Glass Performance Days 2025

10 – 12 JUNE 2025 | NOKIA ARENA - TAMPERE, FINLAND

GLASS PERFORMANCE DAYS 2025

GLASS REUSE: OPEN DATA FOR CIRCULARITY

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EMPATHY FOR GLASS


Photo by myimmo https://pixabay.com/images/id-254604/

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GLASS REUSE

Curved glass panels of the Centre Pompidou ‘caterpillar’, Paris

Photo by Jill Evans from Pexels: https://www.pexels.com/photo/paris-building-construction-industry-15308883/

Internal partitioning walls in Papillon, Saint-Ouen by Maximum Architecture

Photo by Maximum Architecture

Curtain wall panels, The Hague

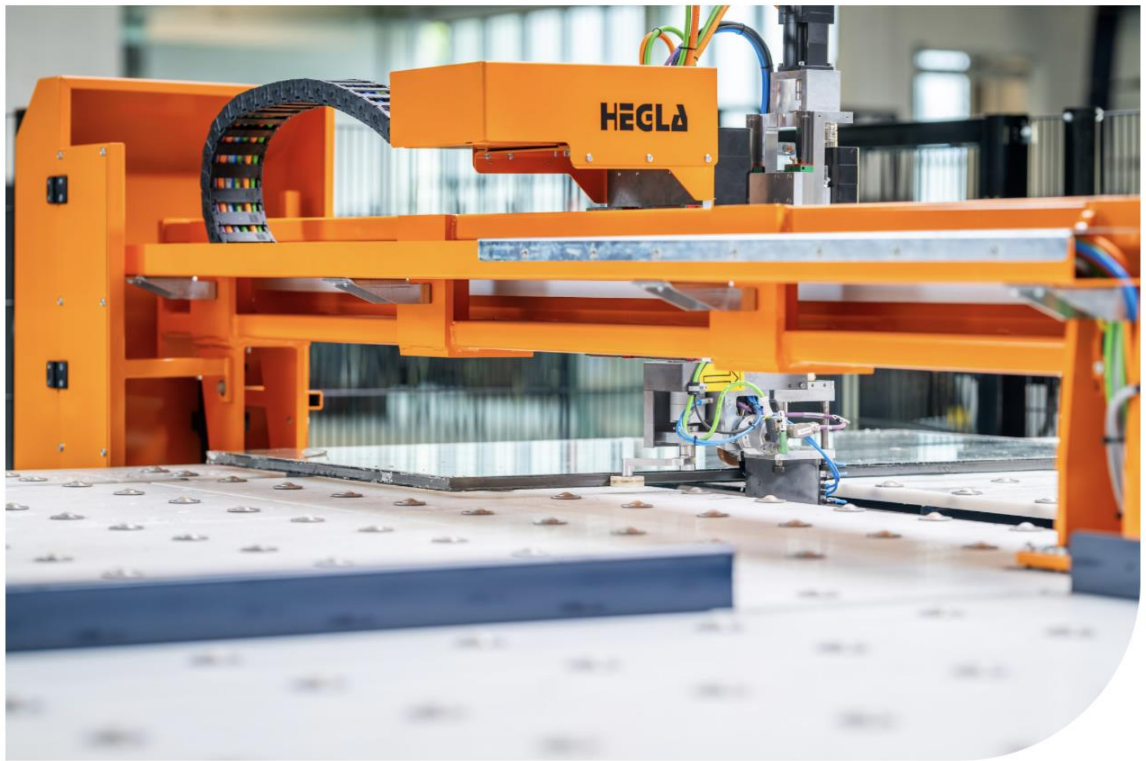
The Natural Pavilion, 2022 Floriade Expo, Almere by DP6 Architectuurstudio

GSF isoMAX

Assortment | Glass Harvesting | References | News | About IsoMAX | English

Request a quote

Collecting glass buck



isoMAX, the world's first circular glass factory

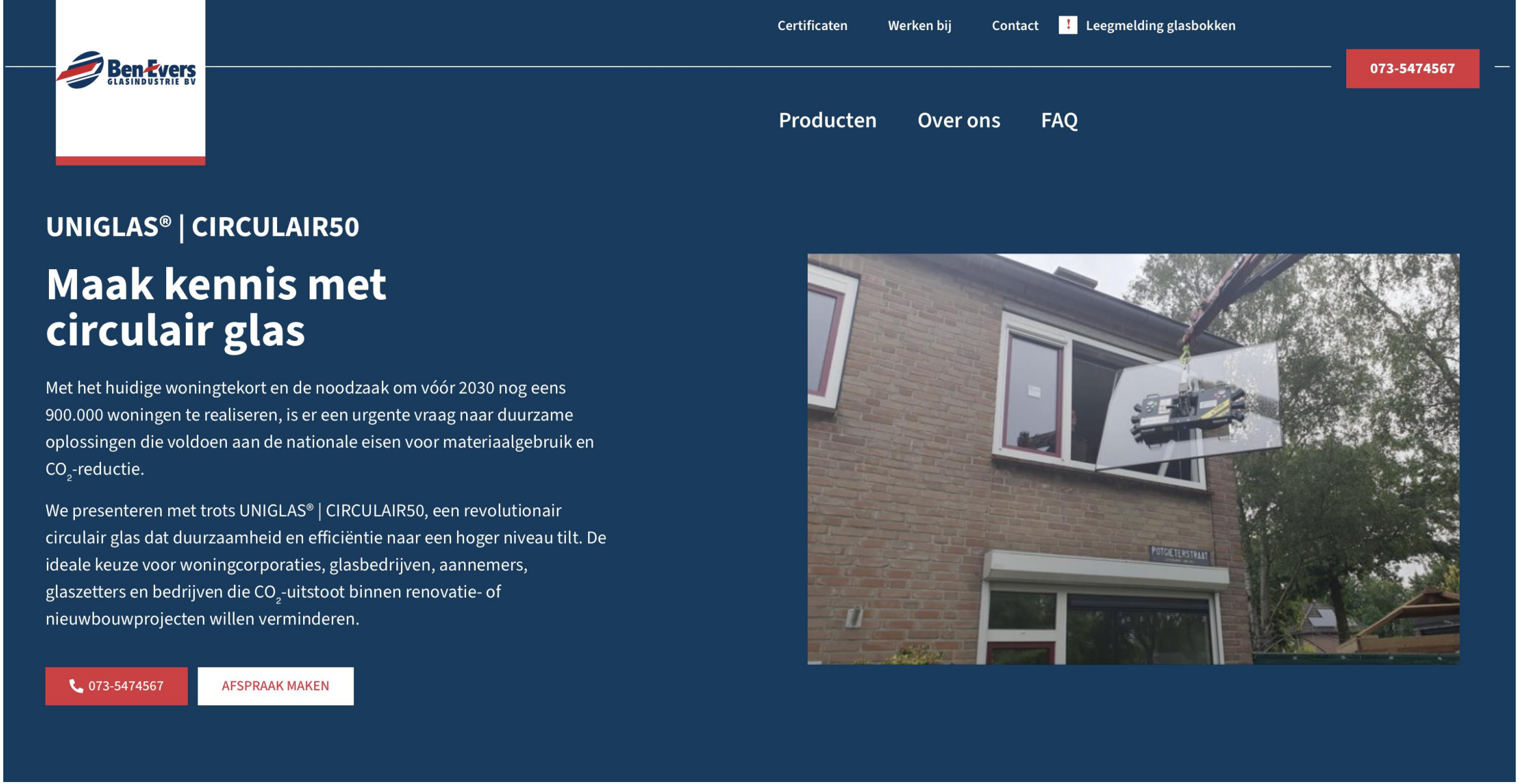
We are proud to be the first glass company in the world to produce **circular insulating glass**. This fulfills a long-held dream for professionals, institutions and organizations working to make them more sustainable.

isoMAX is **available to anyone** who wants to deploy circular insulating glass.

We supply: housing associations, property managers, glass companies, contractors, government, businesses, glaziers, insurers, owners' associations and individuals, among others.

View the assortment

https://isomax.nl/



https://benevers.nl/producten/uniglas-circulair50-2/

Circulair glas

Vlakglas leent zich uitstekend om hergebruikt te worden. Niet alleen door te recyclen maar leent zich uitstekend om hergebruikt te worden in isolerend dubbelglas. Van recycling naar re-using.

Toepassing o.a.: gebouwen welke worden getransformeerd van kantoor naar residentiële gebruik zijn geschikt om het glas her te gebruiken. Van de oude scheidingswanden wordt het glas gebruikt om nieuw isolatieglas te maken. Woningen met enkelglas welke worden gerenoveerd daarvan kan het oude enkelglas hergebruikt worden voor het produceren van isolatieglas.

https://globalglassgroup.com/circulair-glas/

Cor Wittekoek · 1st
Secretaris vakgroep GLAS at Bouwend Nederland, Director at VlakglasR...
4mo • Edited •

With the purchase of this machine, we are taking the next step towards circular glass.

Show original · Translation settings

HEGLA GmbH & Co. KG + Follow
6,050 followers
4mo •

Day 2 at glasstec – International Trade Fair started with a bang!
We are very proud to have sold our new IG2Pieces machine to Vlakglas Recycling Nederland!

We are exhibiting the machine at our show ground and do daily live-runs to demonstrate how it operates. With IG2Pieces you can automatically separate IGUs into its components which is a big step forward in terms of glass recycling, glass reuse and glass repair!

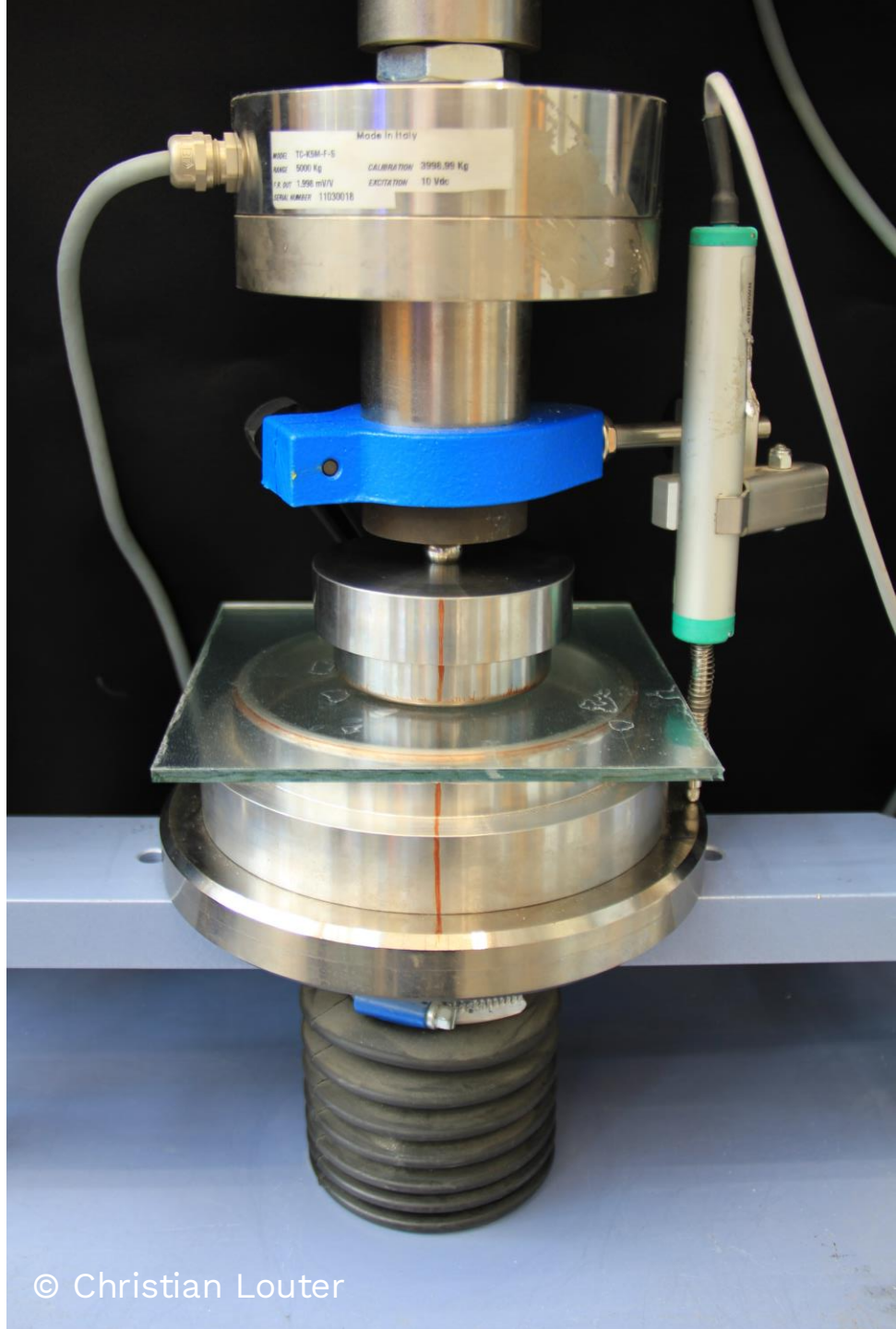
Thank you very much to everyone who has visited our stand A60 in Hall 14 so far and of course a very big thank you again to our friends from Vlakglas Recycling Nederland! 💚

