

SCRATCH RESISTANCE — OF — *CELL PHONE SCREEN PROTECTORS*



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Introduction

Although phone screens are designed to resist shattering and scratching, they are still susceptible to damage. Daily phone usage causes them to wear and tear, e.g. accumulate scratches and cracks. Since repairing these screens can be expensive, screen protectors are an affordable damage prevention item commonly purchased and used to increase a screen's durability.

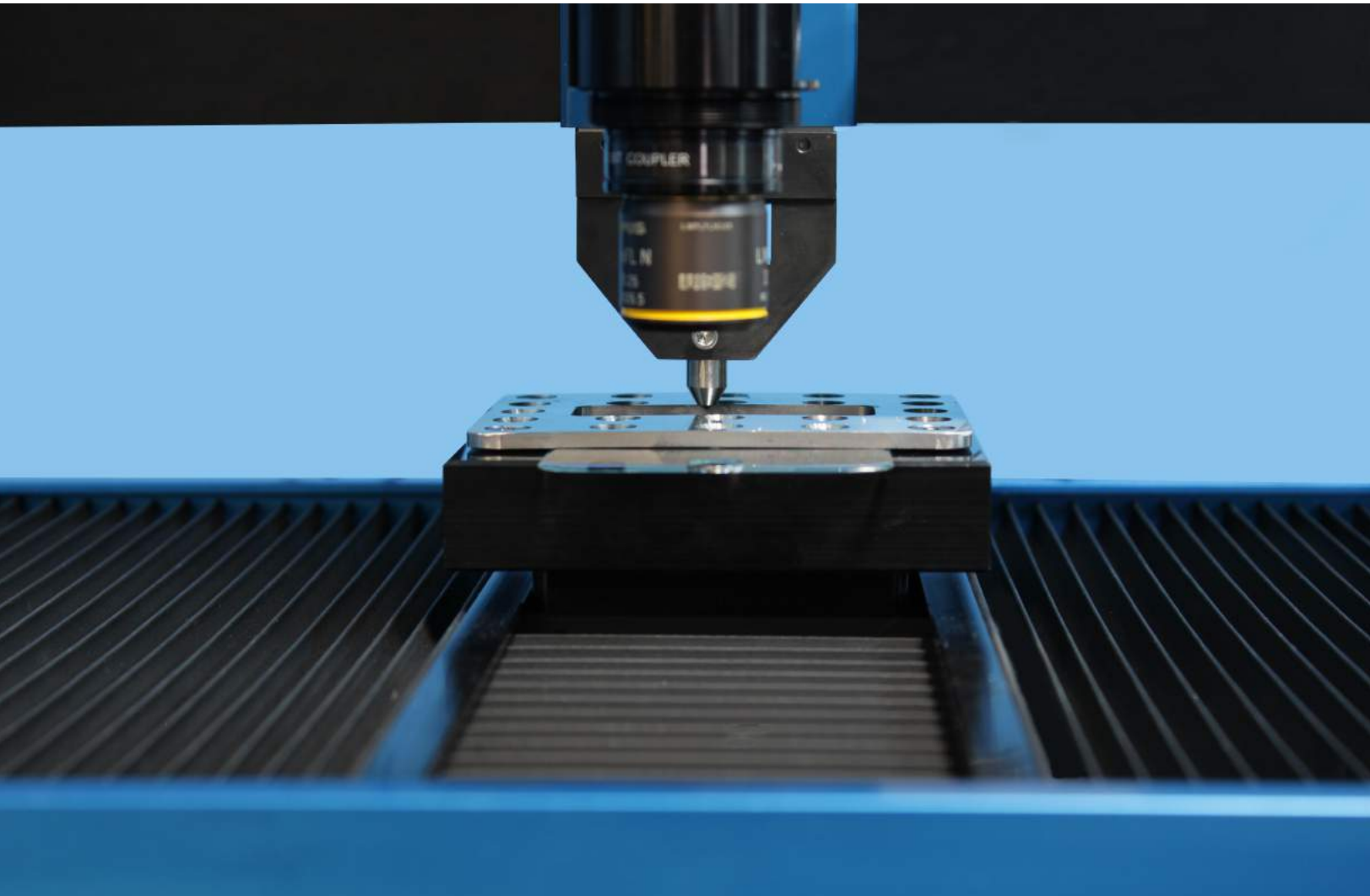
Using the Nanovea PB1000 Mechanical Tester's Macro Module in conjunction with the acoustic emissions (AE) sensor, we can clearly identify critical loads at which screen protectors¹ show failure due to scratch testing to create a comparative study between two types of screen protectors.

