Optical Discs for Archiving

Information Technology Laboratory
Information Access Division

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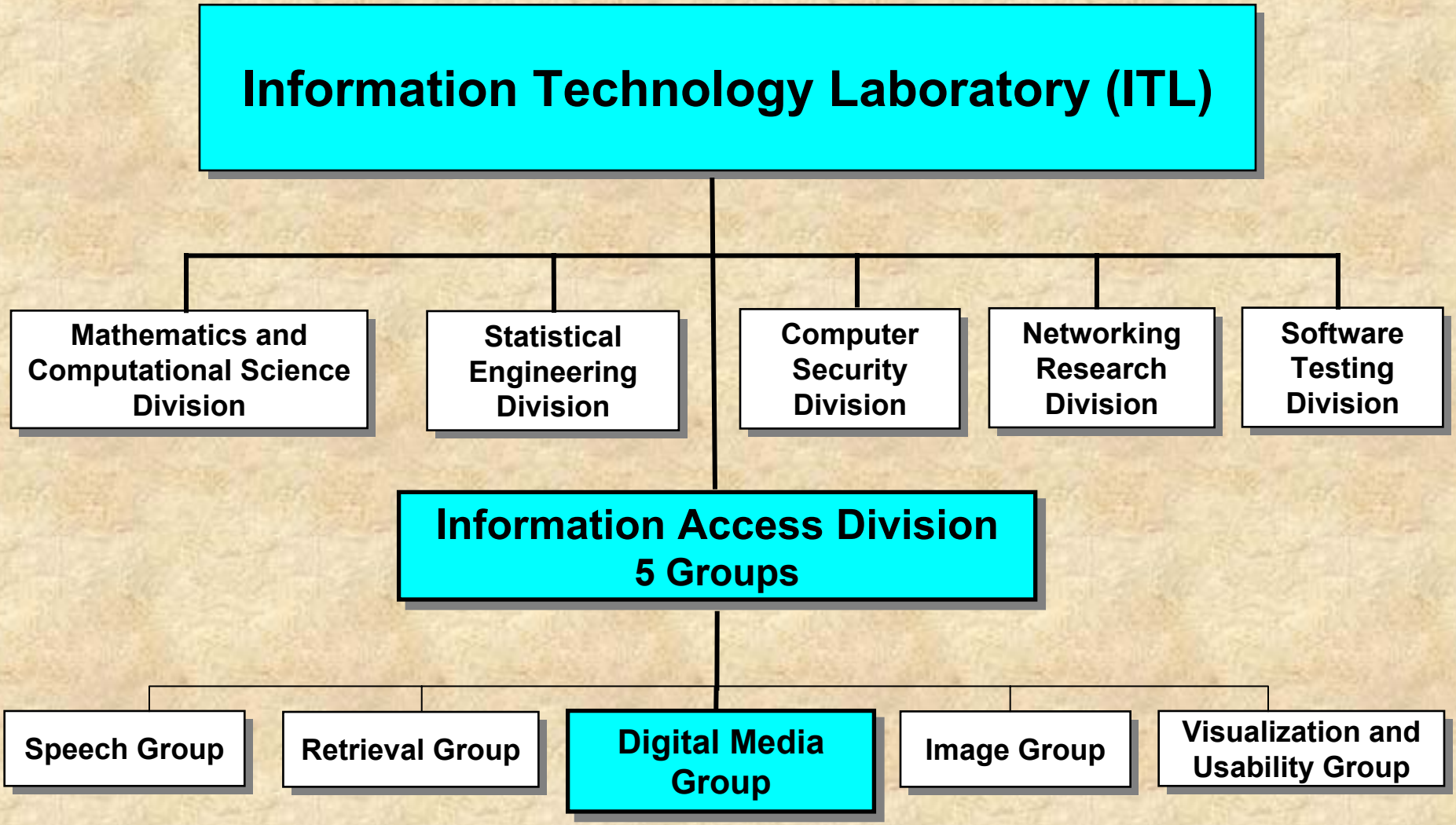
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Topics

- ✓ Background
- ✓ Concerns/questions about media
- ✓ Discs for archiving
- ✓ Test method proposal
- ✓ Monitoring disc performance

*Survey of the Government Information Preservation Working Group

All agencies are expecting exponential growth in the volume of their digital assets.

Media specific concerns are:

1. Capacity of medium
2. Reliability, durability – long-term accessibility of complete data on the medium.
3. Would like media designed for long-term storage use.
4. Would like media analysis tools.

***Source: GIPWoG Survey, Dec. 2003**

Other User Questions About Using Optical Discs

- Can I trust optical discs for long-term or archival storage?
- How long will the content on my disc last?
- What is the minimum number of years I can expect?
- Which disc should I buy?
- What should I look for in a disc?
- Does price or brand make a difference?
- Does the recorder make a difference?