Glass Performance Days 2023

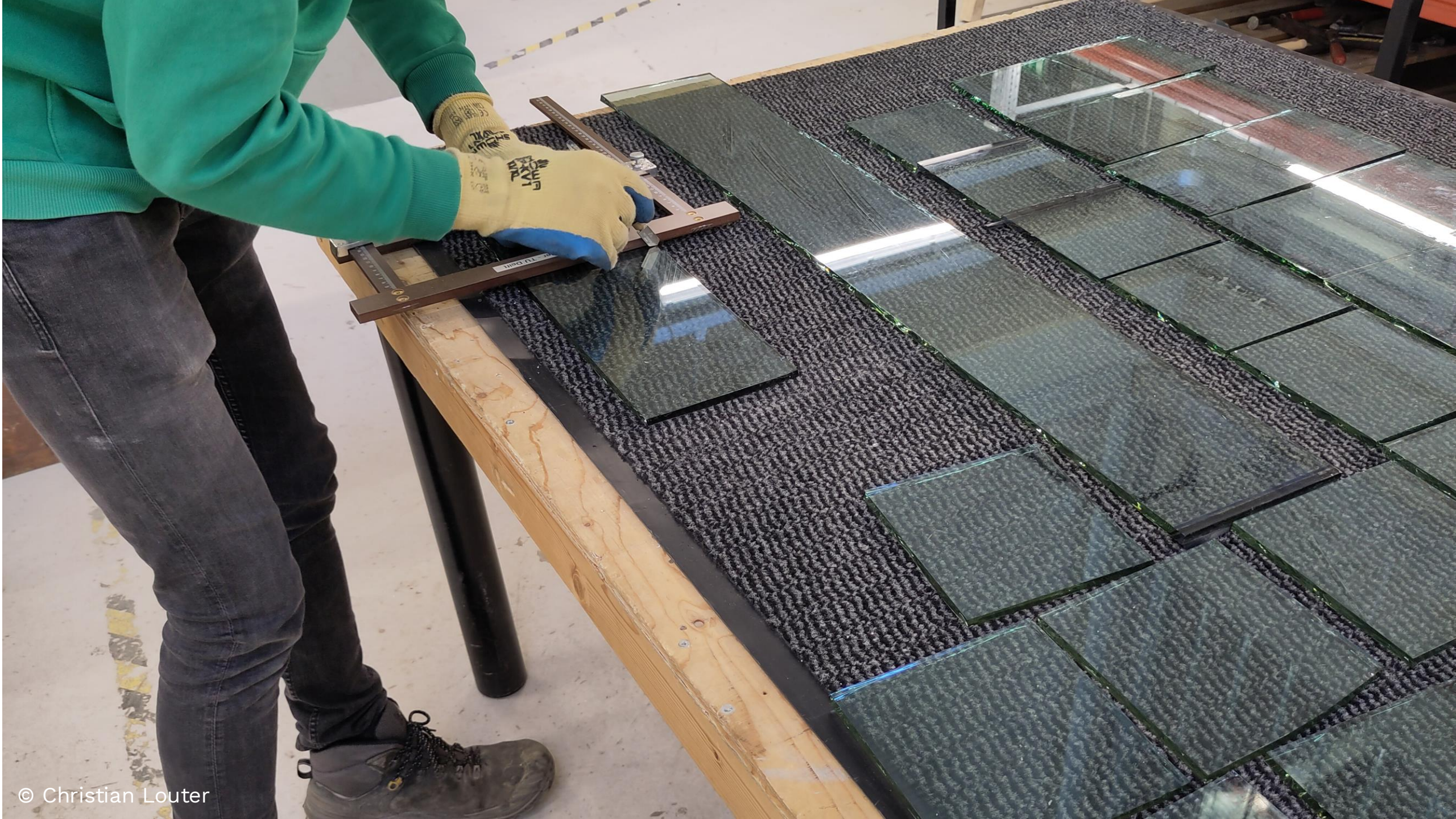
STRENGTH OF AGED GLASS ?

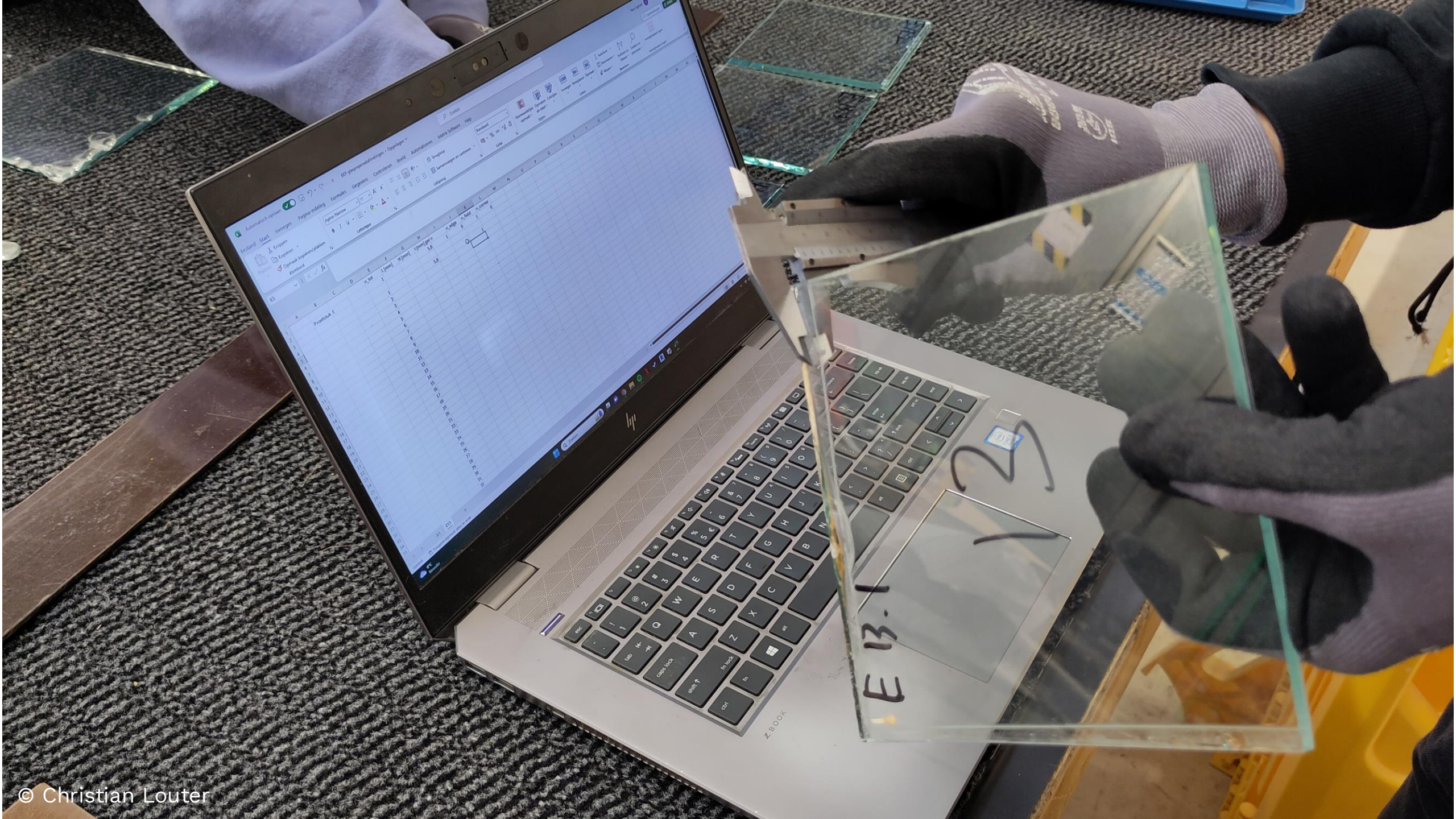
Aged glass sampled from four different projects

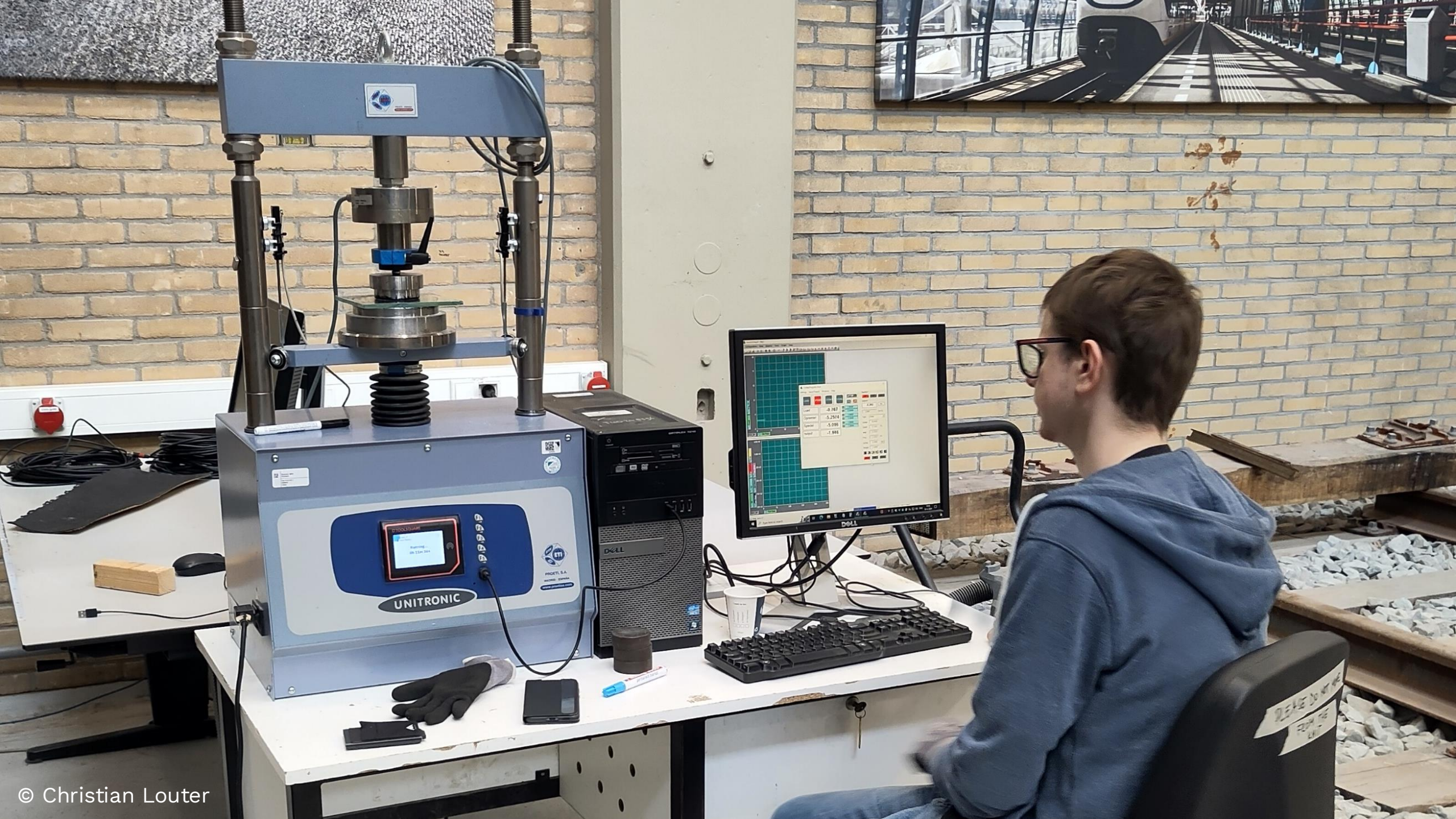
1. **15 years**, DGU, 8 mm external, apartment building, Amsterdam Osdorp
2. **25 years**, DGU, 8 mm external, office building
3. **36 years**, DGU, various thicknesses, apartment building, Amsterdam
4. **55 years**, single glazing, 6 mm, campus building, TU Delft

