

A Discussion about Archiving on CDs/DVDs



Steve Mizelle
President
KMP Media, LLC
September 12, 2006

CD/DVD Disc Longevity

Q: How Long will a typical CD or DVD last?

CD/DVD Disc Longevity

Q: How Long will a typical CD or DVD last?

A: **It Depends!**

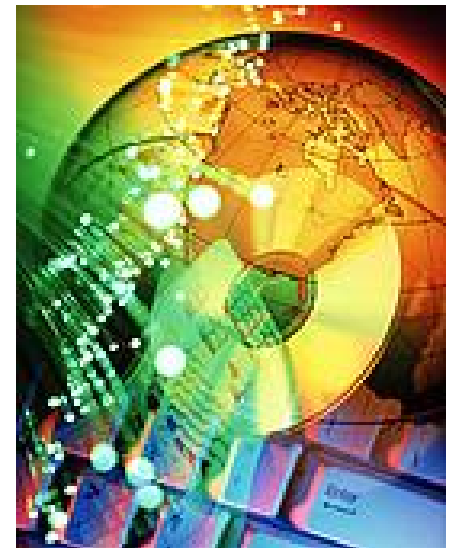
- Longevity Depends on Many Factors

.....Like What?

Factors That Affect Lifetime

The life expectancy of optical discs depends on many factors, some controllable by the user, others not.

- **Storage Characteristics**
 - Temperature
 - Humidity
 - Exposure to UV
 - Exposure of the Reflective material and dye to the air
 - Handling
 - Exposure to solvents or other materials with corrosive characteristics
- **Disc Quality** (w/Price as a Possible Indicator...)
 - Quality of Materials Used (Polycarbonate, Dye, Reflective Material, Lacquer or Hard Coats, Inks)
 - Quality of Manufacturing Process
- **Burner Characteristics**
 - Compatibility with disc drive (firmware)
 - Burner state (laser strength)
- **Other**



Archivability

- Archiving is Important! But....
- Time Consuming
- Expensive
- Cumbersome
- Format incompatibility

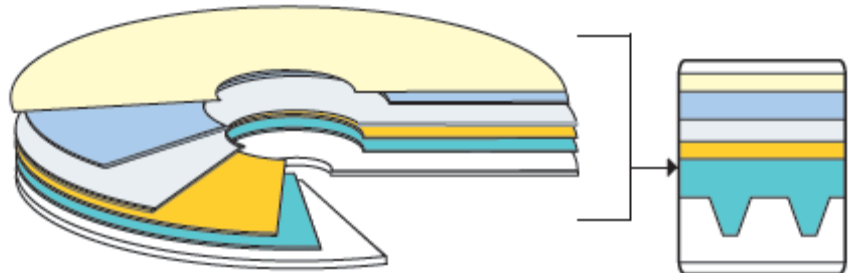
So, is it possible to archive using current and future disc technology?

YES!

What is a CD-R?

- Compact Disc Recordable
- Governed By Red, Yellow & Orange Book Standard
- 74 Minute/650 MB Standard Size
- 80 Minute/700 MB Retail Size
- User Can Record on Desktop or High Speed Duplicator and is readable in all CD-ROM Drives
- Excellent storage for Pictures, Data, Music/Audio, and Video

What is a CD?



A CD-R Has Many Layers

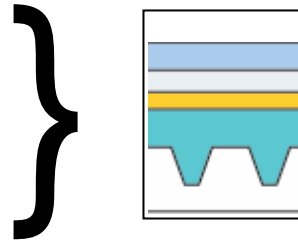
Protective Coating (Lacquer-Other)
 Branding Layer (Ink)
 Protective Layer
 Reflective Layer (Silver, Gold, Alloys)
 Dye (writeable Layer)
 Polycarbonate substrate

- A CD-R is a write once media
(Cyanine/Phthalocyanine dyes)
- A CD-RW is a rewritable media
(photosensitive dye which can change state)
- CD-ROM (Read Only Memory) or replicated disc
(NO dye used – data is pressed into the CD)
- CD-Rs typically store 700MB of data

What is a DVD?

