



# Withstand Tests More than Meets the Eye

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- Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Energy.

# Outline

- Introduction/Motivation
- Length Issues
- Withstand Testing Process
  - Ramp Up
  - Hold
- “Ramp Up” Diagnostic Features
- “Hold” Diagnostic Features
- Recommendations
- Conclusions

# Introduction

- Withstand tests are frequently used by utilities who employ diagnostic tests.
  - As of 2006, approx. 33% of CDFI member utilities employing diagnostic tests use withstand techniques.
- Withstand tests have been defined as “Pass/Fail” only.
- Utilities maintain records that are much more detailed.
- Cable Tested in the last five years: > 4495 miles.

# Motivation

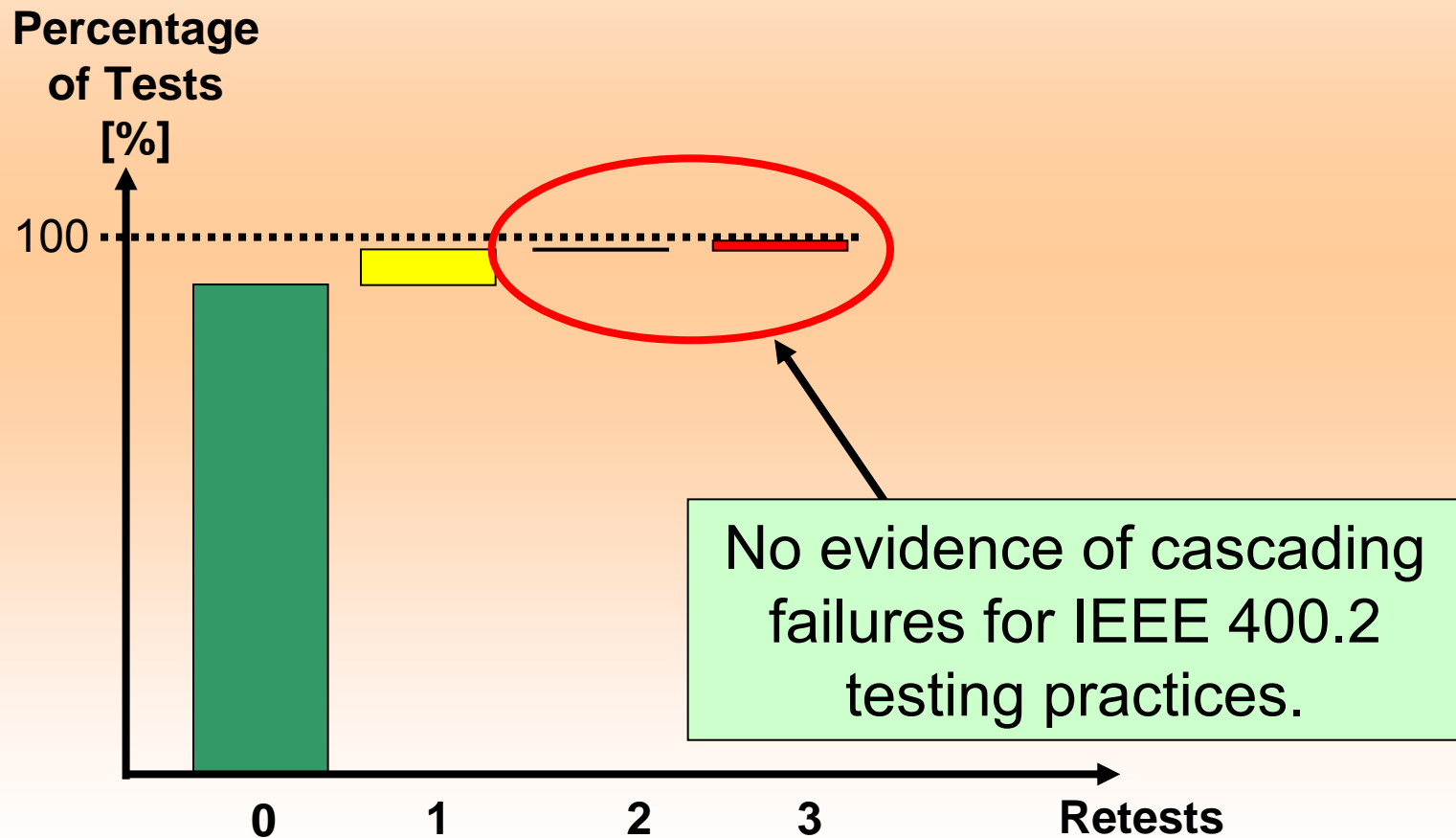
Utility records from withstand tests contain much more information than the result of the test.

- Test Voltage (including voltage at failure)
- Time on Test
- Segment Length
- Segment Insulation
- Segment Location
- Failed Equipment Type

