BALL POWDER® Propellant Stabilizer Analysis

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2000 Joint Services Small Arms Symposium

August 29, 2000

Indianapolis, IN

Introduction

- BALL POWDER® Propellant background
- Accelerated aging method
- Long-term ambient storage
- Results from stabilizer analysis
- Conclusions

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BALL POWDER® Propellant Background

- Produced in US for over 60 years
- Single & double based propellants
- DPA stabilized propellants
- Leading propellant for US military small arms ammunition
- Stabilizer & Red Flume tests performed on all lots

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Accelerated Aging Test

- Accepted method of determining stabilizer depletion rates
- Assumption: stabilizer depletion mechanisms are same at +25°C as at test temperatures (+50, +60 & +70°C)

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Accelerated Aging Test

- Weaknesses:
  - Temperature independent depletion rate mechanism assumption
  - Log scale extrapolation required for determining depletion at 25°C
  - Single sample used to represent propellant
- Strengths
  - Can be completed in relatively short period

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Long-Term Ambient Storage

- Retainer samples maintained form production lots
- Powder samples stored in unconditioned magazine
- Stabilizer levels measured periodically

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Analysis of Ambient Storage Samples

- Initial stabilizer reported on lot certification
- Stabilizer level periodically analyzed on retainer samples
- DPA, nnDPA, 2NDPA & 4NDPA measured to obtain total stabilizer
- Percentage of stabilizer remaining vs. time demonstrates linear relationship
- Ambient stabilizer depletion rate estimated

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Long-Term Ambient Storage

- Weaknesses:
  - Length of time to complete
- Strengths:
  - True measure of stabilizer depletion under realistic storage conditions
  - Many samples from different lots tested

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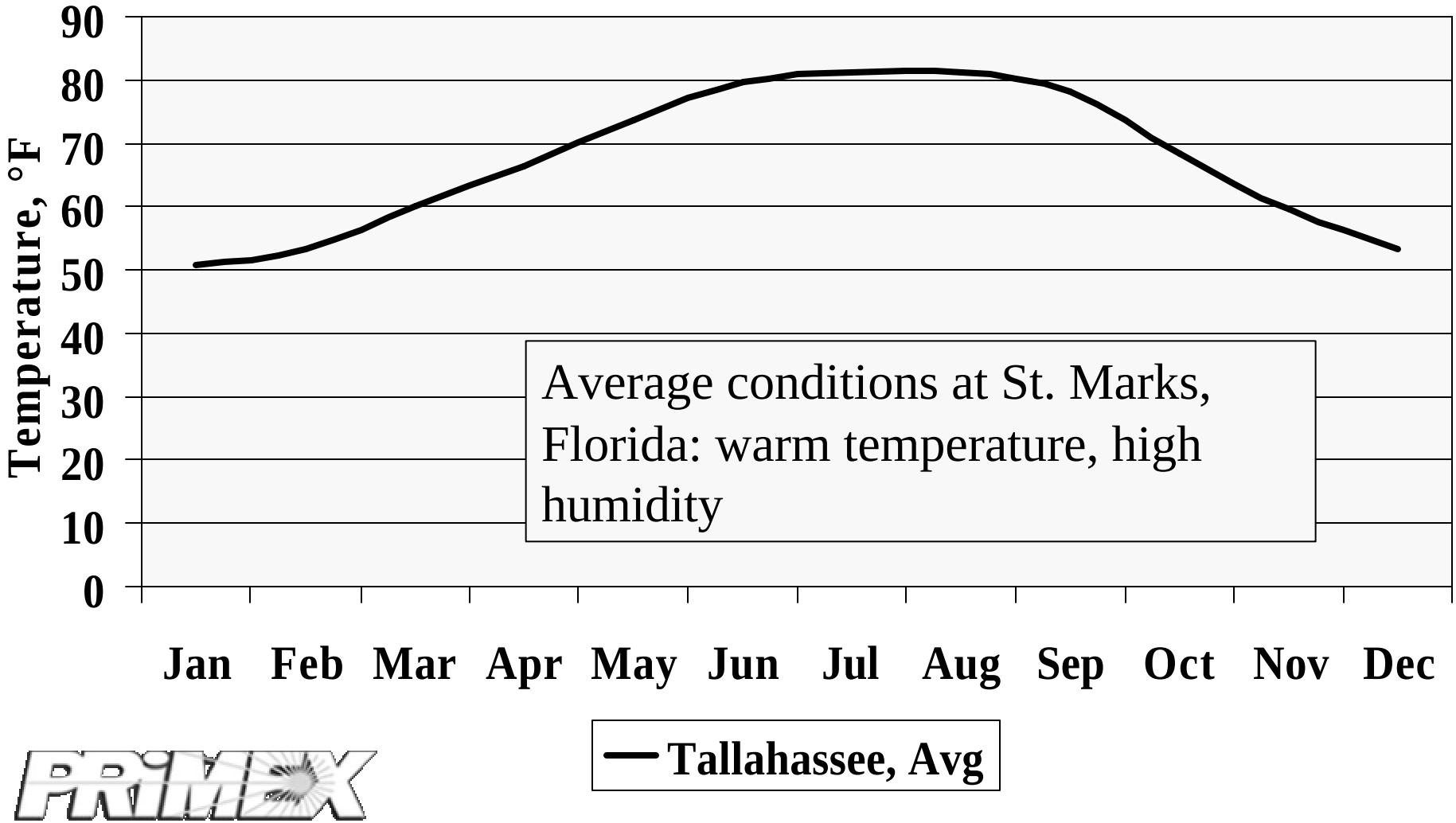
Temperature Summary