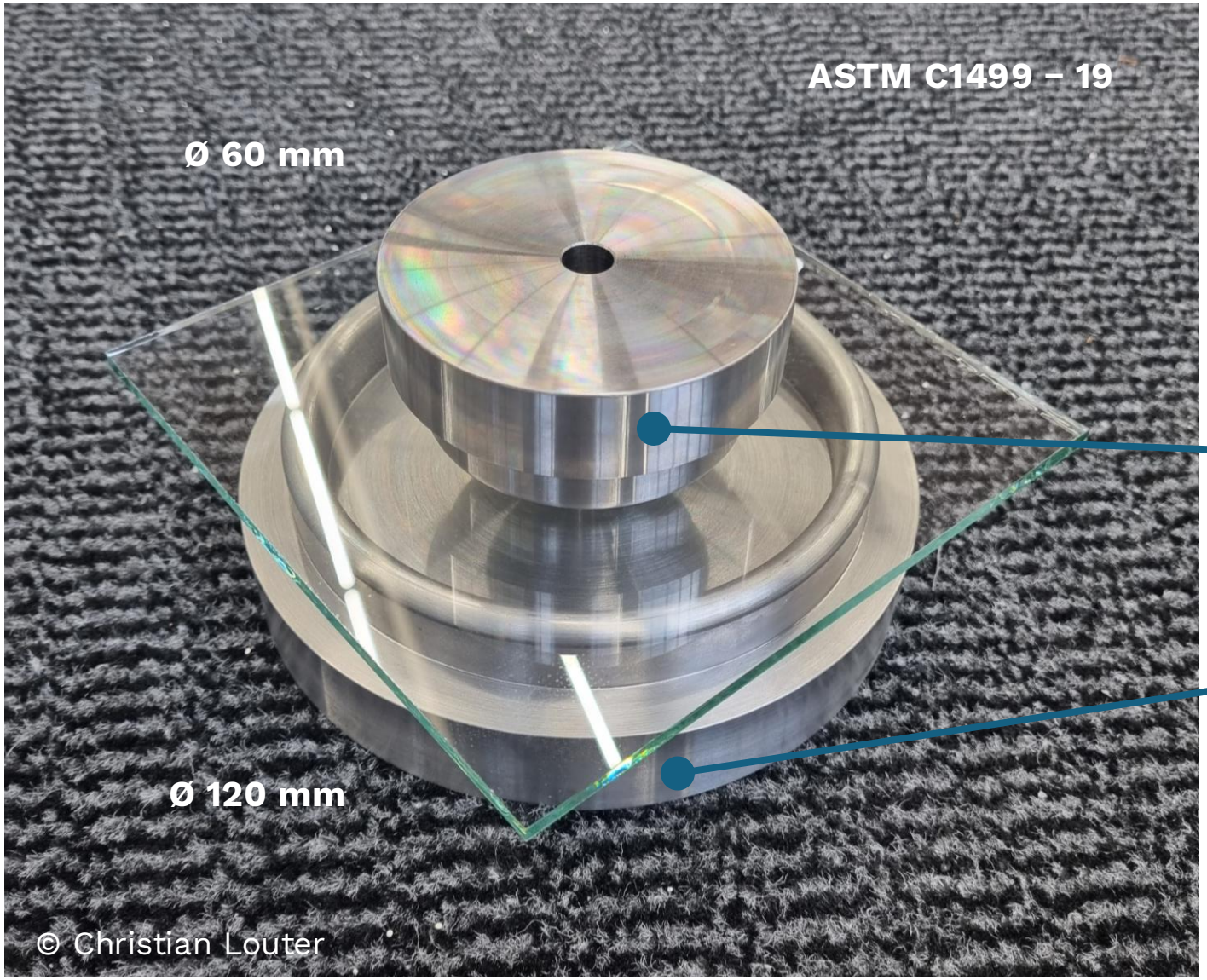


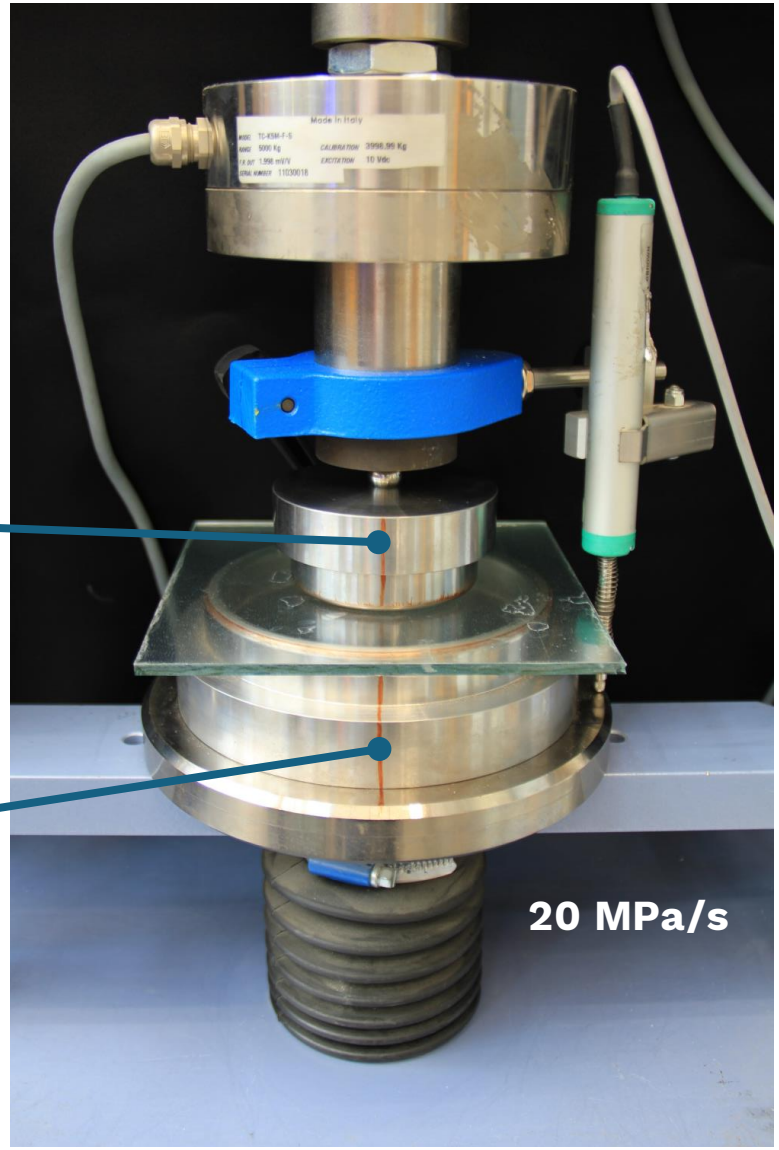

Delft, EWI building, 55 years, single glazing
© Christian Louter

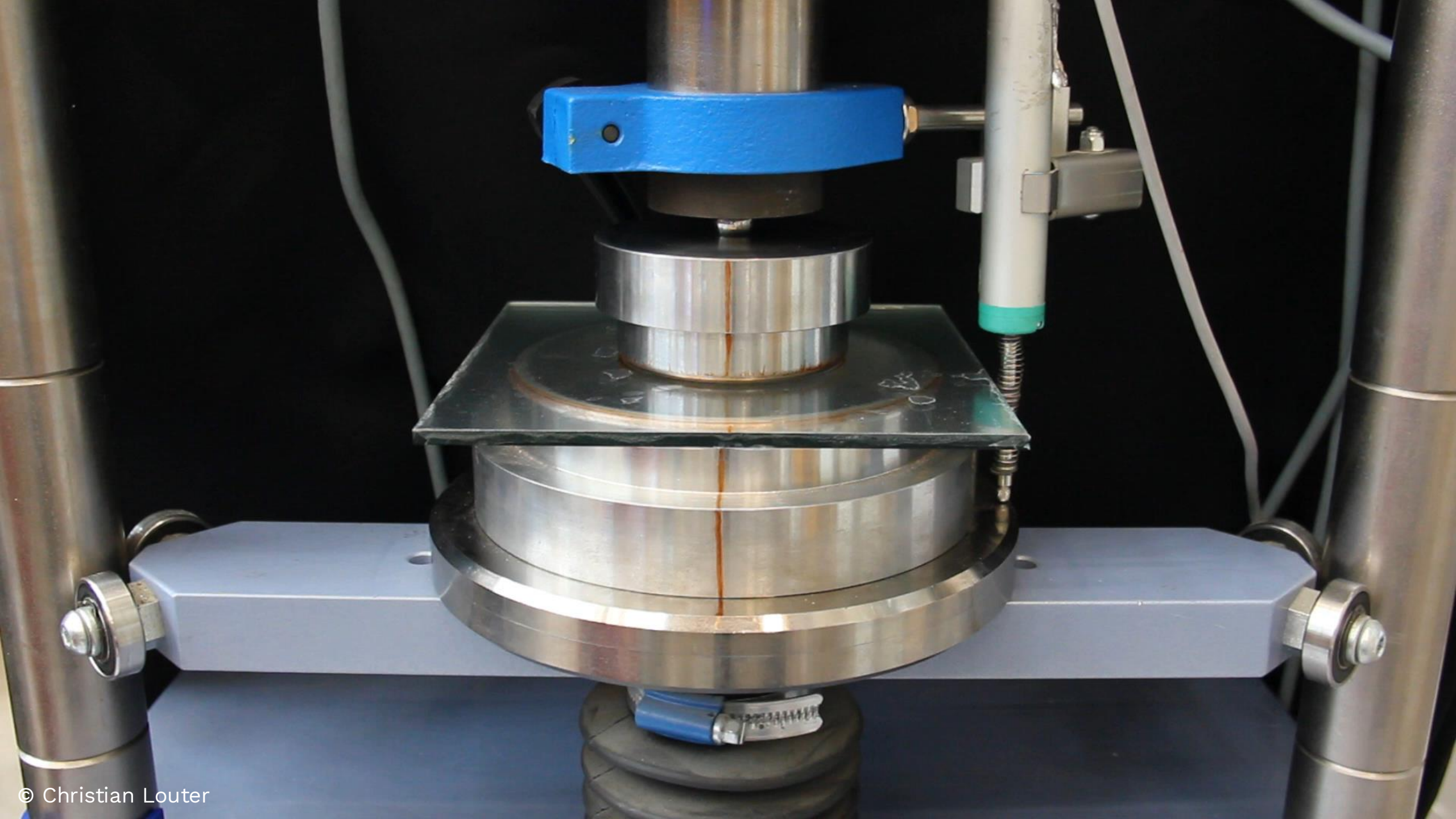




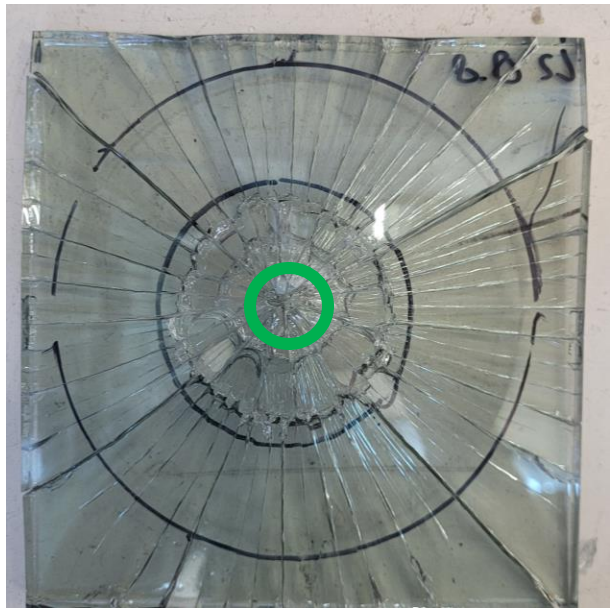


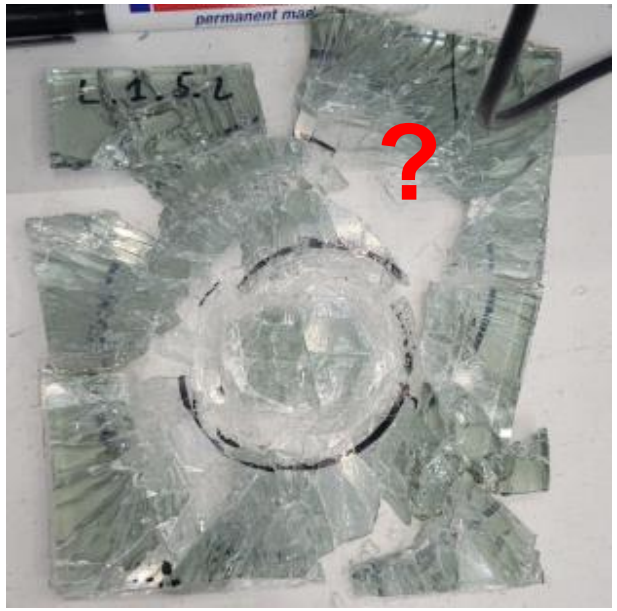

ASTM C1499 – 19
Ø 60 mm
Ø 120 mm
© Christian Louter


20 MPa/s