**A DVD IS Similar to a CD,
but has 2 Polycarbonate Discs
with Many Layers Sandwiched
Between the Polycarbonate Discs**

Polycarbonate Substrate
Protective Layer
Branding – Ink
Protective Layer
Reflective Material
Dye
Polycarbonate Substrate



Protective Layer
Branding – Ink
Polycarbonate Substrate
Protective Layer
Reflective Material
Dye
Polycarbonate Substrate

There are also:

DVD-RWs

2 Sided DVDs

Dual layer, single sided DVDs

Dual Layer, double sided DVDs

A DVD is typically 4.7GB Vs 700 MB for CDs

Typical Disc Layer Specifics

Recordable Discs store data on dye or phase changing dye (RWs). Typical reflective layer is silver, gold or an alloy.



Basic Layers of CDs and DVDs				
<i>Basic layers of CD-ROM and DVD-ROM (Replicated discs for audio, video, computer use, or interactive games)</i>				
CD-ROM (Single-sided)	DVD-ROM (Single-sided)	DVD-ROM (Single-sided)	DVD-ROM (Double-sided)	DVD-ROM (Double-sided)
(All CD-ROMs are one-sided) One recorded layer	(One side) One recorded layer	(One side) Two recorded layers	(Both sides) One recorded layer per side	(Both sides) Two recorded layers per side
Label, optional	Label, optional	Label, optional	Label, optional (hub area only)	Label, optional (hub area only)
Lacquer	Polycarbonate	Polycarbonate	Polycarbonate	Polycarbonate
Metal	Center adhesive	Metal (fully-reflective)	Metal	Metal (semi-reflective)
Polycarbonate	Metal	Center adhesive	Center adhesive	Adhesive
	Polycarbonate	Metal (semi-reflective)	Metal	Metal (fully-reflective)
		Polycarbonate	Polycarbonate	Center adhesive
			Label, optional (hub area only)	Metal (fully-reflective)
				Adhesive
				Metal (semi-reflective)
				Polycarbonate
				Label, optional (hub area only)

*Basic layers of CD -R/-RW and DVD -R/-RW/+R/+RW/RAM
(Blank recordable discs for all applications listed for ROM discs)*

CD-R, CD-RW (Single sided)	DVD-R, DVD-RW, DVD+R, DVD+RW, DVD-RAM (Single sided)	DVD-R, DVD-RW, DVD+R, DVD+RW, DVD-RAM (Double sided)
CD-R/RW are one-sided, One recordable layer only	(One side) One recordable layer only	(Both sides) One recordable layer per side only
Label, optional	Label, optional	Label, optional (hub area only)
Lacquer	Polycarbonate	Polycarbonate
Metal	Center adhesive	Recording/writing layer
Recording/writing layer	Metal	Metal
Polycarbonate	Recording/writing layer	Center adhesive
	Polycarbonate	Metal
		Recording/writing layer
		Polycarbonate
		Label, optional (hub area only)



Pressed or Replicated Discs do not store data on dye. Typical reflective layer is aluminum.