Importance of Testing Screen Protectors

Two common types of screen protector materials are TPU (thermoplastic polyurethane) and tempered glass. Of the two, tempered glass is considered the best as it provides better impact and scratch protection. However, it is also the most expensive. TPU screen protectors on the other hand, are less expensive and a popular choice for consumers who prefer plastic screen protectors. Since screen protectors are designed to absorb scratches and impacts and are usually made of materials with brittle properties, controlled scratch testing paired with in-situ AE detection is an optimal test setup for determining the loads at which cohesive failures (e.g. cracking, chipping and fracture) and/or adhesive failures (e.g. delamination and spallation) occur.

Measurement Objectives

In this study, three scratch tests were performed on two different commercial screen protectors using Nanovea's PB1000 Mechanical Tester's Macro Module. By using an acoustic emissions sensor and optical microscope, the critical loads at which each screen protector showed failure(s) were identified.



Screen Protector sample on Nanovea PB1000 Mechanical Tester

Measurement Parameters

The Nanovea PB1000 Mechanical Tester was used to test two screen protectors applied onto a phone screen and clamped down to a friction sensor table. The test parameters for all scratches are tabulated in Table 1 below.

Test Parameters	
Load Type	Progressive
Initial Load	0.1 N
Final Load	12 N
Sliding Speed	3.025 mm/min
Sliding Distance	3 mm
Indenter Geometry	Rockwell (120° cone)
Indenter Material (tip)	Diamond
Indenter Tip Radius	50 μ m
Atmosphere	Air
Temperature	24 °C (room temperature)

Table 1: Test parameters used for scratch testing

TPU SCREEN PROTECTOR



TEMPERED GLASS



Figure 1: Image of TPU and tempered glass screen protectors on cell phone

Results and Discussion

Because the screen protectors were made of a different material, they each exhibited varying types of failures. Only one critical failure was observed for the TPU screen protector whereas the tempered glass screen protector exhibited two. The results for each sample are shown in Table 2 below. Critical load #1 is defined as the load at which the screen protectors started to show signs of cohesive failure under the microscope. Critical load #2 is defined by the first peak change seen in the acoustic emissions graph data.

For the TPU screen protector, Critical load #2 correlates to the location along the scratch where the protector began to visibly peel off the phone screen. A scratch appeared on the surface of the phone screen once Critical load #2 was surpassed for the remainder of the scratch tests. For the Tempered Glass screen protector, Critical load #1 correlates to the location where radial fractures began to appear. Critical load #2 happens towards the end of the scratch at higher loads. The acoustic emission is a larger magnitude than the TPU screen protector, however, no damage was done to the phone screen. In both cases, Critical load #2 corresponded to a large change in depth, indicating the indenter had pierced through the screen protector.

Type of Screen Protector	Critical Load #1 (N)	Critical Load #2 (N)
TPU	n/a	2.004 ± 0.063
Tempered Glass	3.608 ± 0.281	7.44 ± 0.995

Table 2: Summary of critical loads for each sample.

Results and Discussion

TPU Screen Protector

TPU Screen Protector	
Scratch	Critical Load #2 (N)
1	2.033
2	2.047
3	1.931
Average	2.003
Standard Deviation	0.052