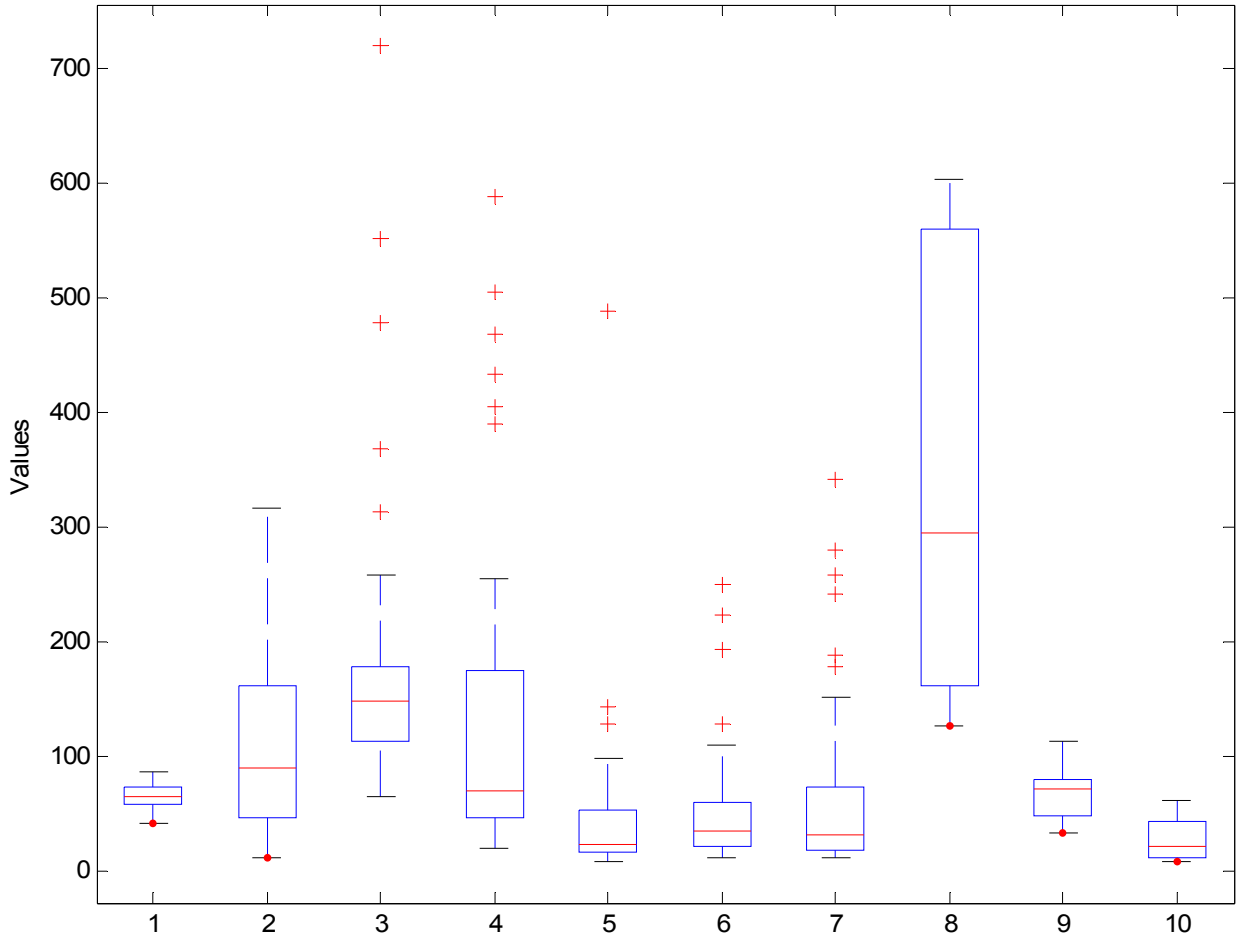
These above points are not unique to optical discs.

Most Commonly Asked Question:
How long will [my] optical discs last?

Answer: It depends

1. Handling — √ User can control
2. Storage — √ User can control
3. Initial recording quality — ? User can control
   - Condition of disc before recording
   - Quality of burn (depends on disc and burner)
4. Disc construction — × User cannot control
   - Materials
   - Manufacturing process, quality control

Initial DVD Recording Analyzed



Approximately 80 discs per set (column)

Disc Construction:

Media Marketed for Archiving, Long-Life,

- Discs marketed for long-term storage
  - How is their performance different from regular discs?
  - How many years will they last? Longer LE?
  - How does manufacturer A compare to manufacturer B?
  - How are they determined to be longer lasting?
- No standard short test for these discs.