{NCDC Averages: 1961-1990}



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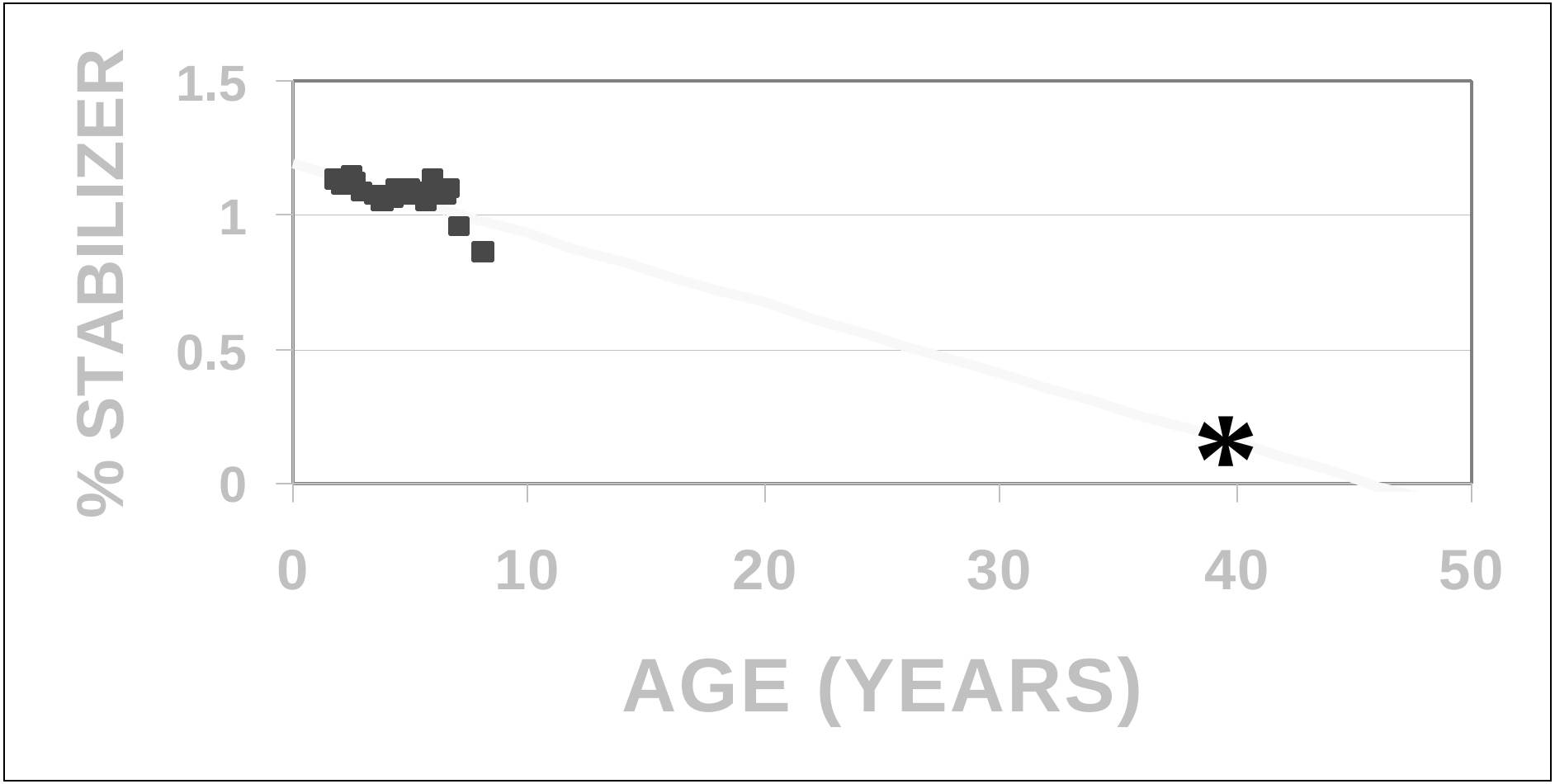
WPR® 289 Propellant



