

First practical Utility Implementations of Monitored Withstand Diagnostics in the USA

**C. L. Fletcher¹, R. N. Hampton², J. C. Hernandez³, J. Hesse¹,
M. G. Pearman⁴, J. Perkel², C. T. Wall⁵, W. Zenger⁶, S. Stangvik⁷**

¹ Duke Energy, ²NEETRAC, ³ Universidad de Los Andes,
⁴ Georgia Power, ⁵ Alabama Power, ⁶PG&E, & ⁷Snopud

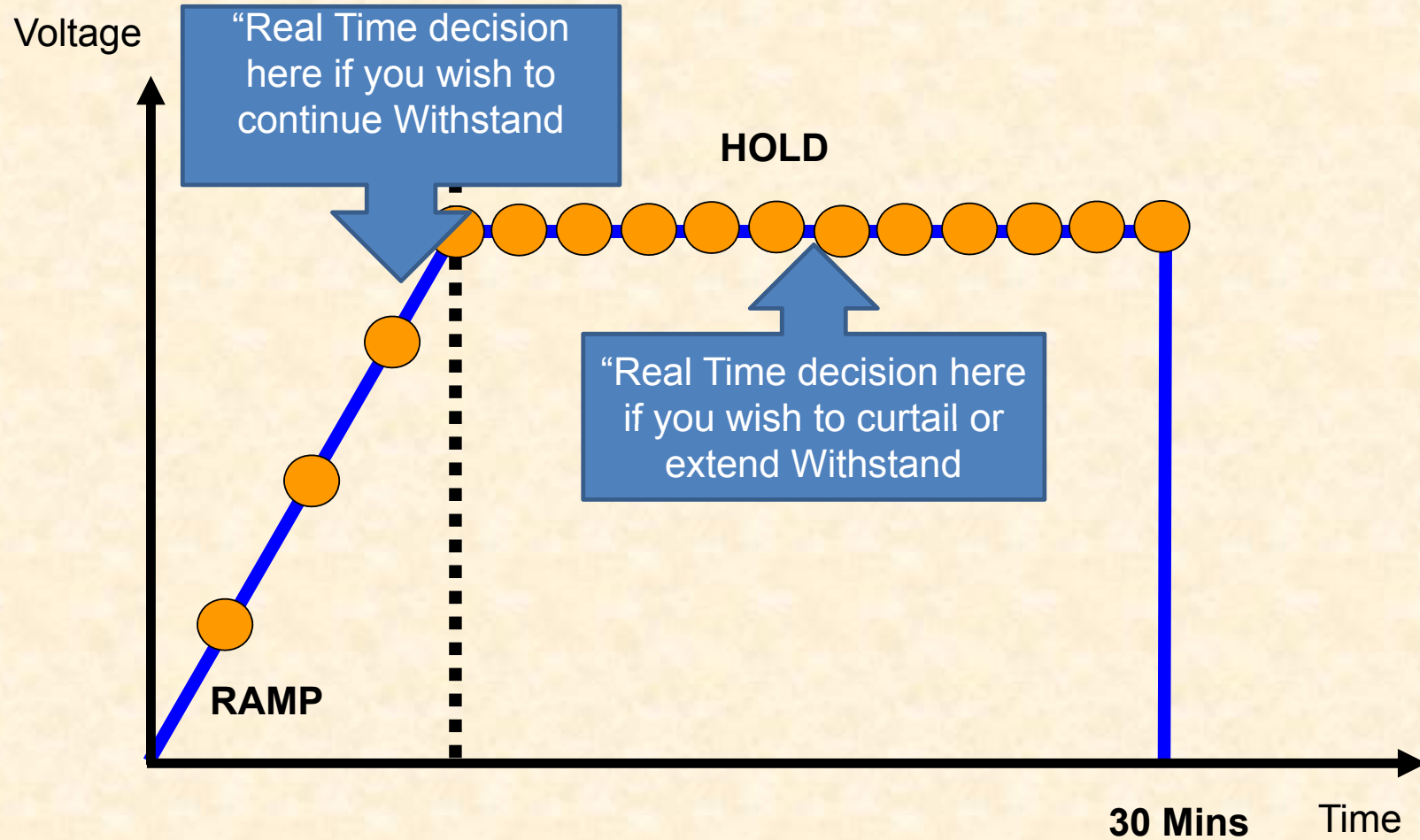
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Introduction

- Simple Withstand (Pass / Fail) tests are commonly employed by. However
 - No indication of the Pass margin
 - No indication if system is healthy enough for withstand
 - No indication if system is so healthy that withstand has little value
- A diagnostic property that is monitored during the withstand test provides additional information
 - Helps to quantify the Pass margin
- Monitored Withstand data had yet to be collated and analyzed to give assessment criteria

Preferred Test Protocol



Ways Not to Pass a Monitored Withstand

Failure – Insulation puncture

OR

High value of Diagnostic Property

OR

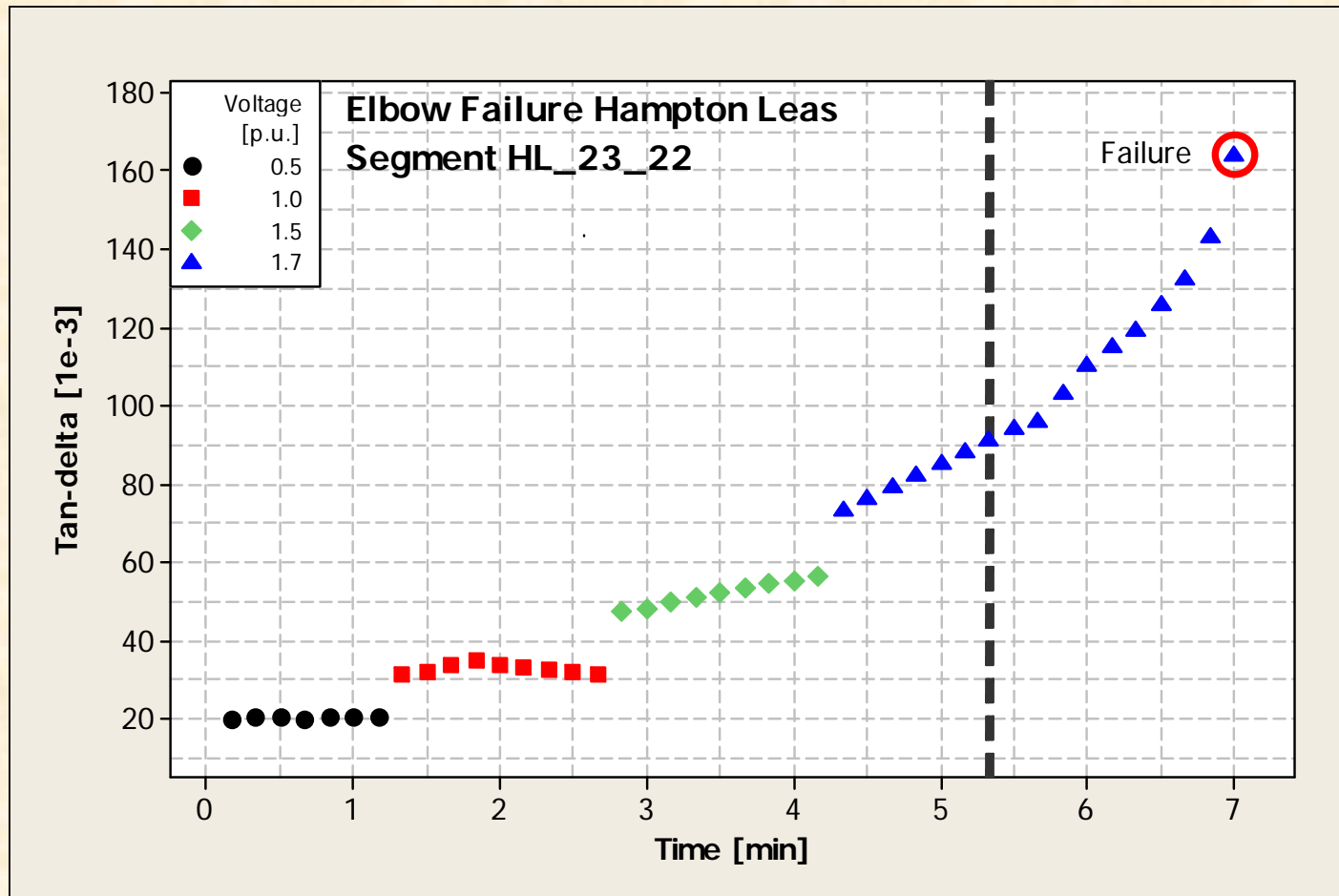
High instability in Diagnostic Property – Measured by standard deviation in consecutive measurements at one voltage level

