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New Technology for a precise and repeatable Measurement of Distortion after the Furnace

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True Edge™ Distortion Technology

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Strategic Vision for each glass fabricator

Produce Permanent
perfect tempered glass quality!

Independent

of qualified furnace operator!

True Edge™ Distortion Technology

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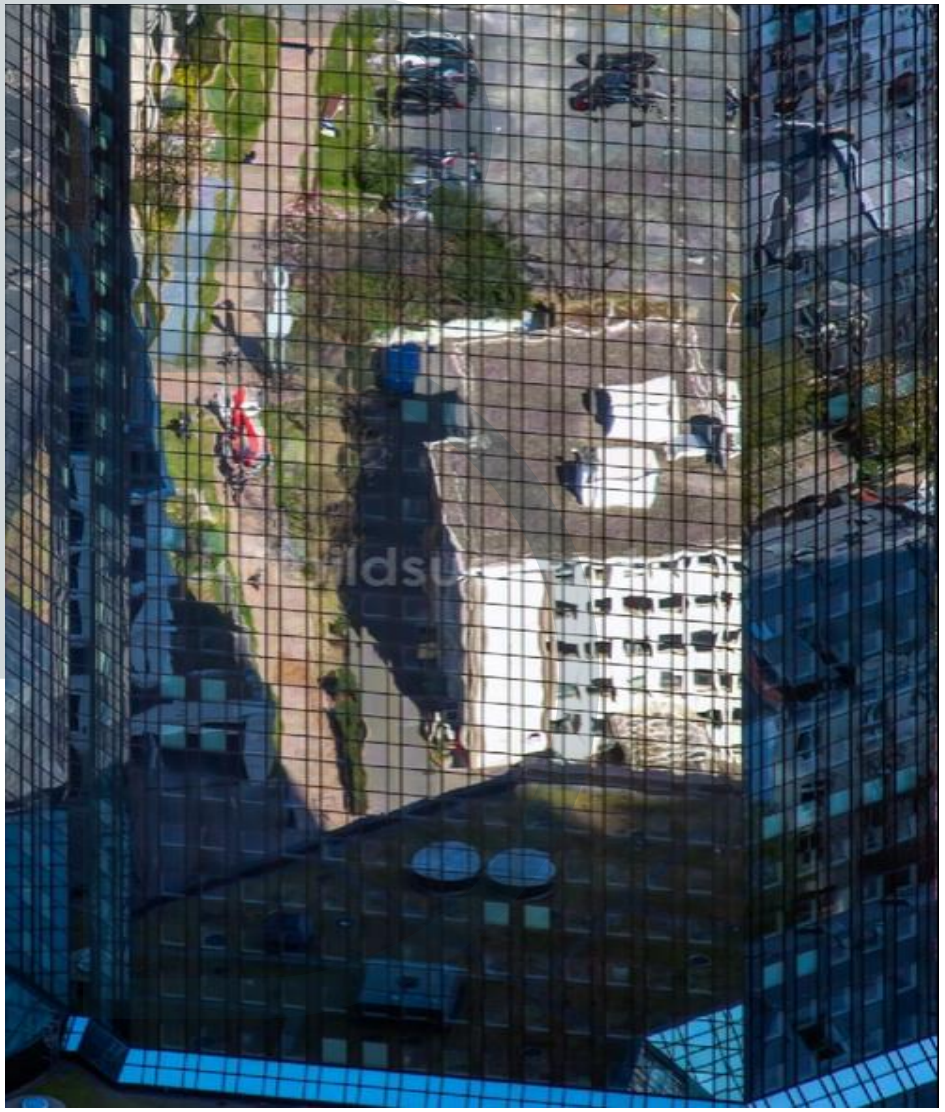
Introduction & Motivation

- Customer expectations rise for flawless tempered glass
- High-end projects require distortion-free glass
- Existing furnace processes still produce visible distortions
- Furnace optimization is complex – without reliable measurement and experienced operator



New solutions must deliver precise and repeatable measurements!