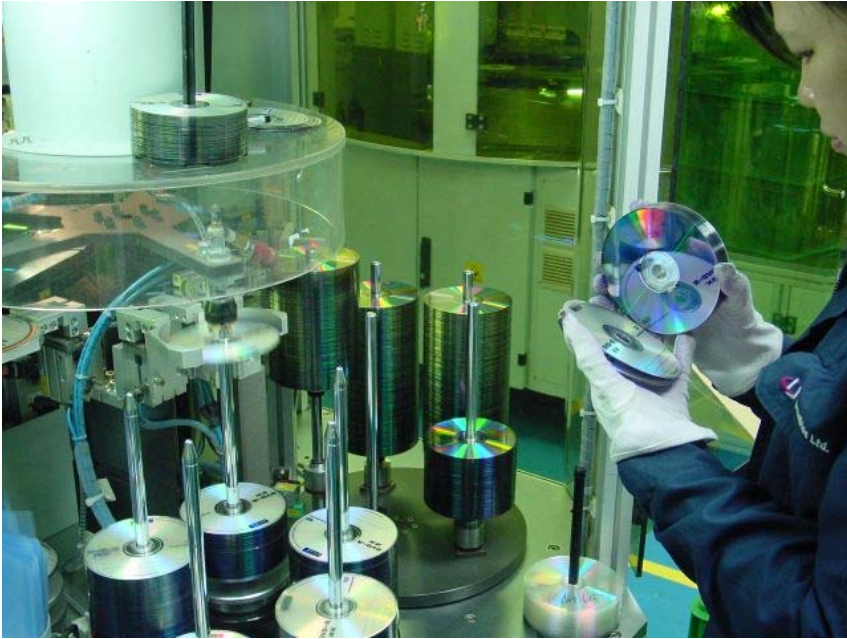
FOR DVDs, What is +R and -R?

- Originally there were 2 competing groups of companies that brought out slightly different DVDs. One group +R, the other -R.
- The standards provided for slightly different “potential” capabilities
- At the start burners were only +R or -R burners and capable of only writing to their media. +R and -R could be played back on either burner.
- Now almost all burners are dual burners; capable of writing and reading either format, so it doesn't matter which you buy.
- -R is about 60-65% of the mix today.

How are CD-Rs Manufactured

- Polycarbonate beads are melted and formed into a disc in a mold
- A stamper puts grooves and data on the polycarbonate
- Cooling
- Dye is spun on the polycarbonate
- A reflective layer is “sputtered” onto the dye (vacuum chamber at high temperature)
- A protective layer is added (typically lacquer coating)
- UV curing
- Check for defects
- Branding is added (ink)
- Lacquer coating or other “hard-coat” protective coating is added
- Product is Packaged

Disc Manufacturing is Hi-Tech



Data Archiving on Recordable CD and DVD Media

- Preservation Grade Media - How long should it last?
- What Makes it “Preservation Grade”?
- Archiving Guidelines



Preservation Media: How long is long enough?

- Eventual migration to another media is inevitable for long term data storage as formats change
- Migration is expensive
- It makes sense to keep your data on one media as long as possible.
- Start with media with the longest expected lifetime.



Long Enough to transfer to the next format?

Kodak 24K Gold Preservation CD-R

- **Superior Protection**

- Superior protection with **extra tough triple layers of scratch resistance** ensures that the Kodak Preservation CD protects your pictures, data, audio, & video longer.

- **24 Karat Gold Reflective Layer**

- **Gold promotes longer disc life.** Gold does not oxidize or break down, therefore data is preserved longer. Kodak Preservation Disc uses only 100% 24 Karat Gold.

- **Highest Performance Dye**

- Phthalocyanine Dye is **most resistant to heat, humidity, UV and Oxidation damage**

- **Up to 300 Years Archival**

- ✓ Using superior burn technology, Kodak Preservation Disc has been tested under light and accelerated aging to preserve data, photos, and documents for 300 years with proper handling.



What makes it “Preservation Grade” ?

- High Performance Dye
- Long-life Dye
- 24 Karat Gold Reflective Layer
- UV Resistant
- Heat Resistant
- Scratch Resistant