Monitored Withstand Equipment

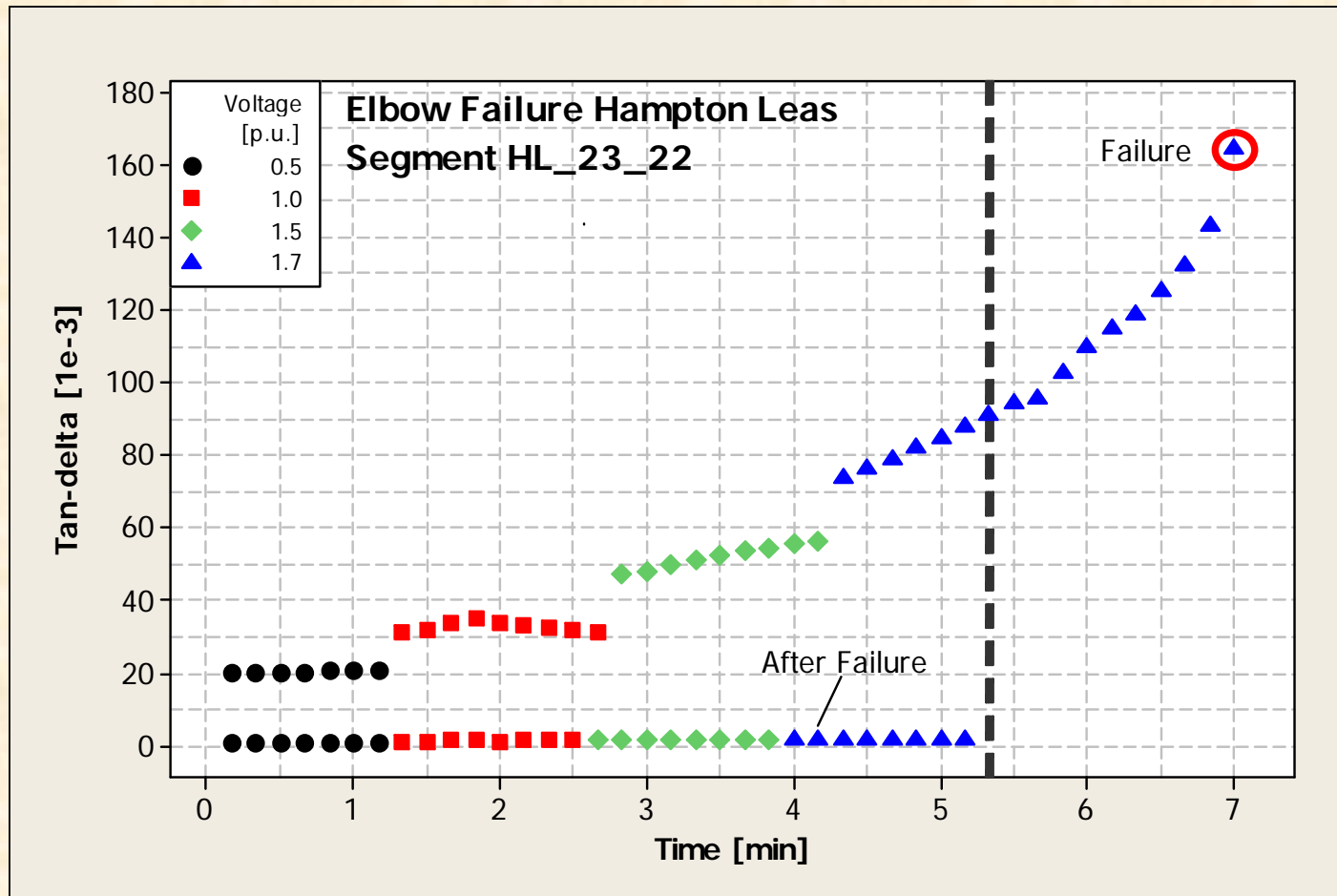


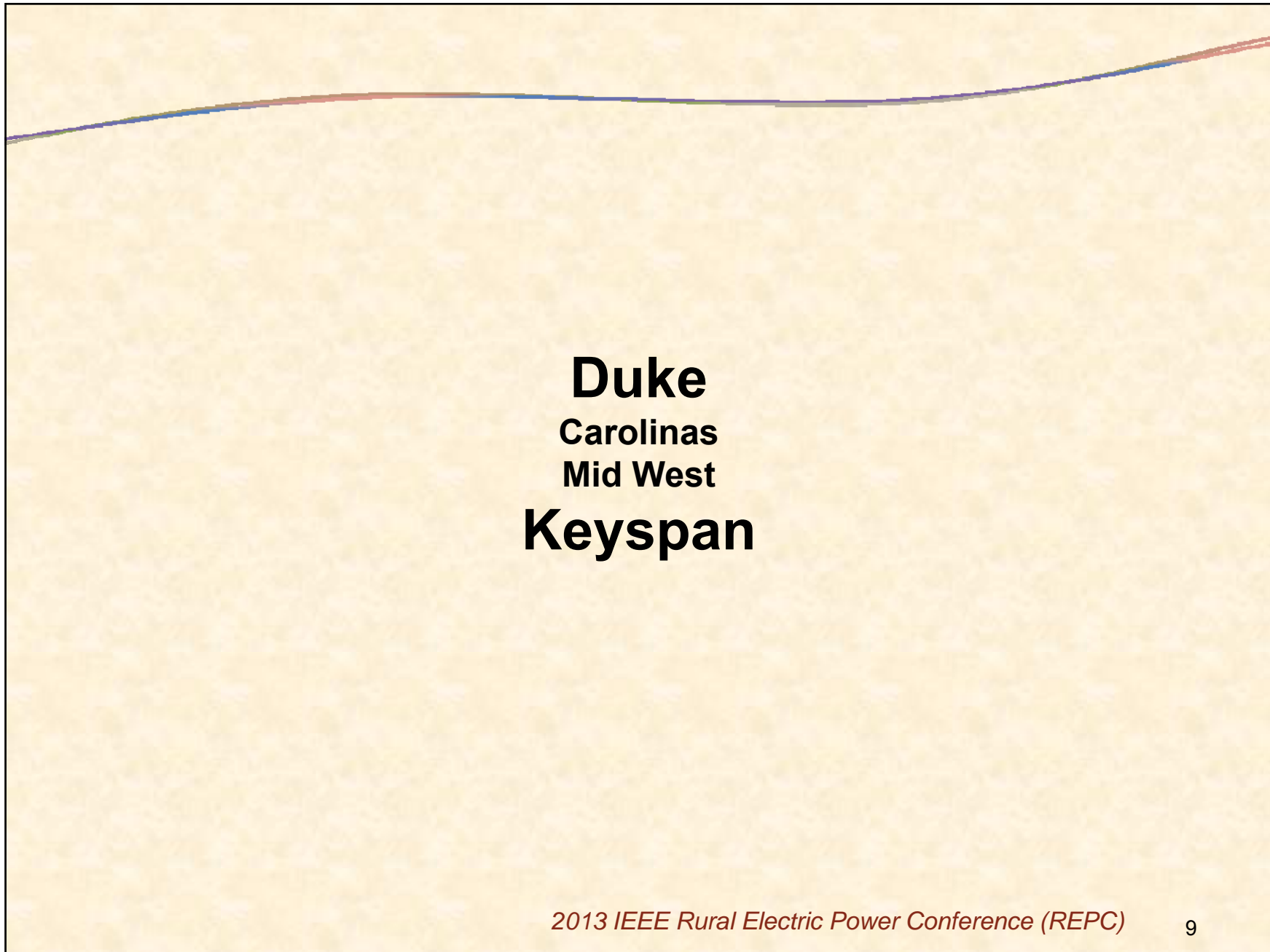
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Example Tan δ Ramp & Monitored Withstand