**How to use this information in a diagnostic manner?**

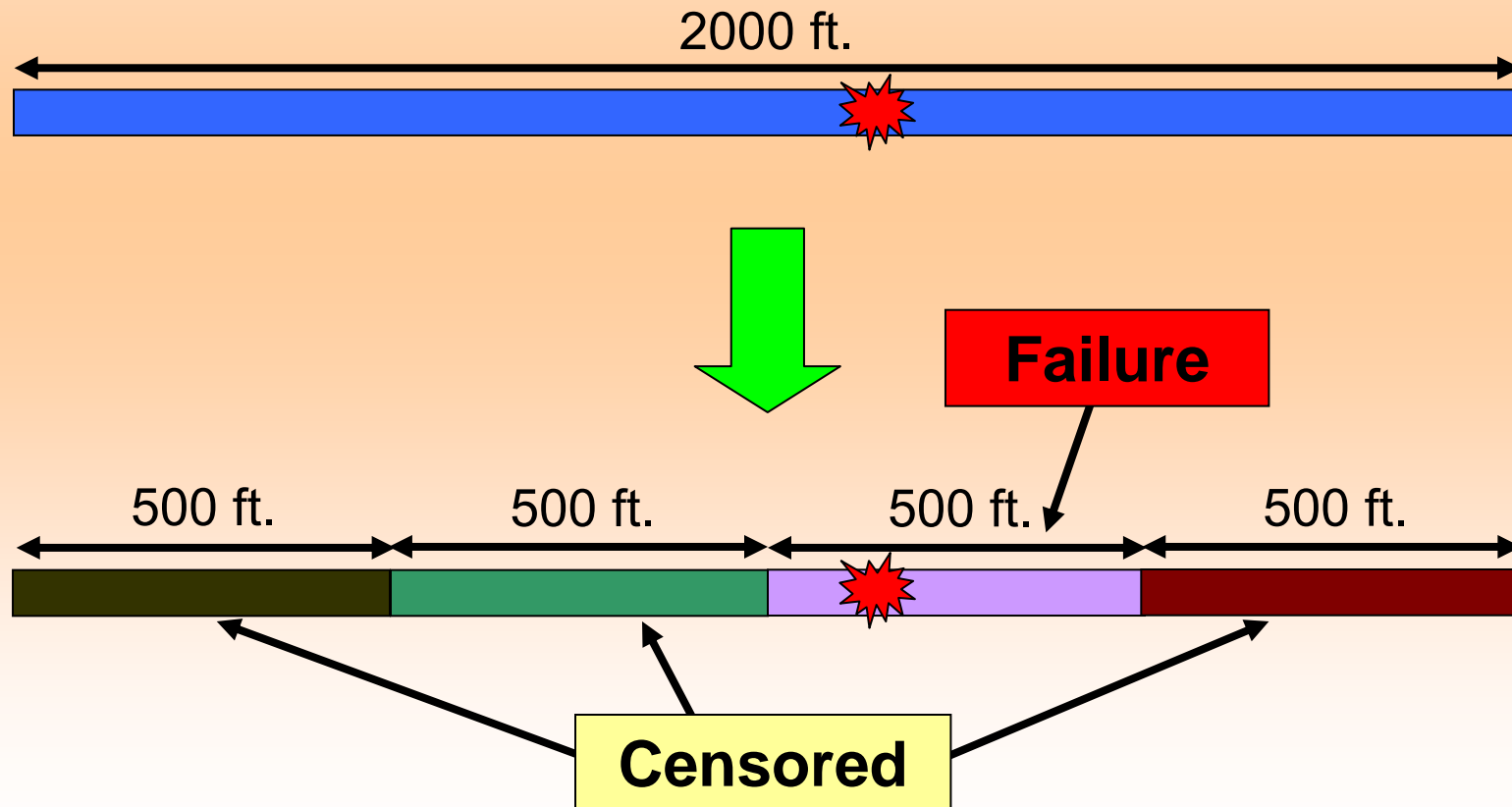
# Results of Withstand Tests

618 Conductor Miles Tested  
(one utility feeder cable system)

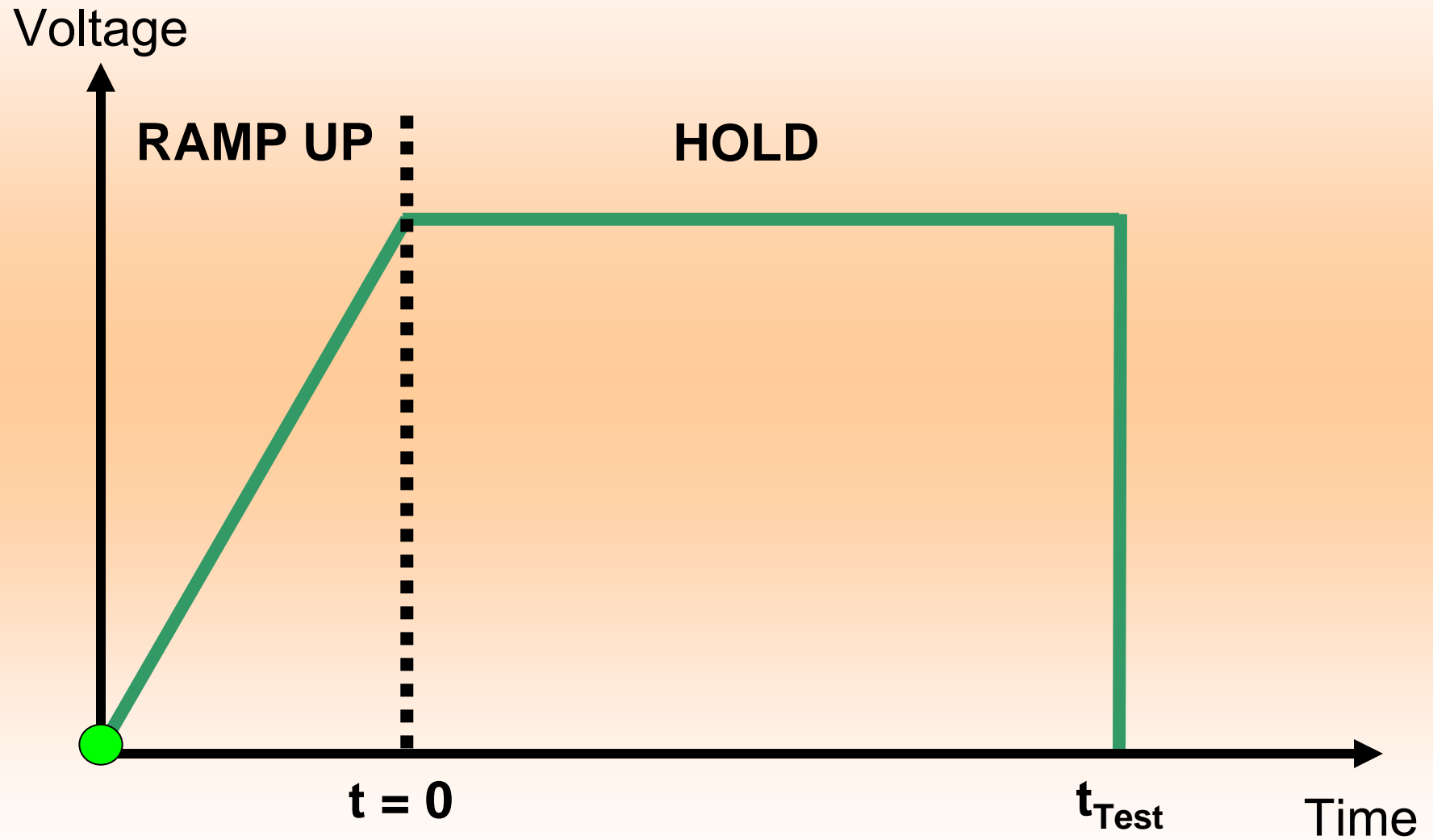


# Length Effects

- Withstand tests can be used to test long lengths of cable.
- Comparison of withstand failure on test rates must include length adjustments.