The key for advanced furnace optimization!

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Key Takeaways

- What makes True Edge™ Distortion Technology unique
- Measurement results right from a fabricator
- Benefits for glass processors and architects
- What's next: optimization, automation, and beyond

Understand how to take a significant step towards your vision!

True Edge™ Distortion Technology

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The Innovation – True Edge™ Technology

- Provides a High-resolution mapping of distortion

  - from leading to trailing edge

- Patented Edge-to-Edge scanning removes blind spots near glass edges

  – provides real edge kink results

- Identifies all kind of distortion, edge kink, roller waves, pockets, saddles, …

Key for advanced furnace optimization,

reliable laminating

and architectural glass standards!

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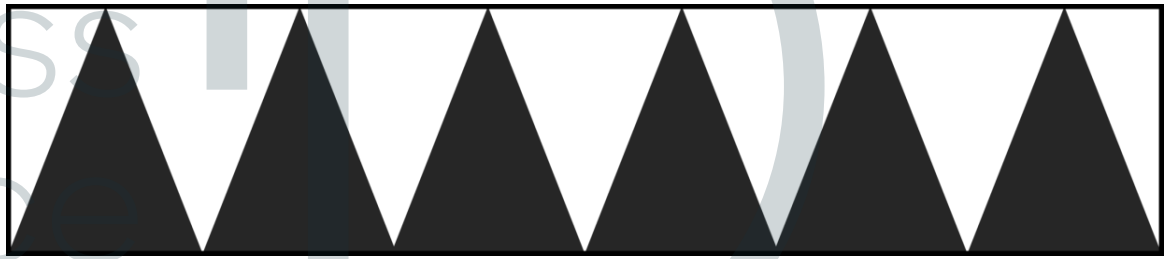
Measurement principle – What Makes True Edge™ Measurement So Precise?