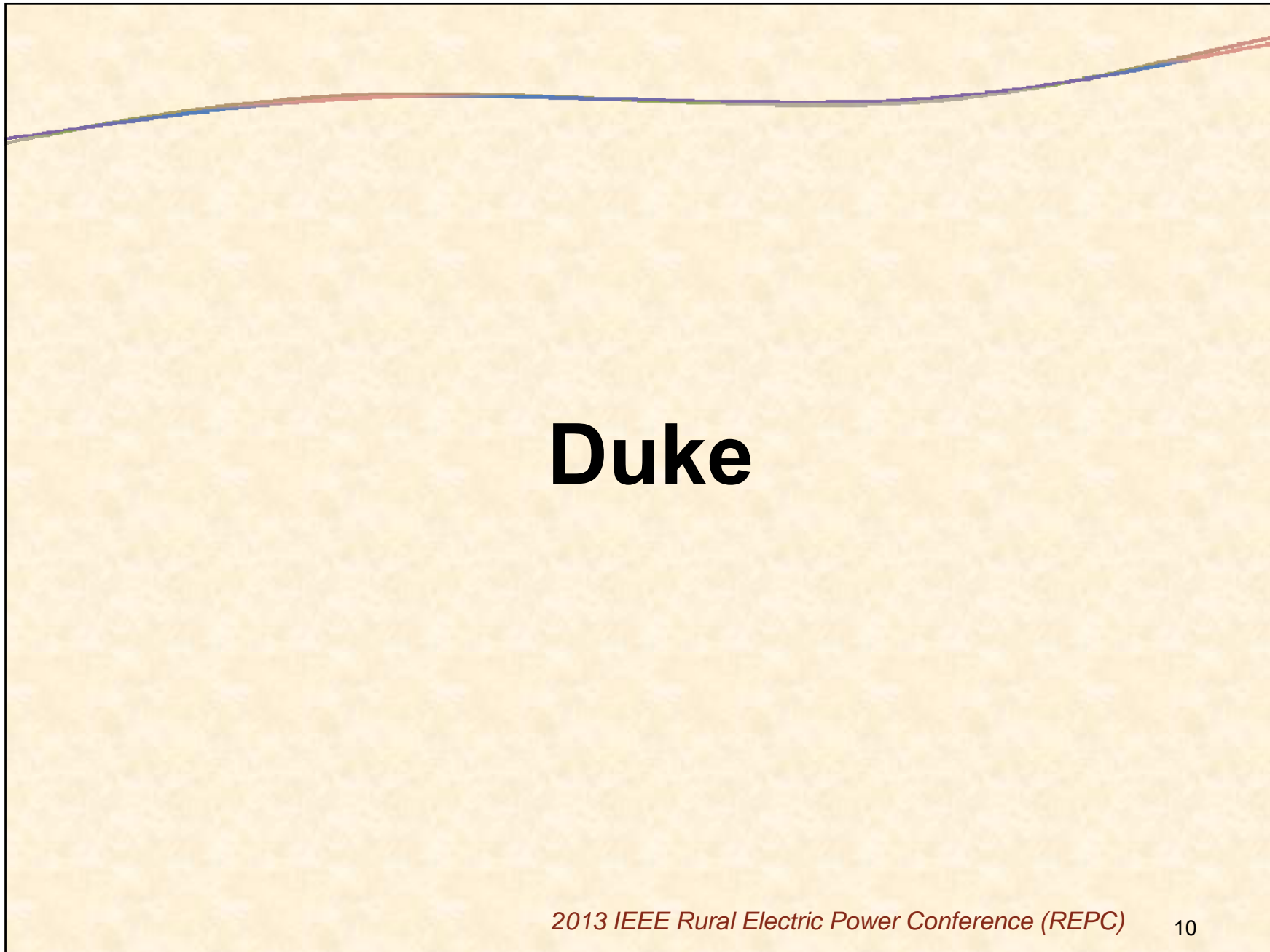


After Repair...