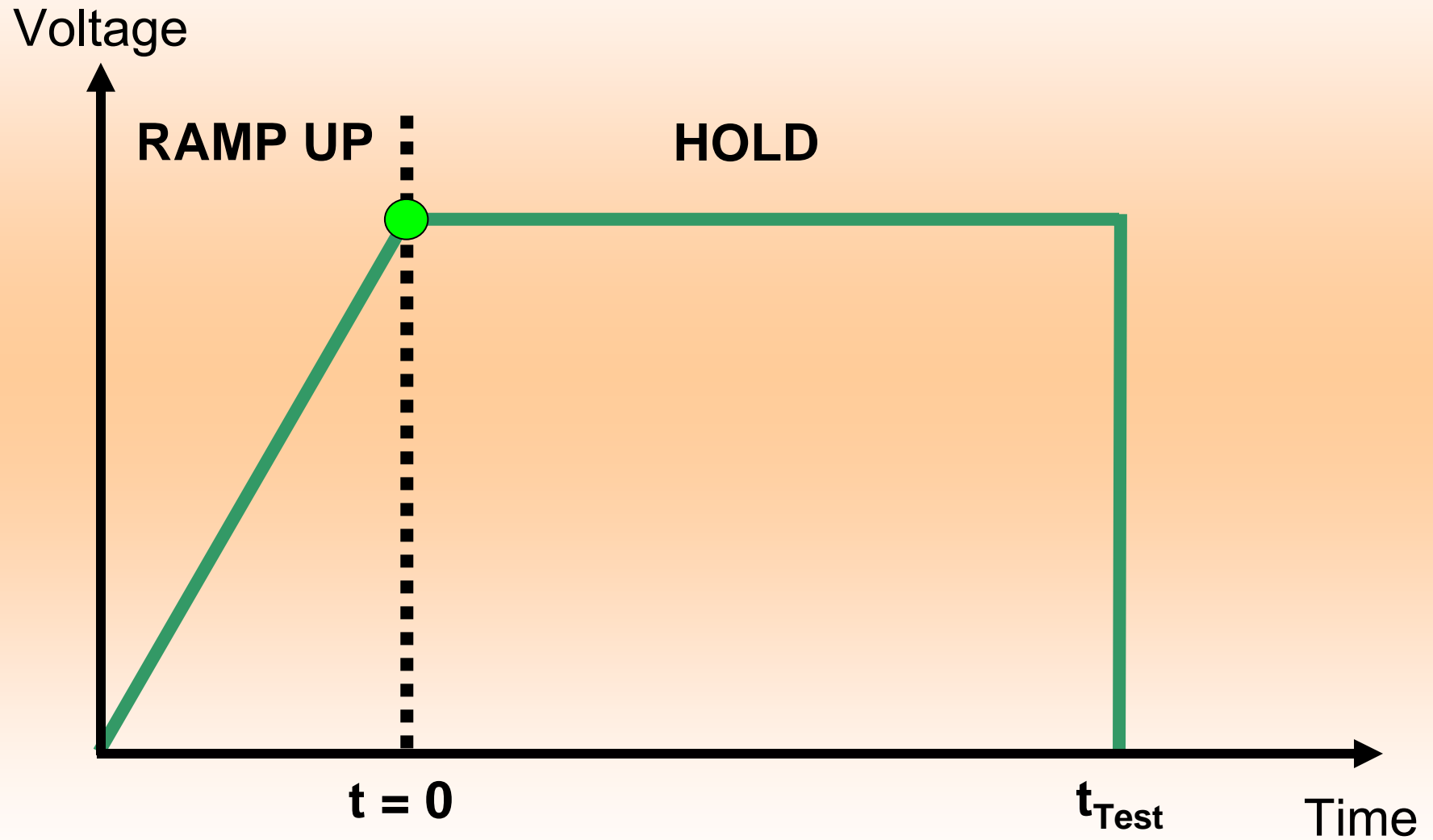


# Withstand Test Process



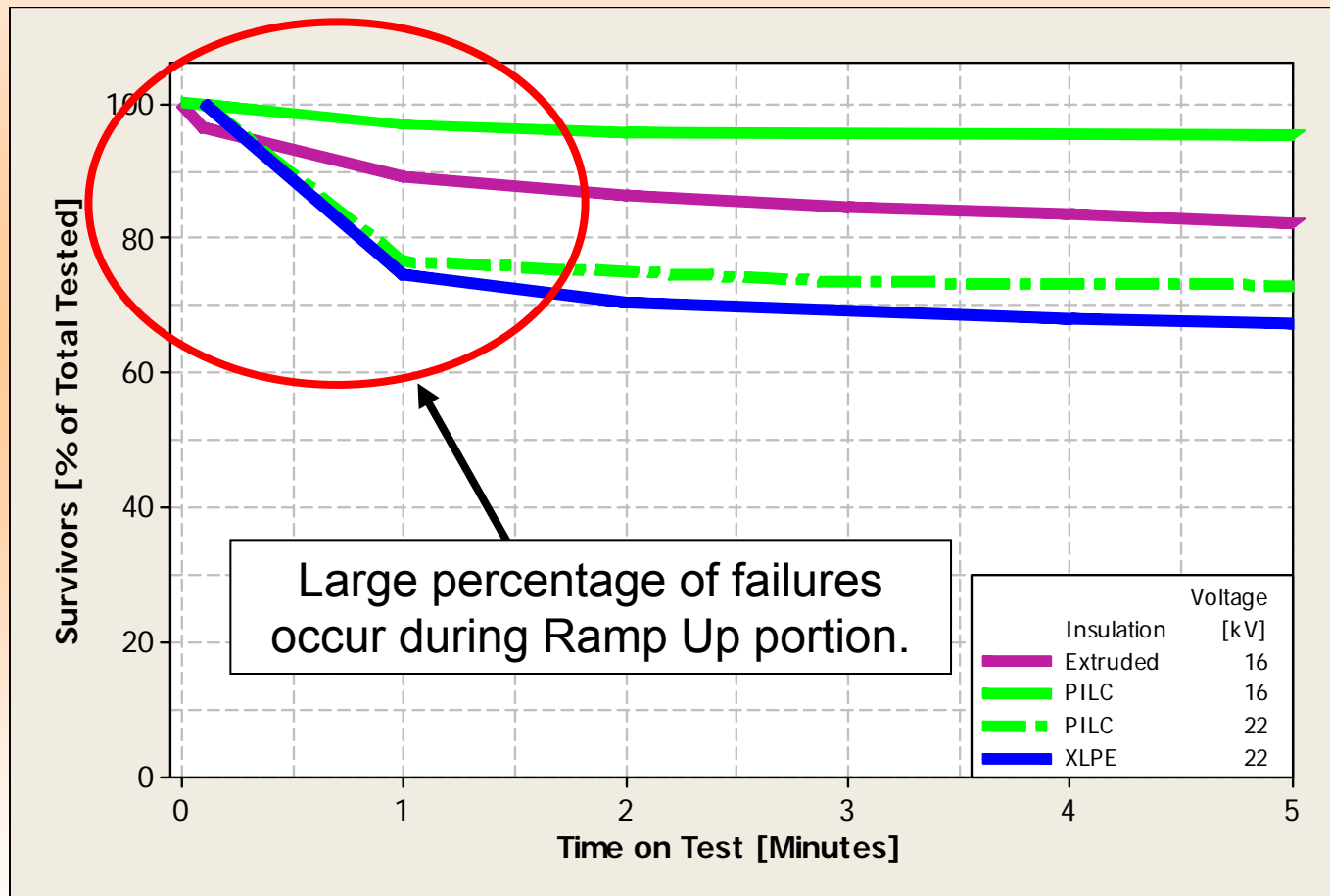


# Withstand Test Process



# Why “Hold” and “Ramp Up” Phases?

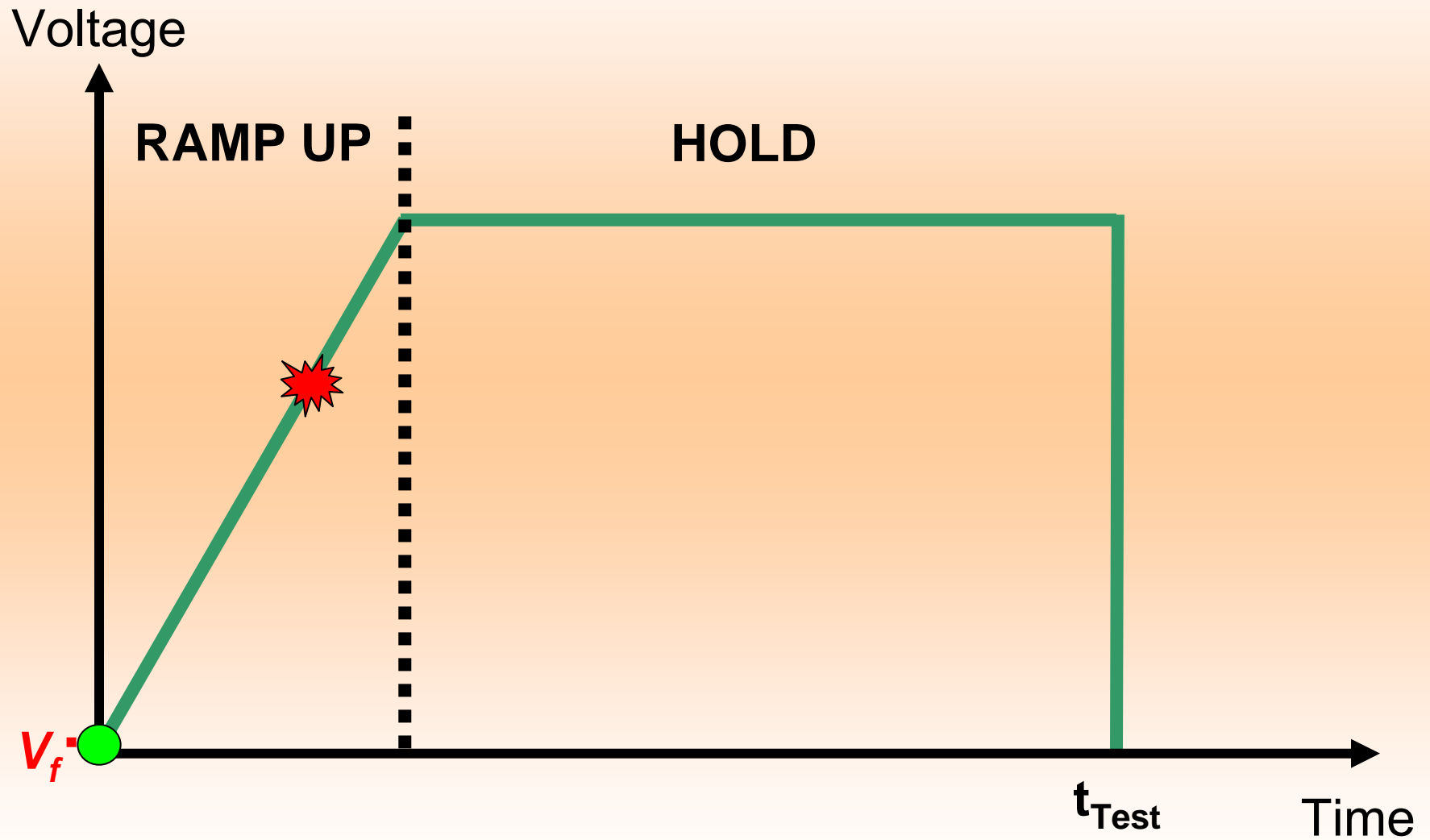
Focus is generally on the “Hold” phase but “Ramp Up” is important too.