- First - line scan cameras

+

- Second - triangle patterns
- Black AND White triangles



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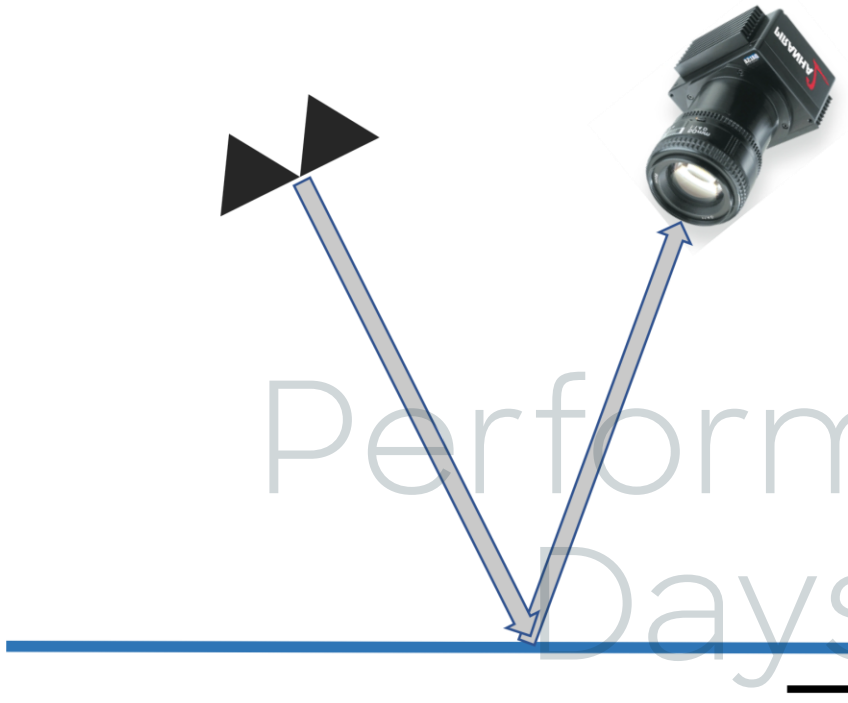
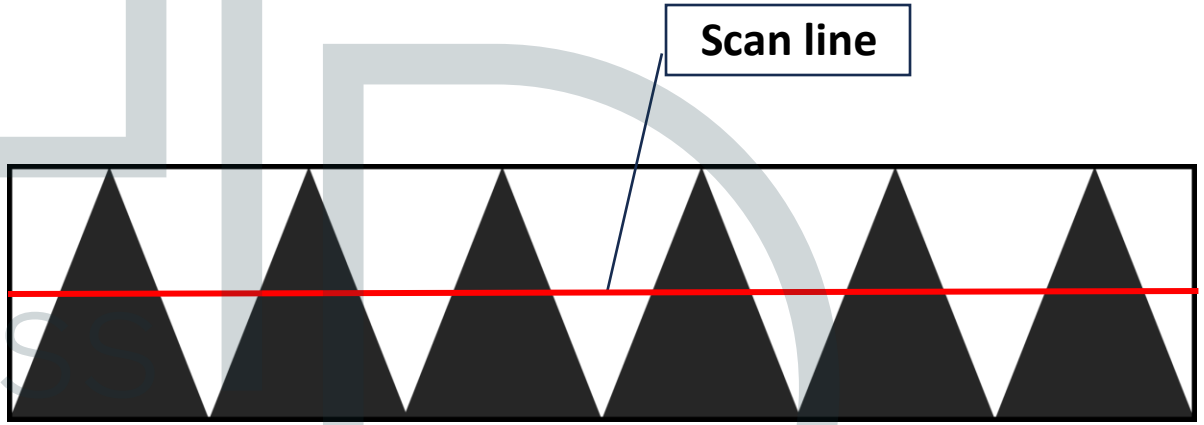
Measurement principle – What Makes True Edge™ Measurement So Precise?

- Line scan camera captures the glass in reflection
- Glass reflects the projected Triangle pattern back





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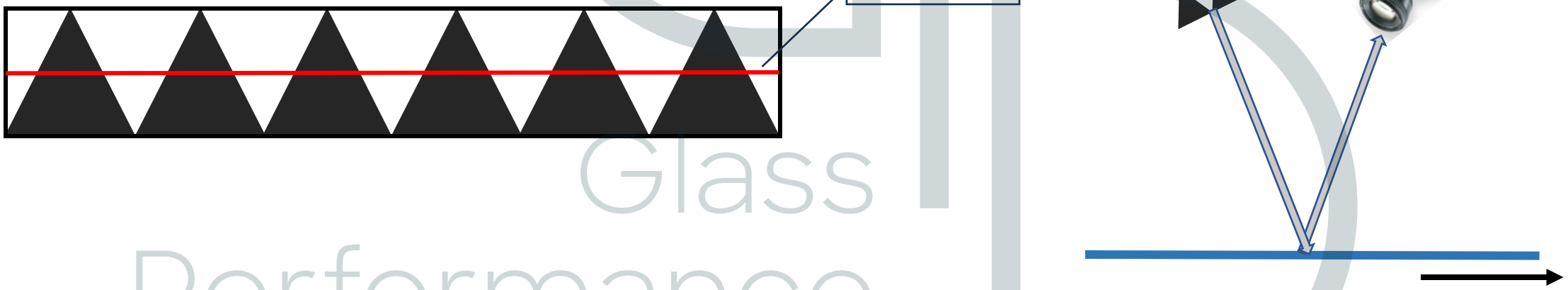
Measurement principle – What Makes True Edge™ Measurement So Precise?