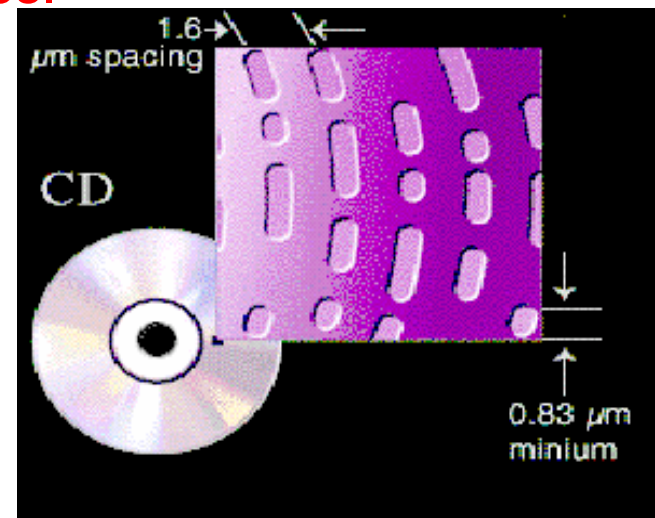


High Performance Dyes

All CD-R and DVD-R discs incorporate a thin dye layer that gets “burned” when you save your data. The stability of that dye layer determines how long your data will be readable. Phthalocyanine (thay-lo-sy-a-neen) dye is extremely stable in a wide range of environmental conditions, providing a platform for long term data storage. The dye is the single most important component for overall disc performance.

KODAK Preservation CD-R only uses Phthalocyanine dye while other CDs use cheaper, less stable dyes.

When you “burn” a disc, your writer creates “pits” in the dye layer that make up the “0”s and “1”s for digital recording. Phthalocyanine dye reacts more quickly to the writing laser than other dyes.



Dyes Used Today

- Dye stores the data
- Three primary dyes used in CDs and DVDs today and with great variation in quality

Dye Type

Cyanine

Phthalocyanine*

Azo/Metal Azo

Color

Blue Green

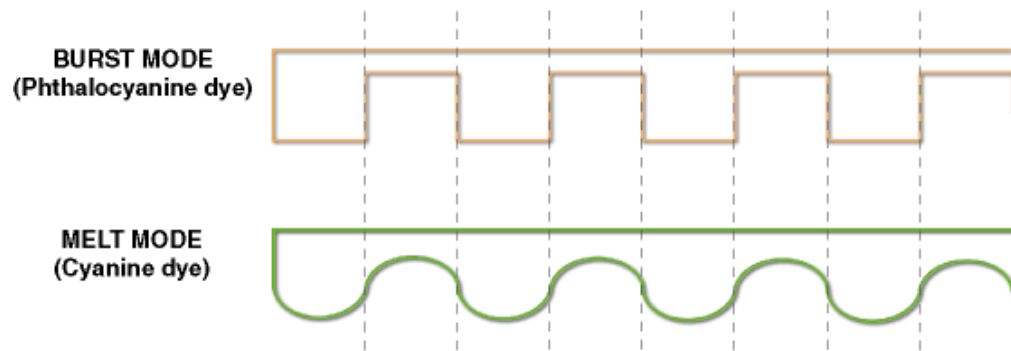
Green

Blue/Purple-Blue

- * **Phthalocyanine Dye is best for longevity!**
Best for UV protection, and protection from heat and humidity

More sensitive to the writing laser

- Phthalocyanine dye reacts in a "burst" mode instead of a "melt" mode as with cyanine (blue) dyes, so sharper pit edges are created. These sharper edges are easier for CD drives to read, so more faithful sound reproduction is possible; more reliable data storage.