# **“Ramp Up” Phase Diagnostic Features**

Getting up to test voltage is half the battle

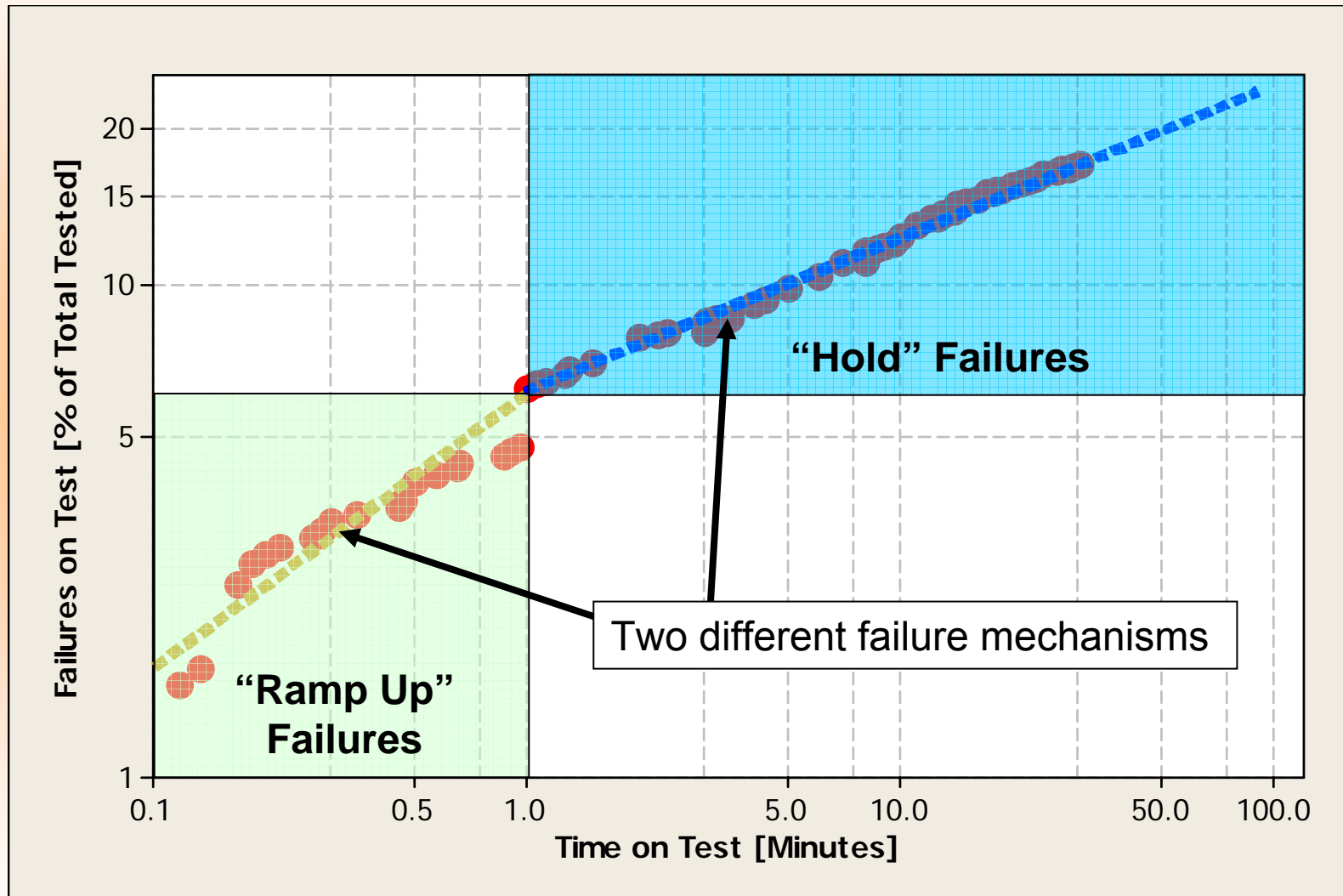
# “Ramp Up” Data



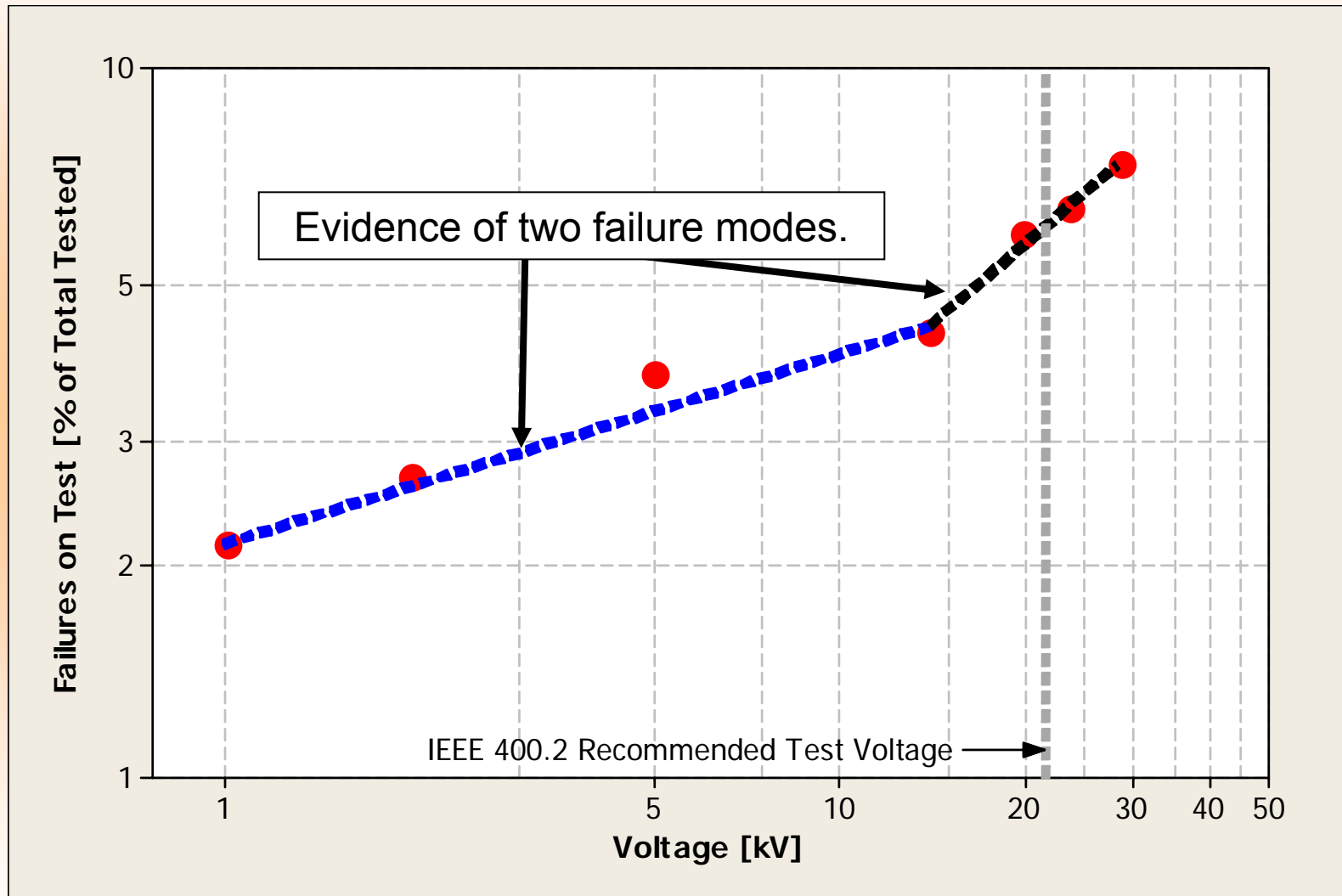
# Ramp Up Failures

- Failures during the “Ramp Up” phase have accounted for as much as **70%** of the total failures on test.
- The failure mechanism during “Ramp Up” phase is different from the “Hold” phase mechanism.