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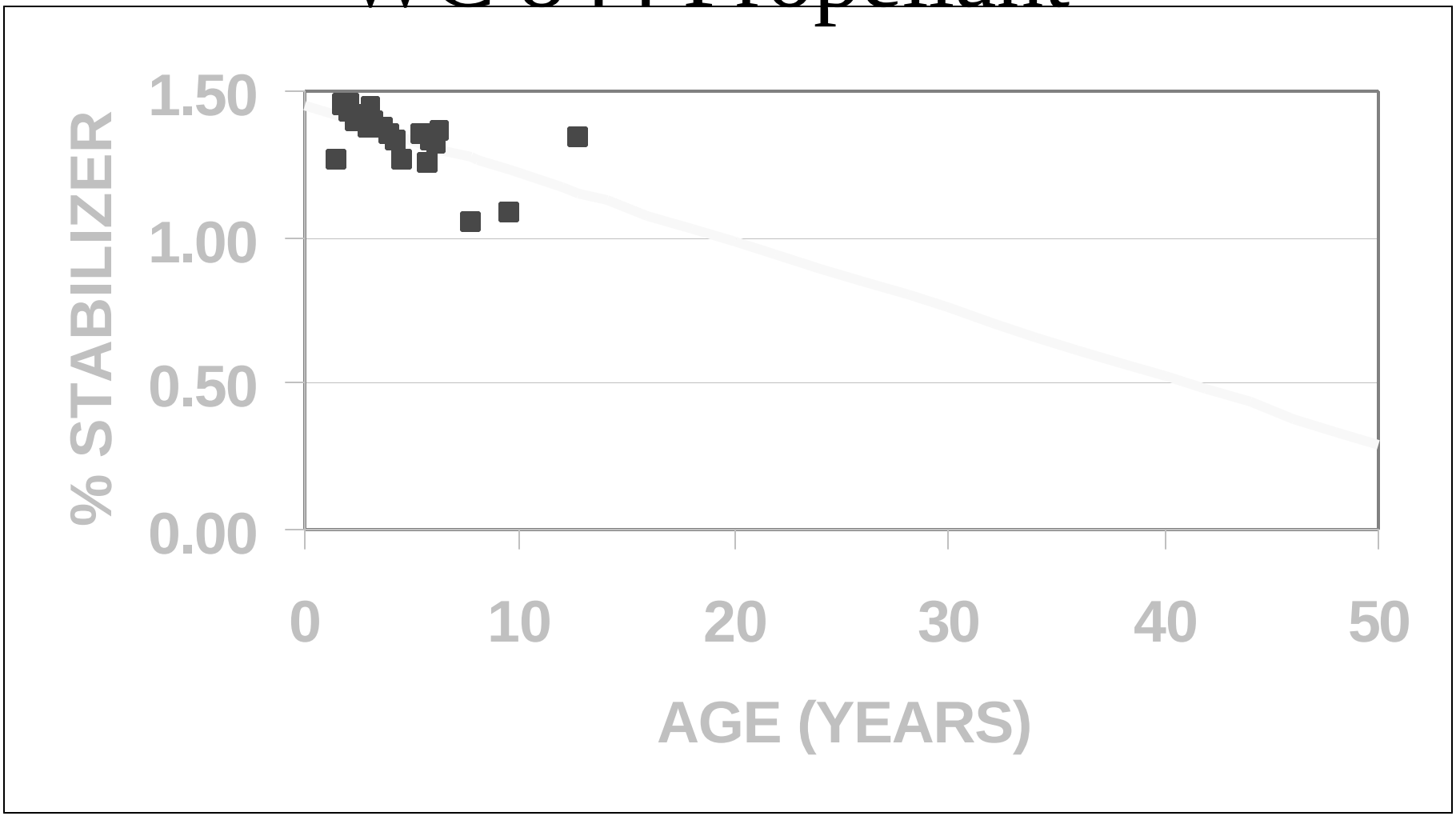
Total Stabilizer: DPA+0.854nnDPA+0.79(2NDPA +4NDPA)