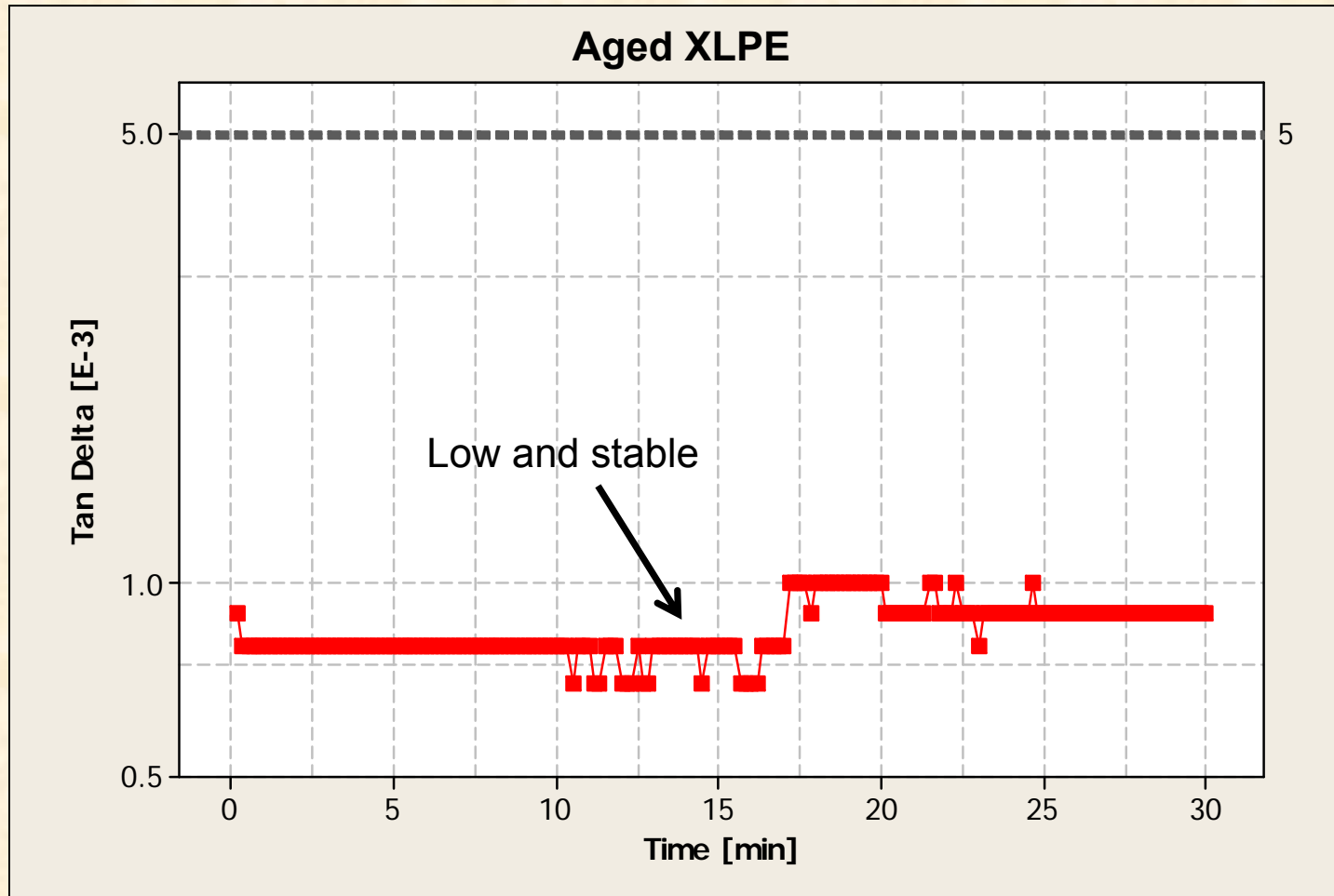




Duke
Carolinas
Mid West
Keyspan

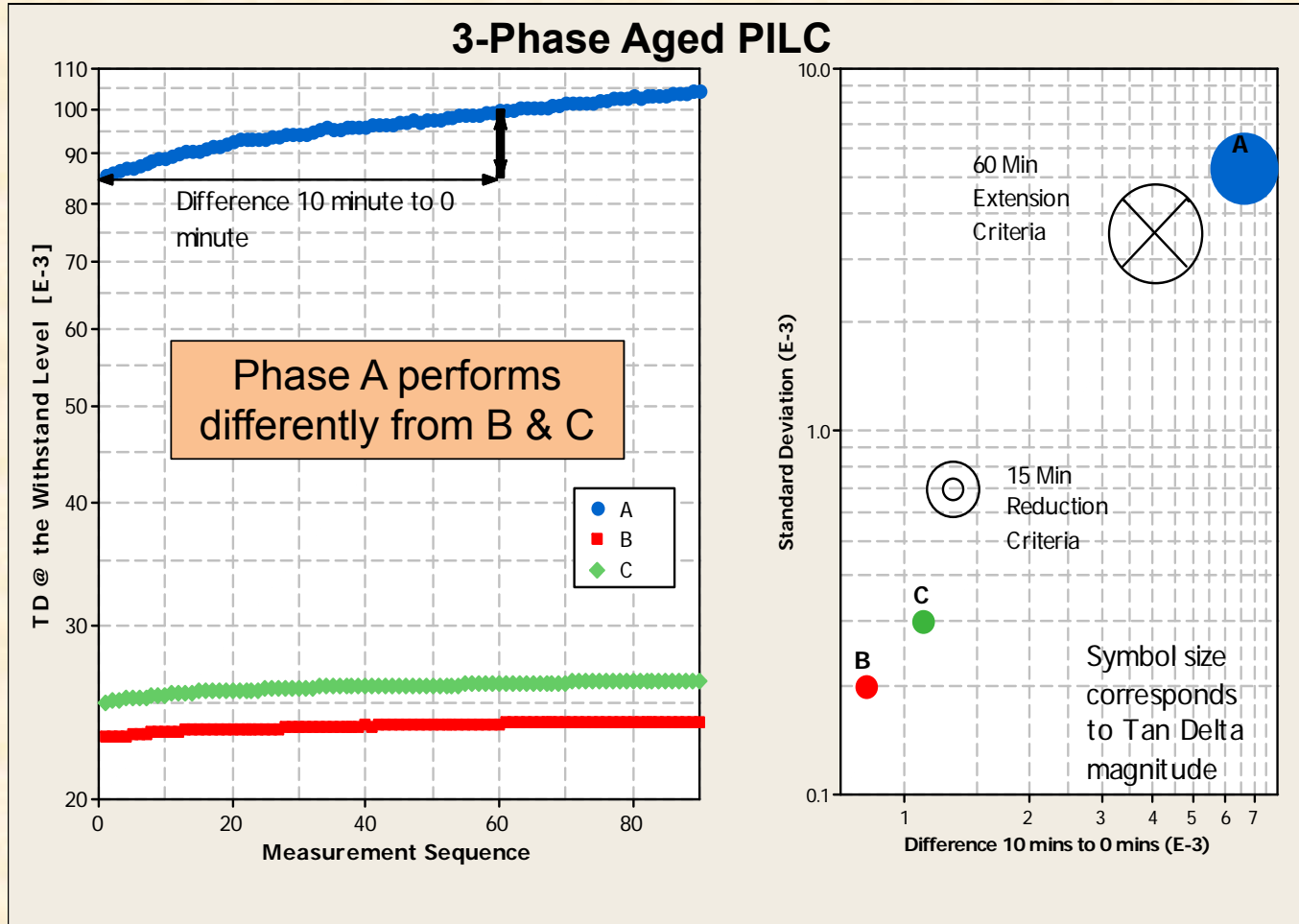


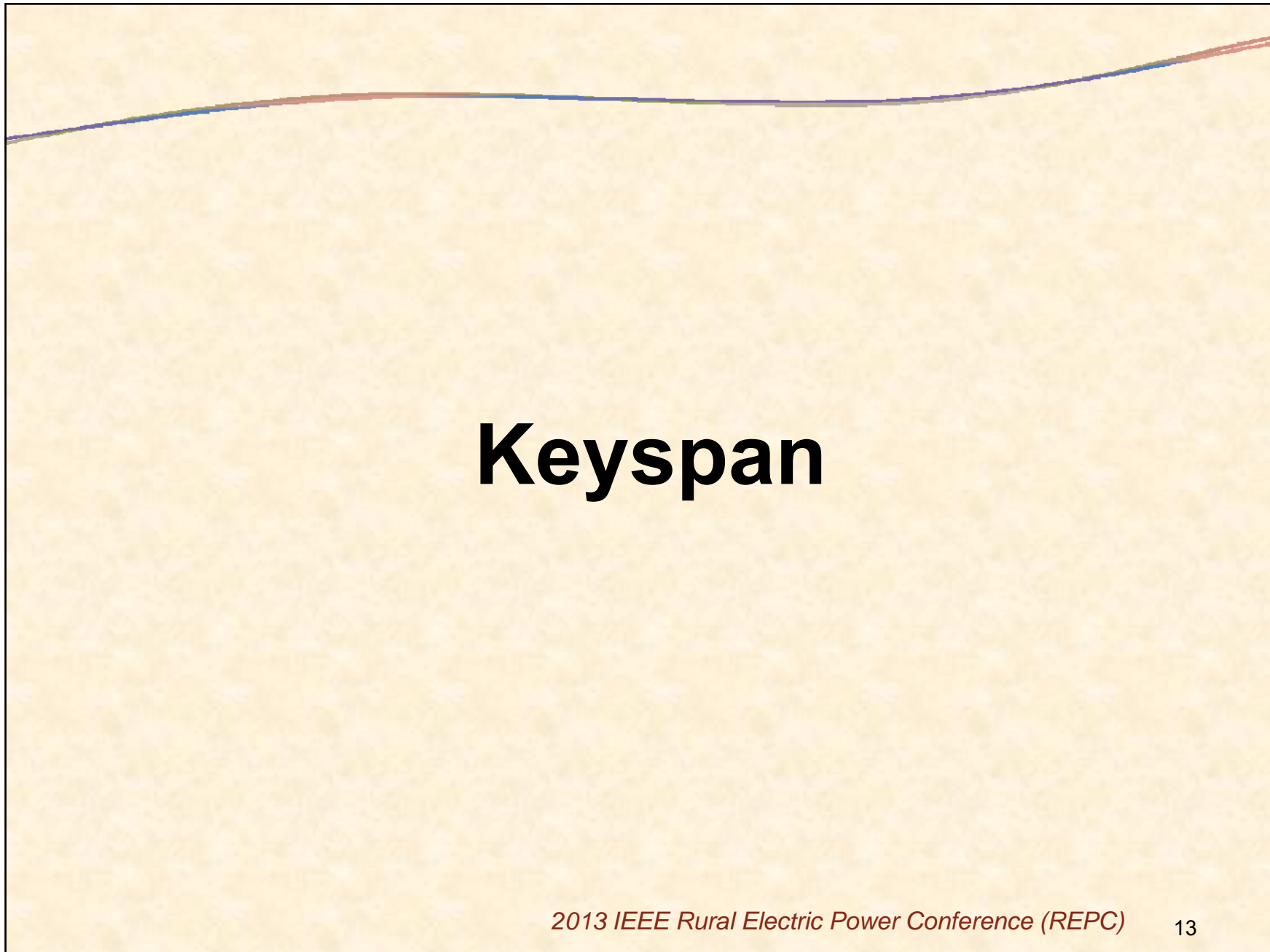
Aged XLPE - Stable



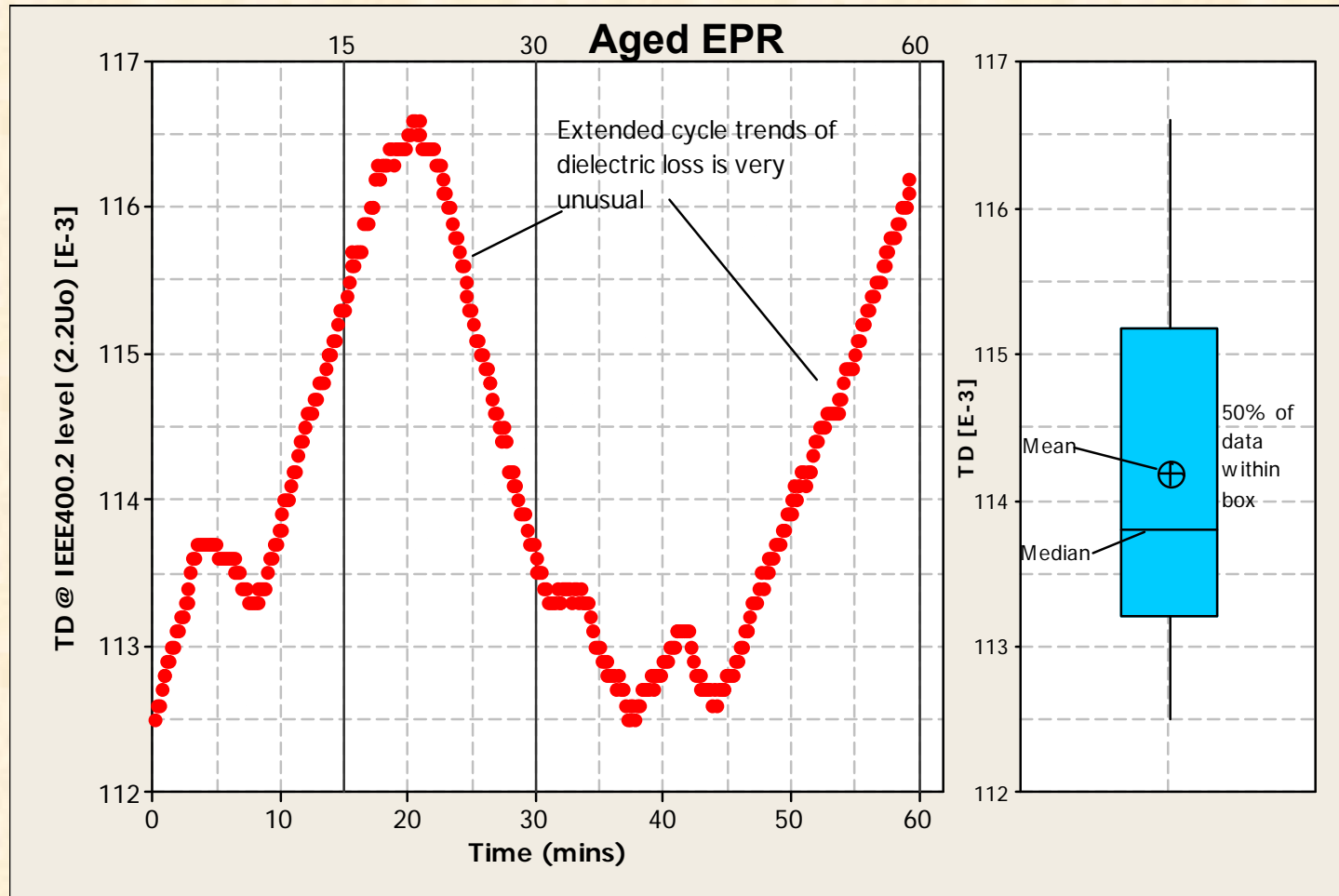
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3-Phase PILC – Not all Phases Test the Same





Aged EPR - Unstable



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How do we know what is Stable & Unstable?