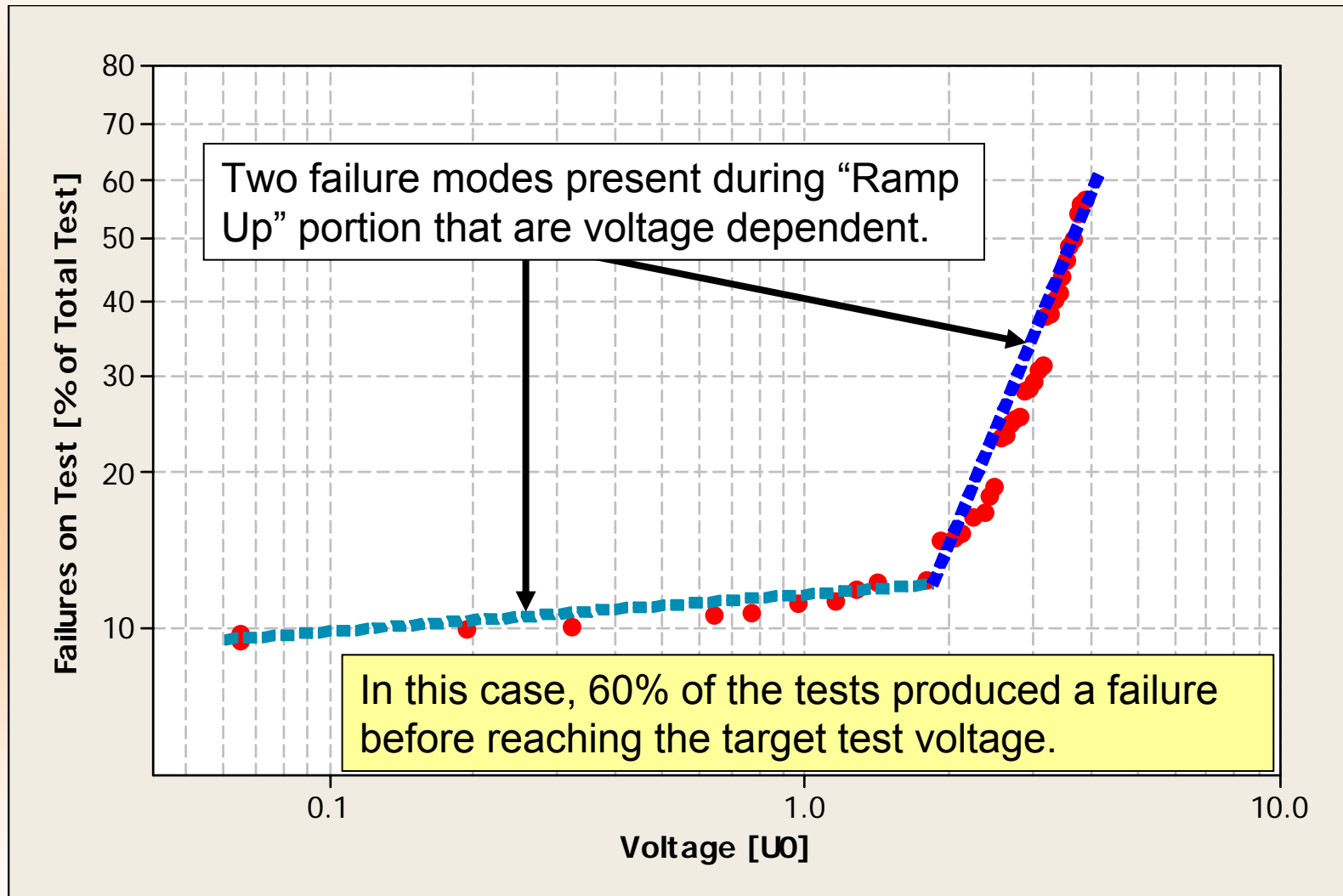
# “Ramp Up” and “Hold” Failure Mechanisms