WC 844 Propellant



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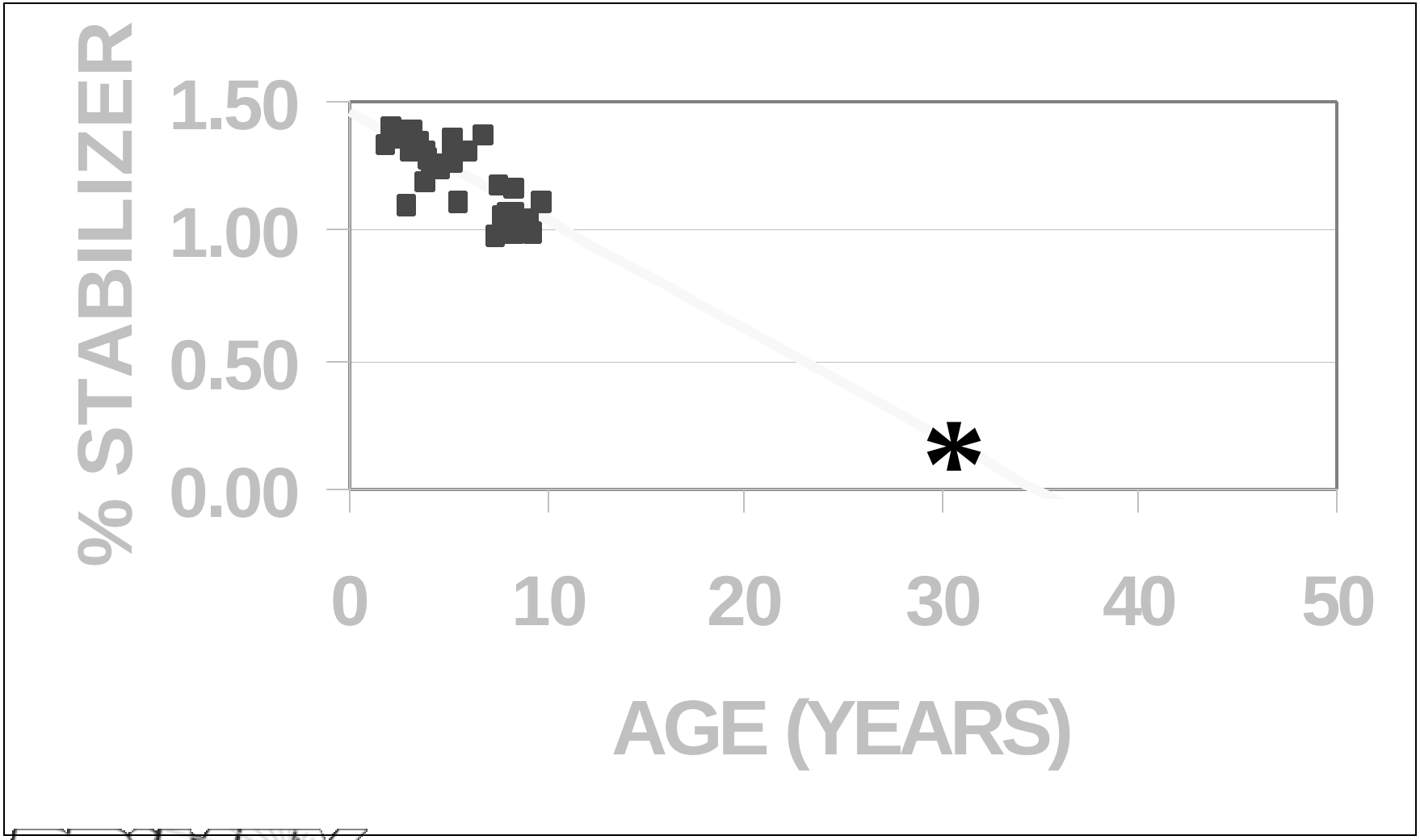
Total Stabilizer: DPA+0.854nnDPA+0.79(2NDPA +4NDPA)

WC 859, WC 860, WC 867, WC 872



PRIMEX TECHNOLOGIES

Total Stabilizer: DPA+0.854nnDPA+0.79(2NDPA +4NDPA)

Conclusions

- Ambient long-term storage test
  - Generates accurate stabilizer depletion rates for ambient storage conditions
  - Linear extrapolation based on multiple samples
- Accelerated aging methods
  - Requires assumption on depletion rate mechanism
  - Requires logarithmic extrapolation, making results sensitive to small fluctuations in data
  - Single sample tested for propellant type

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Conclusions

{Continued}

- Long term stabilizer sampling provides a preferred predictor of propellant shelf life under realistic conditions.
- Ambient long term storage tests demonstrate that BALL POWDER® propellants for small arms have a shelf-life in excess of 30 years

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