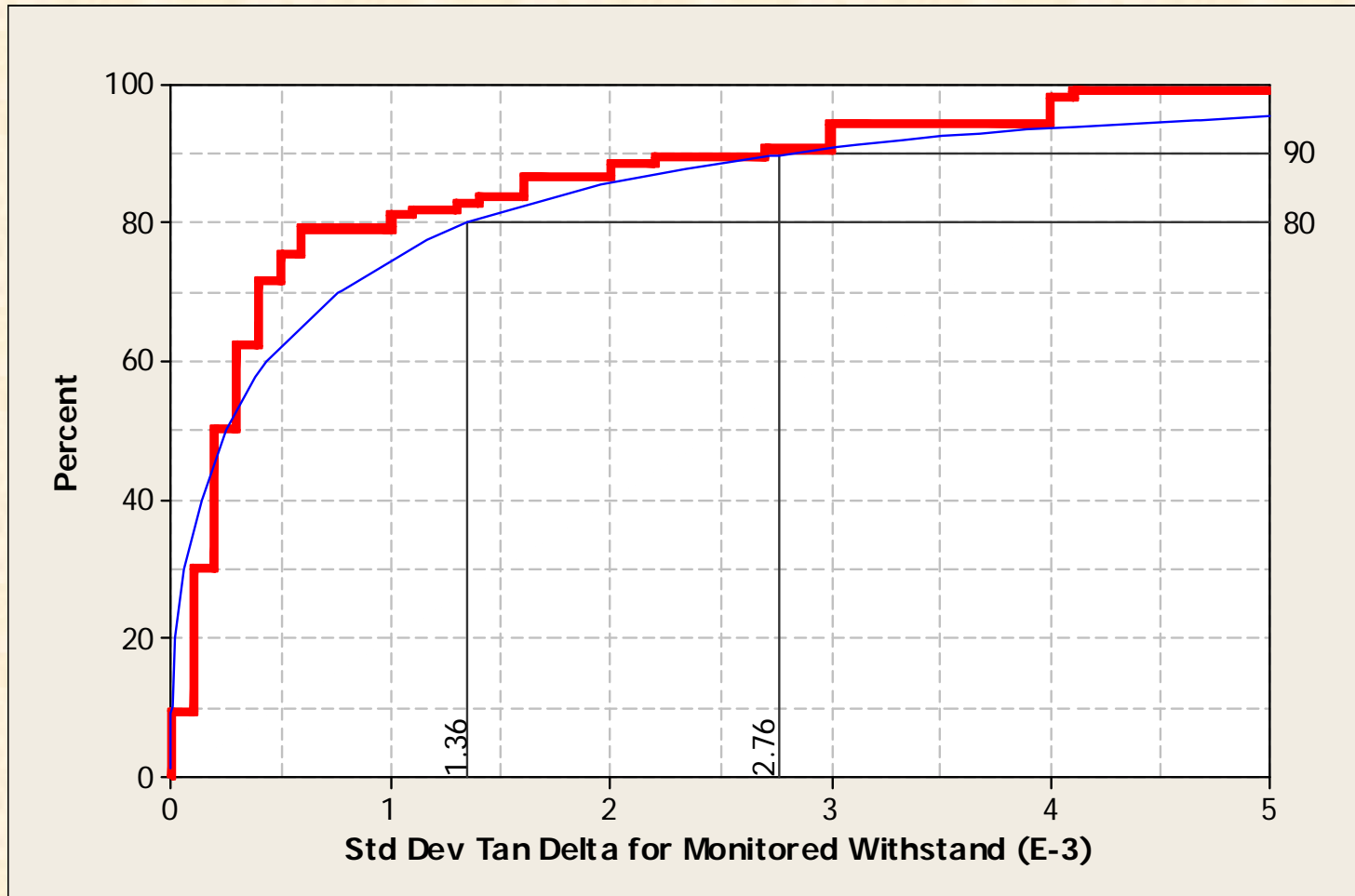
Where do the Criteria come from?

Monitored Withstand Criteria

- Data from multiple users of MW compiled into database
 - PG&E
 - Duke – Carolinas and Midwest
 - Georgia Power
 - Snopud
 - AEP
 - Ameren
 - NEETRAC CDFI
 - IREQ
- Data are segregated by insulation type
- Diagnostic properties (Tan δ)
 - Stability
 - standard deviation
 - difference between 0 & 10 min
 - Mean value

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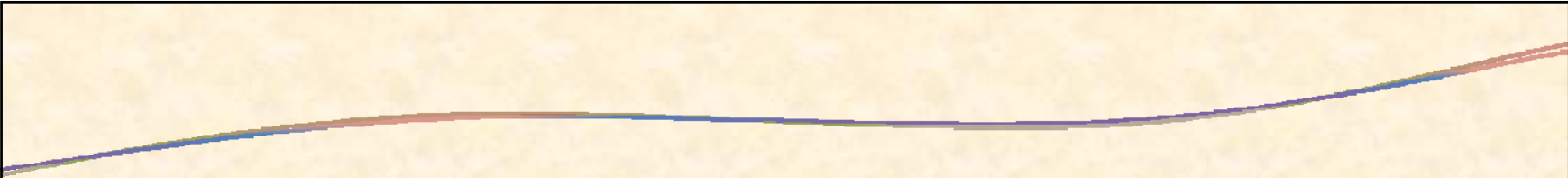
Distribution of Tan δ Stability



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PE-Based and PILC Real-Time Decision Making

Condition Assessment after Hold Period	Test Time Guidance within Hold Period	Tan δ Time Change (0 to 10 min) [E-3]		Tan δ Stability (std dev) [E-3]		Mean Tan δ [E-3]
PE-based Insulations (i.e. PE, XLPE, WTRXLPE)						
No Action Required	Reduce to 15 Mins	<0.25	and	<0.25	and	<5
Further Study Advised	Retain 30 Mins	>0.25 and <17		>0.25 and <6		>5 and <45
Action Required	Extend to 60 Mins	>17	or	>6	or	>45
Paper Insulations (i.e. PILC)						
No Action Required	Reduce to 15 Mins	<1.3	and	<0.7	and	<75
Further Study Advised	Retain 30 Mins	>1.3 and <4		>0.7 and <3.5		>75 and <135
Action Required	Extend to 60 Mins	>4	or	>3.5	or	>135