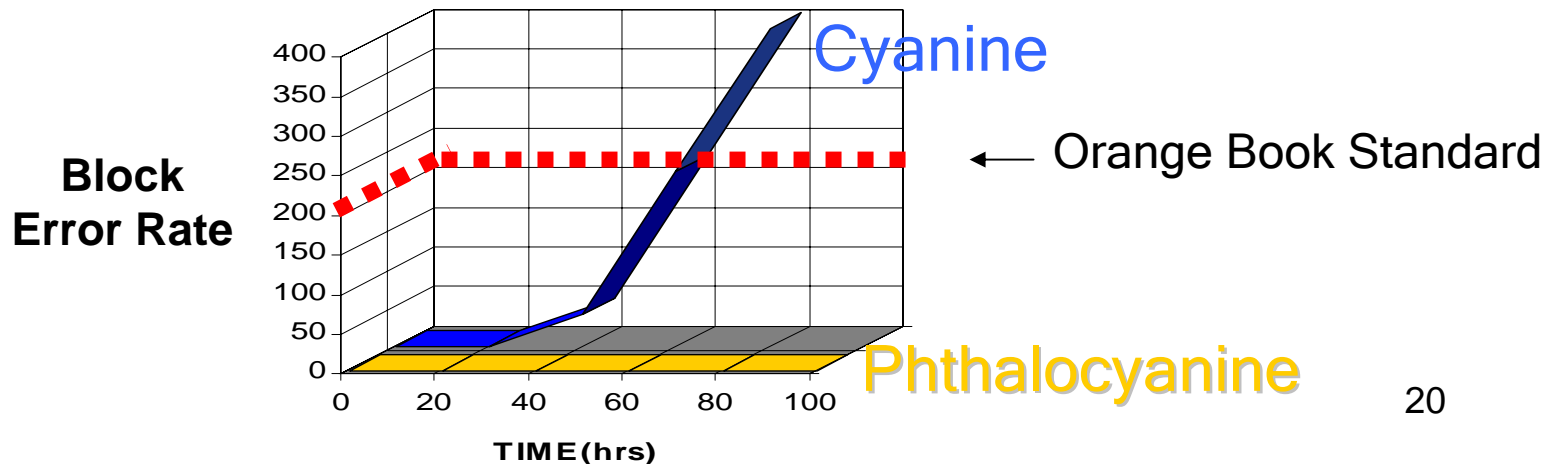


- Because the "PIT" edges are more clearly defined in BURST MODE, CD players read back the signal more accurately, resulting in a faithful, warmer-sounding audio reproduction.

UV Resistance

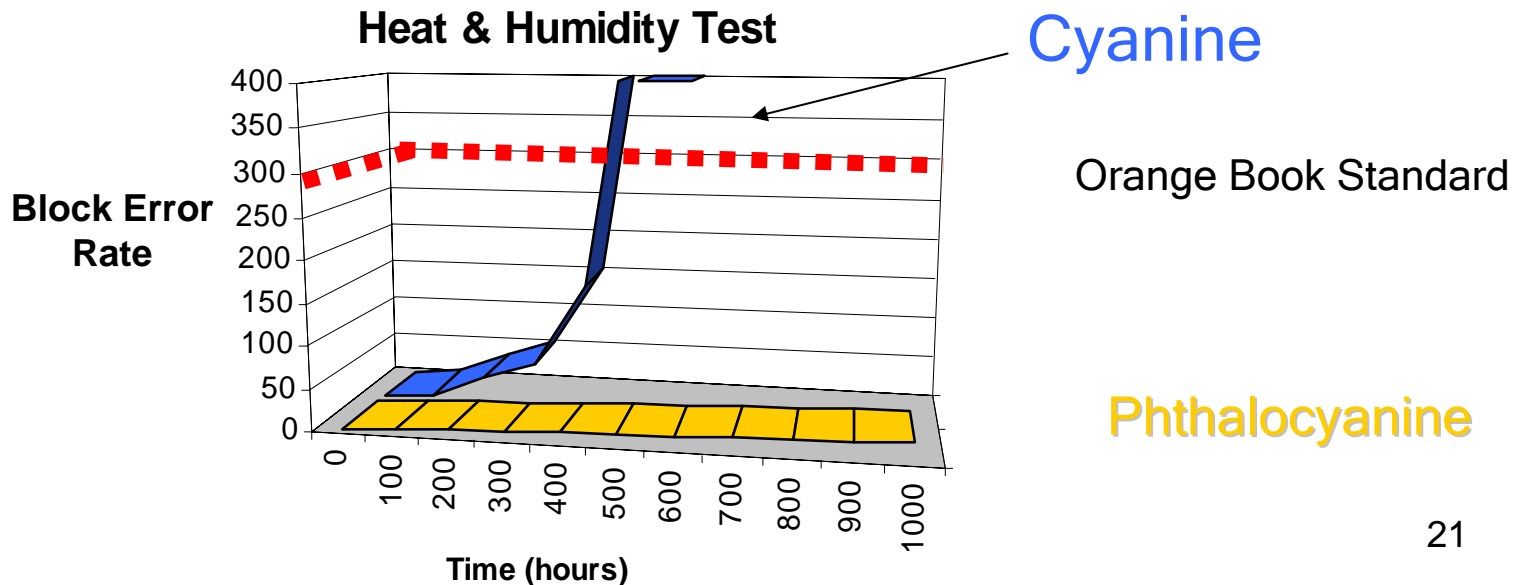
Phthalocyanine dye, developed and patented by Mitsui and the research partially funded by Kodak, makes discs more resistant to UV light. While other dyes are very reactive to UV light unless “stabilizers” are added, Phthalocyanine dye is naturally stable, so no additives are needed.