# Weibull Curve – “Ramp Up” Failures (VLF)



# Weibull Curve – “Ramp Up” Failures (DC)

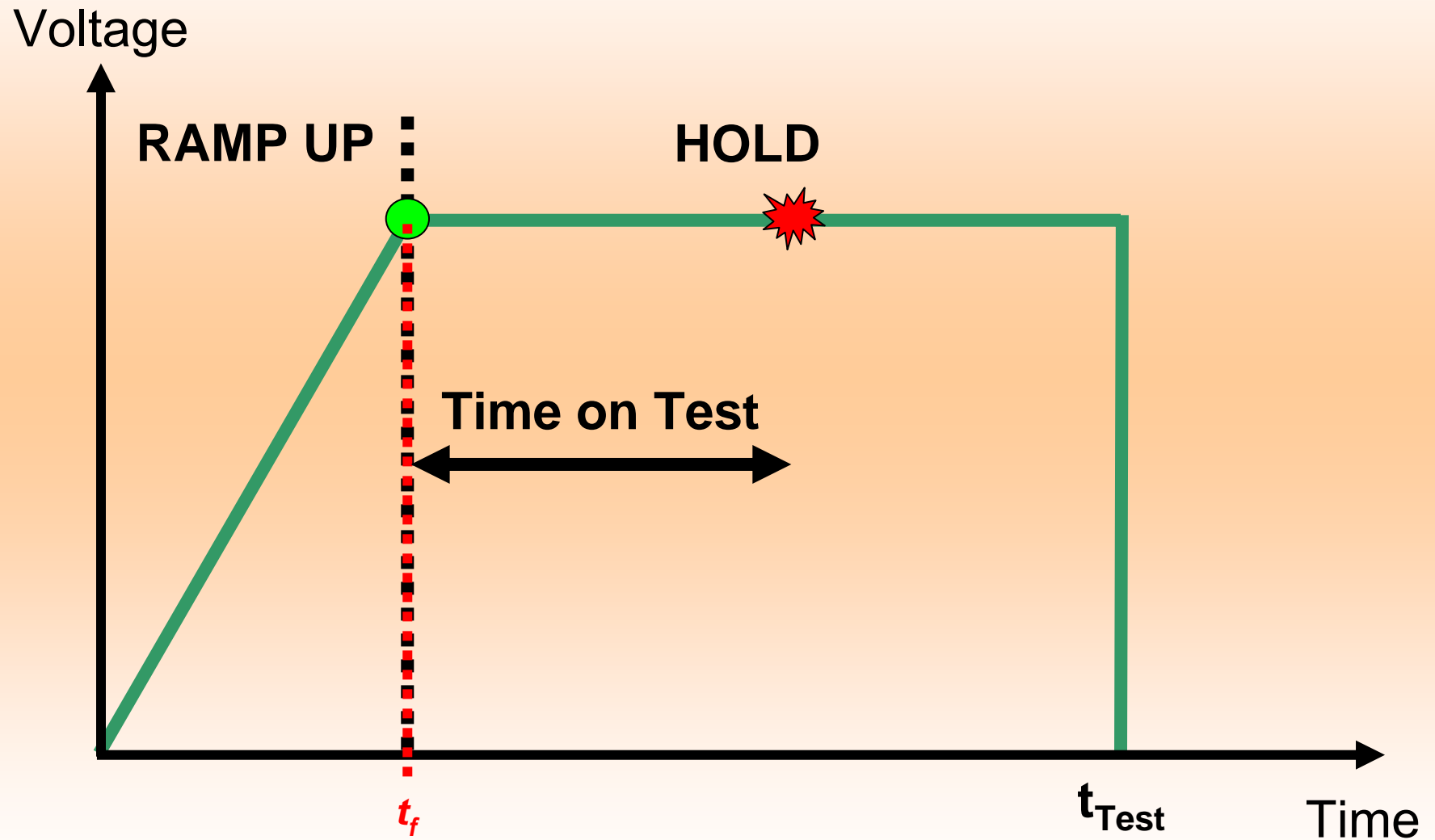




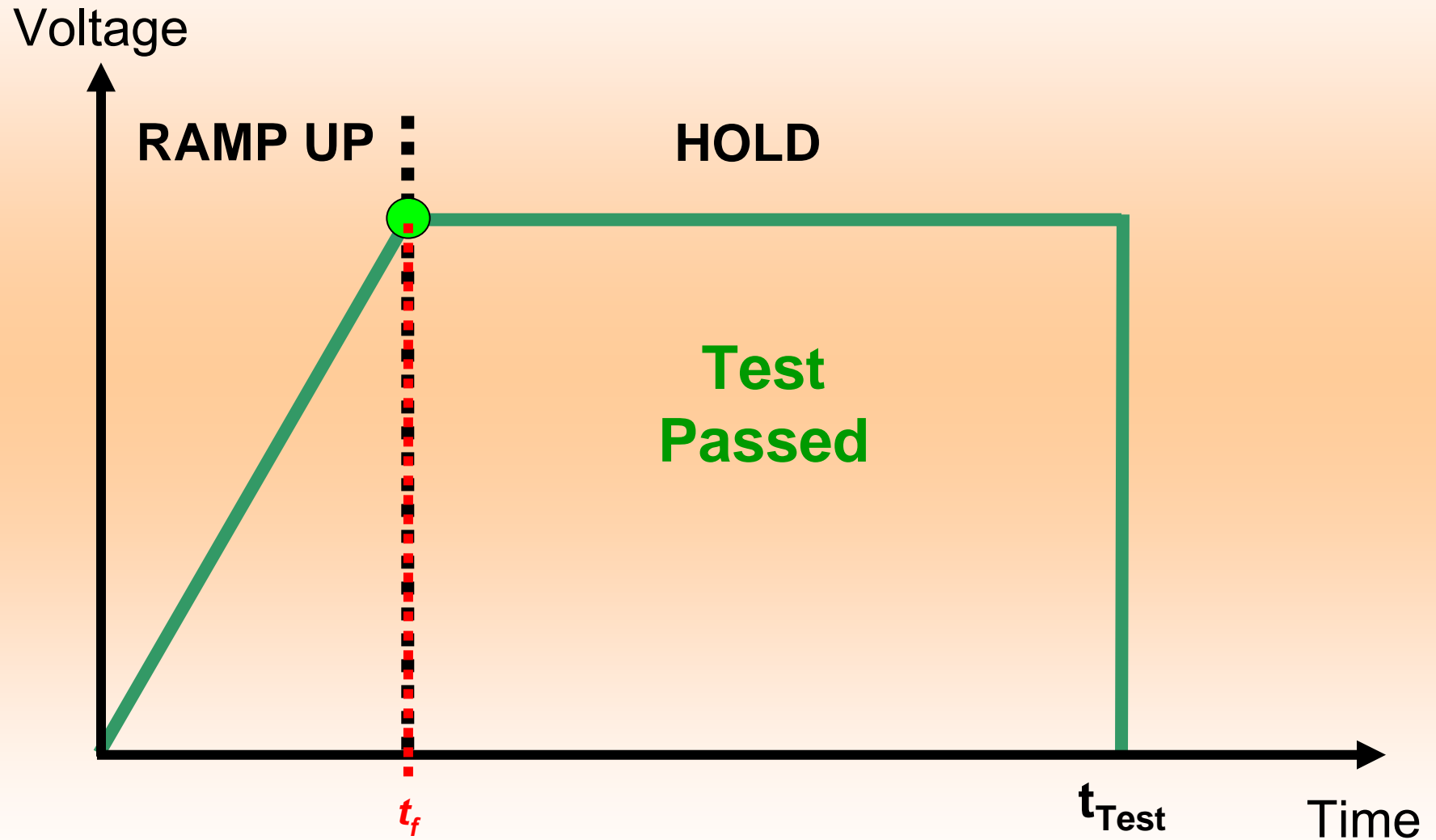
# **“Hold” Phase Diagnostic Features**

Time is everything

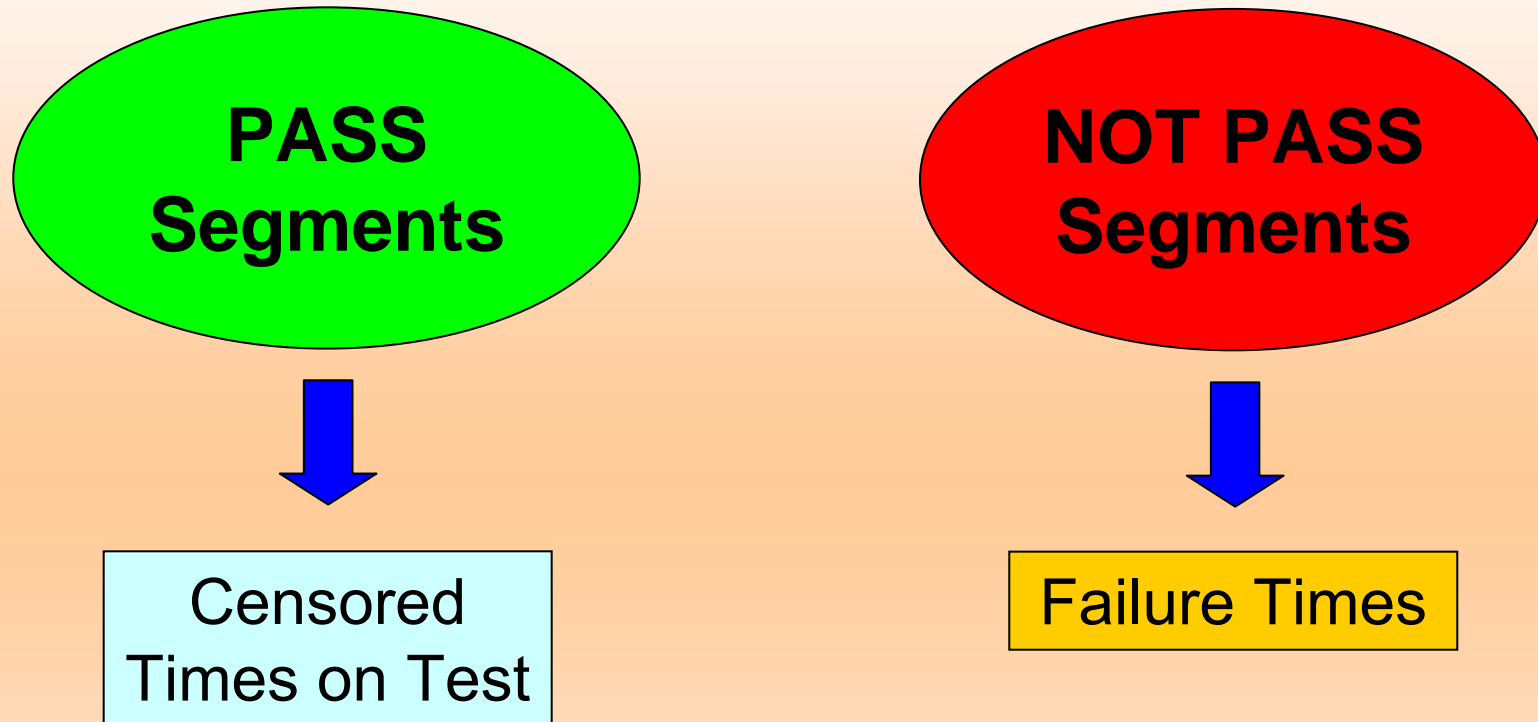
