

M-Disc Lifetime Testing

A Review of the Methods and Standards for Estimating Lifetime of Optical Data Storage Discs

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Introduction to M-Disc

- M-Disc is produced by Millenniata, Inc.
 - Millenniata is partnered with Hitach-LG Data Storage (HLDS)
 - HLDS is the #1 manufacturer of optical disc drives
 - Over 1,300,000 M-Disc compatible drives each month
 - Millenniata has two manufacturing partners:
 - Northern Star located in Europe
 - Ritek in Taiwan
- Millenniata is focused on Permanent Digital Data Storage Technologies
- M-Disc DVD is a new format that we call DVD+M
- DVD+M is a DVD+R-compatible format

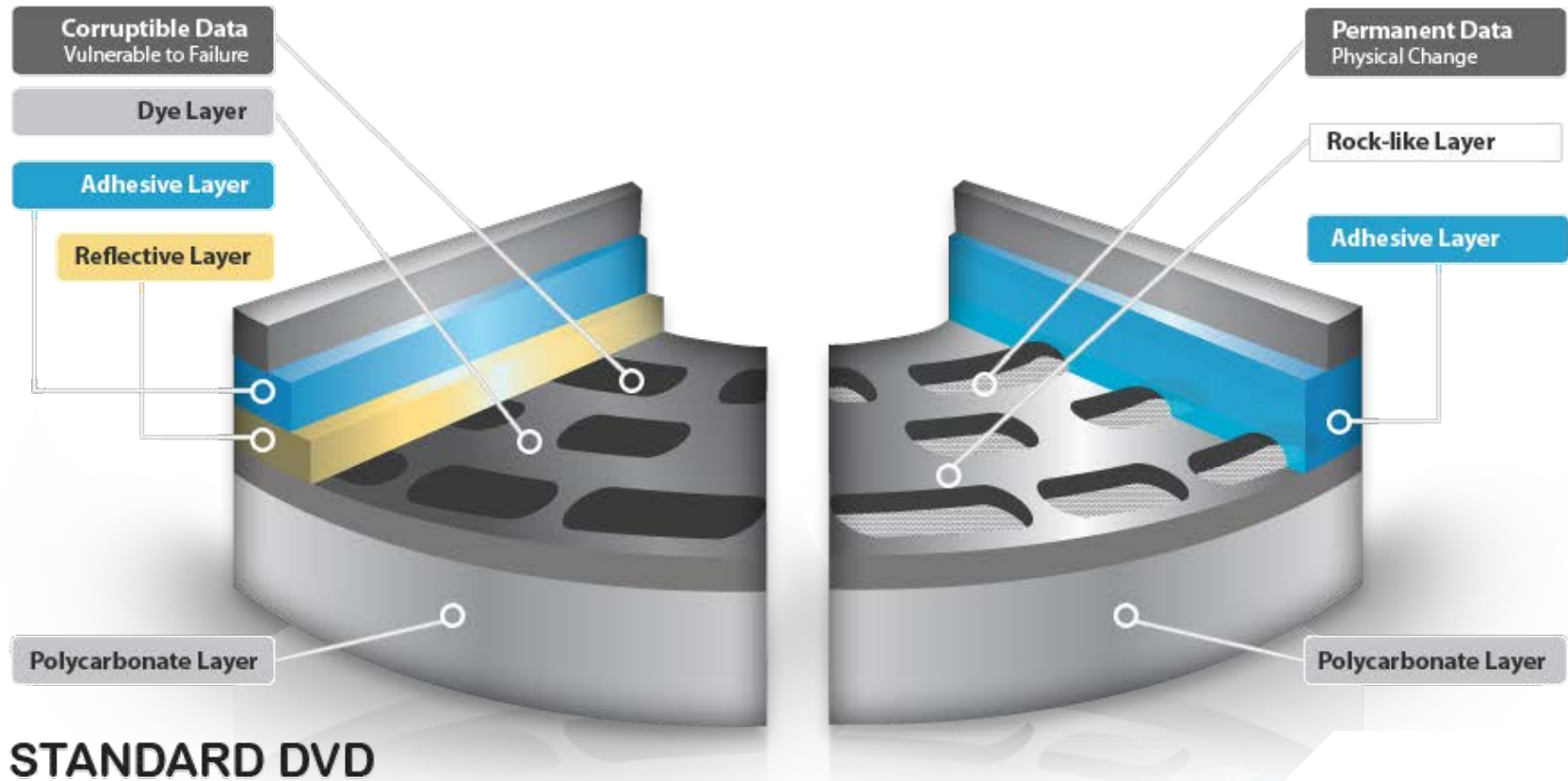
Introduction to M-Disc

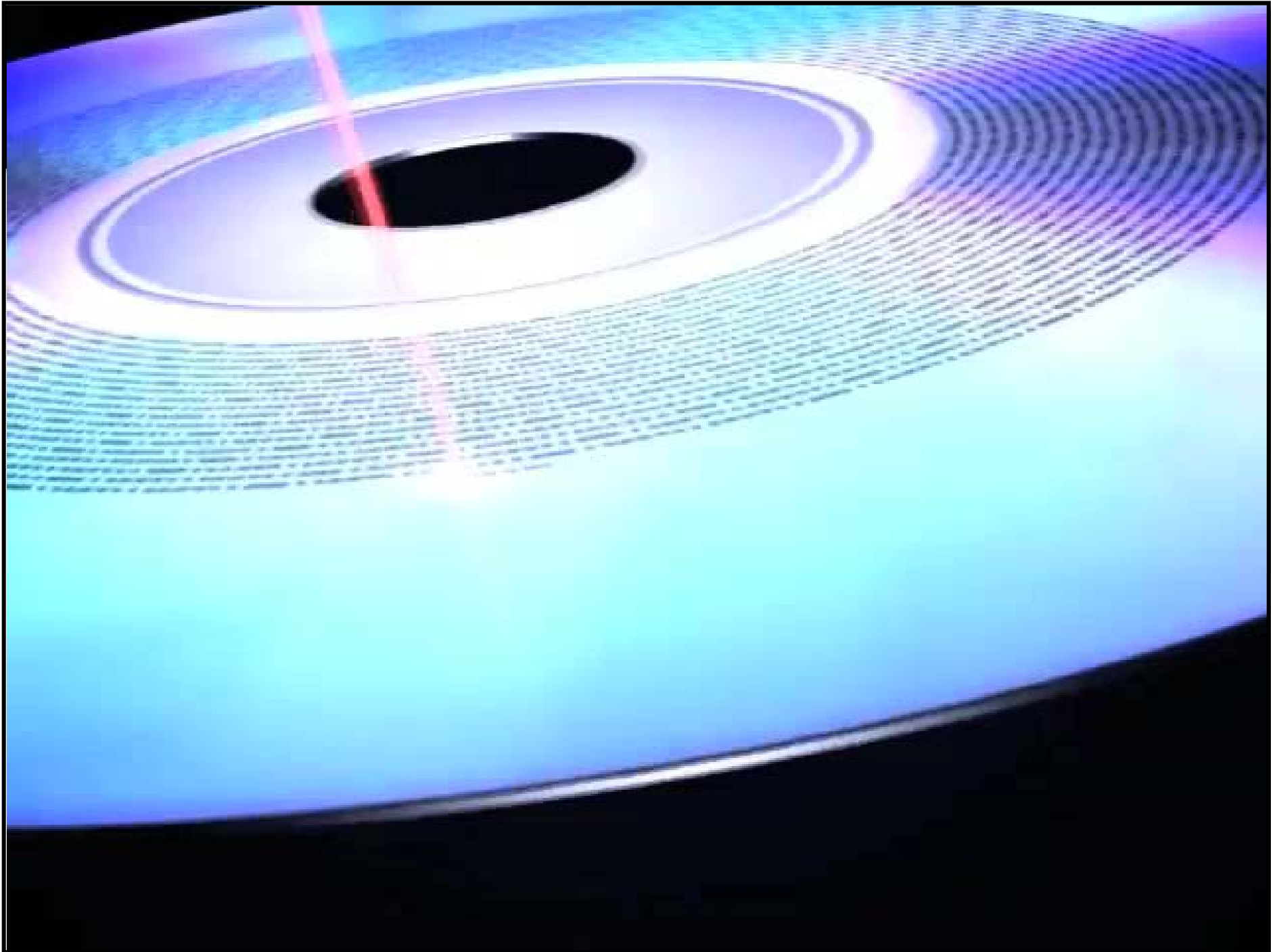
- M-Disc is coming to market through multiple channels
- Announced Partners Include:
 - Dell Computer & ACER Computer
 - DuTec
 - LG
 - Other world-wide distribution and branding agreements are pending
- European Channels
 - API, CONRAD, REDCOON, RINGFOTO , SYSTEAM, WAVE, BIDUL
 - Other European Distributors are pending
- World-wide availability in the next 6 months