Fracture origin





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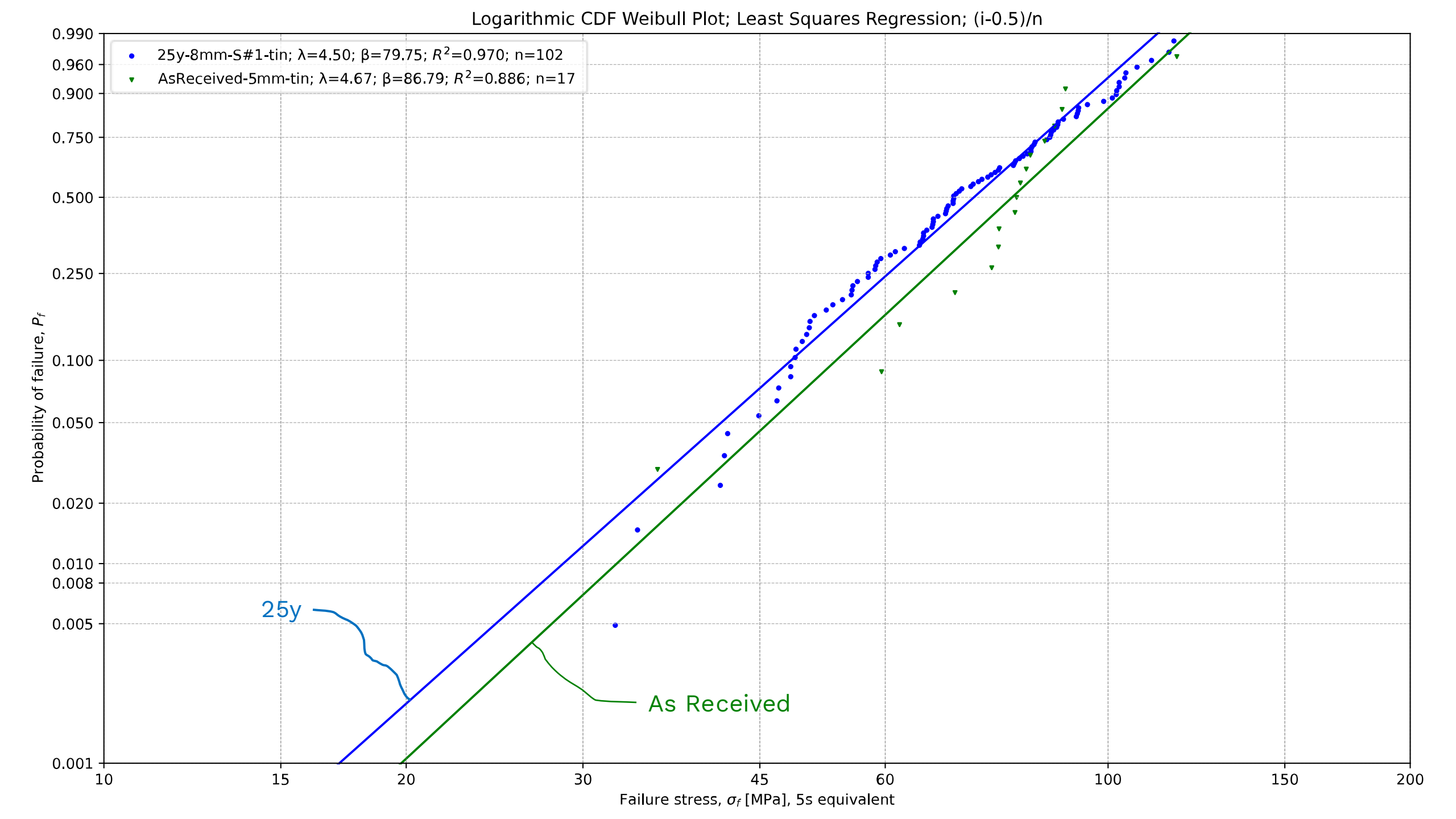
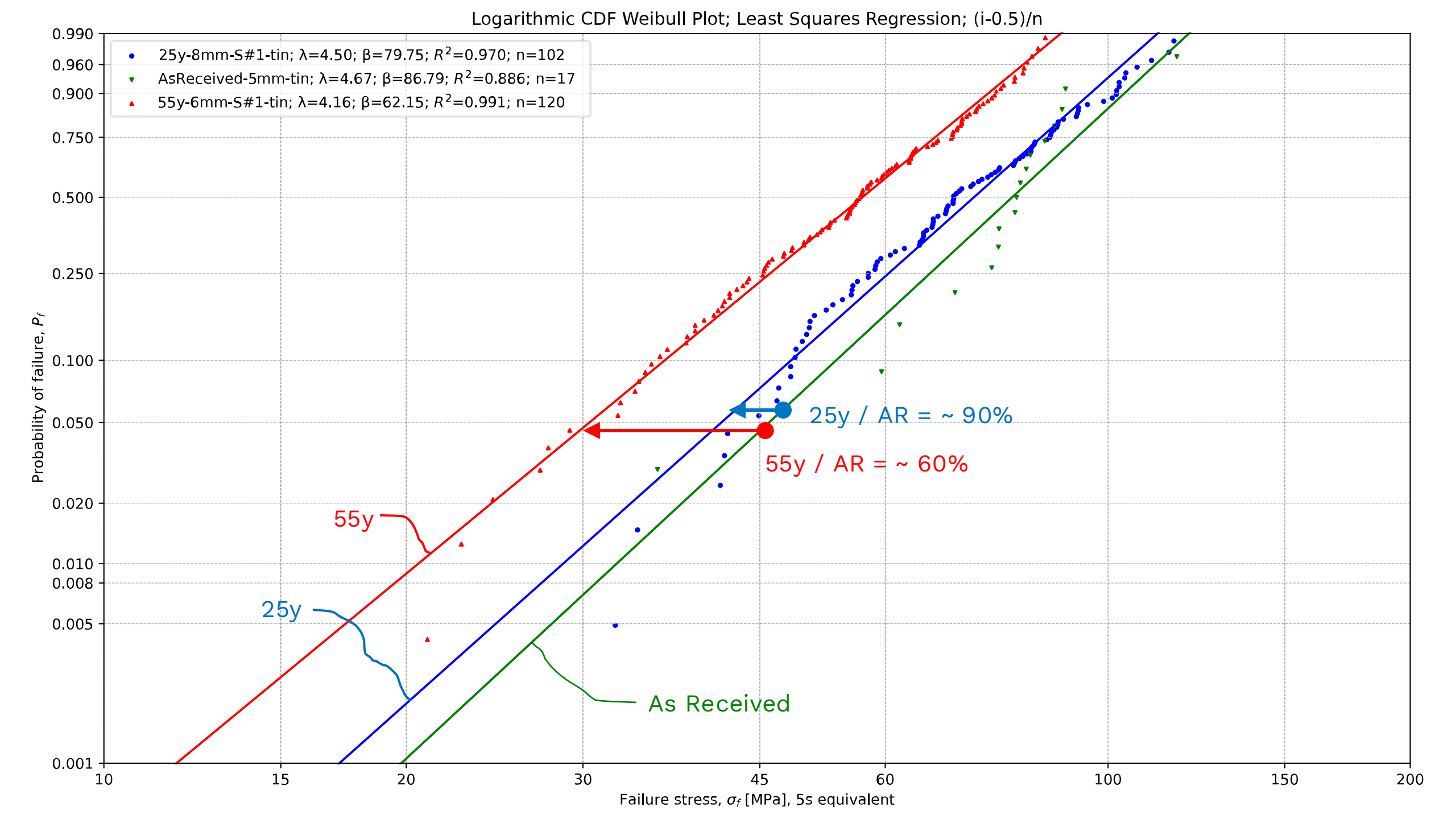
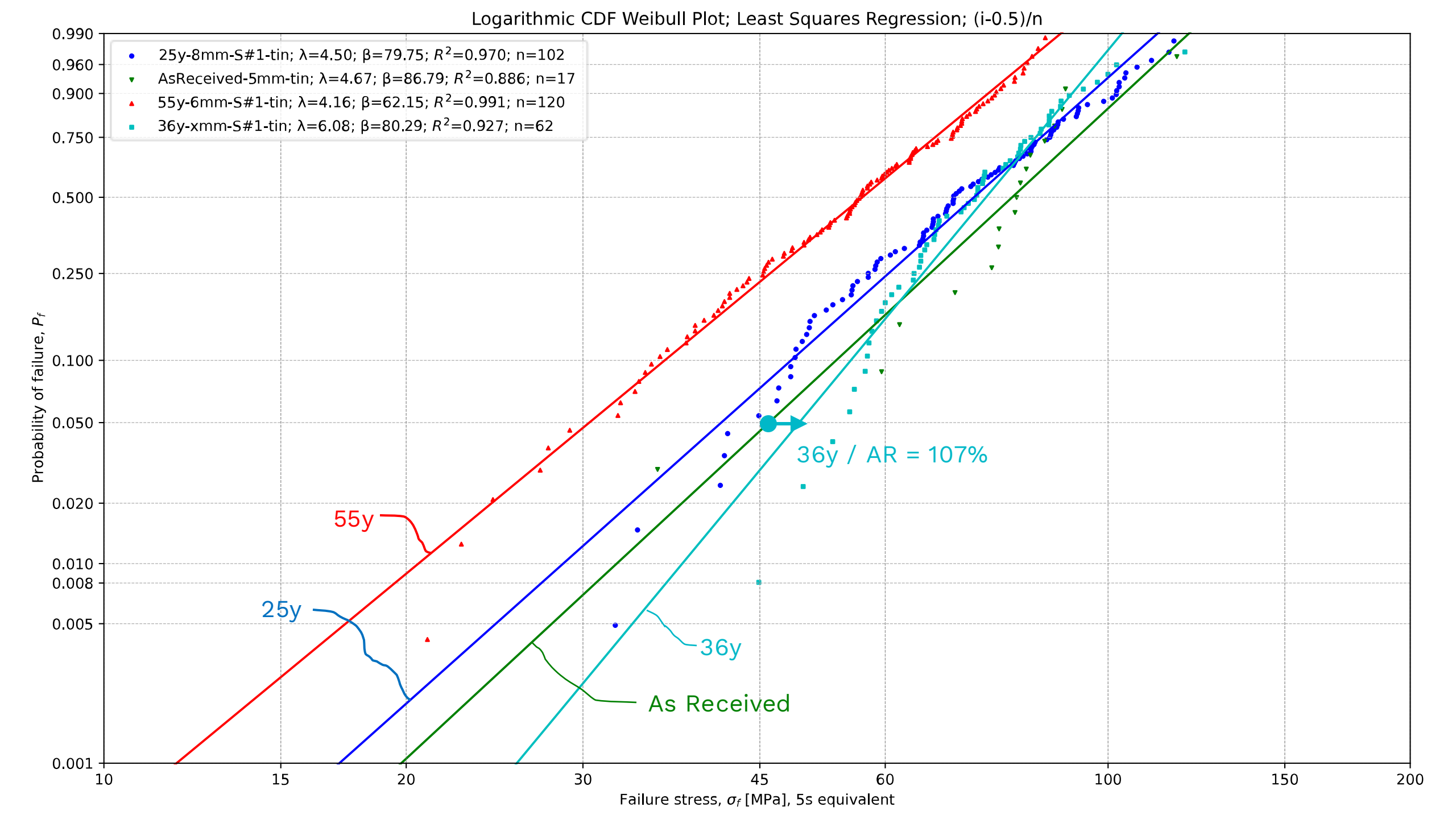
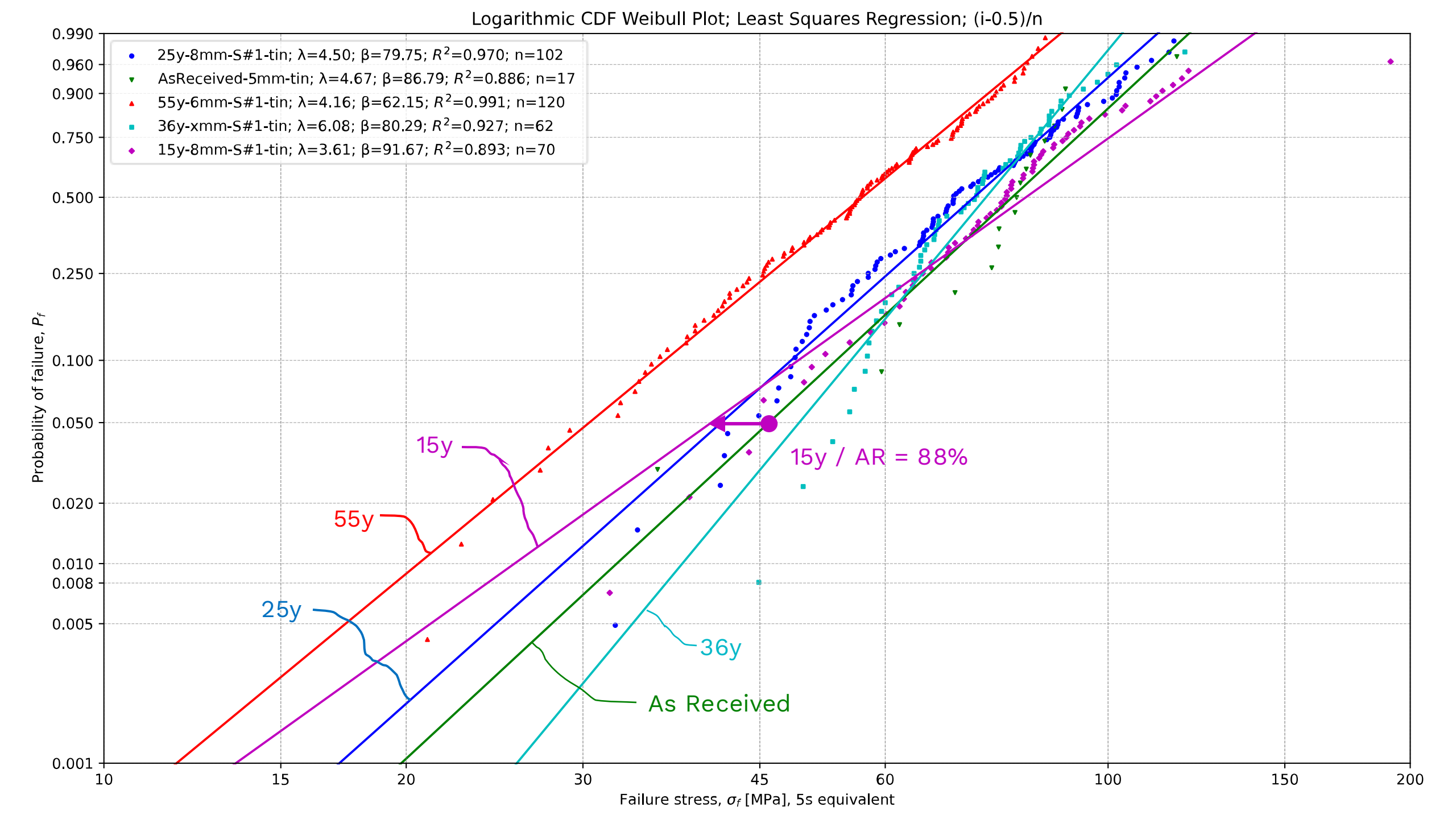
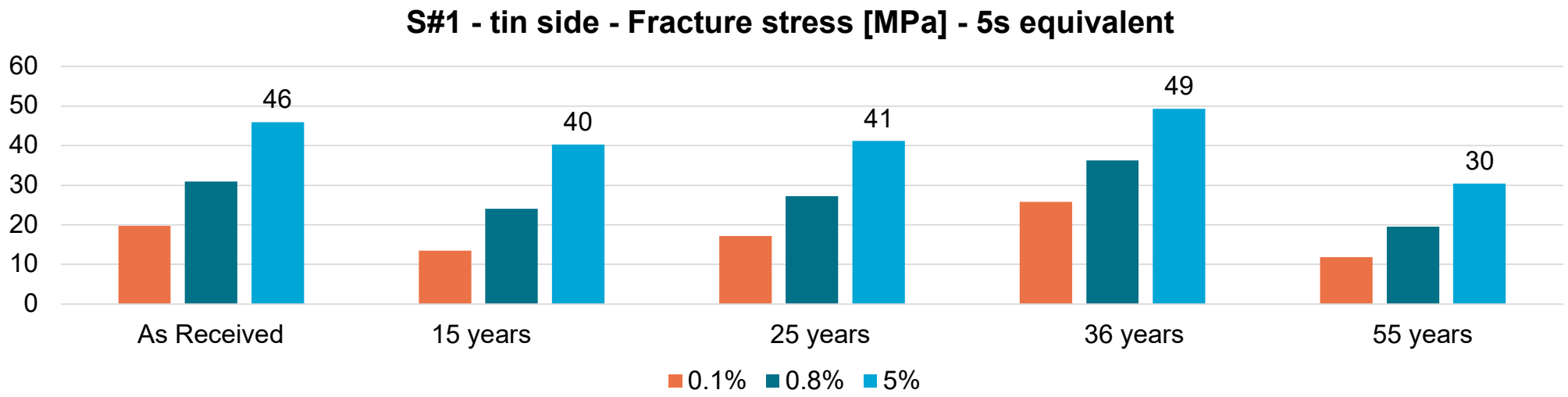
RESULTS

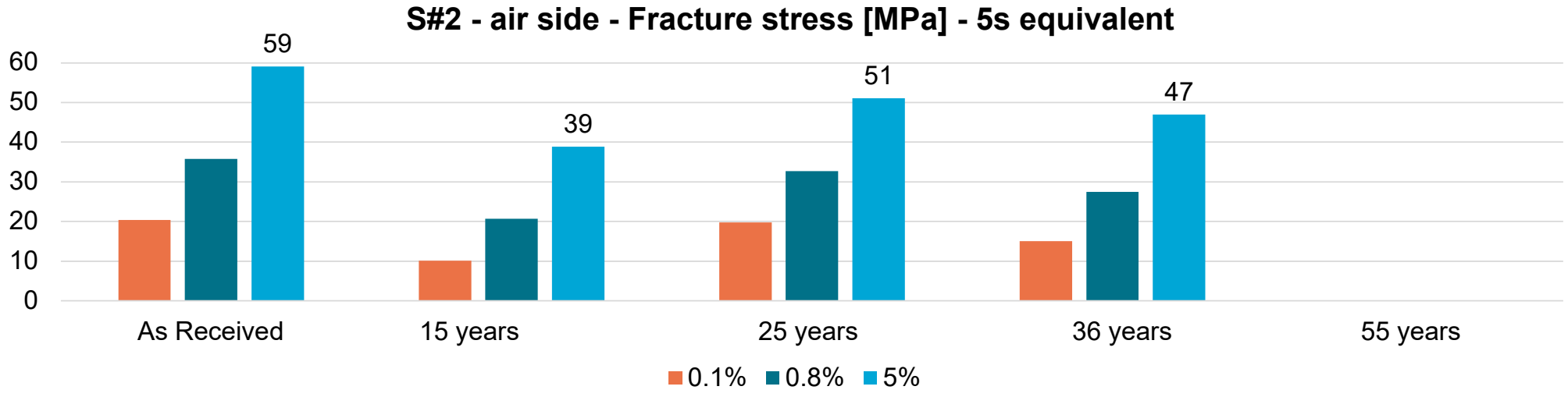

Logarithmic CDF Weibull Plot; Least Squares Regression; (i-0.5)/n
25y-8mm-S#1-tin; λ=4.50; β=79.75; R^2=0.970; n=102
AsReceived-5mm-tin; λ=4.67; β=86.79; R^2=0.886; n=17
Probability of failure, P_f
0.990
0.960
0.900
0.750
0.500
0.250
0.100
0.050
0.020
0.010
0.008
0.005
0.001
10
15
20
30
45
60
100
150
200
Failure stress, σ_f [MPa], 5s equivalent
25y
As Received