Proposed Method for Test

Goals:

- Industry Standard Test Method
  - A consistent across industry test for long-term or archival storage marketed discs
- A test that industry accepts
  - Industry supports the development and the use
- Labeling for consumers
  - Statement or logo identifying disc as passing the test
  - A metric for the consumers to use

Existing LE Standard Test: is Time Consuming, Expensive

- Typically one to two years (shortest time possible is still > 6 mos.)
  - too long to bring new disc to market
- Need equipment , space, expertise
- Cost of skilled labor resource or cost of out sourcing

LE - Accelerated Aging Times

Stress Test-Set	Stressed at (T_{inc}, RH_{inc})	Incubation duration	Minimum total time	Specimen quantity
1	80ºC, 85%	500 hrs	2000 hrs	10
2	80ºC, 70%	500 hrs	2000 hrs	10
3	80ºC, 55%	500 hrs	2000 hrs	15
4	70ºC, 85%	750 hrs	3000 hrs	15
5	60ºC, 85%	1000 hrs	4000 hrs	30
			13,000 hrs total	80 total

Incubation + Testing Time

No. of Chambers	Incubation time	No. of weeks	Testing time (2 analyzers)	Total Time
1	13,000 hrs	78 wks	6 wks	84 wks
2	7,000 hrs	42 wks	6 wks	48 wks
3	5,000 hrs	30 wks	6 wks	36 wks
4	4,000 hrs	24 wks	6 wks	30 wks

$$T_{50} = Ae^{\Delta H/kT}e^{(B)RH}$$

or

$$\ln T_{50} = \ln A + \Delta H/kT + (B)RH$$

Existing CD-R Standard LE Test:

Constants:	Derived from test data:	Calculate:
k, T (Temp.), RH	T_{50} (Time)	A, ΔH, B

$$T_{50} = Ae^{\Delta H/kT}e^{(B)RH}$$

or

$$\ln T_{50} = \ln A + \Delta H/kT + (B)RH$$

Existing CD-R Standard LE Test:

Constants:	Derived from test data:	Calculate:
k, T (Temp.), RH	T_{50} (Time)	A, ΔH, B

Alternative Use of Existing Equation

Constants:	Make T_{50} a given:	Calculate from T_{50}= X:
k, T (Temp.), RH, T_{50}	Make T_{50} = X years	A, ΔH, B

$\ln T_{50} = \ln A + \Delta H/kT + (B)RH$

Celsius	(Kelvin) T	RH	From AES38-2000 Standard example		
			ΔH/k	B	A
20	293.15	≤50%	7.83E+03	-9.72E-03	8.26E-07
25	298.15	≤50%			
60	333.15	≤85%			
70	343.15	≤85%			
80	353.15	≤85%			
Boltzmann's constant **k** = 1.38E-23 J/K					

$\ln T_{50} = \ln A + \Delta H/kT + (B)RH$

Celsius	(Kelvin) T	RH	From AES38-2000 Standard example		
			ΔH/k	B	A
20	293.15	≤50%	7.83E+03	-9.72E-03	8.26E-07
25	298.15	≤50%			
60	333.15	≤85%	**Possibilities from alternate data for 50 yrs**		
70	343.15	≤85%	ΔH/k	B	A
80	353.15	≤85%	8.01E+03	-6.20E-03	8.26E-07
Boltzmann's constant			8.00E+03	-9.72E-03	1.00E-06
k = 1.38E-23 J/K			7.83E+03	-9.84E-03	1.80E-06

CD-R LE Test Standard Data Calculated

Using the standard's data for 14.7 years at 25C/50%RH

			Condition Variables			
	Condition	**Celsius**	**T**	**RH%**	**ΔH/kT**	**B(RH)**
Room Temp.	25C/50%RH	25	298.15	50	2.63E+01	-4.86E-01
Storage	20C/50%RH	20	293.15	50	2.67E+01	-4.86E-01

ln(t50) =	**Projected Time to Failure**	
ln mean	**Hours**	**Years**
ln(A)+ΔH/kT+ B(RH)	**EXP(ln(t50))**	
11.77	129220.77	14.75
12.22	202238.79	23.09

Example for 50 years

$$\ln T_{50} = \ln A + \Delta H/kT + (B)RH$$

$\ln T_{50}$ for 50 years = 12.99 at 20ºC, 50%RH

$$\rightarrow \ln T_{50} = 12.99$$

$12.99 = \ln A + \Delta H/kT + (B)RH$

$\ln(t_{50}) = 12.99 = 50$ years

ln(A) + ΔH/kT + B(RH) for 50 years

			Condition Variables					Time to Failure	
							ln(t50) =	Hours	Years
	Condition	Celsius	T	RH%	ΔH/kT	B(RH)	ln(A)+ΔH/kT+ B(RH)	EXP(ln(t50))	
Storage	20C/50%RH	20	293.15	50	2.73E+01	-3.10E-01	12.99	438085.09	50.01
Stress 1	80C/85%RH	80	353.15	85	2.27E+01	-5.27E-01	8.13	3407.56	0.39
Stress 2	80C/70%RH	80	353.15	70	2.27E+01	-4.34E-01	8.23	3739.66	0.43
Stress 3	80C/55%RH	80	353.15	55	2.27E+01	-3.41E-01	8.32	4104.14	0.47
Stress 4	70C/85%RH	70	343.15	85	2.33E+01	-5.27E-01	8.79	6596.67	0.75
Stress 5	60C/85%RH	60	333.15	85	2.40E+01	-5.27E-01	9.49	13287.04	1.52