# “Hold” Data – Failure During Test



# “Hold” Data – Test Passes

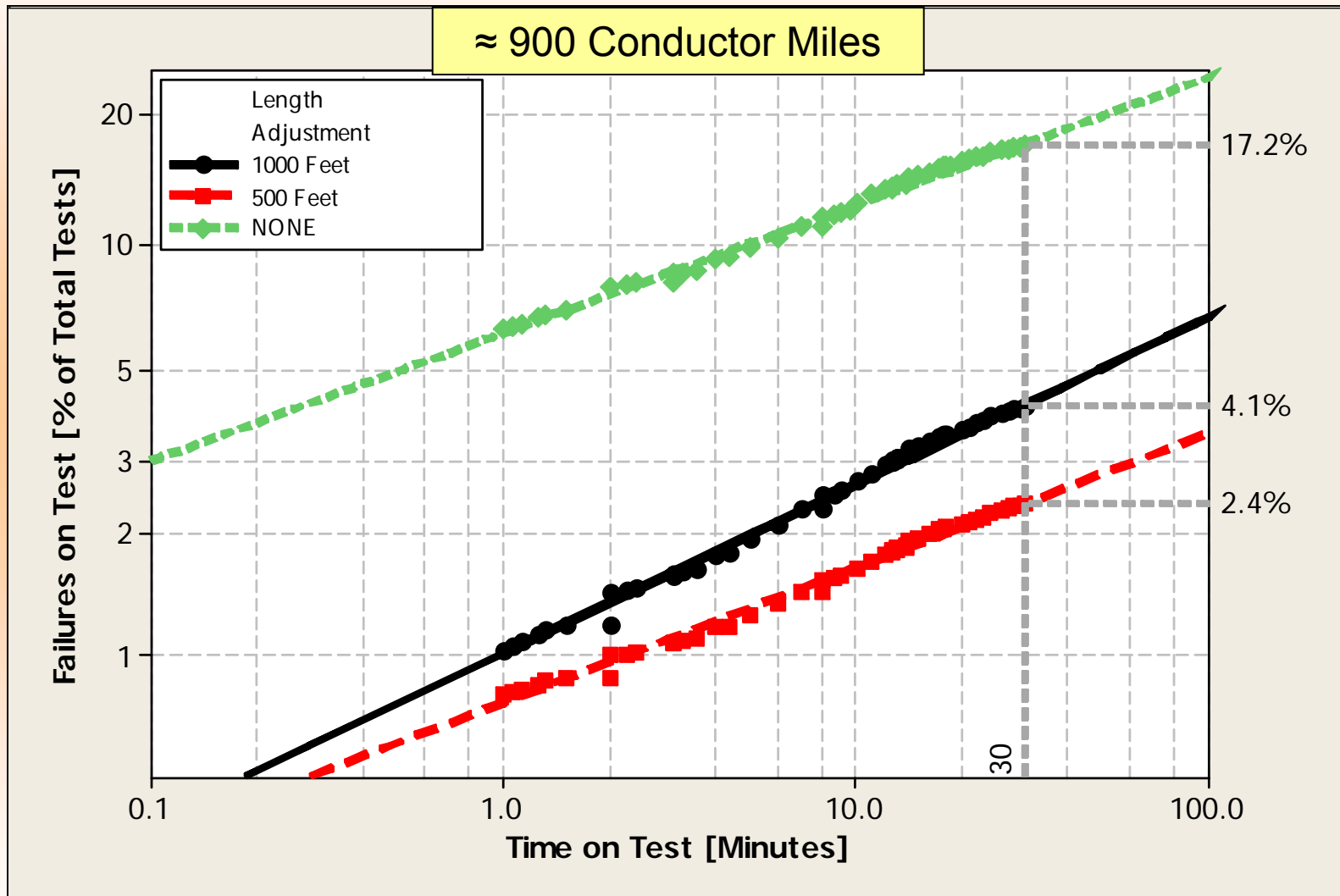


# Analysis of Times on Test

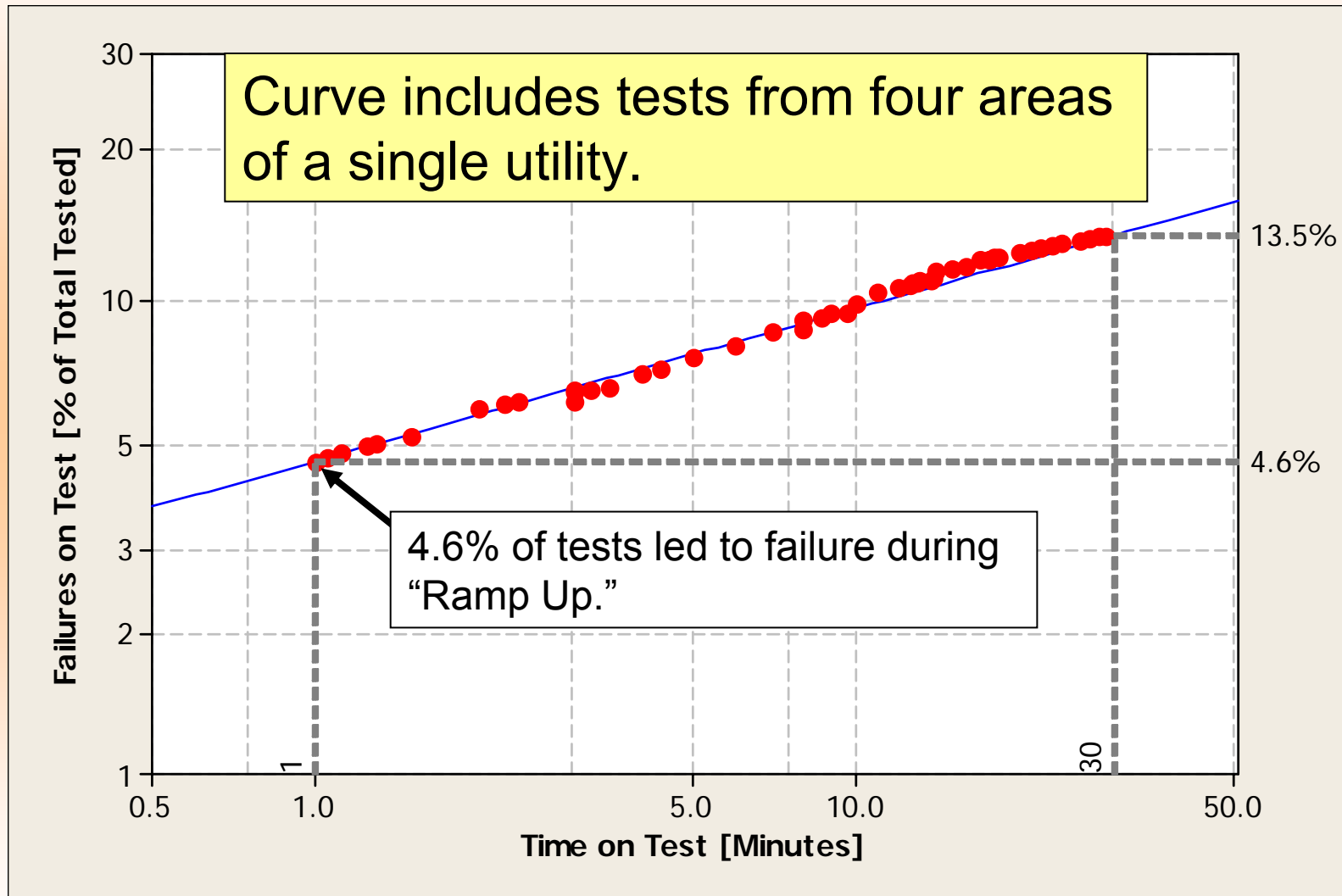


Use data to construct Weibull curves for different areas  
These curves represent a diagnostic feature.