Logarithmic CDF Weibull Plot; Least Squares Regression; (i-0.5)/n
25y-8mm-S#1-tin; λ=4.50; β=79.75; R^2=0.970; n=102
AsReceived-5mm-tin; λ=4.67; β=86.79; R^2=0.886; n=17
55y-6mm-S#1-tin; λ=4.16; β=62.15; R^2=0.991; n=120
25y / AR = ~ 90%
55y / AR = ~ 60%
55y
25y
As Received
Probability of failure, P_f
0.990
0.960
0.900
0.750
0.500
0.250
0.100
0.050
0.020
0.010
0.008
0.005
0.001
10
15
20
30
45
60
100
150
200
Failure stress, σ_f [MPa], 5s equivalent


Logarithmic CDF Weibull Plot; Least Squares Regression; (i-0.5)/n
25y-8mm-S#1-tin; λ=4.50; β=79.75; R^2=0.970; n=102
AsReceived-5mm-tin; λ=4.67; β=86.79; R^2=0.886; n=17
55y-6mm-S#1-tin; λ=4.16; β=62.15; R^2=0.991; n=120
36y-xmm-S#1-tin; λ=6.08; β=80.29; R^2=0.927; n=62
Probability of failure, P_f
0.990
0.960
0.900
0.750
0.500
0.250
0.100
0.050
0.020
0.010
0.008
0.005
0.001
10
15
20
30
45
60
100
150
200
Failure stress, σ_f [MPa], 5s equivalent
36y / AR = 107%
55y
25y
36y
As Received


Logarithmic CDF Weibull Plot; Least Squares Regression; (i-0.5)/n
25y-8mm-S#1-tin; λ=4.50; β=79.75; R^2=0.970; n=102
AsReceived-5mm-tin; λ=4.67; β=86.79; R^2=0.886; n=17
55y-6mm-S#1-tin; λ=4.16; β=62.15; R^2=0.991; n=120
36y-xmm-S#1-tin; λ=6.08; β=80.29; R^2=0.927; n=62
15y-8mm-S#1-tin; λ=3.61; β=91.67; R^2=0.893; n=70
Probability of failure, P_f
0.990
0.960
0.900
0.750
0.500
0.250
0.100
0.050
0.020
0.010
0.008
0.005
0.001
10
15
20
30
45
60
100
150
200
Failure stress, σ_f [MPa], 5s equivalent
15y
55y
25y
36y
As Received
15y / AR = 88%


S#1 - tin side - Fracture stress [MPa] - 5s equivalent
60
50
40
30
20
10
0
46
40
41
49
30
As Received
15 years
25 years
36 years
55 years
0.1%
0.8%
5%


S#2 - air side - Fracture stress [MPa] - 5s equivalent
60
50
40
30
20
10
0
59
39
51
47
As Received
15 years
25 years
36 years
55 years
0.1%
0.8%
5%

COMPARISON WITH THE STANDARDS

Design value of bending strength

EN16612

$$f_{g;d} = \frac{k_e k_{mod} k_{sp} f_{g;k}}{\gamma_{M;A}}$$

$f_{g;k}$ = 45 MPa

k_{mod} 5 seconds = 1

γ_M = 1.6 or 1.8

→ 25 – 28 MPa

Eurocode 10

$$f_{g,d} = k_e \cdot k_{sp} \cdot \lambda_A \cdot \lambda_1 \cdot k_{mod} \cdot \frac{f_{g,k}}{\gamma_M} + k_p \cdot k_{e,p} \cdot \frac{f_{b,k} - f_{g,k}}{\gamma_p}$$

$f_{g;k}$ = 45 MPa

k_{mod} 5 seconds = 1

γ_M = 1.6 or 1.8 or 2.0

→ 22.5 – 28 MPa

NEN2608

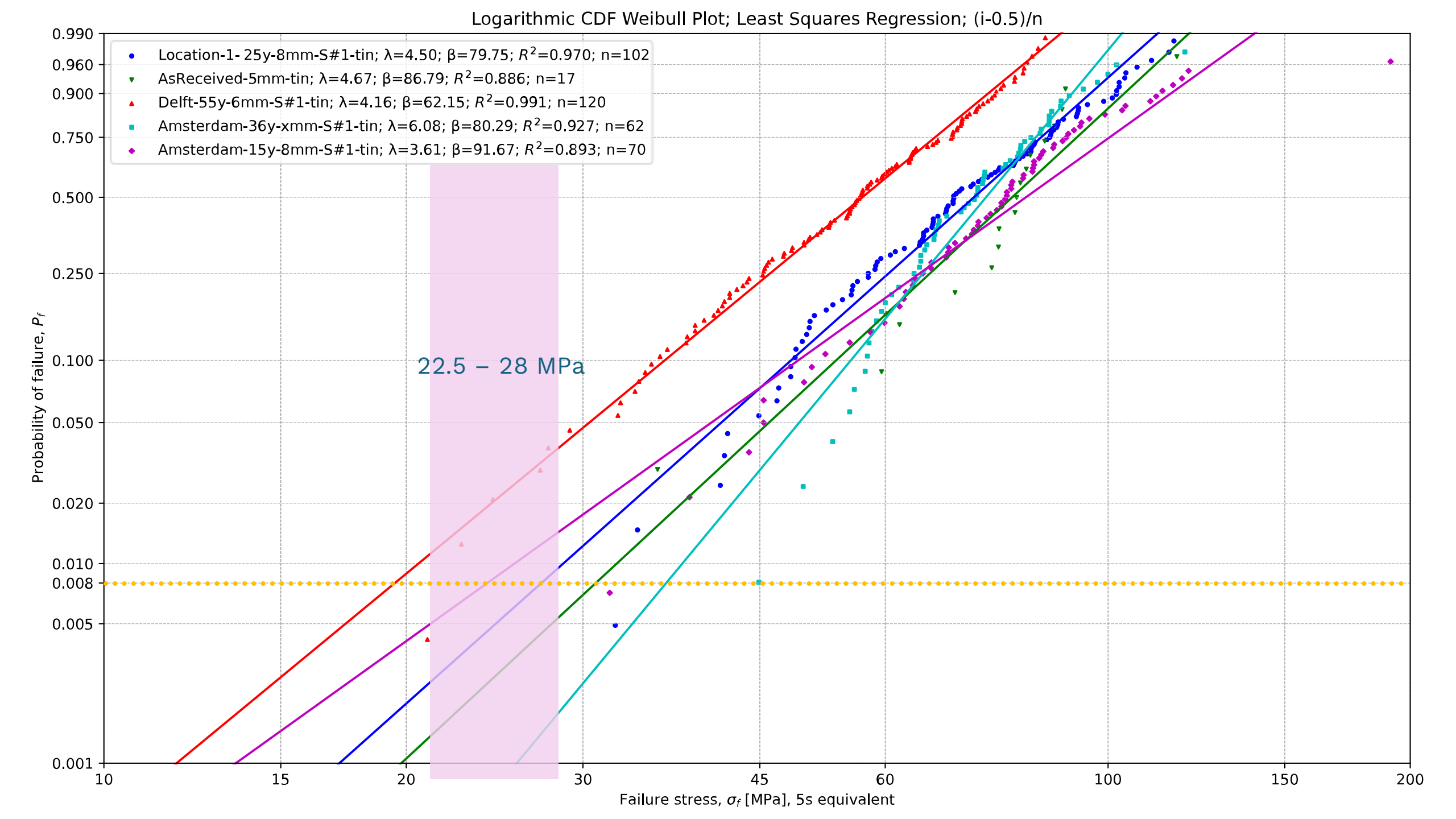
$$f_{mt;u;d} = \frac{k_a \times k_e \times k_{mod} \times k_{sp} \times f_{g;k}}{\gamma_{m;A}}$$