Table 3: Critical loads from scratch testing on TPU screen protector

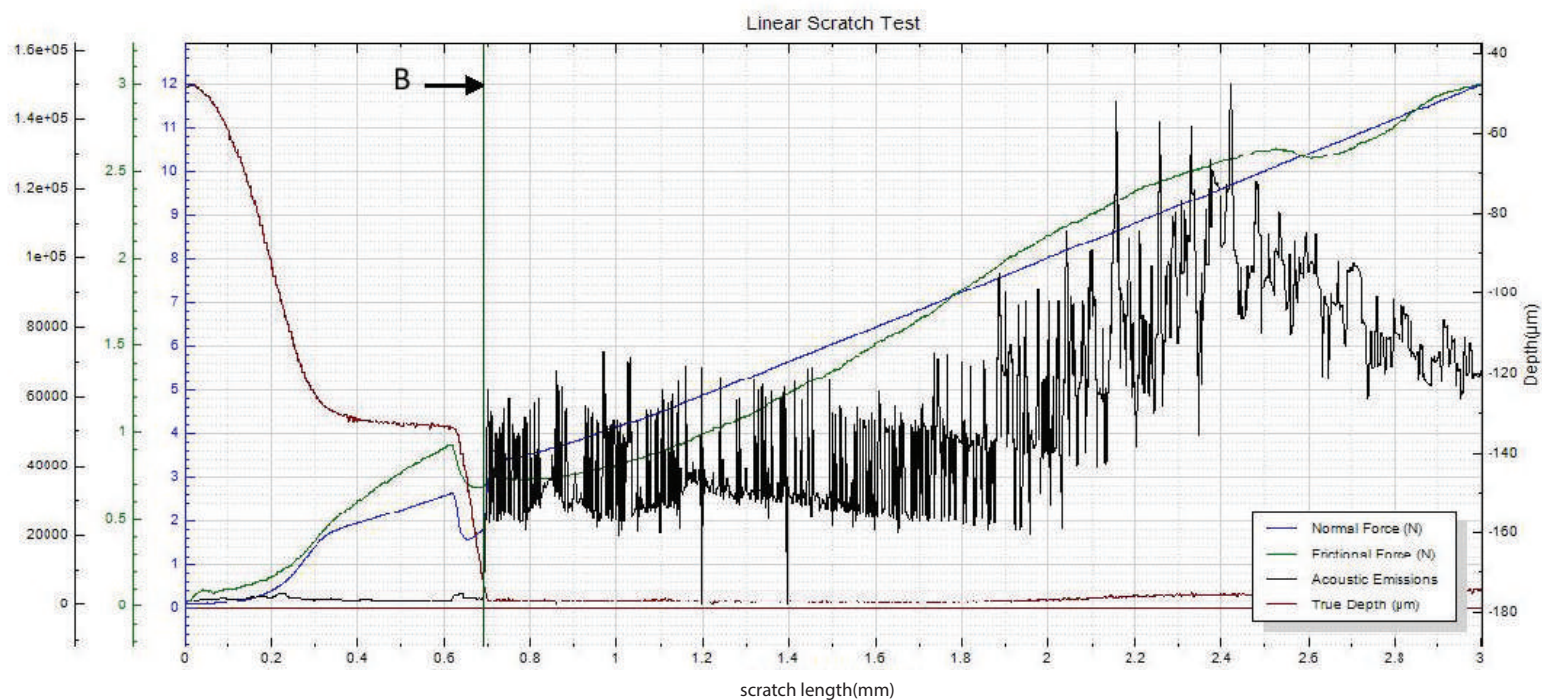


Figure 2: Friction, Normal force, AE, and Depth vs Scratch length - TPU Screen Protector
(B) Critical Load #2

