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# Technical Note: Accelerated Life Testing

Reliability Verification  
for  
Adtron Flash Disks

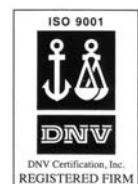
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## Introduction

This document summarizes the results of a reliability verification program focused at establishing empirical MTBF for Adtron flash disks. In September of 2000 Adtron engaged an independent consulting firm to define an accelerated life test program to test the validity of MTBF predictions for flash disks that were calculated using MIL-HDBK-217F and Belcore standards.

The first accelerated life test program of ten 600 MByte flash drives was initiated in November 2000 and a second group of ten 512 MByte flash drives was started in February 2003. Both groups remain in continuous test, and will continue to an undetermined date. This document summarizes the test conditions, test results to date, and a conclusion regarding the MTBF prediction.

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## Test Conditions

Adtron identified several modes of failure in a flash disk:

- Silicon aging based on activation energy that predominately detects oxide quality, contamination, and electro-migration that causes component failures typically referred to as device wear-out
- Write endurance limits reached through erasing and writing to a flash cell
- Write and read disturb and other operational failures caused by latent semiconductor defects

This accelerated life test was established to focus on silicon aging. Other tests for write endurance and read disturb were established as a part of a separate qualification program.

During the life test, the unit must be powered on and operating with the operating conditions at a low enough level to ensure proper operation and detect failures, without activating any operation-induced failure modes, for example reaching write endurance limits.

Based on the activation energies of the flash drive components as applied to the Arrhenius equation, the acceleration factor calculates to 25.

- First group: ten (10) 600 MByte, S35CF-600C SCSI flash drives for this test from a standard production lot
- Second group: ten (10) 512 MByte, S35FA-512C SCSI flash drives for this test from a standard production lot
- The flash drives operate in a 65°C temperature chamber
- The flash drives connect to Pentium based PCs using Adaptec SCSI controllers running the Adtron test suite LoopTest.

The operating functions are:

1. Write 1 random location for a random length from 1 to 64 blocks
2. Read 100 random locations each a random length from 1 to 64 blocks
3. Repeat Steps 1 and 2 for 10,000 times
4. Make a log entry
5. Perform a media verify on the entire drive (sector by sector read ECC check)
6. Make a log entry
7. Loop to Step 1

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## Results

To date there have been no failures detected in any of the two groups of flash drives.

In Group 1, each drive performed the following operations during this time:

- 2,800 read cycles through the entire capacity of the drive:  
600 Mbytes \* 2,800 cycles = 1,680 trillion bytes read plus ECC media verify
- 28 write cycles through the entire capacity of the drive:  
600 Mbytes \* 28 cycles = 16.8 billion bytes written to each drive
- The drives have been operating for 20,233 hours under the accelerated life test conditions
- Accelerated life of these drives approximates 58 years of equivalent operation at 25°C

In Group 2, each drive performed the following operations during this time:

- 437 read cycles through the entire capacity of the drive:  
512 Mbytes \* 437 cycles = 224 billion bytes read plus ECC media verify
- 4.4 write cycles through the entire capacity of the drive:  
512 Mbytes \* 4.4 cycles = 2.25 billion bytes written to each drive
- The drives have been operating for 7,000 hours under the accelerated life test conditions
- Accelerated life of these drives approximates 20 years of equivalent operation at 25°C

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## Conclusion

Adtron predicted 250K hours, 28 years, of life under normal operating conditions and this accelerated life test validates these predictions.

These two groups, totaling twenty flash drives continue to operate and will remain in this accelerated test program until failures occur. Any failures will be analyzed to determine the root cause in order to gain an understanding of the relationship of aging and reliability in the flash drives.

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## Other Test Programs

Other testing performed to validate the reliability and durability of Adtron flash drives includes:

- Long term, high write duty cycle testing to validate write endurance and read disturb failure mechanisms. Summaries of the qualification process are available upon request.
- MIL-STD-810F shock, vibration and altitude testing. Copies are available upon request.