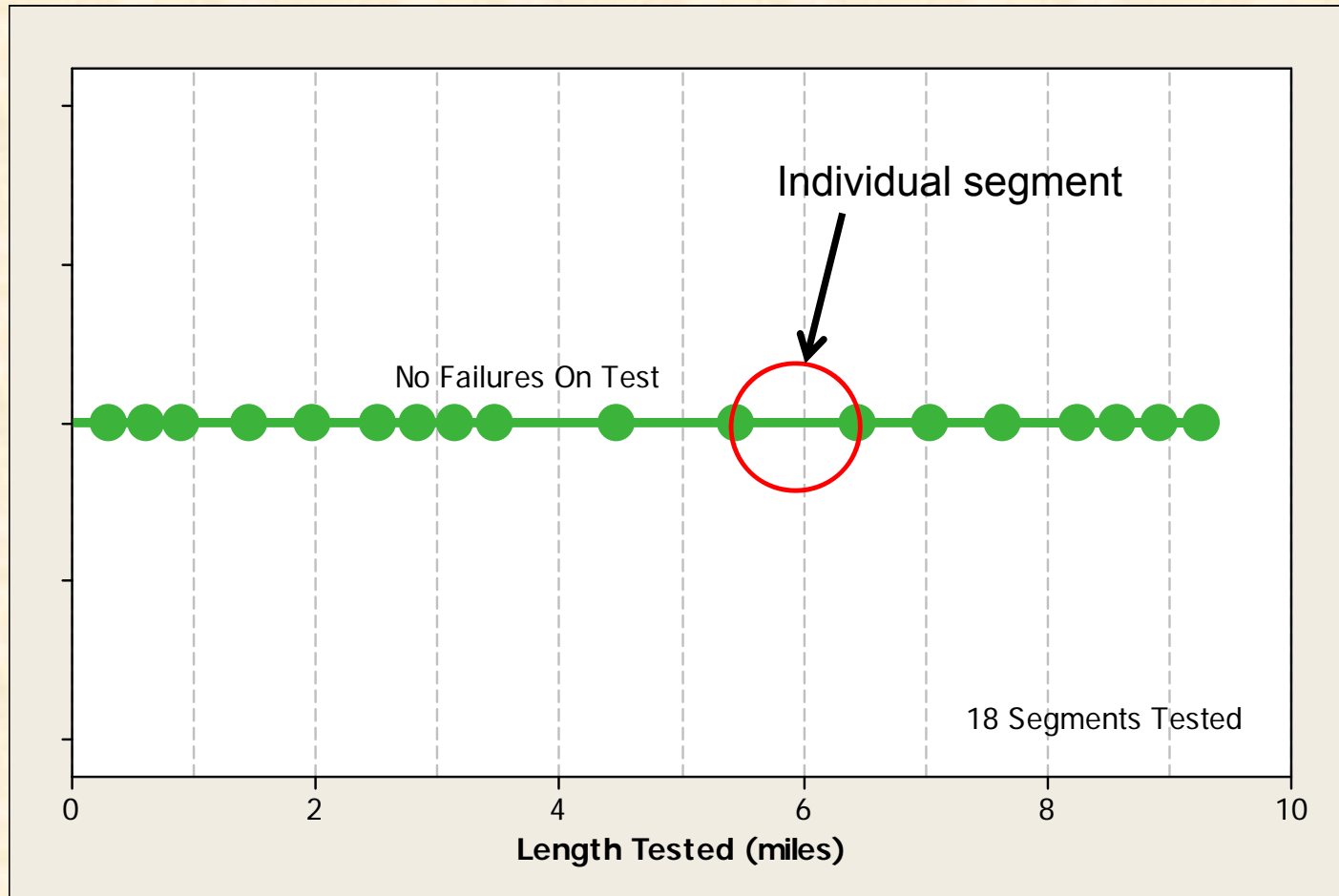
Comparison – Georgia Power

**Simple Withstand
versus
Monitored Withstand**

Georgia Power Roswell

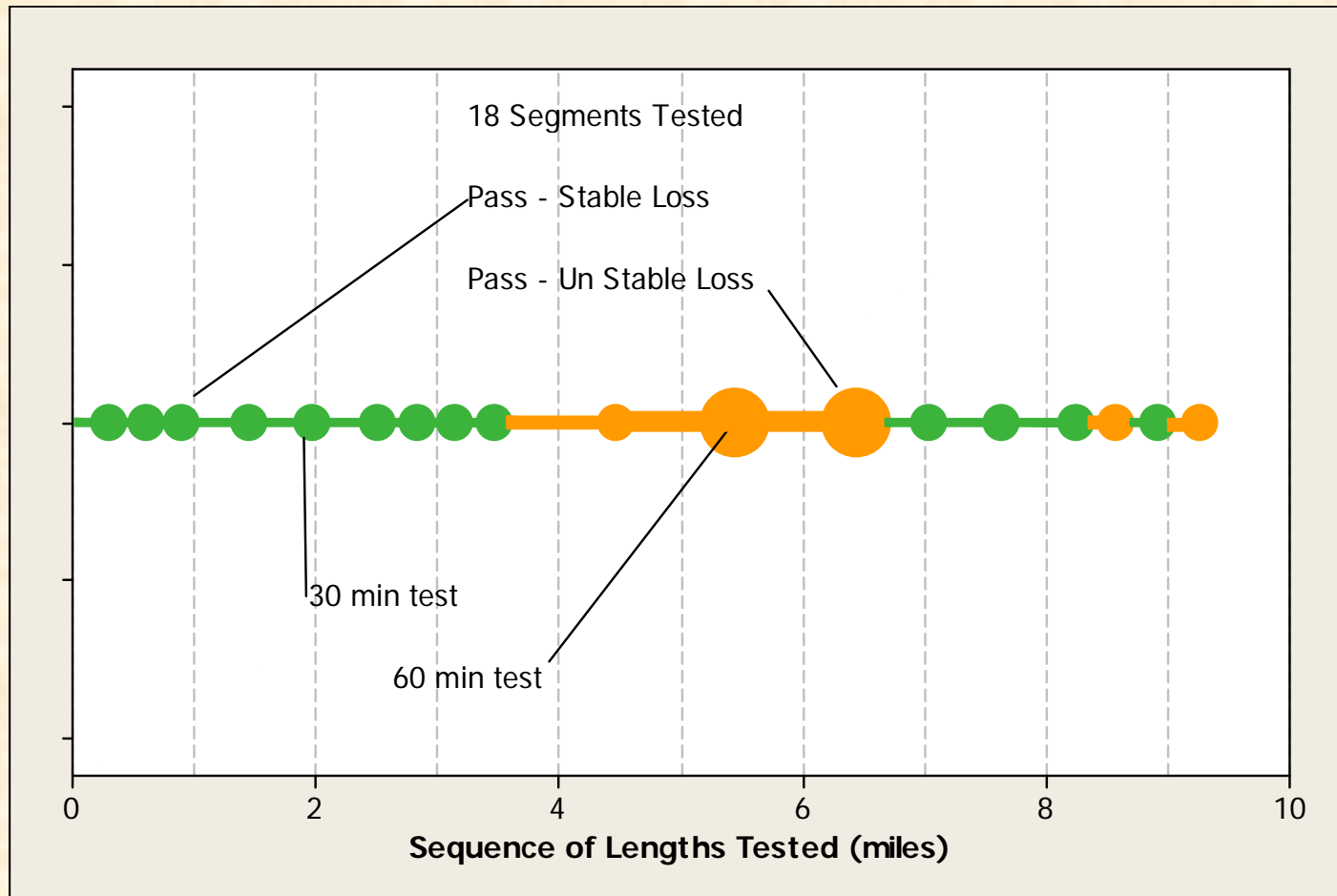
- Aged XLPE system
 - 25 kV system
 - 1000 kcmil conductor
 - LC shield
- 18 Segments (6 3-Phase runs) tested using Monitored Withstand protocol
- All phases tested separately

Simple Withstand Perspective



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Monitored Withstand Perspective



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SNOPUD

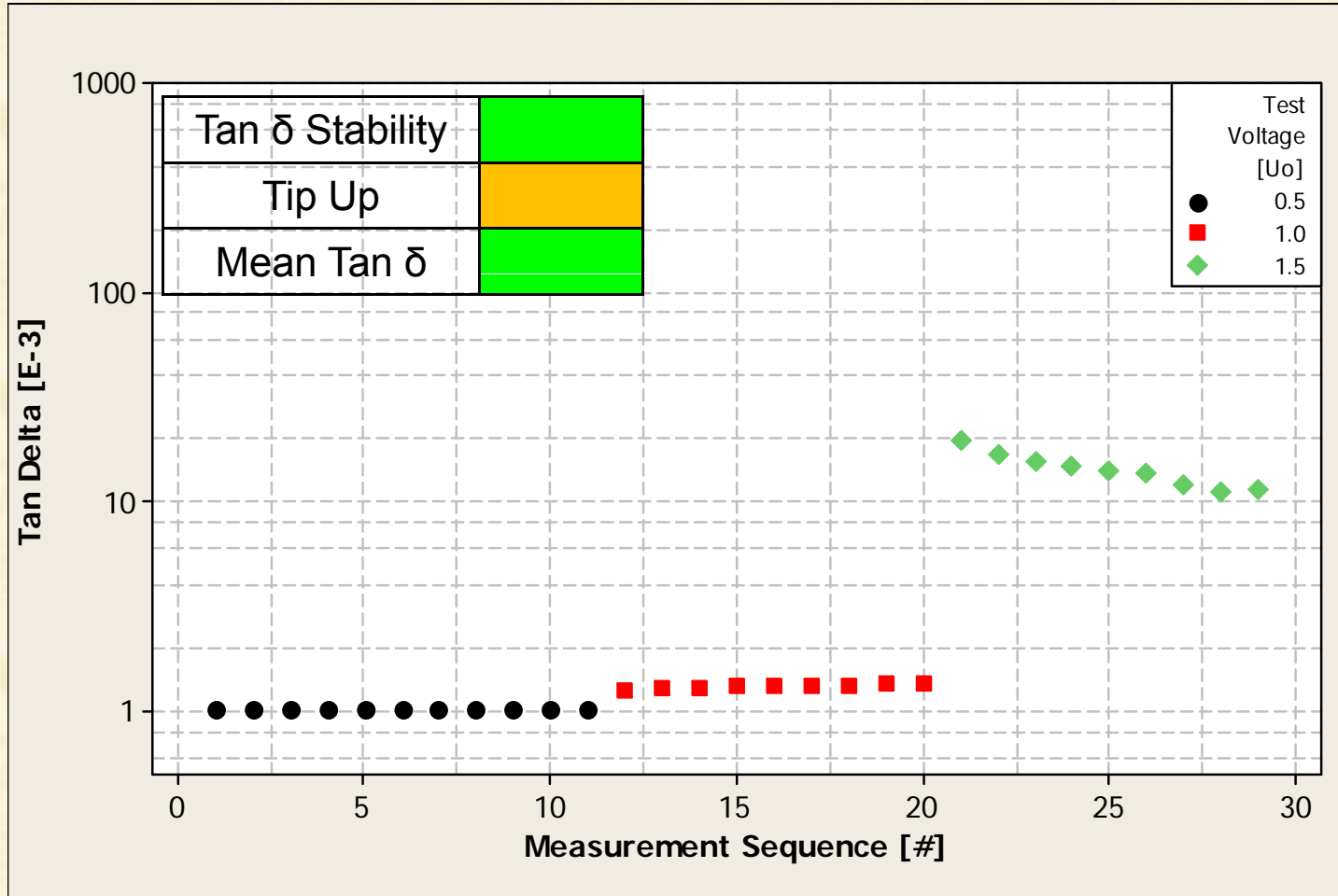
Tan Delta – pre test
Monitored Withstand
Tan Delta - post test