$\ln(t_{50}) = 12.99 = 50$ years

$\ln T_{50} = \ln A + \Delta H/kT + (B)RH$

	Condition	°C	°K	RH%	ΔH/kT	B(RH)
Storage	20C/50%RH	20	293.15	50	2.73E+01	-3.10E-01
Stress 1	80C/85%RH	80	353.15	85	2.27E+01	-5.27E-01
Stress 2	80C/70%RH	80	353.15	70	2.27E+01	-4.34E-01
Stress 3	80C/55%RH	80	353.15	55	2.27E+01	-3.41E-01
Stress 4	70C/85%RH	70	343.15	85	2.33E+01	-5.27E-01
Stress 5	60C/85%RH	60	333.15	85	2.40E+01	-5.27E-01

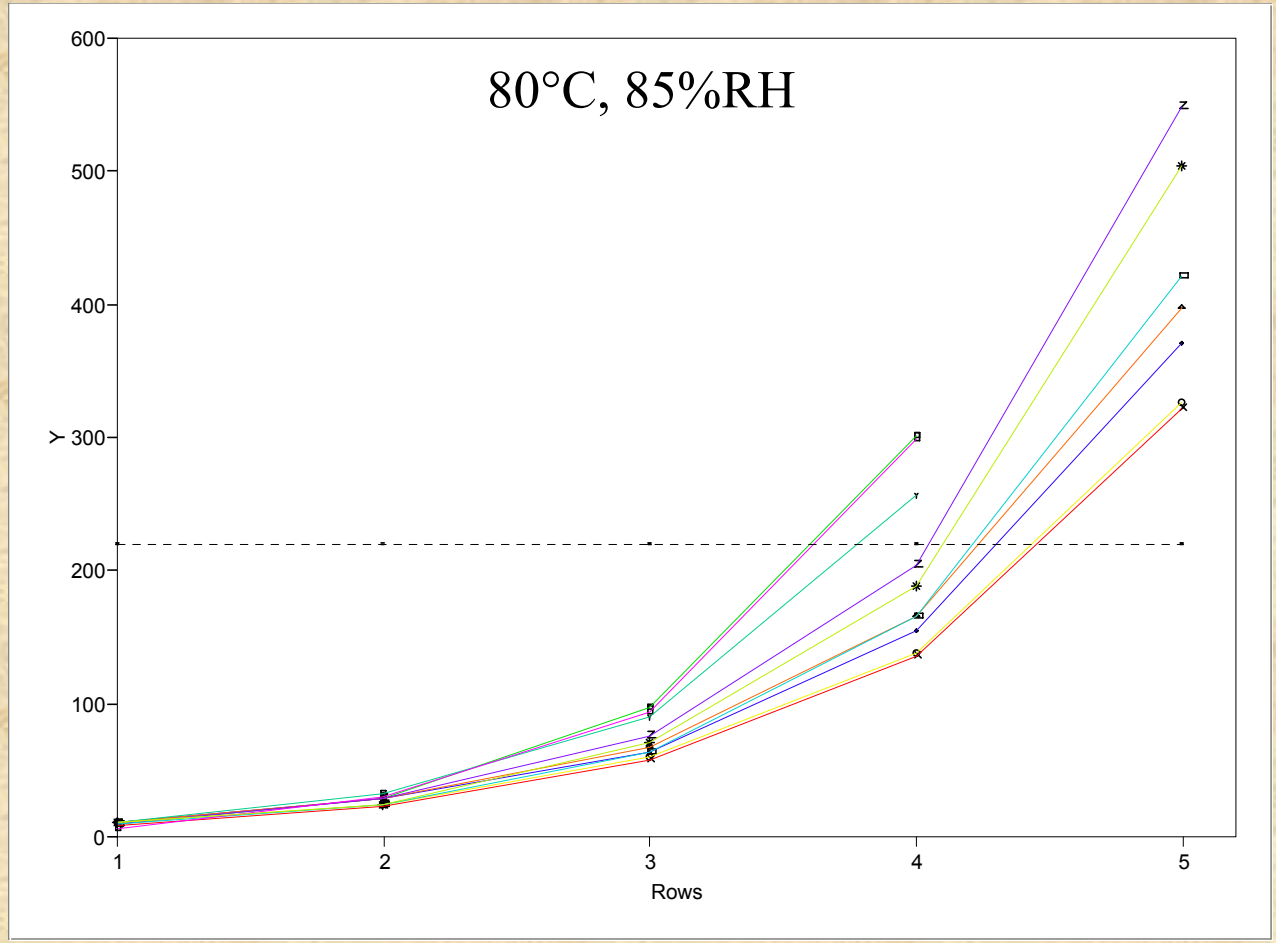
$\ln(t_{50}) = 12.99 = 50$ years

	ln(t50)	Time to Failure	
		Hours	Years
	ln(A) + ΔH/kT + B(RH)	EXP(ln(t50))	
Storage	12.99	438085.09	50.01
Stress 1	8.13	3407.56	0.39
Stress 2	8.23	3739.66	0.43
Stress 3	8.32	4104.14	0.47
Stress 4	8.79	6596.67	0.75
Stress 5	9.49	13287.04	1.52

