Archive Drive Study

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Seagate
We turn on ideas

Technical Objectives

- **Evaluate possibility of an Archival drive capable of 10 year operation & storage**

Longevity of the Storage Device

Key Technical Issues

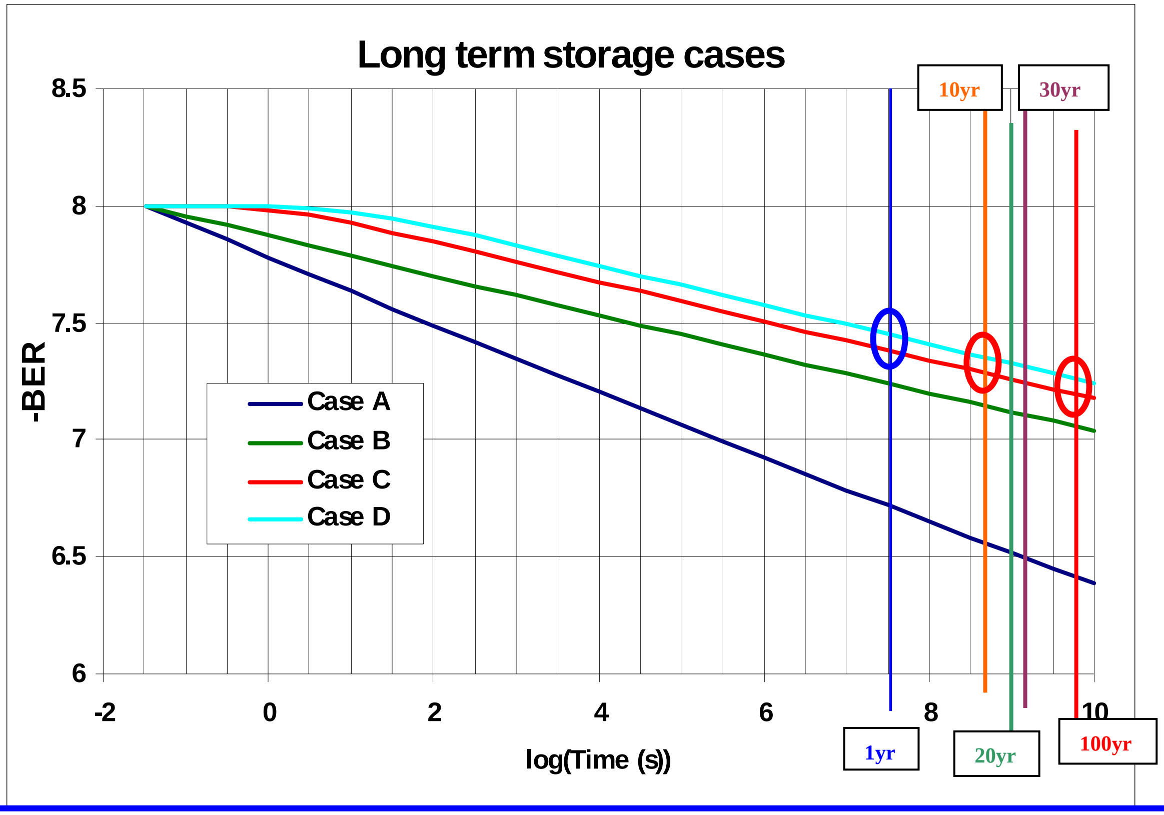
- **Drive Lifetime**
  - **Thermal Stability**
  - **HDI Reliability (css, stiction, tribology)**
  - **Lubricant Lifetimes**
  - **Corrosion (media, internal parts)**
  - **Head(Reader) Lifetime**
  - **Electronics/PCBA Lifetime**
- **Handling/Transportability**
  - **Non-Op Shock**
  - **Op Shock & vibration**
  - **Weight**

Usage Model & Environment for 10-Yr Life

- **Usage Model**
  - **MAID system to reduce power consumption**
  - **Power on approx. 12X/day for duration of 2-3 minutes, otherwise powered off**

- **Environment Expected**
  - **Temperature Range: 20-35°C**
  - **Relative Humidity Range: 20-60%**
  - **Handling: gentle; install once & leave in system for entire life**

Thermal Stability Modeling



RMO Model for Longitudinal Media Stability, applied to Tonka2 media with Archival conditions

NOTE that even 100 years for Cases C & D degrade ber by less than 0.5 decades !!