Results and Discussion

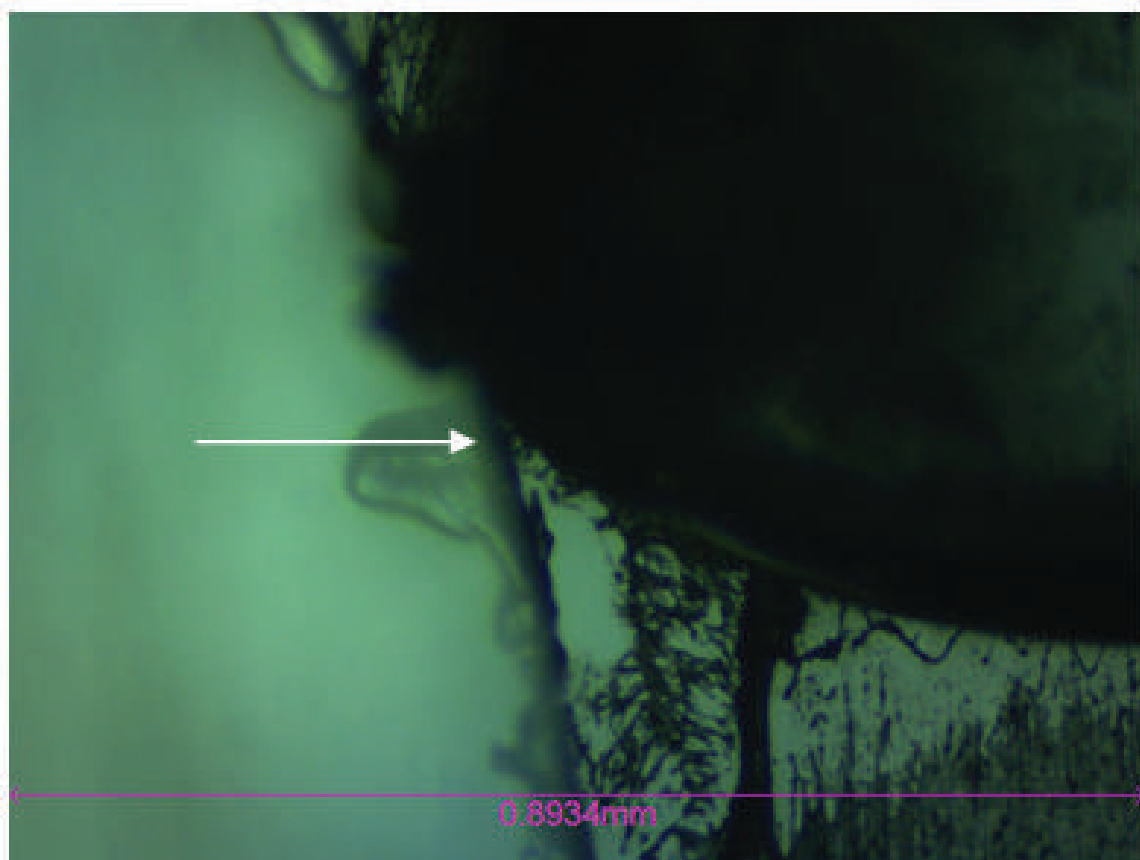


Figure 3: Optical microscopy of Critical Load #2 for TPU Screen Protector.
Image was taken with 5x magnification (image width 0.8934 mm).

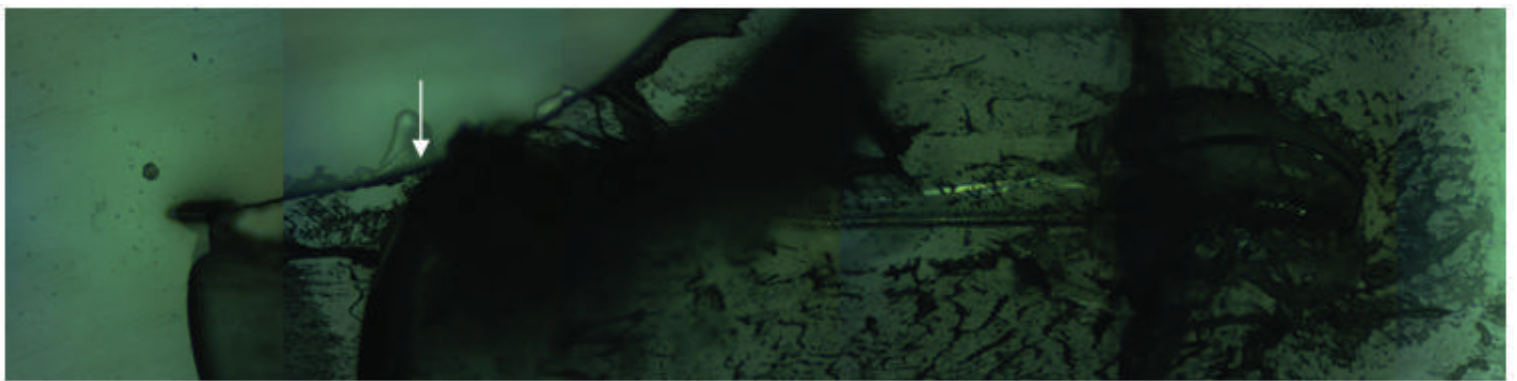


Figure 4: Full length image of post scratch test for TPU Screen Protector
Image was taken after scratch test was performed

Results and Discussion

Tempered Glass Sample

Tempered Glass Screen Protector		
Scratch	Critical Load #1 (N)	Critical Load #2 (N)
1	3.923	7.366
2	3.382	6.483
3	3.519	8.468
Average	3.653	6.925
Standard Deviation	0.383	0.624