Accelerated Life Time Testing

- Major Optical Disc Failure Mechanisms
 - Data Layer Failure
 - Delamination
 - Mechanical distortion
 - Disc warping
 - Tilt
 - Photochemical effects (environmental UV exposure primarily)
- Standard accelerated life testing only addresses Data Layer Failure
 - chemical reactions such as oxidation of materials
- M-Disc takes steps to address all failure mechanisms

Physical versus Chemical Change





Permanence requires mechanical strength

Accelerated Life Time Testing

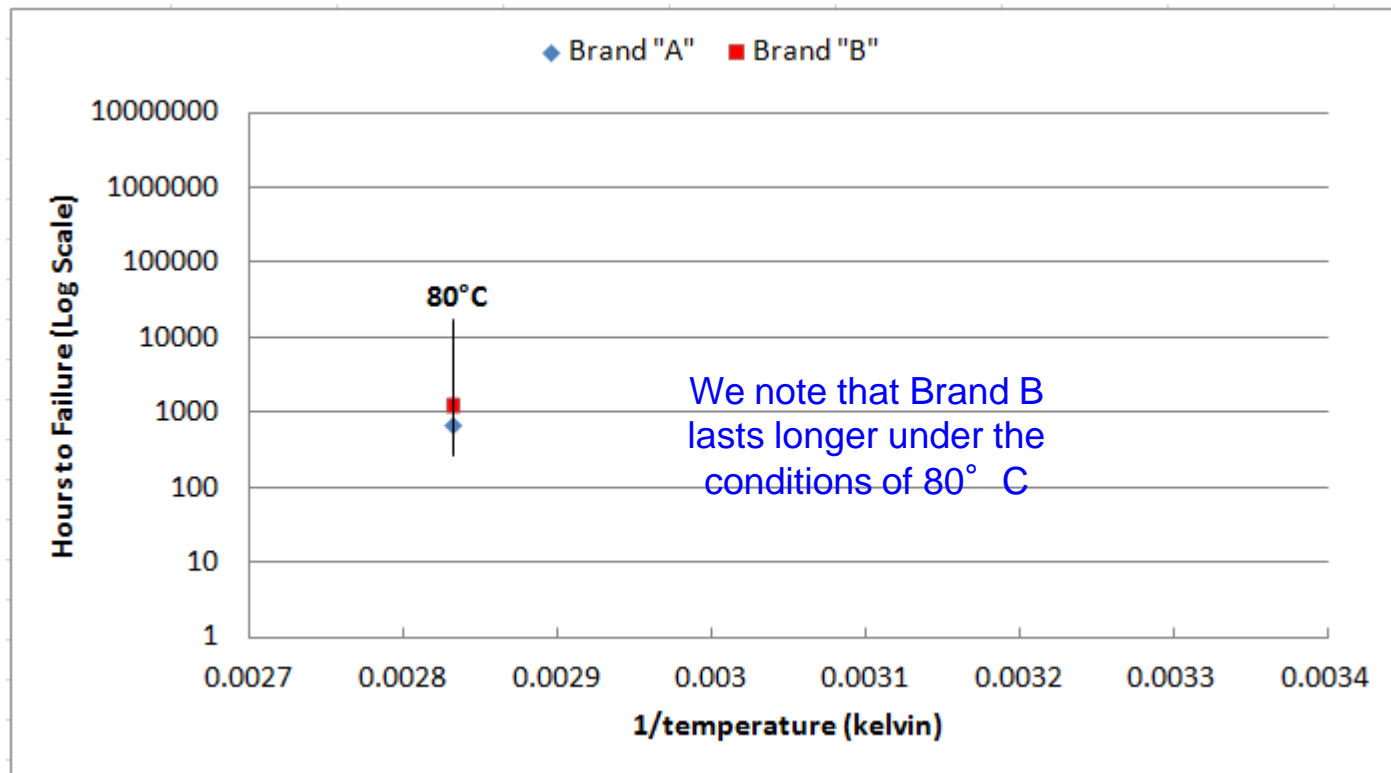
- Accelerated Lifetime testing assumes a stable aging process.
 - Changes in temperature and other environmental conditions do not introduce new chemical reactions to the aging process.
- The Arrhenius and Eyring methods are based on this assumption.
- These methods require:
 - Multiple test conditions ((combinations of heat & humidity)
 - The product aging behavior is log-linear under the test condition
 - An acceleration of the aging reaction rate through elevated temperature and/or humidity.