Case A:	50°C disk temp,	100% duty cycle (always on)
Case B:	26°C disk temp,	100% duty cycle (always on)
Case C:	26°C disk temp,	2% duty cycle
Case D:	26°C disk temp,	0.3% duty cycle

Analysis of 10 yr Archive

- **HDI Reliability, Long-Term**
  - **Contact Stop Starts:**
    - **Max number of css would not exceed 50kcss in 10-year life of archival drive.**
    - **This is normal spec limit for drives, so probably not a reliability risk.**
    - **Archival tape specs for css-equivalent much smaller: (load/unloads of the cartridge into the drive) of 20k (LTO-3) and 30k (SAIT-1)**
  - **Stiction:**
    - **Risk of unknown magnitude if the drives are shut OFF for extended periods**
    - **If the drive is stored in power off condition for years at a time, we have no data on the stiction risk. It is probably significant.**
    - **Solution requires drive to be powered on an regular intervals**

Analysis of 10 yr Archive (cont.)

- **Drive Longevity**
  - **Corrosion and Lube Puddling**
    - **The relative humidity inside the drive is ideally held in the range of 20% to 60%. Environments encountered could have humidity as high as 80% for limited times (up to approx. 3 months)**
    - **Studies show that HDD by itself will readily exceed 60% RH when in a 35C/80% environment.**
    - **For long-time storage, all the underground facilities (such as Iron Mountain) have rooms with virtually any temperature and humidity desired, from <0ºC to >40ºC and 0% $\leq$ RH $\leq$ 80%. Hard drives could be specified to be stored in low temp and RH<60%**

Evaporation is a function of Lube Vapor Pressure

- **Spin Motor Lubricant**
  - **Hydrocarbon Ester**
  - **Vapor Pressure: 2.8 X 10 $^{-6}$ mmHg**
- **Actuator Pivot Lubricant**
  - **Hydrocarbon Grease**
  - **Vapor Pressure: 5 X 10 $^{-8}$ mmHg**
- **Disc Lubricant**
  - **Perfluoropolyether**
  - **Vapor Pressure: 2 X 10 $^{-8}$ mmHg**

- **Evaporation rate of lube doubles every 10°C, so for two temperatures it goes like: $2^{(T2-T1)/10}$**
- **Hence, if T1~65°C (normal hdd specs) and T2~35°C (archival drive spec) then**
- **Relative lube evaporation rate of archival drive is ~2^{-3} = 1/8 as fast, implies 8X lifetime**
- **8X lifetime would mean 40 years instead of 5 yrs**

Interim Technical Conclusions

- ***Thermal decay* will be less than 0.2 decades of ber degradation & is therefore within the limits of BER loss**
- ***Lubricants/Oils* are well within evaporation limits**
- ***Drive must be maintained in an environment with controlled humidity***
- ***Maximum number of CSS* in 10-year life does not exceed normal spec limit**
- ***Stiction* risk exists, if drive is stored in power-off state for years at a time.**
- ***Shock* & handling may be an issue.**

On the other hand

- Not clear that drive life is the right way to attack the problem of longevity
  - If a drive is used for 10 years, it will last through 2-4 generations
  - Power, floor space would probably be more valuable after 5 years
  - Drives already designed to last 5 years
  - Assume areal density CAGR of 27%

Capacity	x			2x			4x			8x	
Year	0	1	2	3	4	5	6	7	8	9	10
Actual	30 GB			200 GB			500 GB			2 TB	

Conclusion: while designing drives for longer life is technically feasible,
It won't happen; too much of the market gets more benefit from regular transitions to newer technology