Table 4: Critical loads from scratch testing on tempered glass screen protector

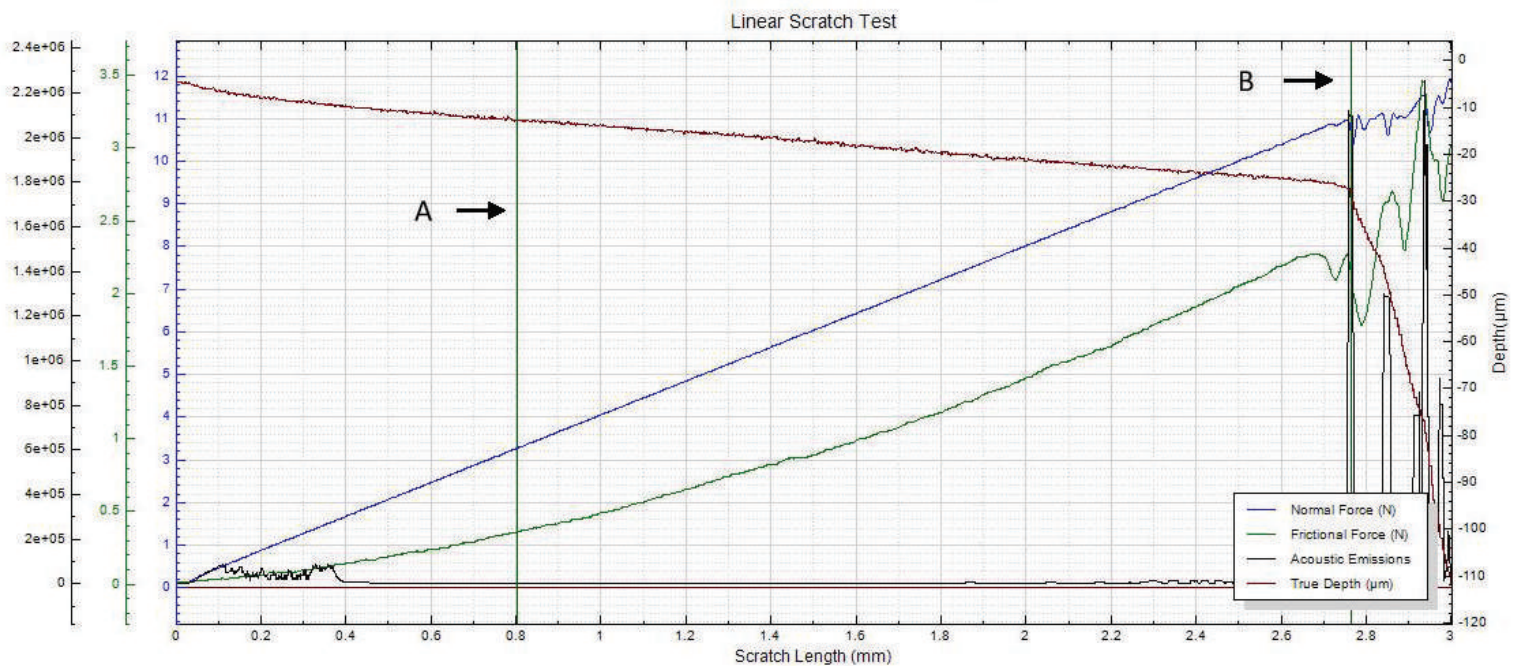


Figure 5: Friction, Normal force, AE, and Depth vs Scratch length - Tempered Glass Screen Protector
(A) Critical Load #1
(B) Critical Load #2