$\ln(t_{50}) = 12.99 = 50$ years

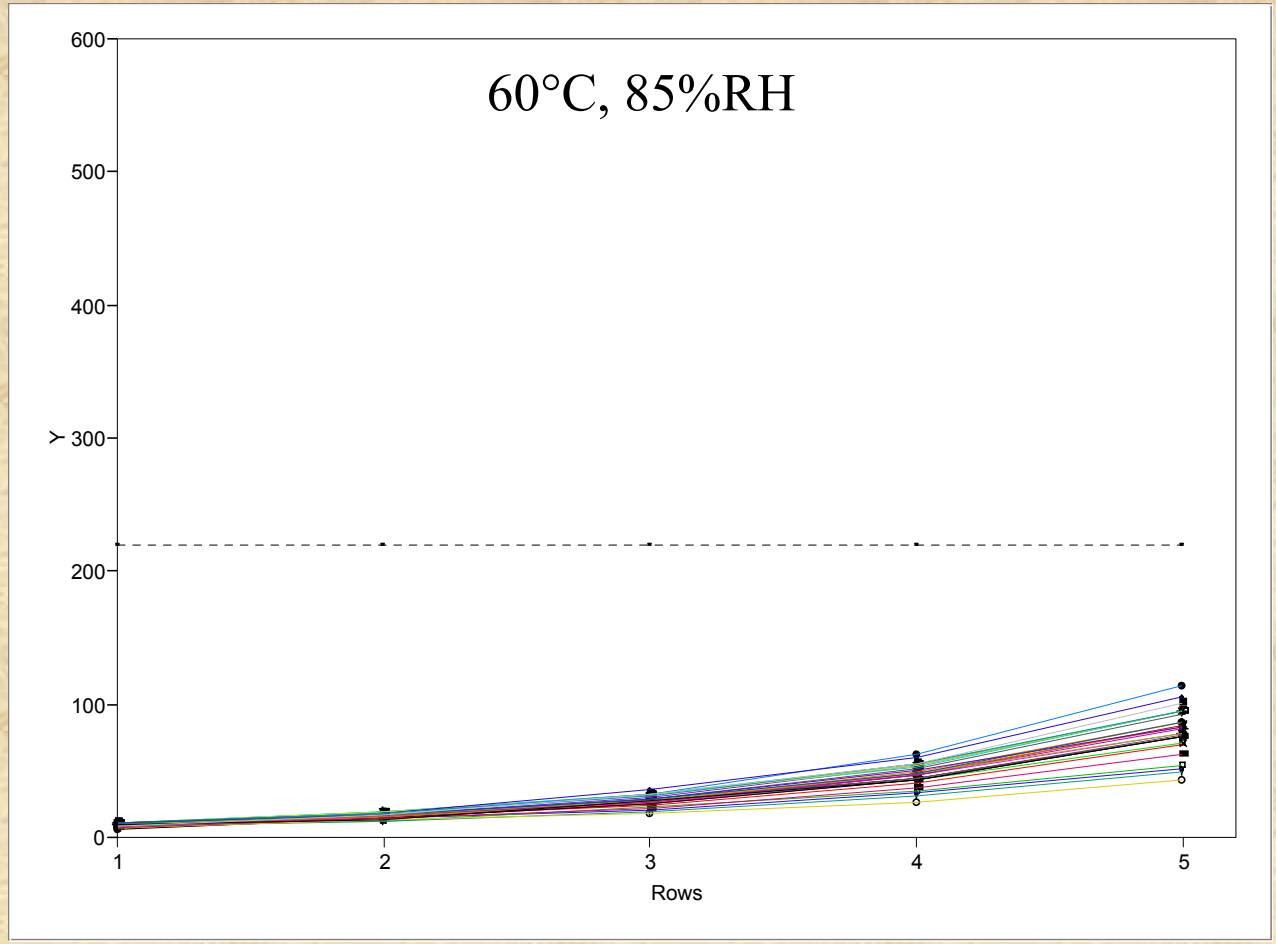
	Possibilities from alternate data for 50 yrs		
	ΔH/k	B	A
	8.01E+03	-6.20E-03	8.26E-07
	8.00E+03	-9.72E-03	1.00E-06
	7.83E+03	-9.84E-03	1.80E-06
Condition	**Years**	**Years**	**Years**
Storage 20C,50%RH	50.01	50.09	50.01
Stress 1	0.62 (32wks)	0.35 (18wks)	0.39 (20wks)
Stress 2	0.72 (37.5wks)	0.40 (21wks)	0.43 (22wks)
Stress 3	0.83 (43wks)	0.46 (24wks)	0.47 (24.5wks)
Stress 4	1.20	0.67 (35wks)	0.75 (39wks)
Stress 5	2.42	1.35 (70wks)	1.52 (79wks)