The Light Fastness Test below shows that the Kodak Preservation CD-R will withstand the full spectrum of light, same as the sun, for 100 continuous hours without damage. Cyanine dye begins to deteriorate after only 20 hours and fails at 65 hours.



Heat & Humidity Resistance

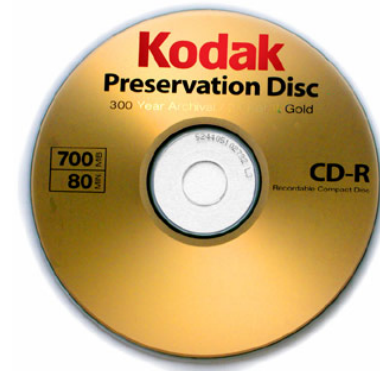
- The chart below shows that a combination of a stable gold reflector and stable dye make for a disc with a very long life. Even the darker color of some dyes can contribute to the amount of heat absorbed by the disc.



Reflective Layers

- Materials (Silver, Gold, Aluminum, Alloys)
- Aluminum is typically used in CD-ROMs (replicated discs)
- Silver, Gold and alloys are primarily used in CD-Rs

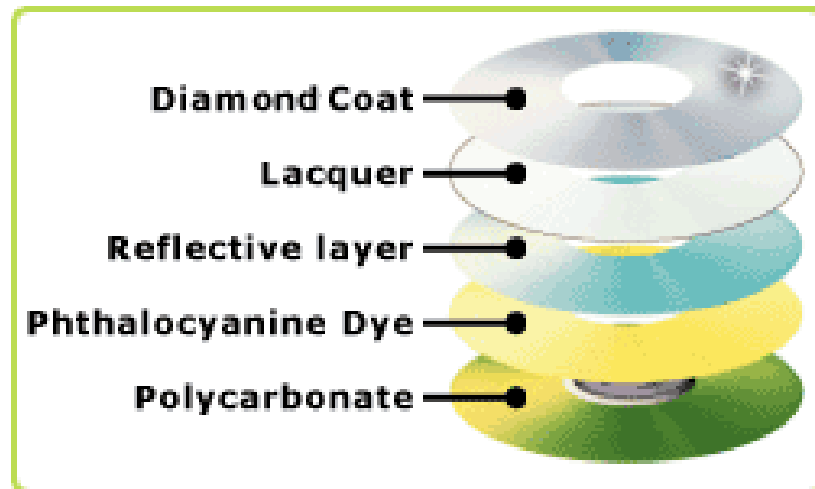
Pure Gold Reflective Layer



- Disc failure is often caused by degradation of the reflective layer.
- When the metal layer oxidizes, the disc can become unreadable
- Gold never oxidizes
- Kodak Preservation CD-R disc use 99.99% pure gold (24 karat) for archive grade media.