Accelerated Life Time Testing

- The Arrhenius method applies to high temperature stress conditions only.
- The Eyring method applies to multiple simultaneous stress conditions (heat & humidity).
- Both methods require the definition of a failure point
- The application of these test methods to optical discs is standardized under ISO 10995 and ISO 16963
- Both ISO standards specify:
 - Multiple Test Conditions
 - Verification of linearity of behavior under test
 - DVD Failure Point is $PISum8 = 280$

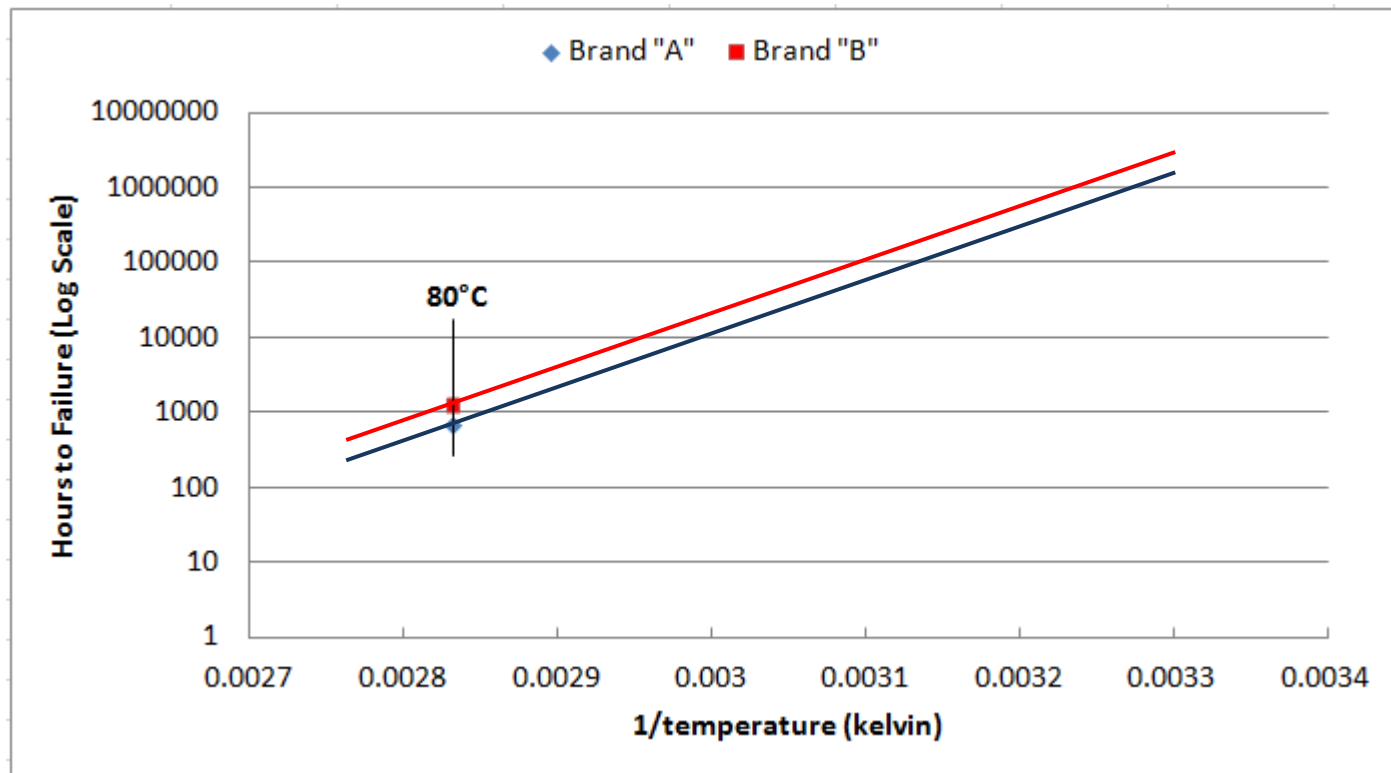
Understanding Lifetime Testing

In order to understand the importance of adhering to the ISO standards, let us consider an example of 2 brands of DVD's tested to failure under high temperature (80° C) conditions