First Stress Test Set
500 hour intervals x 4



Each color represents the ageing result of each disc

Fifth Stress Test Set
1000 hour intervals x 4



Each color represents the ageing result of each disc

Performing the short test

- Test at three stress test levels (instead of five) long enough to determine T_{50} at each stress level.
  - "Long enough time" needs To Be Determined (TBD).
  - Acceptable time for manufacturers needs TBD
  - Shorter incubation time intervals.
- Calculate A, ΔH, B from T_{50} at each stress level
- Compare A, ΔH, B against possible combinations for 50 years at storage condition, 20ºC, 50%RH

Still Needed

- Spreads/window for A, ΔH, B
  (reasonable/actual highs and lows)
- Do tests at shorter times/intervals

Consumer/Industry Benefits From "Archival Grade" Test Method

- Consumer
  - Consumer uncertainty reduced
  - More realistic consumer expectation
  - Better, or more confident migration planning
- Industry
  - Industry-wide standard test method
  - Time to market
  - Testing cost (compared to existing LE testing)
  - Pricing (cost/margin recovery for testing, QC, etc.)

Request for Analysis Tools

* Would like media analysis tools.

  - A suggestion for drive manufacturers

*GIPWoG Survey, Dec. 2003

- Measuring Performance -

- Early Warning Indicator
  - Error Alert
  - Check Disc
- A warning about error rates that are approaching BLER-max (CD) or PI-SUM8 max (DVD).
  - May also consider burst errors, reflectance or other parameters
- Possibilities:
  - a light as an indicator
  - a pop-up window giving suggestions for corrective action
  - actual number shown (good for initial error rate)
  - included in virtually all drives or only high-end drives.

Consumer/Industry Benefits From "Early Warning Indicator"

- Consumer
  - Easy monitoring of disc performance
  - Copy disc before uncorrectable errors occur
  - Significantly reduce the chance of a catastrophic failure
- Industry
  - Value added drives
  - Higher-end drives?
  - Drives as testers

Thank you!

NIST
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Information Access Division
Digital Data Preservation