- Perfectly flat glass ➔ Camera looks straight into the triangle centre
- Spacing is analyzed between both Black AND White triangles



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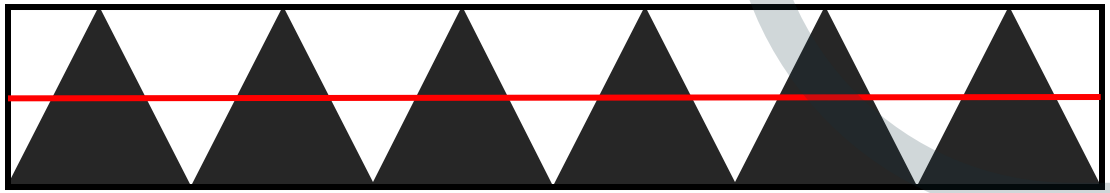
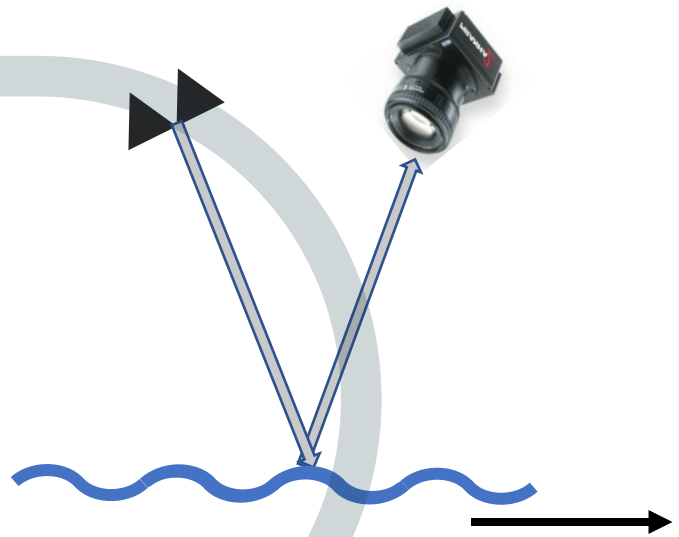
Measurement principle – What Makes True Edge™ Measurement So Precise?

- Measuring tempered glass with Distortion
- Varying spacing of black/white lines can be calculated into Millidiopter





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Precision Testing in certified Lab

- 6mm 1m X 1m glass
- Glass Completely measured tactile in a Lab
- On granite table in air-conditioned Lab room
- Highest precision you can get!

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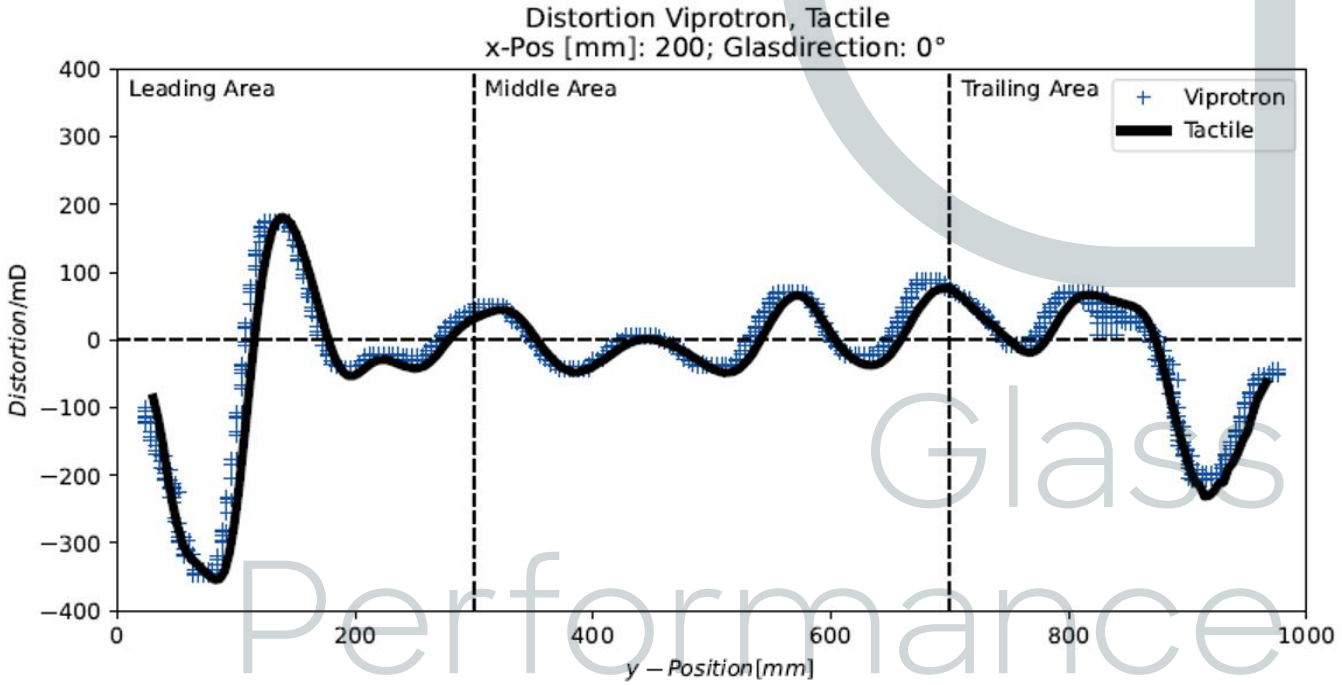
Lab Repeatability Testing (30x)