Knowledge Rule Field Tool Monitored Withstand Criteria (PE)

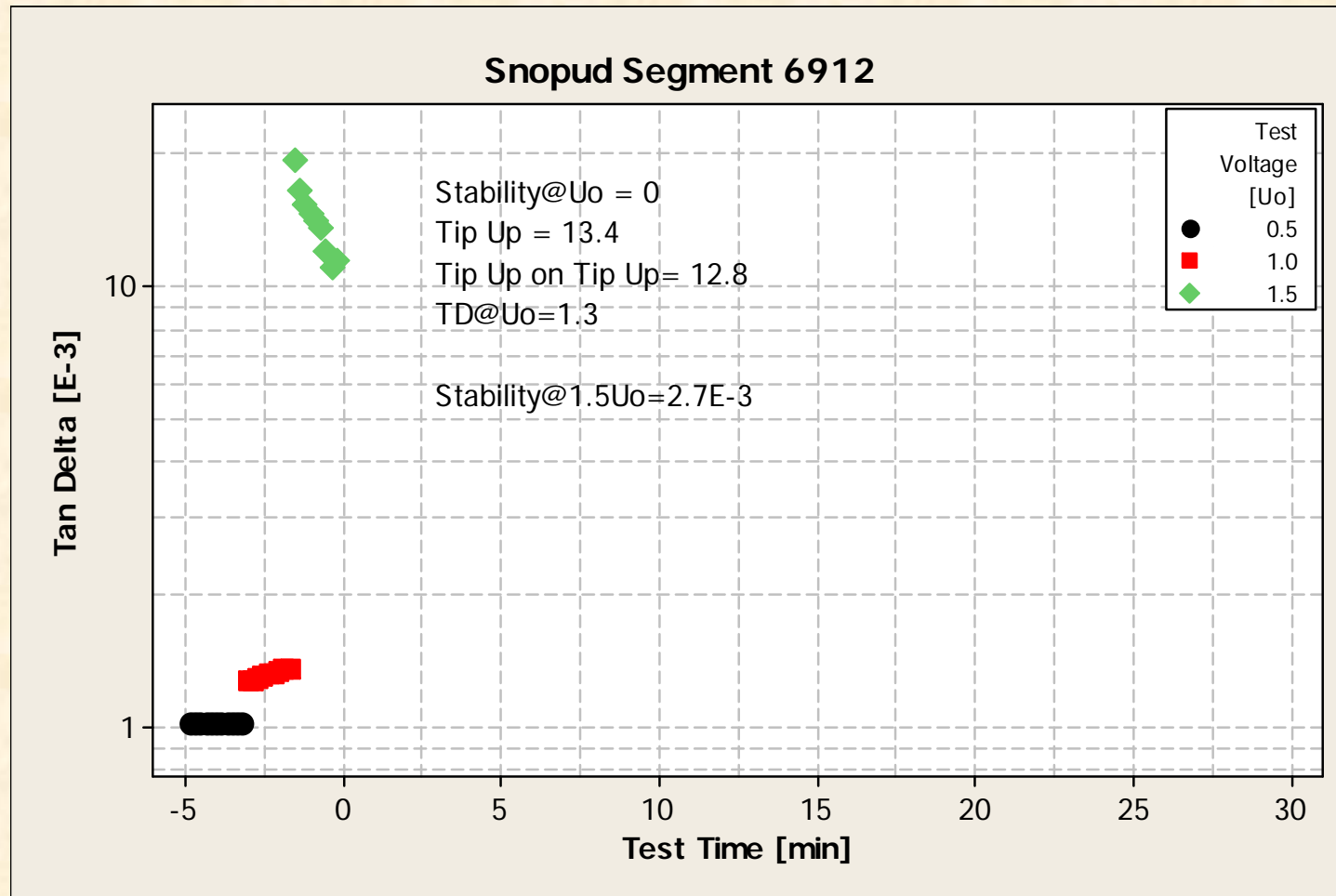
Condition Assessment	Change in Tan Delta between 0 and 10 mins (E-3)		VLF-TD Stability (standard deviation) at Maintenance Level [10-3]		Mean VLF-TD at Maintenance Level [10-3]
Reduce to 15 Mins	<0.25	and	<0.25	and	<5
Extend to 60 Mins	>17	or	>6	or	>45