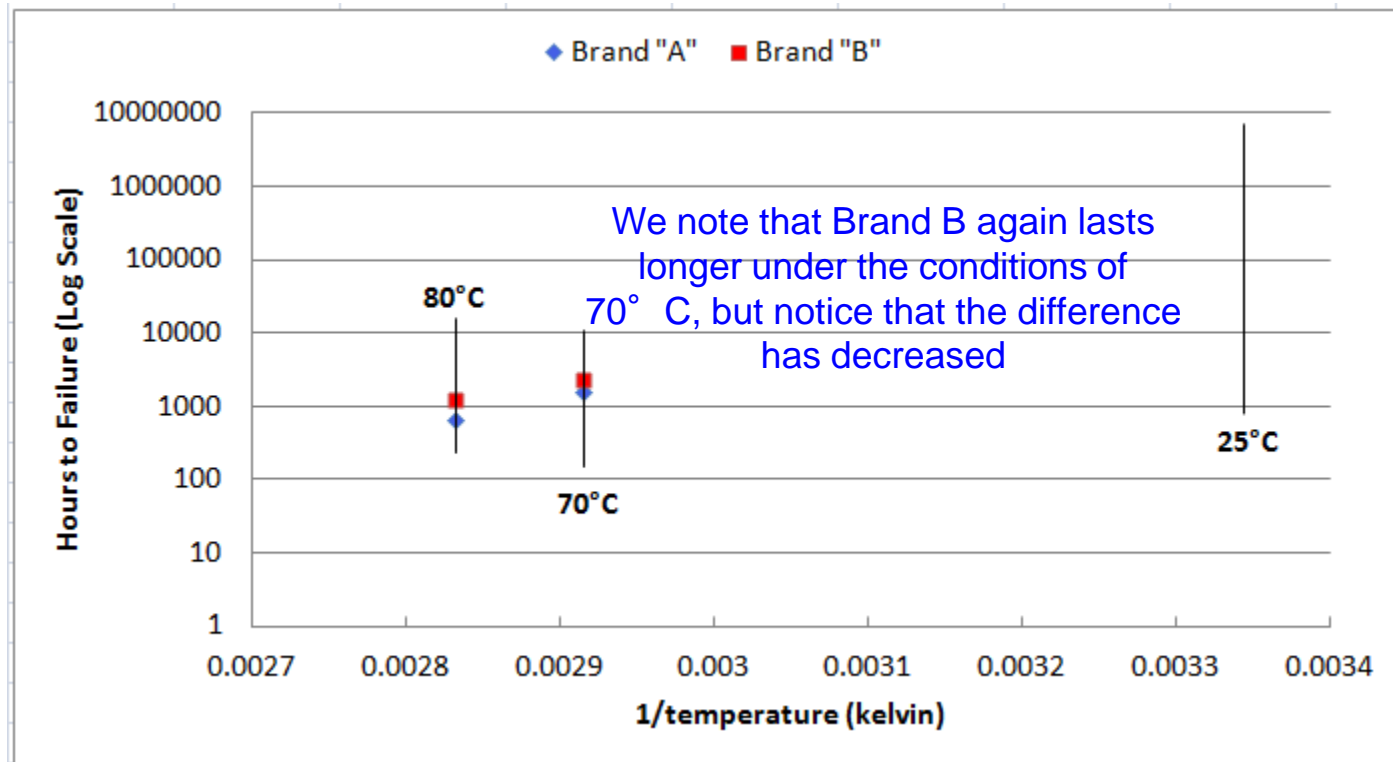
Understanding Lifetime Testing

If Brand "B" also has a longer lifetime at lower temperatures, we would expect to see results similar to those depicted below.



