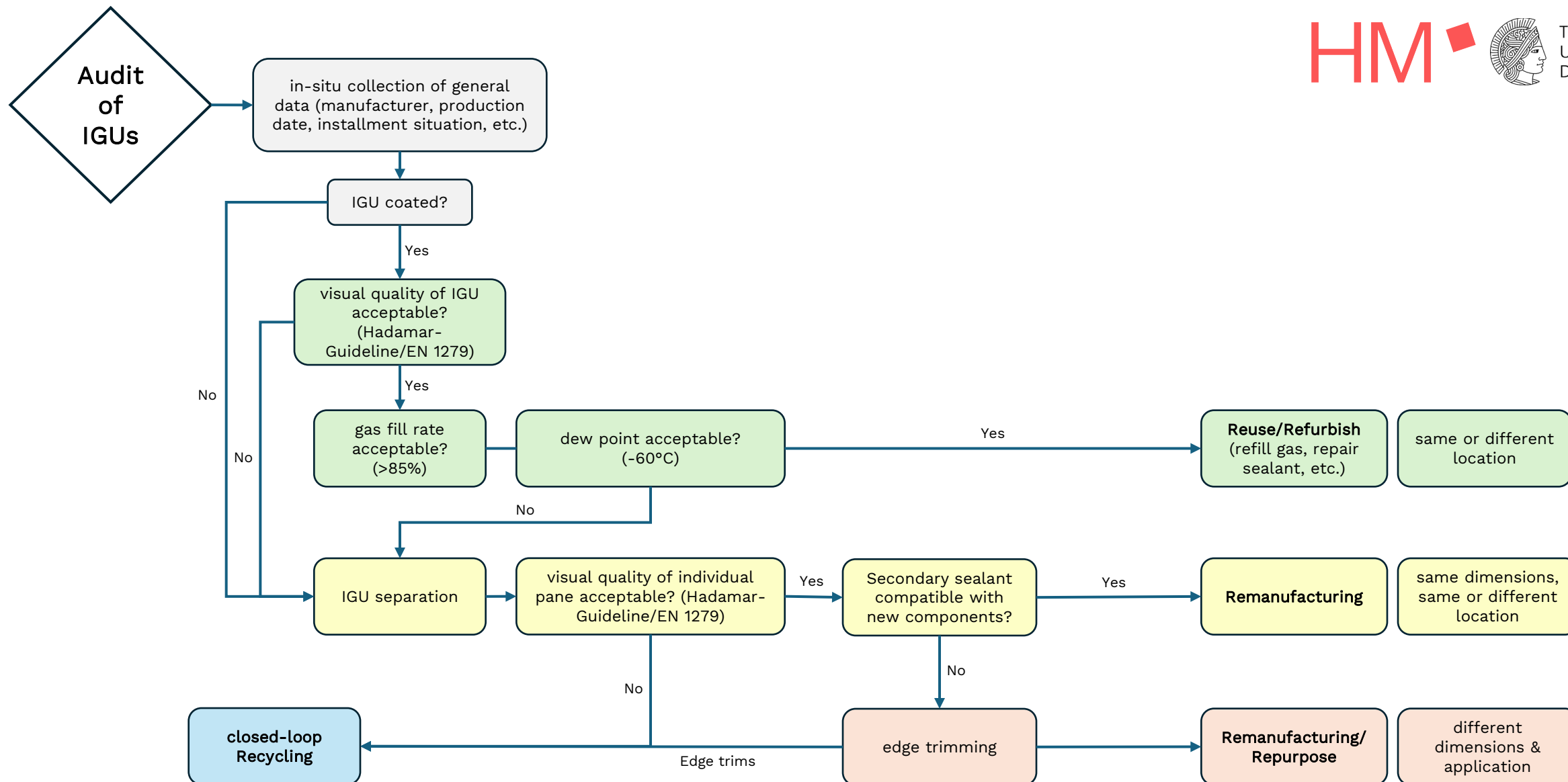
U-value of 1,38 W/m²K

Polysulfide as Secondary Sealant

Surface strength ~ 55 MPa (5% fractile, 95% confidence)



qualifies for
Reuse/Refurbishment
or **Upgrade** to Triple IGU



Next Steps

- **Large Strength Series:** Double-Ring Bending Tests
(Exchange with other European Research Projects)
- Manufacturing of IGUs for **Long-Term Climatic Tests**
- Detailed **LCA-Studies** including Remanufacturing Process

Acknowledgements

Research Project

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Studies on Architectural Glass for Reuse and Remanufacturing (“Re-Use”)

Untersuchungen zur Wieder- und Weiterverwendung von Bestandsglas (“Re-Use”)

<https://www.zukunftbau.de/projekte/forschungsfoerderung/1008187-2422>

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und Bauwesen



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Industrial Partners



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Kömmerling



BOLLINGER+GROHMANN

Q & A



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