Repeatability check: 30 measurements vs. Tactile measurement



Distortion [mD]	Standard deviation	Confidence Interval 90%
Leading	3	5
Center	2	3
Trailing	2	3

High conformity of the scanner results compared to tactile measurement

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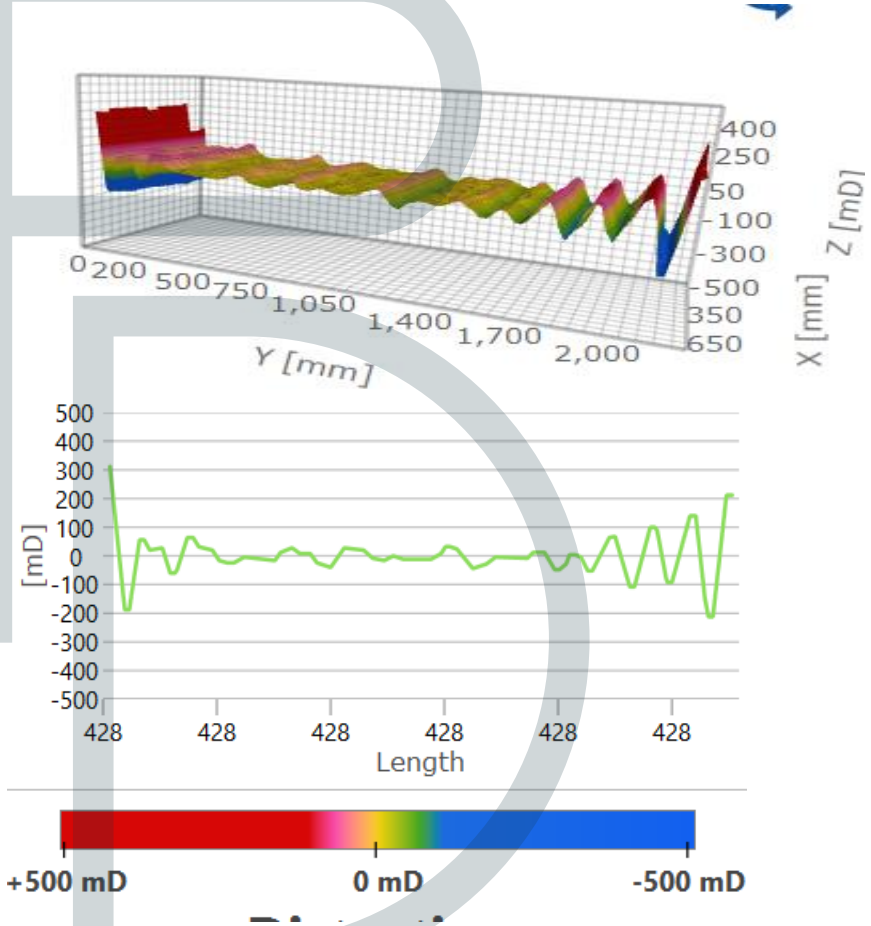
Precision of measurement by comparison