$f_{g;k}$ = 45 MPa

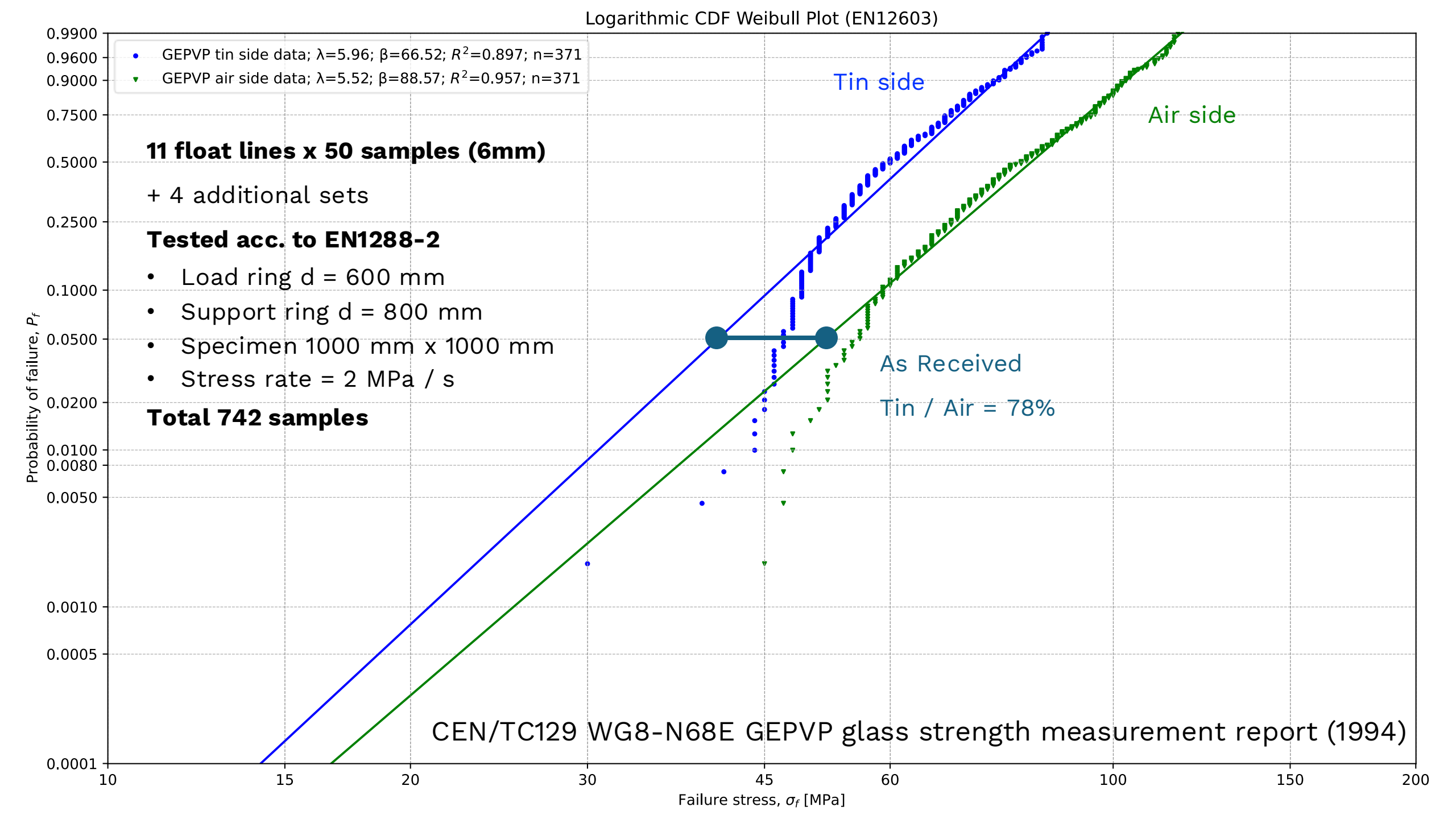
k_{mod} 5 seconds = 1

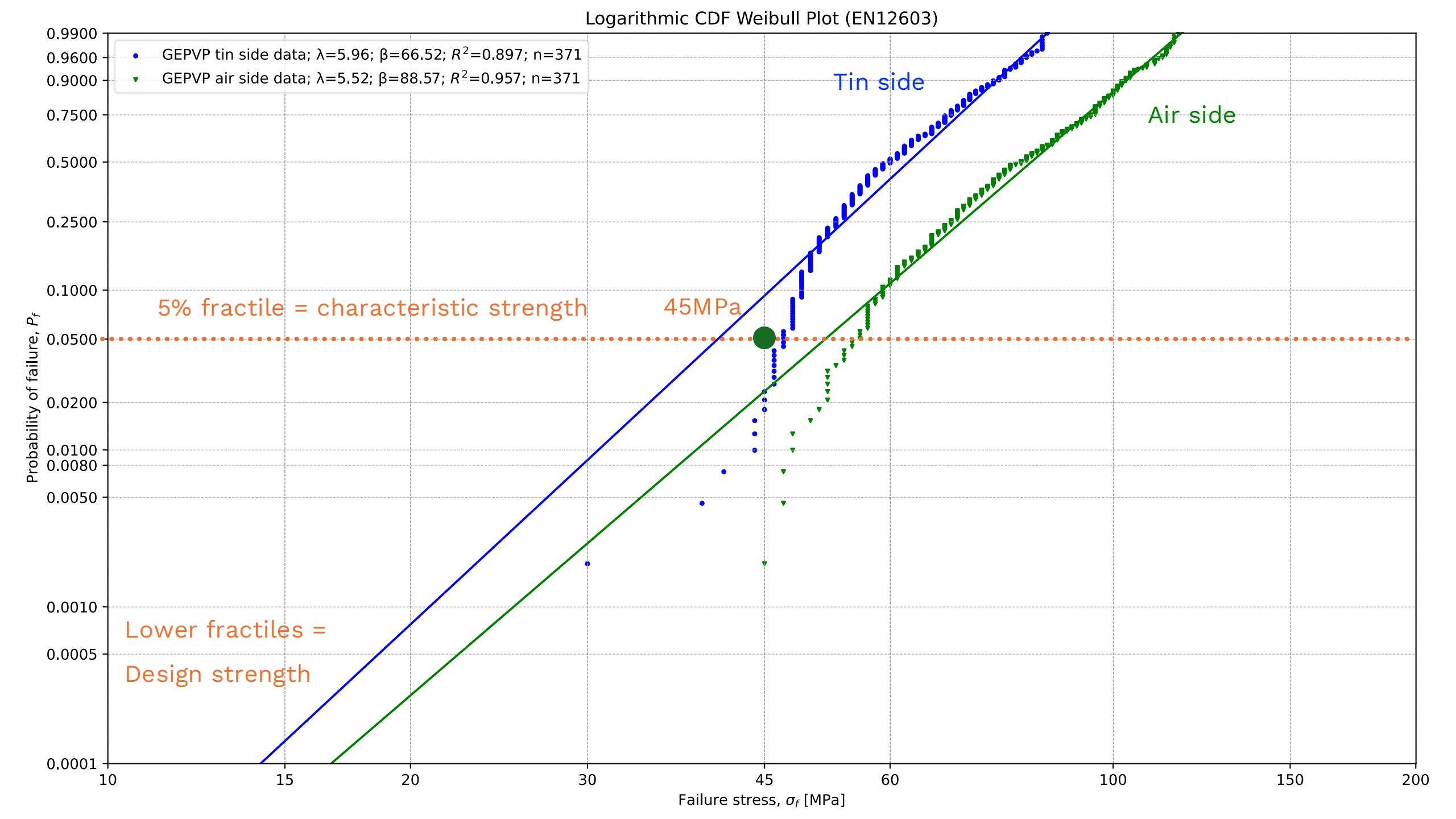
γ_M = 1.8

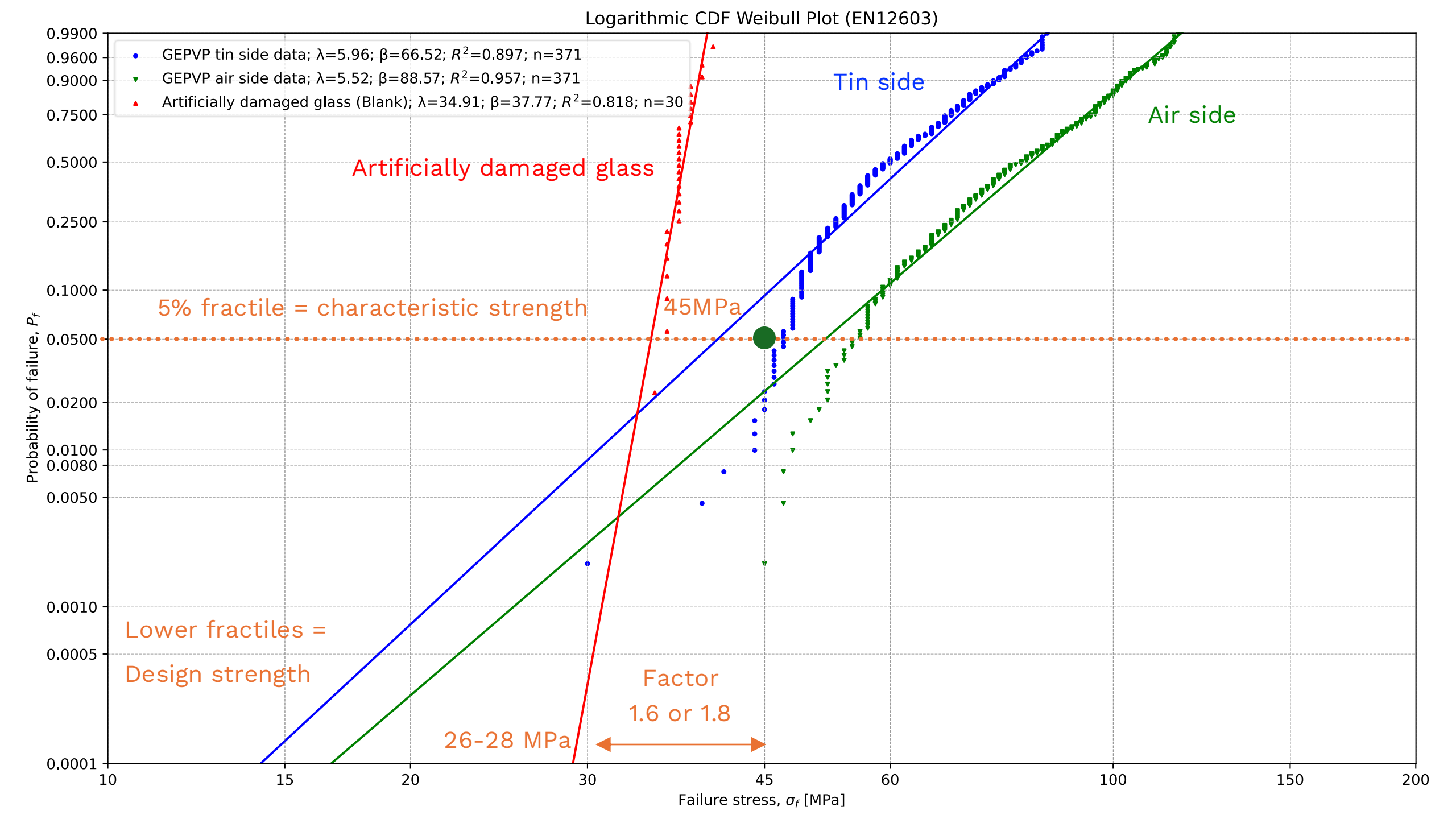
→ 25 MPa


Logarithmic CDF Weibull Plot; Least Squares Regression; (i-0.5)/n
Location-1- 25y-8mm-S#1-tin; λ=4.50; β=79.75; R^2=0.970; n=102
AsReceived-5mm-tin; λ=4.67; β=86.79; R^2=0.886; n=17
Delft-55y-6mm-S#1-tin; λ=4.16; β=62.15; R^2=0.991; n=120
Amsterdam-36y-xmm-S#1-tin; λ=6.08; β=80.29; R^2=0.927; n=62
Amsterdam-15y-8mm-S#1-tin; λ=3.61; β=91.67; R^2=0.893; n=70
22.5 – 28 MPa
Probability of failure, P_f
0.990
0.960
0.900
0.750
0.500
0.250
0.100
0.050
0.020
0.010
0.008
0.005
0.001
10
15
20
30
45
60
100
150
200
Failure stress, σ_f [MPa], 5s equivalent

45 MPa ?


Logarithmic CDF Weibull Plot (EN12603)
GEPVP tin side data; λ=5.96; β=66.52; R^2=0.897; n=371
GEPVP air side data; λ=5.52; β=88.57; R^2=0.957; n=371
11 float lines x 50 samples (6mm)
+ 4 additional sets
Tested acc. to EN1288-2
• Load ring d = 600 mm
• Support ring d = 800 mm
• Specimen 1000 mm x 1000 mm
• Stress rate = 2 MPa / s
Total 742 samples
Tin side
Air side
As Received
Tin / Air = 78%
CEN/TC129 WG8-N68E GEPVP glass strength measurement report (1994)
Probability of failure, P_f
0.9900
0.9600
0.9000
0.7500
0.5000
0.2500
0.1000
0.0500
0.0200
0.0100
0.0080
0.0050
0.0010
0.0005
0.0001
10
15
20
30
45
60
100
150
200
Failure stress, σ_f [MPa]


Logarithmic CDF Weibull Plot (EN12603)
GEPVP tin side data; λ=5.96; β=66.52; R^2=0.897; n=371
GEPVP air side data; λ=5.52; β=88.57; R^2=0.957; n=371
Tin side
Air side
5% fractile = characteristic strength
45MPa
Lower fractiles =
Design strength
Probability of failure, P_f
Failure stress, σ_f [MPa]
0.9900
0.9600
0.9000
0.7500
0.5000
0.2500
0.1000
0.0500
0.0200
0.0100
0.0080
0.0050
0.0010
0.0005
0.0001
10
15
20
30
45
60
100
150
200


Logarithmic CDF Weibull Plot (EN12603)
GEPVP tin side data; λ=5.96; β=66.52; R^2=0.897; n=371
GEPVP air side data; λ=5.52; β=88.57; R^2=0.957; n=371
Artificially damaged glass (Blank); λ=34.91; β=37.77; R^2=0.818; n=30
Tin side
Air side
Artificially damaged glass
5% fractile = characteristic strength
45MPa
Lower fractiles =
Design strength
Factor
1.6 or 1.8
26-28 MPa
Probability of failure, P_f
Failure stress, σ_f [MPa]
0.9900
0.9600
0.9000
0.7500
0.5000
0.2500
0.1000
0.0500
0.0200
0.0100
0.0080
0.0050
0.0010
0.0005
0.0001
10
15
20
30
45
60
100
150
200

COMPARISON WITH OTHER STUDIES

Variations from study to study

Cupać et al. (2024); Datsiou et al. (2017a,b); Overend & Louter (2015); Rota et al. (2023); Schula (2015); Teich et al. (2024); Veer et al. (2023)

Test methods: coaxial double ring test

- ASTM C1499
- EN 1288-5
- ~~EN 1288-2~~

Test data mostly unavailable

Ring geometries, loading ring/supporting ring:

- 18/90, 15/48, 20/80, 40/80, 51/127, 60/120, 72/150, 80/120, 80/150, 80/160, 180/250

Stress rates:

- 2 MPa/s, 2.3 MPa/s, 4.2 MPa/s, 7.6 MPa/s, 20 MPa/s, 50 MPa/s, 70 MPa/s, 90 MPa/s

Test conditions: mostly ambient (1 study at inert conditions)

Strength data: failure stress (as recorded); time equivalent failure stress (incl. time to failure)

Statistical analyses: 2-parameter Weibull distribution

- Least squares regression
- Weighted least squares regression
- Matlab
- ~~Good Linear Unbiased Estimator (EN 12603)~~

Glass Performance Days 2023

FAIR DATA

Findable, Accessible, Interoperable, and Reusable


open
glassroom

https://oit.tudelft.nl/open-GLASSlab/

Welcome to the Open GLASSlab!