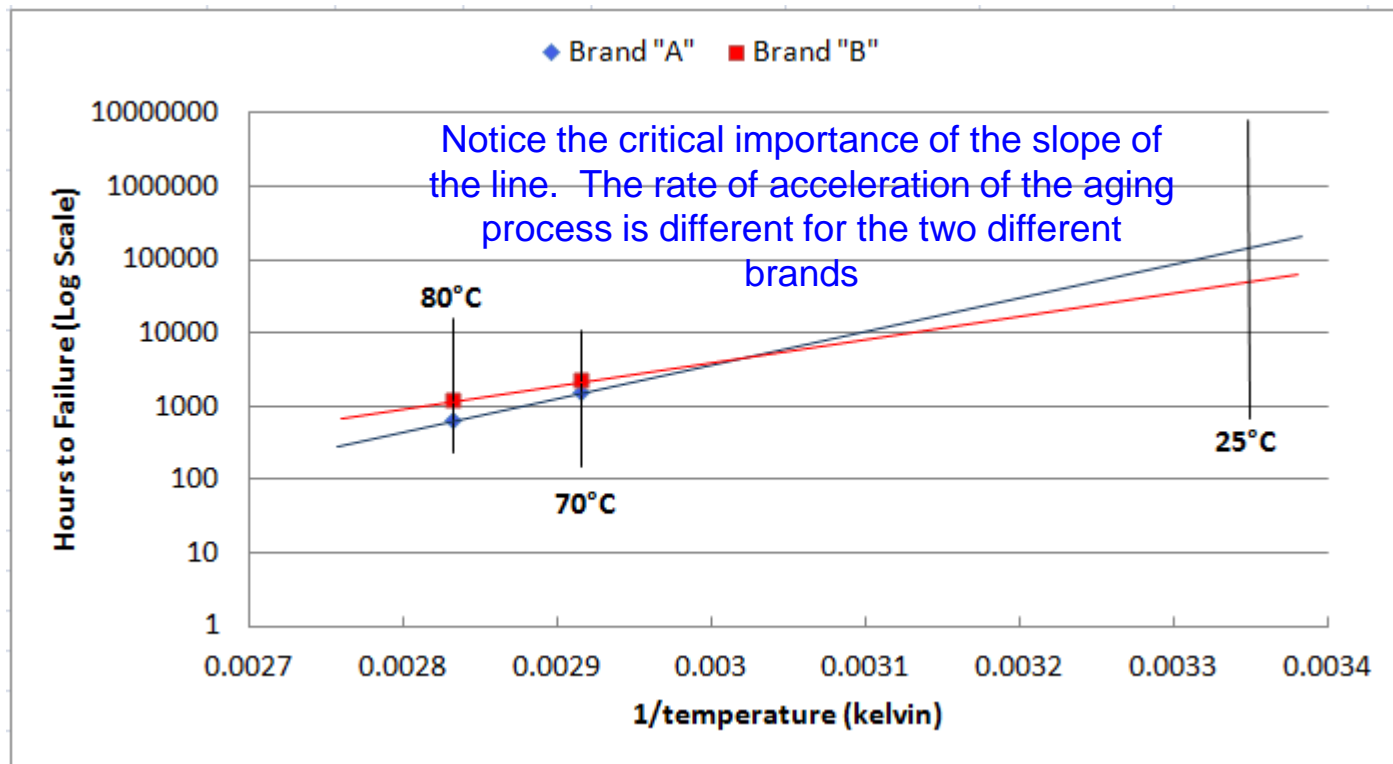
Understanding Lifetime Testing

However, tests at another temperature condition (70° C) could also show the following results.



Understanding Lifetime Testing

With data from two different test conditions, we have sufficient information to predict behavior and we can see why results from a single test condition are insufficient to make either relative or quantitative predictions.