Results and Discussion

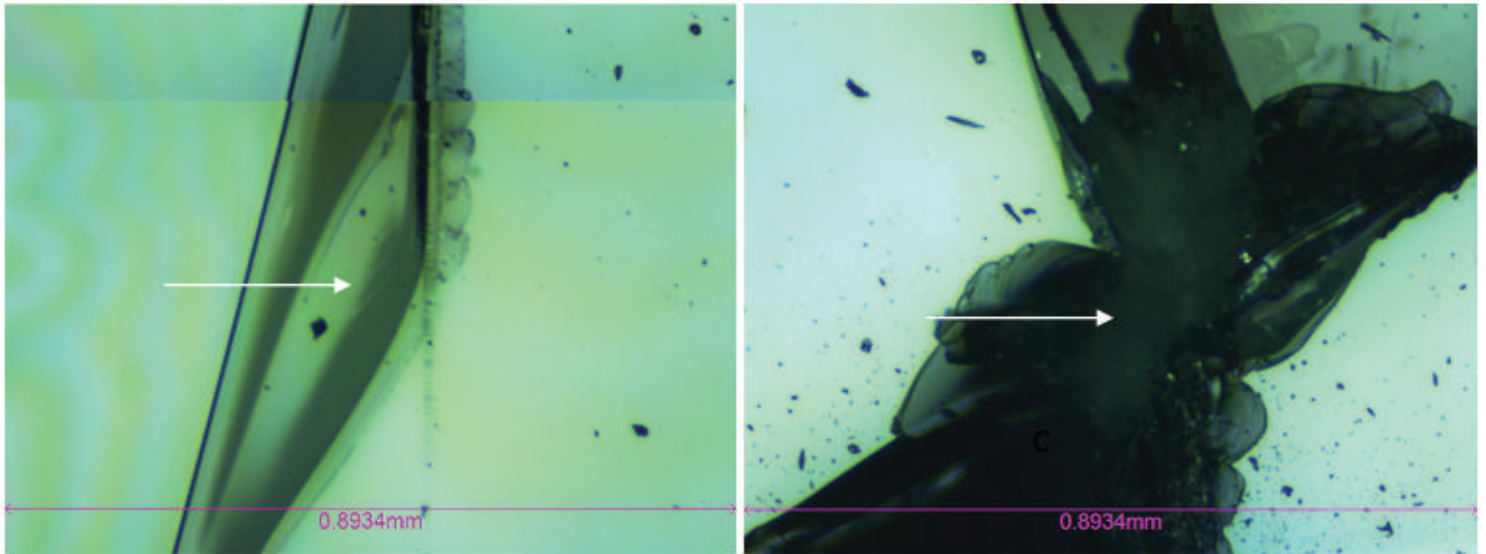


Figure 6: Optical microscope image of Critical Load #1 location (left) and Critical Load #2 location (right) - Tempered Glass Screen Protector
Image was taken with 5x magnification (image width: 0.8934 mm).

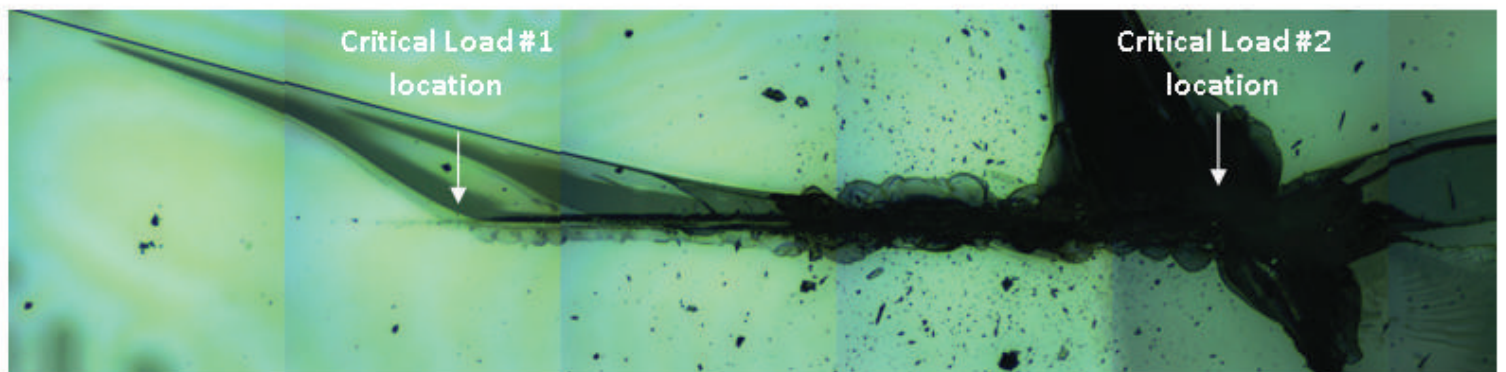


Figure 7: Optical microscope image of Critical Load #1 location (left) and Critical Load #2 location (right) - Tempered Glass Screen Protector
Image was taken after scratch test was performed.