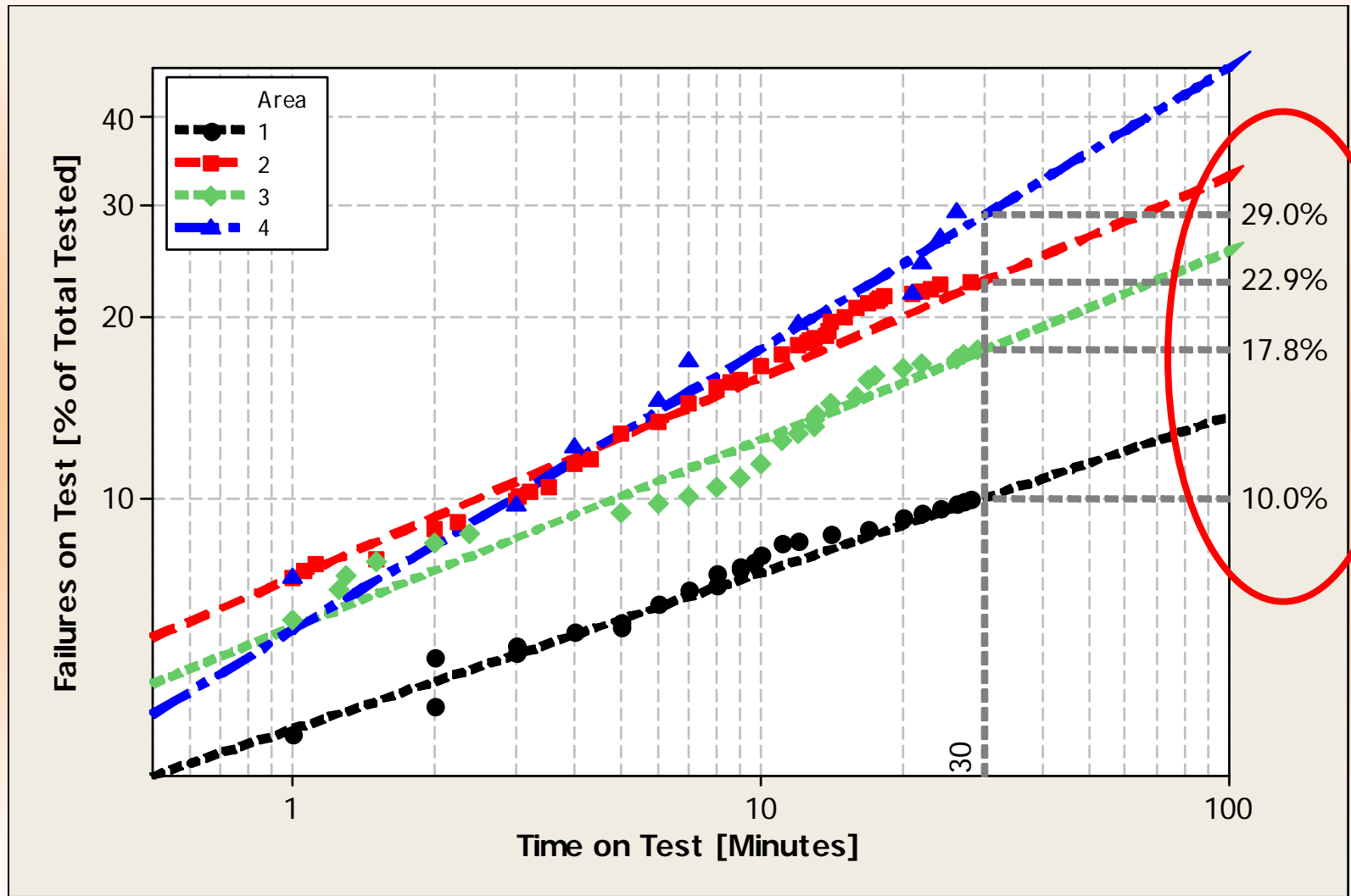
# Length Effect on Failures on Test



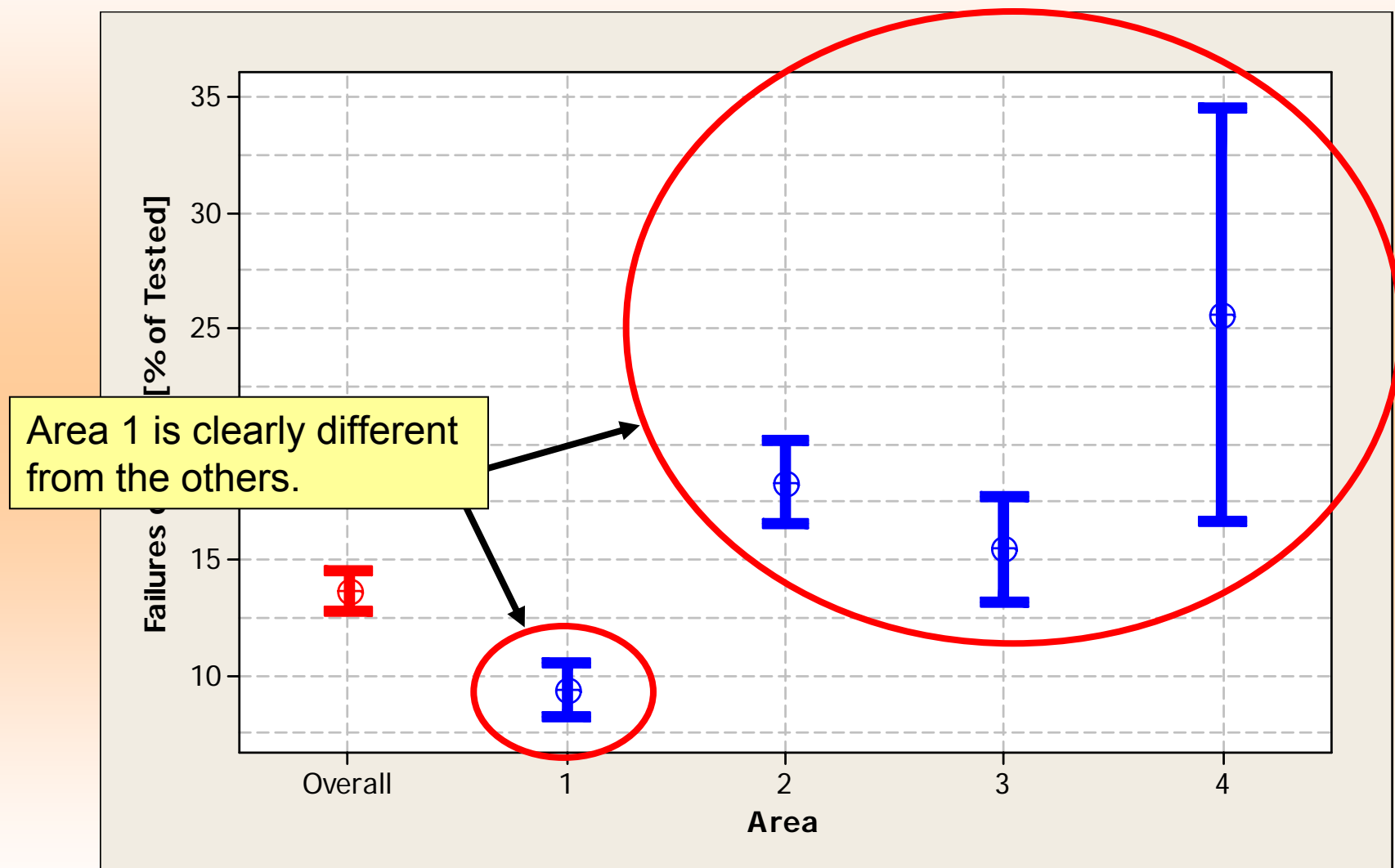
# System Subset (Length Adjusted)



# Weibull Curves by Area (Length Adjusted)



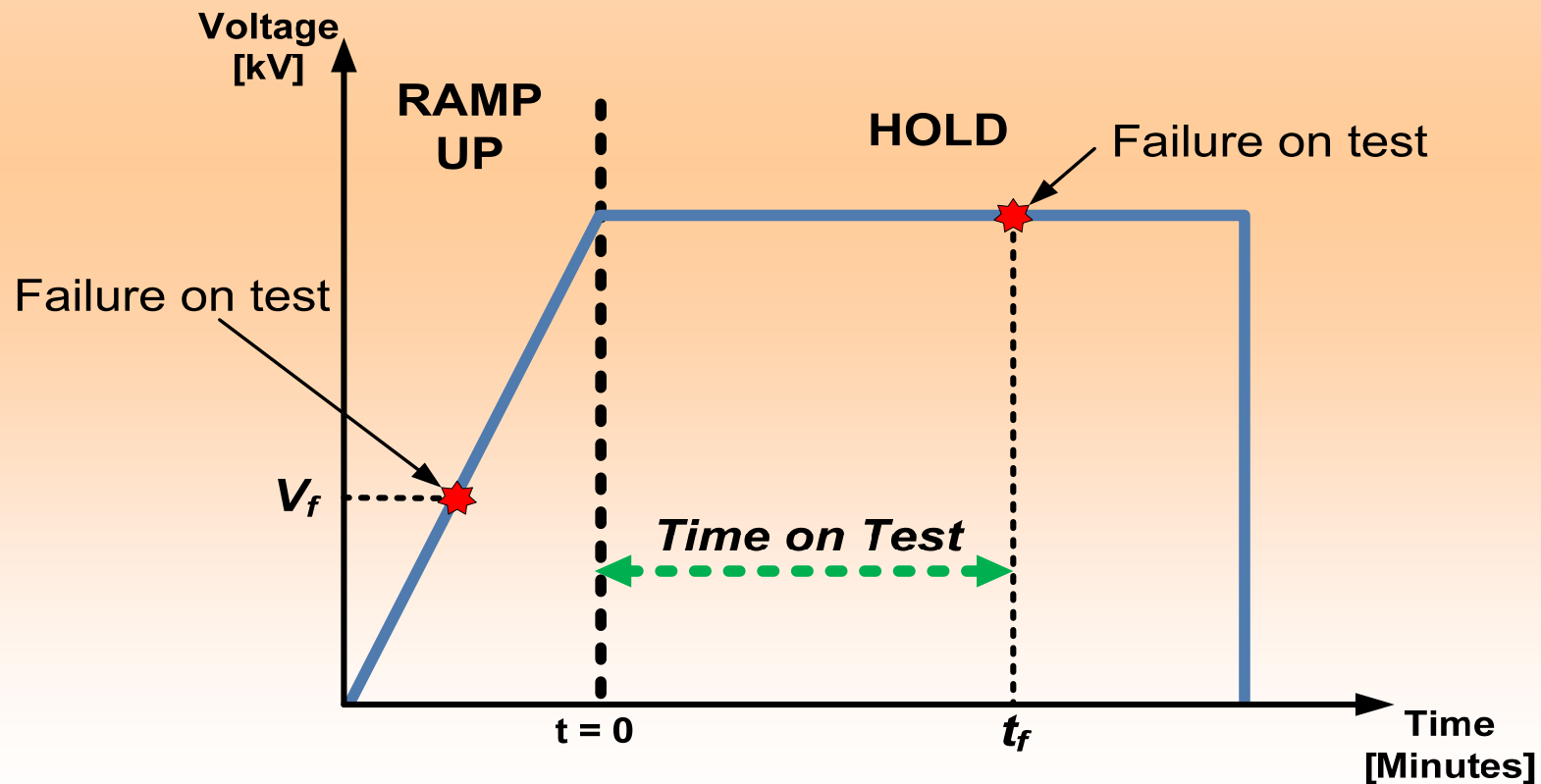
# Separation of Regions





# Recommendations

- Defined “Ramp Up” procedure should be employed with each test.
- Detailed records should be maintained.



# Conclusions

- Withstand tests consist of two phases:
  - “Ramp Up”
  - “Hold”
- A significant percentage of failures occur during “Ramp Up” phase.
- Useful diagnostic features can be derived from withstand data.
  - Voltage at failure (“Ramp Up”)
  - Time on test at final test voltage (“Hold”)
- Results can be used to prioritize areas for action.