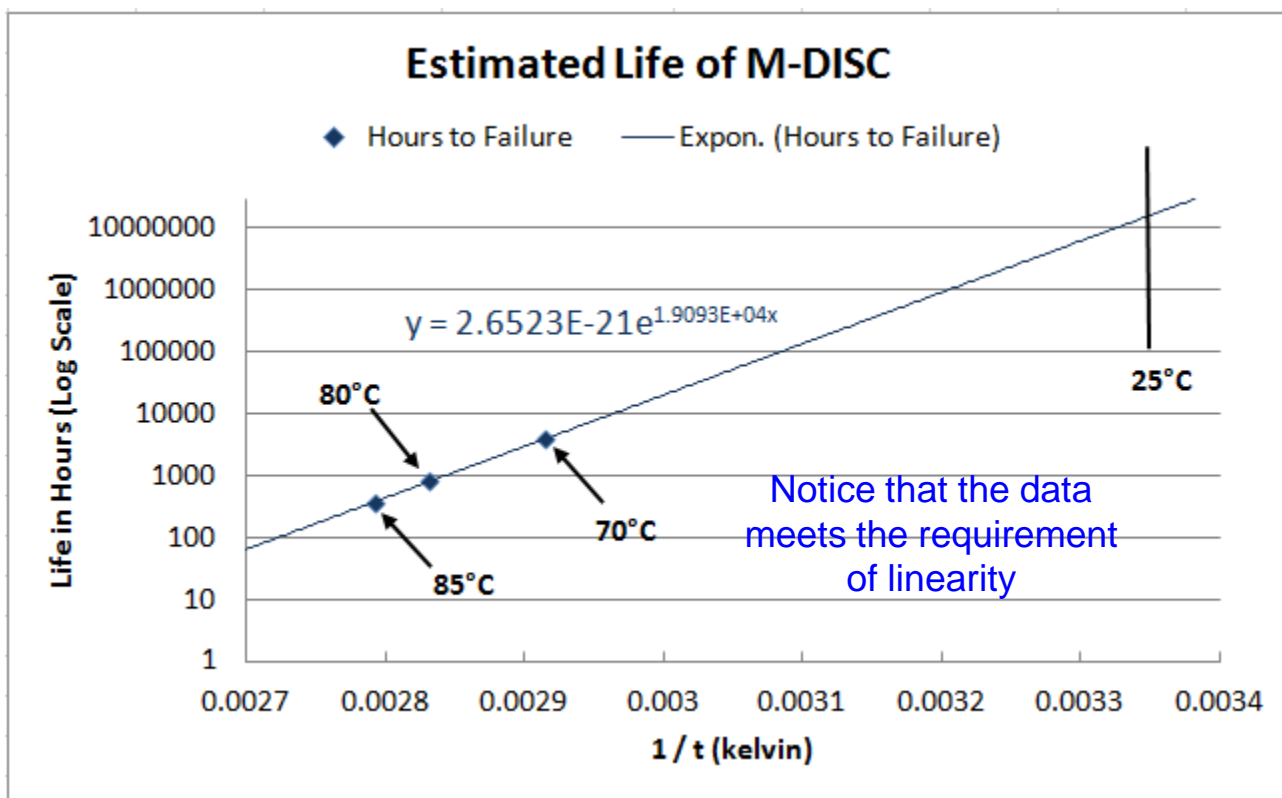


M-Disc Life Time Testing

- Most in-house testing of the M-Disc to date has followed the Arrhenius method of elevated temperature with humidity held constant at 85% RH
- We have always used multiple temperatures to evaluate lifetime under normal storage conditions ($\sim 25^{\circ}\text{C}$).
- Millenniata is now conducting an accelerated lifetime test that closely adheres to the ISO standards:
 - Eyring method
 - 4 test conditions
 - varying both temperature and relative humidity.
- Our results at 80°C closely match the results obtained by LNE during their recent test of various DVDs

M-Disc Life Time Testing

Preliminary M-Disc Lifetime Tests under three temperature conditions: 85, 80 and 70 degrees C (85% RH) yields the data shown below



M-Disc Life Time Testing

Analysis of the data shown in the previous chart yields the following:

$$\text{M-Disc Lifetime} = 6.2523\text{E-}21 e^{(19093*x)}$$

$$x = 0.003354 \text{ (1/room temperature, kelvin)}$$

$$\text{Lifetime} = 17,176,663 \text{ Hours}$$

Or,

Lifetime = 1961 years (expected average value)

M-Disc Life Time Conclusions

- The Arrhenius and Eyring methods are the standard.
- Other failure modes need to be considered but are not evaluated by these methods.
- Test results obtained at only one temperature condition do not provide sufficient information to evaluate lifetime under normal storage conditions.
- In-house testing of the M-Disc predicts an average lifetime in excess of 1500 years at 25° C and 85% RH
 - Results are consistent with the LNE test results
- Millenniata is conducting a full ISO test of the M-Disc that will be publicly released in 2013. Test results to date are consistent with the results shown here.