Repeatability check: 30 measurements vs. Tactile measurement

Distortion [mD]	Tactile/3D	Viprotron True Edge
Leading	306	303
Center	61	64
Trailing	171	177

Peak-to-Valley [mm]	Tactile/3D	Viprotron True Edge
Leading	0.36	0.32
Center	0.11	0.10
Trailing	0.20	0.20

- **Near-Perfect Match: Center and Edge Distortion**



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Conveyor Repeatable Test (Preformed by Vandaglas Eckelt)

eckelt
a vandaglas company

- 6mm Float 360mm x 1000mm
- Test on left / middle / right side
- 10 times each side

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Conveyor Repeatable Test (Preformed by Vandaglas Eckelt)

Evaluation of reproductibility for Peak to Valley

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Samples: PLC 6mm — 1 glass float 6mm toughened 360mmx1100mm

Procedure: the toughened sample will be measured 10 times (without tempering) in 3 different locations of the scanner (left, centre and right side)

	left side			centre side			right side		
	Front edge	Trailing edge	Roller wave	Front edge	Trailing edge	Roller wave	Front edge	Trailing edge	Roller wave
Measurement Nb. 1 [mm]	0,12	0,12	0,06	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 2 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 3 [mm]	0,13	0,12	0,07	0,13	0,12		0,14	0,12	0,06
Measurement Nb. 4 [mm]	0,13	0,12	0,07	0,13			0,14	0,12	0,06
Measurement Nb. 5 [mm]	0,13	0,12	0,07	0,13		0,04	0,14	0,12	0,06
Measurement Nb. 6 [mm]	0,13	0,12	0,07			0,04	0,14	0,12	0,06
Measurement Nb. 7 [mm]	0,13	0,12			0,12	0,04	0,14	0,12	0,06
Measurement Nb. 8 [mm]	0,13	0,		0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 9 [mm]	0,13	0,	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 10 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Min value [mm]	0,12	0,12	0,06	0,13	0,12	0,04	0,14	0,12	0,06
Max value [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Max minus Min value [mm]	0,01	0	0,01	0	0	0	0	0	0

Conclusion: Max 30 µm deviation

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Conveyor Repeatable Test (Preformed by Vandaglas Eckelt)

- Manual verification confirms all measurements
- Variance: < ±25 µm across all

A benchmark result,

which could never achieved before!

Measured according EN12150-1 [mm]		
Leading	Center	Trailing
0.18	0.05	0.10

Evaluation of reproductibility for Peak to Valley

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Procedure: the toughened sample will be measured 10 times (without tempering) in 3 different locations of the scanner (left, centre and right side)

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Measurement Nb. 3 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 4 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 5 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 6 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 7 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 8 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 9 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Measurement Nb. 10 [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Min value [mm]	0,12	0,12	0,06	0,13	0,12	0,04	0,14	0,12	0,06
Max value [mm]	0,13	0,12	0,07	0,13	0,12	0,04	0,14	0,12	0,06
Max minus Min value [mm]	0,01	0	0,01	0	0	0	0	0	0