Conclusion

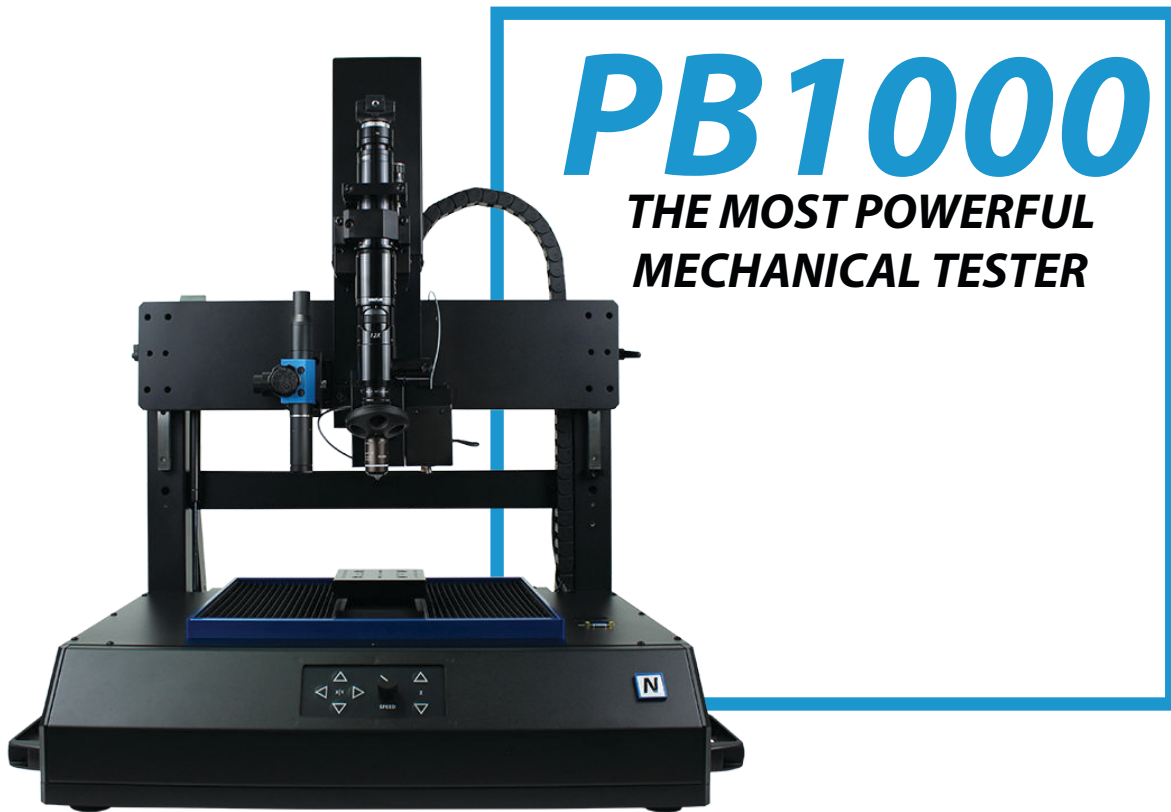
In this study we showcase the Nanovea PB1000 Mechanical Tester's ability to perform controlled and repeatable scratch tests and simultaneously use acoustic emission detection to accurately identify the loads at which adhesive and cohesive failure occur in screen protectors made of TPU and tempered glass. The experimental data presented in this document supports the initial assumption that Tempered Glass performs the best for scratch prevention on phone screens.

The Nanovea Mechanical Tester offers accurate and repeatable indentation, scratch and wear measurement capabilities using ISO and ASTM compliant Nano and Micro modules. The Mechanical Tester is a complete system, making it the ideal solution for determining the full range of mechanical properties of thin or thick, soft or hard coatings, films and substrates.

To learn more about the [Nanovea Mechanical Tester](#) or [Lab Services](#).

Reference

1. "PET, TPU, or Tempered Glass – all you need to know to choose a screen protector." phoneArena, 15 Jul. 2014, https://www.phonearena.com/news/PET-TPU-or-Tempered-Glass--all-you-need-to-know-to-choose-a-screen-protector_id58204.



Multi Module Platform

3 Testing Modes in 1 (Scratch/Indent/Wear)

Loading Ranges from 0.8uN to 400N

XYZ Motion with 0.20um Step Resolution

Fully Automated (Up to 100 indents in 15mins)

Integrated Imaging (AFM, Profilometer, Microscope)

[Learn More about the PB1000!](#)

Thank you for reading!

We appreciate your interest in our technology and services. Read more about all of our product line and lab services at www.nanovea.com

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If you have any questions please email us at info@nanovea.com

Recommended Reading

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