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Unusual Tan δ

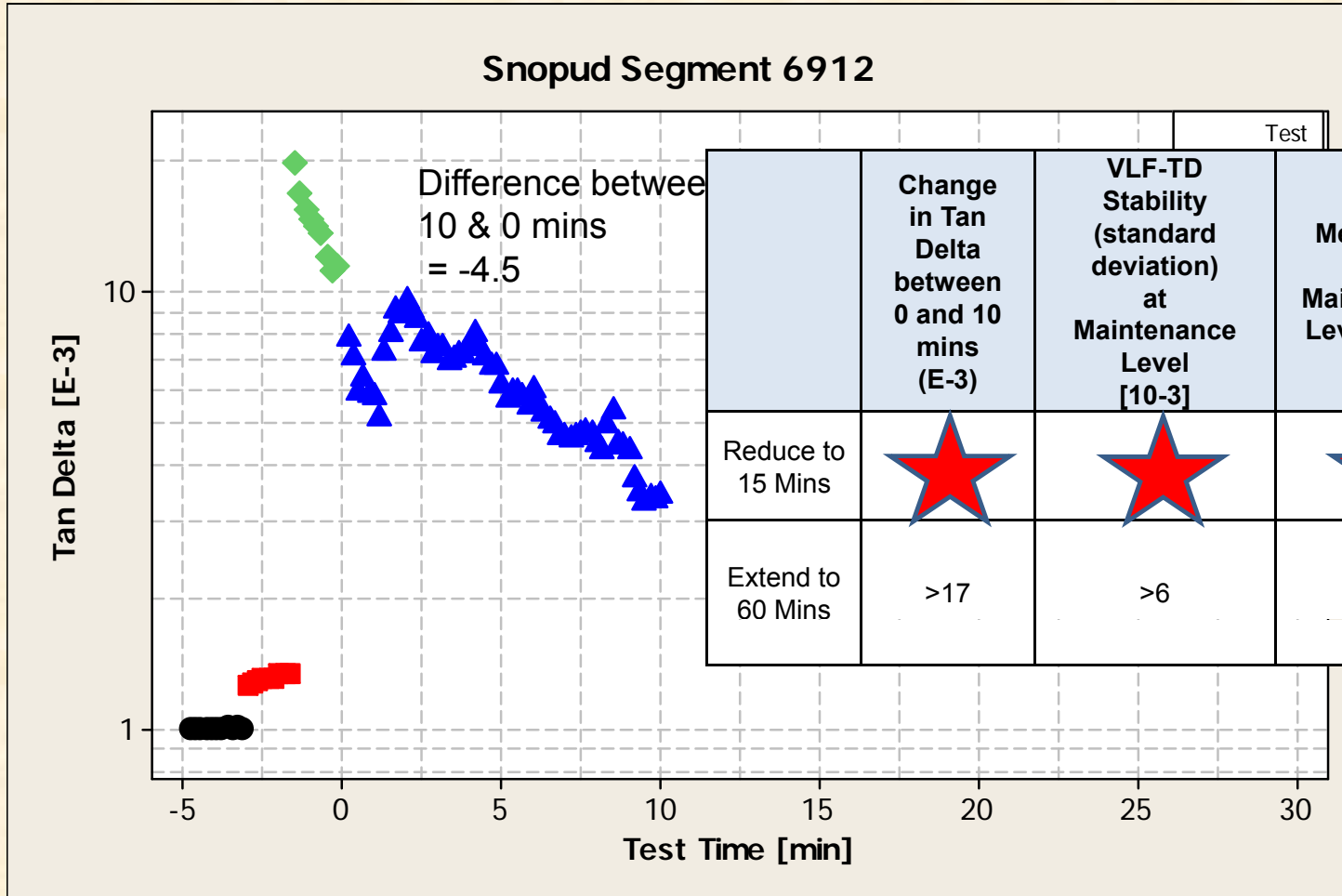


Monitored Withstand



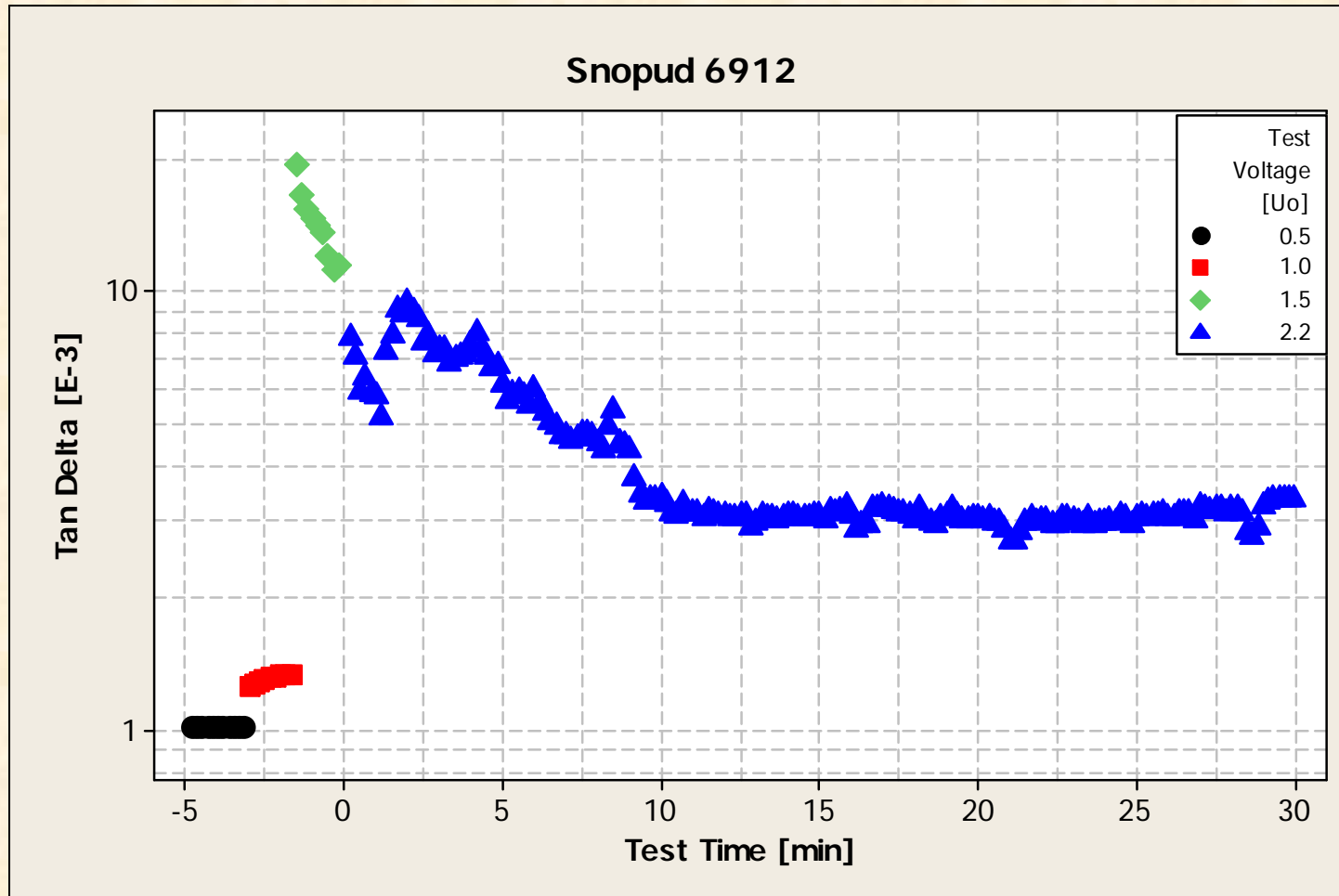
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0 to 10 mins



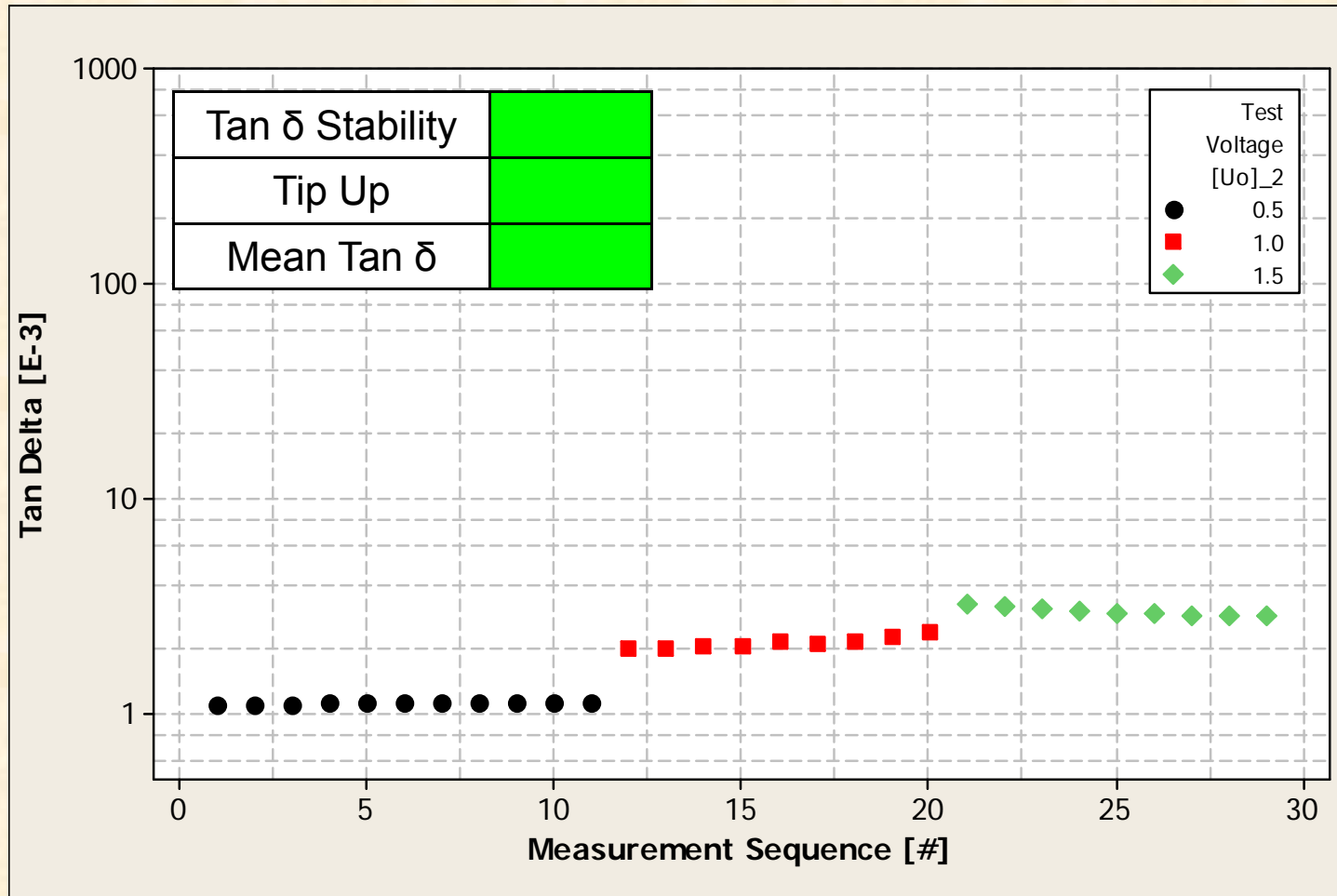
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0 to 30 mins



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Final Classification - Retest



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Conclusion

- Monitored Withstand data enhances information available from standard diagnostic measurements
- Practical criteria are available for VLF Tan δ Monitored Withstand tests.
 - Currently in use at several US utilities
- Dual Monitored Withstand tests are also possible but difficult to perform.
 - Unclear what property/properties to look at
 - Combines the benefits of all commonly used offline diagnostics