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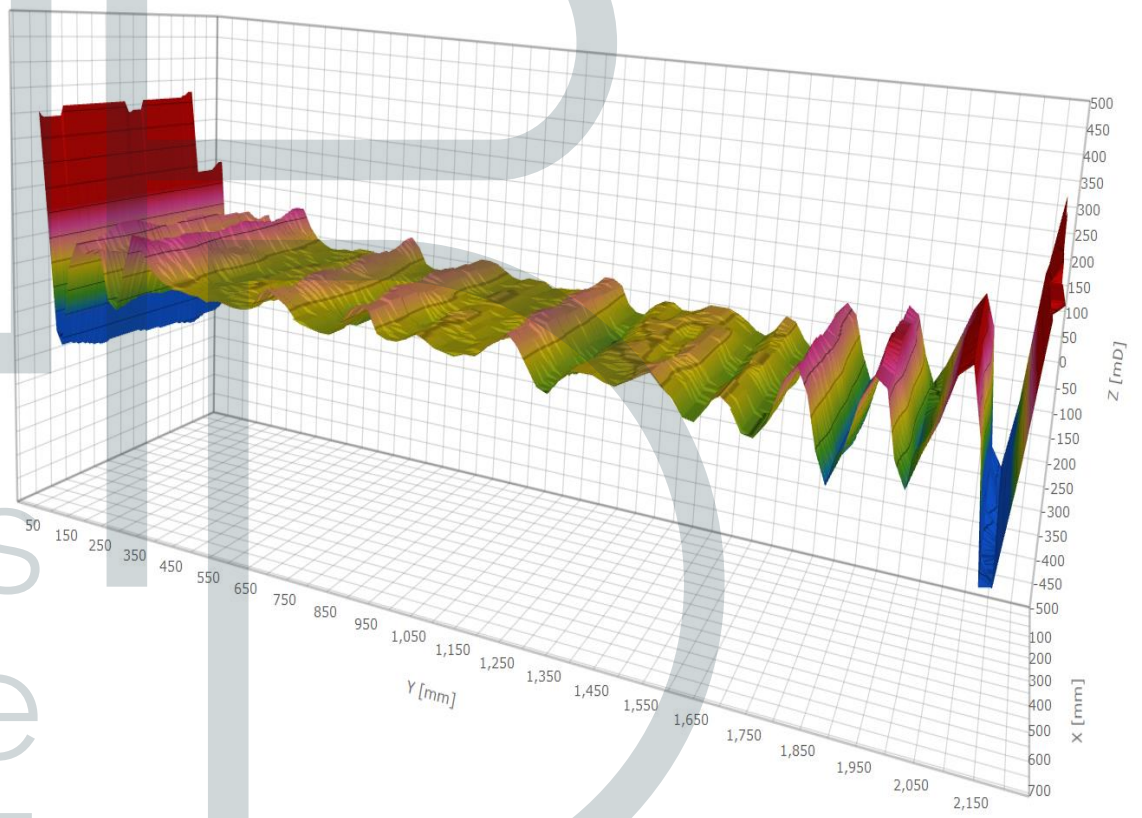
True Edge™ – Engineered to Go All the Way to the Edge

- **High resolution - measure glass distortion every 0.5 mm**
- **High distortion resolution - ± 4 mDiopt**
- **Measurement starts right at the glass edge – No blind zones**



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True Edge™ – Engineered to Go All the Way to the Edge

- Records both mDiopt values and Peak-Valley in mm
- Identifies all kind of distortion,

  - edge kink, roller waves, pockets, saddles, …
- Unique and modern technology - Modular and Upgradeable

Key for furnace optimization

and future advanced automation!

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Technology That Delivers – Benefits Across the Entire Value Chain

- **Architects:** Enhanced transparency confidence in visual outcome
- **Glass Processors:** 100% trust - no manual control necessary
  Stable and Predictable lamination
- **Quality managers:** Reliable validation tool
  Consistent and traceable On-Line documentation
- **Sales Manager:** Simplified QA documentation
- **General:** Reduction of costly post-delivery, complaints and returns

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Outlook: Towards Furnace Optimization and Automation

- **Reliable Data - Smarter Furnaces**
  - **– Data the Key to Furnace Optimization and Automation**

- **Current:**
  - **- Manual furnace optimization is possible**
  - **- Together with a qualified operator**

- **Future:**
  - **- Automatic furnace control via data integration**
  - **- Continuous improvement through machine learning feedback loops**
  - **- Full process automation – independent of skilled operator**

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Strategic Vision for each glass fabricator

Produce Permanent perfect tempered glass quality!