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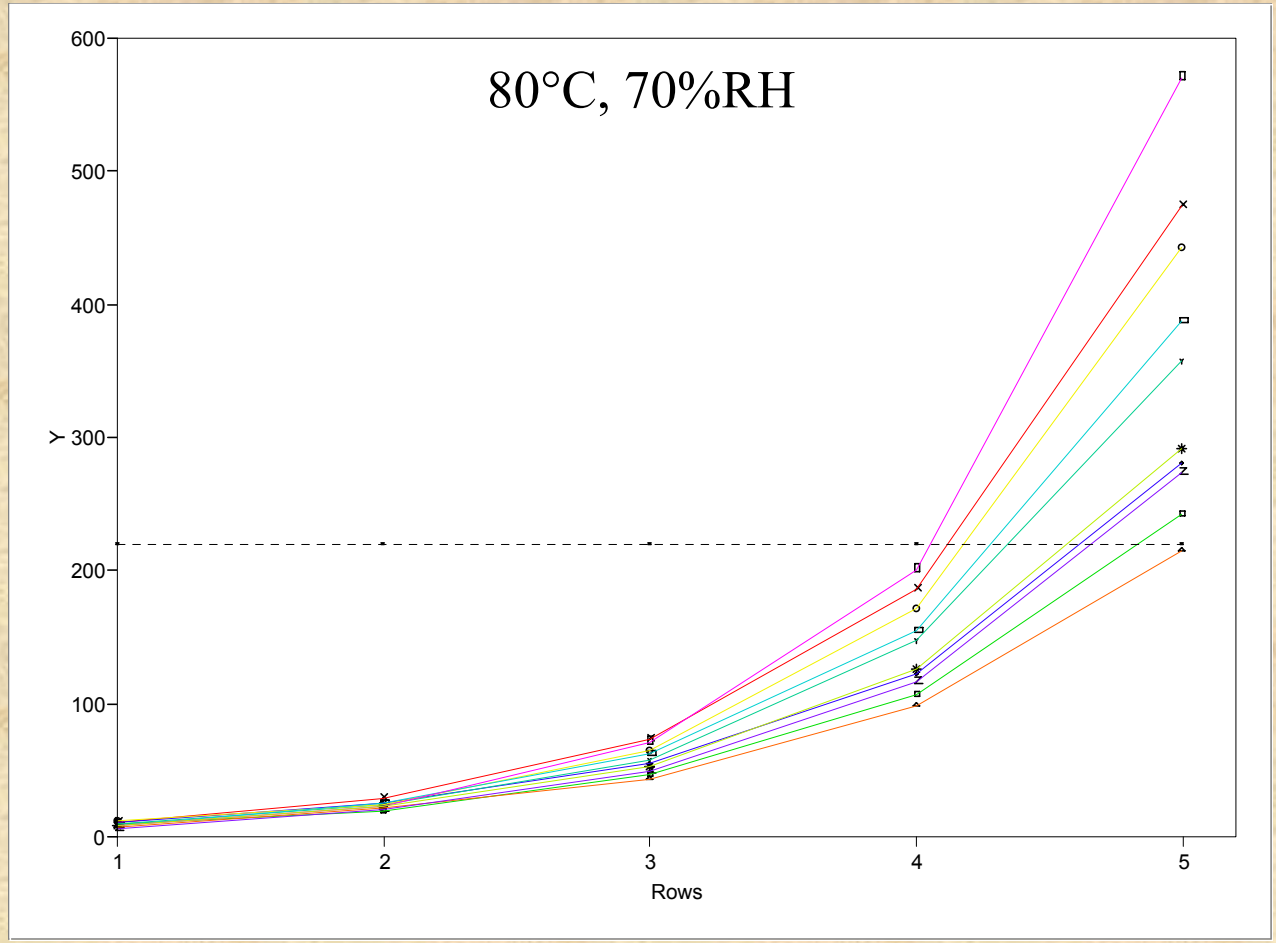
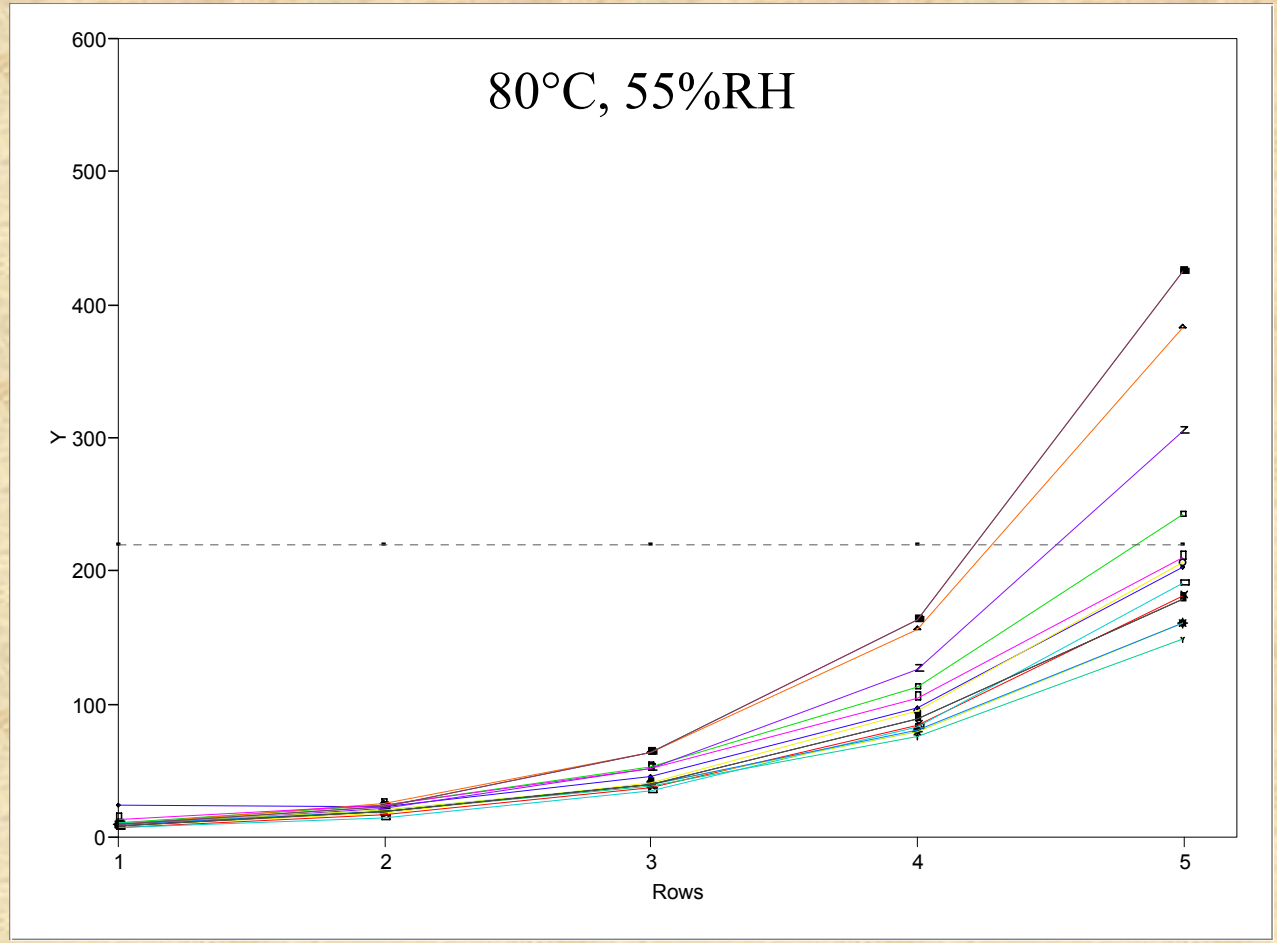
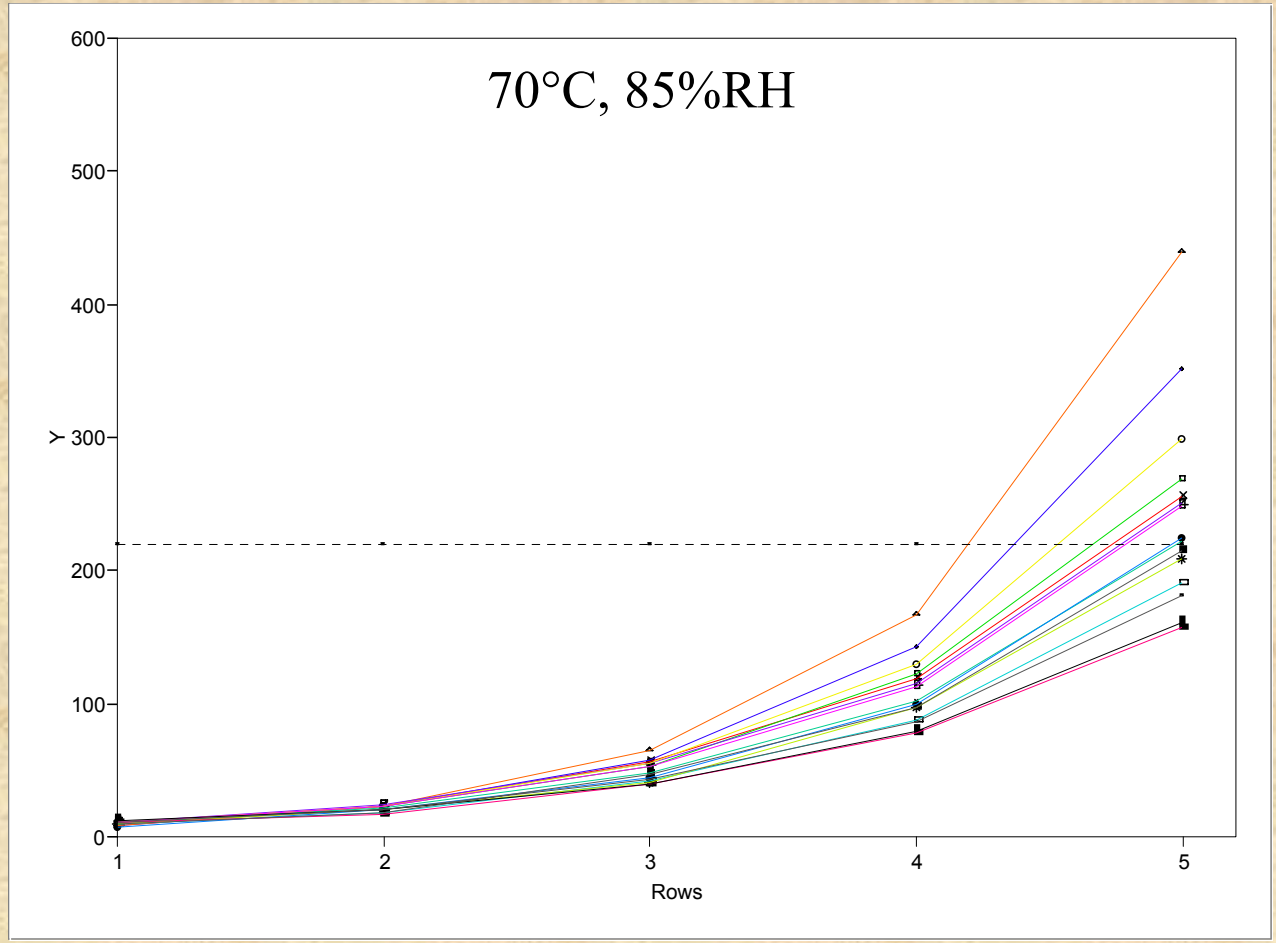
Second Stress Test Set
500 hour intervals x 4



Third Stress Test Set
500 hour intervals x 4



Fourth Stress Test Set
750 hour intervals x 4



- Joint Technical Commission AES/SC-03/ ISO TC-42, WG-5, Task group 5