Open GLASSlab combines data sharing, research, and education in a collaborative space dedicated to the study and reuse of aged glass in construction. The main objective of Open GLASSlab is to support the circular use of glass by providing a central repository for strength data from across Europe, as well as an interactive **TeachBook** where users can learn and apply standardised post-processing methods.

This platform allows users to analyse and interpret aged glass data in a consistent and standardised way, ensuring more reliable and comparable research outcomes. Whether you are a student, researcher, engineer, or industry professional, this **TeachBook** will guide you through the methods you can use to process the data, providing tools to support your work and enhance the reliability of your results.

edu.nl/jgw4w

Motivation and Background

The reuse of aged glazing requires a thorough understanding of its surface quality and structural performance to ensure it can be safely integrated into new building applications. While research has shown that aged glass generally exhibits lower bending strength compared to new glass, it still holds considerable potential for reuse in specific applications where strength requirements can be met.

One of the major challenges in working with aged glass is the great variability in its strength, which is influenced by a range of factors such as glazing type, location, age, building use, and environmental conditions. On top of this unavoidable variability, the inconsistency in testing and data processing methods across different studies further complicates the ability to compare results and establish reliable, standardised design parameters for aged glass. This is a challenge that **Open GLASSlab** aims to address.

https://oit.tudelft.nl/open-GLASSlab/

open glasslab

Open GLASSlab - Interactive Strength Analysis Handbook

Search ⌘ + K

Content

Data Repository and Growth

To achieve its objective, Open GLASSlab aggregates strength data from across Europe and provides it in a central, publicly accessible repository: the **4TU.ResearchData**, where the Open GLASSlab collection is hosted (DOI: 10.4121/fdaebd59-63ca-4439-81f5-93c7729a4d1c).

As the repository grows with contributions from a wide range of studies, it will become an increasingly comprehensive, open-access resource for strength data. This will make it easier to explore the various factors influencing the strength of aged glazing.

Open Interactive TeachBook

In addition to the data repository, **Open GLASSlab** offers this interactive **TeachBook** that provides guidance on commonly used post-processing methods for glass strength data. The methods are shared through interactive Python scripts, allowing users to process their data directly within the **TeachBook**.

You can use the 🚀 `Live Code` button in the top right – to activate the interactive features in the browser. Alternatively, users can download the Python scripts using the download button on the top right to work with their data locally, customising them as needed. This feature ensures that users have the tools to analyse and interpret the data in a standardised and consistent manner.

edu.nl/jgw4w

https://oit.tudelft.nl/open-GLASSlab/

Python interaction ready!

How It Works:

1. Click **"Confirm"** to generate input fields for the failure stress datasets.
2. *(Optional)* Click **"Yes"** and enter the time-to-failure values corresponding to each failure stress dataset.
3. Enter values and click **"Evaluate"** to process the data.

> **Note:** The script checks for errors in the input or mismatch in the dimensions between the time-to-failure datasets and the failure stress datasets.

▶ Show code cell source

Enter the data separated by commas, with decimal point (e.g. "1.44, 2.33, 4.22, 3.01,...")

Data protection declaration: The data entered will not be saved or transmitted over the network.

Number of Datasets: 2

Confirm

Name 1: Air Values 1: 82, 84, 85, 100, 52, 59, 60, 61, 61, 62, 62, 64, 64, 66, 66, 66, 66, 68, 68, 70, 71, 71, 71, 72, 74, 75, 79

Name 2: Tin Values 2: 79, 85, 85, 85, 86, 30, 39, 47, 48, 50, 50, 50, 52, 53, 54, 55, 59, 61, 61, 64, 66, 67, 68, 68, 69, 70, 70, 71, 82

Target stress fractile: 0.05

Target confidence interval: 0.1

Lower x limit: 20

Upper x limit: 200

Probability Estimator:

(i-0.5)/n | i/(n+1)

Convert to equivalent constant failure stress for a reference time period?

No | Yes

Evaluate

edu.nl/jgw4w

https://oit.tudelft.nl/open-GLASSlab/

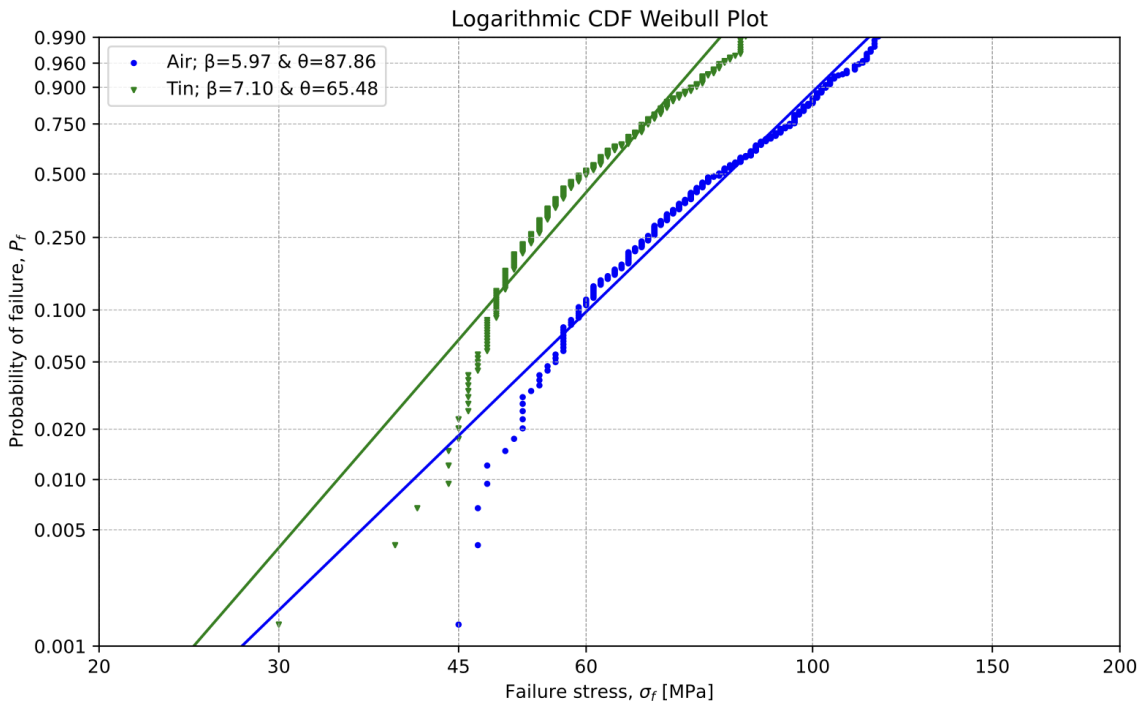
open glasslab

Open GLASSlab - Interactive Strength Analysis Handbook

Search ⌘ + K

Content

Python interaction ready!



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STANDARDISATION OF TEST METHODS

Standardisation of test methods

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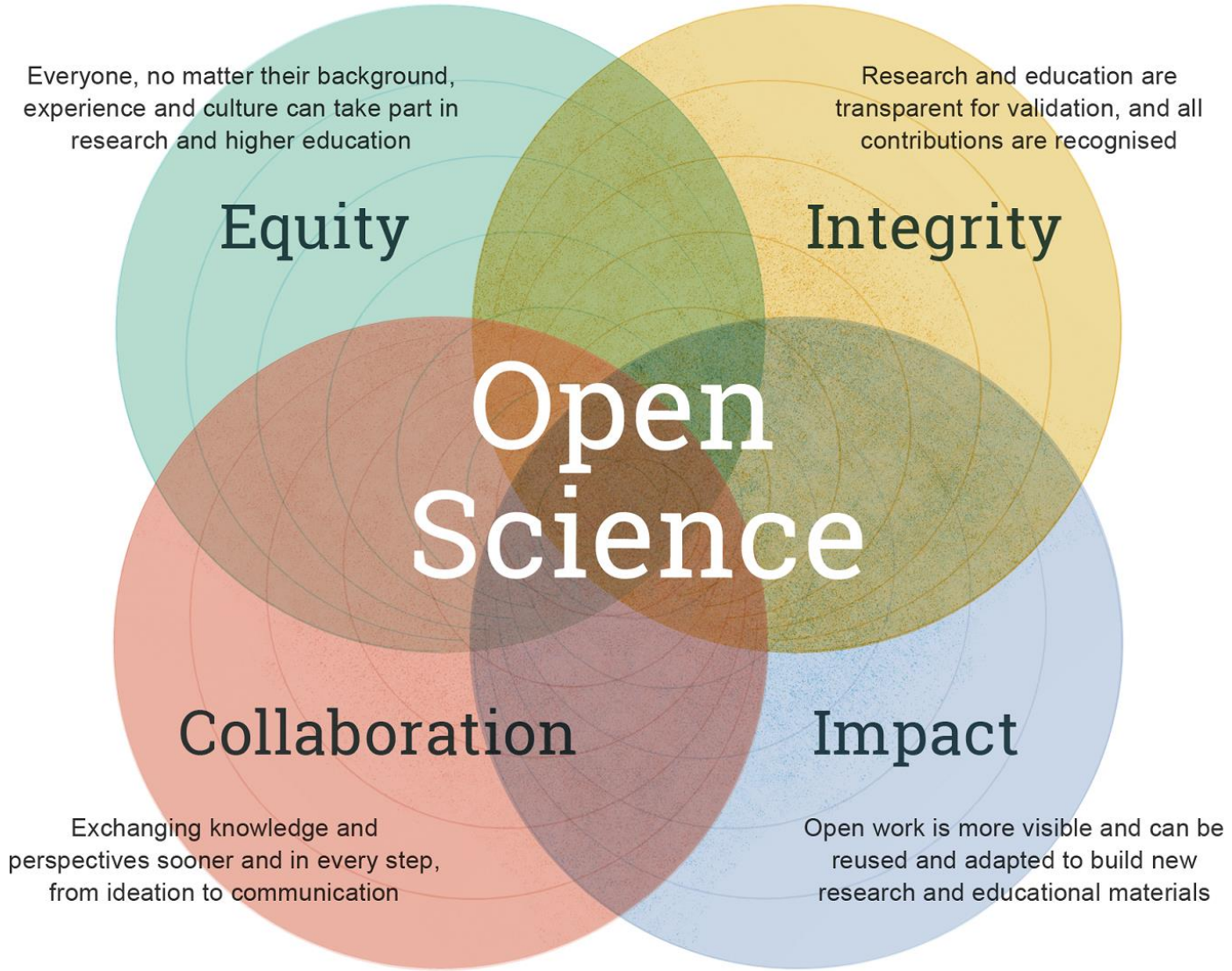
WIP test method: CDR | ring geometry: 40 mm/80 mm (AN) | stress rate: 2/20 MPa/s | strength analysis: time equivalent failure stress data + Open GLASSlab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Research and education are transparent for validation, and all contributions are recognised
Integrity
Open Science
Collaboration
Exchanging knowledge and perspectives sooner and in every step, from ideation to communication
Impact
Open work is more visible and can be reused and adapted to build new research and educational materials

Glass Performance Days 2025

GLASS REUSE: OPEN DATA FOR CIRCULARITY

Jagoda Cupać / Delft University of Technology

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