Driven by precise measurements and skilled operators!

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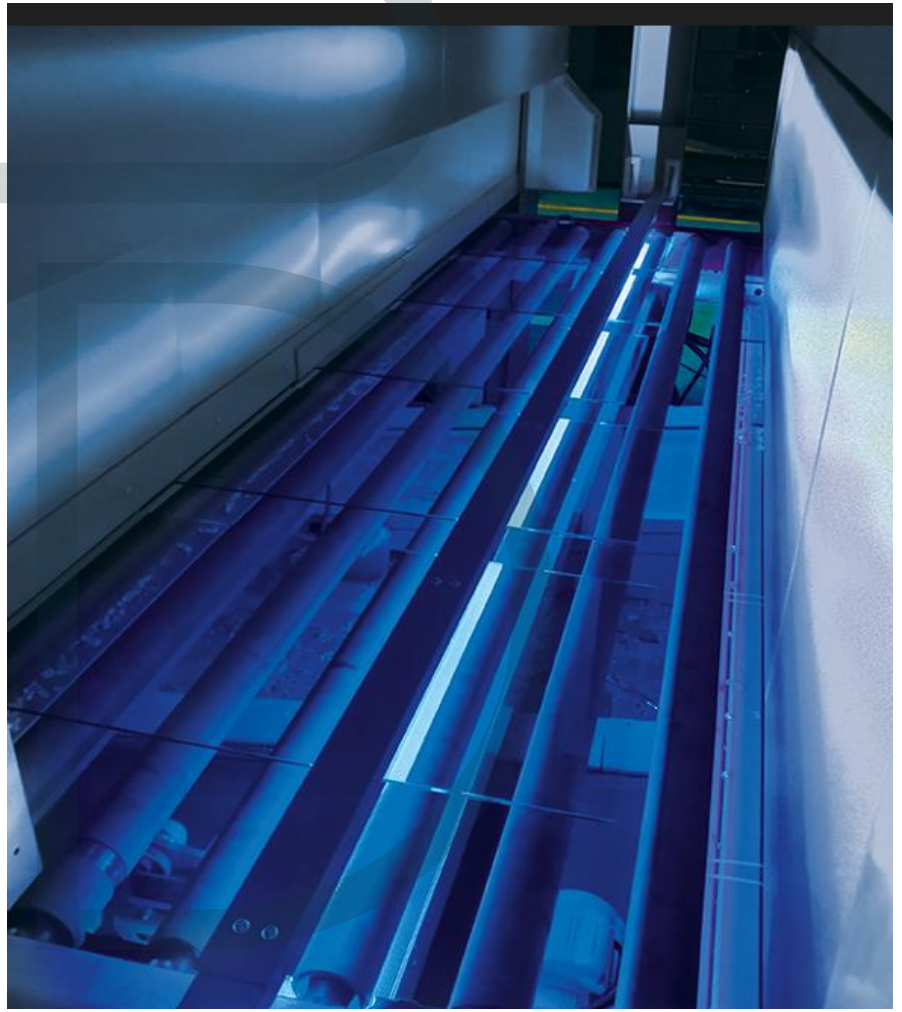
Conclusion

- True Edge™ Distortion:
  - New benchmark for distortion measurement
  - With Full transparency and repeatability
- Drives quality, efficiency and customer satisfaction
- Ready for dynamic manual furnace control
- Ready for future full furnace automation



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Let’s turn your company vision

into quality excellence and

intelligent processes!

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