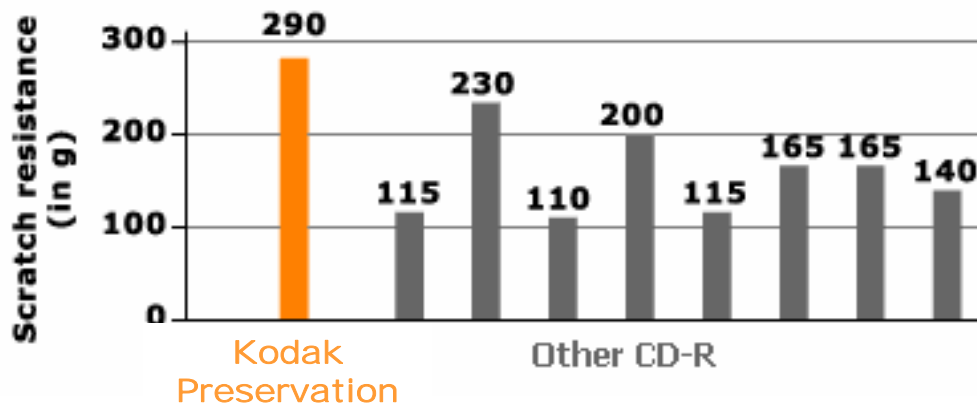
Scratch Resistance

- The dye layer is where your data is stored. It lies just beneath several layers on the top of the polycarbonate disc. If the surface is damaged by scratches or a ball point pen, data will be irretrievably lost.
- With the use of digital photography, no negatives exist, so loss of data can mean loss of your valuable photos.



Scratch Resistance

- For maximum safety, there should be a protective layer that guards the data against physical damage. The chart below shows a comparison of CD-R media subjected to a scratch test. A diamond stylus is pulled across the top side of the disc with increasing amounts of force until the disc shows unrecoverable data loss. Many CD-Rs currently available have only a thin (shiny) lacquer layer.



Calculating Lifetime

- KMP Media longevity tests are conducted according to industry standard ISO 18927-2002 guidelines.
- In general, the test consists of placing samples in an environmental chamber at specified temperature and humidity levels for 5 different "stress conditions".
- Life expectancy is estimated based on the use of the Eyring model (Very similar to the Arrhenius Test Model) which is a mathematical equation derived from thermodynamic laws.
- Based on these tests, lifetime estimates are 300 years for Kodak Preservation CD-R and 100 years for Kodak Preservation gold DVD-/+R.



Test Cell	Test Stress	Number of Samples	Incubation Period (hours)	Minumujm Total Time (hours)	Min. Equilibration Duration (hours)
1	80C, 85% RH	10	500	2000	6
2	80C, 70% RH	10	500	2000	5
3	80C, 55% RH	10	500	2000	4
4	70C, 85% RH	15	750	3000	8
5	60C, 85% RH	30	1000	4000	11

Archiving Guidelines

- Factors Affecting the Lifetime of Discs
- General Storage guidelines from NIST
- “Do’s” of disc handling and storage
- “Don’ts “
- Marking



General Archiving Recommendations from NIST*

General recommendations for long-term storage conditions:
For archiving recordable (R) discs, **it is recommended to use discs that have a gold metal reflective layer.**

Media	Temperature	Relative Humidity (RH)
CD, DVD	4°C to 20°C (39° to 68° F)	20% to 50% RH
A temperature of 18°C and 40% RH would be considered suitable for long-term storage.		
A lower temperature and RH is recommended for extended-term storage.		

*“Care and Handling of CDs and DVDs—A Guide for Librarians and Archivists”
National Institute of Standards and Technology
Technology Administration, US Dept of Commerce

Handling Discs Properly

"Do's"*

*NIST

1. Handle discs by the outer edge or the center hole.
2. Use a non-solvent-based felt-tip permanent marker to mark the label side of the CD-R disc, preferably only in the clear, center hub area.
3. Store discs upright (book style) in plastic cases specified for CDs and DVDs.
4. Return discs to storage cases immediately after use.
5. Leave discs in their packaging (or cases) to minimize the effects of environmental changes.
6. Open a recordable disc package only when you are ready to record data on that disc.
7. Store discs in a cool, dry, dark environment in which the air is clean.
8. Check the disc surface before recording.
9. Protect discs from dirt and foreign material; clean with CD/DVD cleaning detergent, isopropyl alcohol or methanol to remove stubborn dirt.



Improper Disc Handling

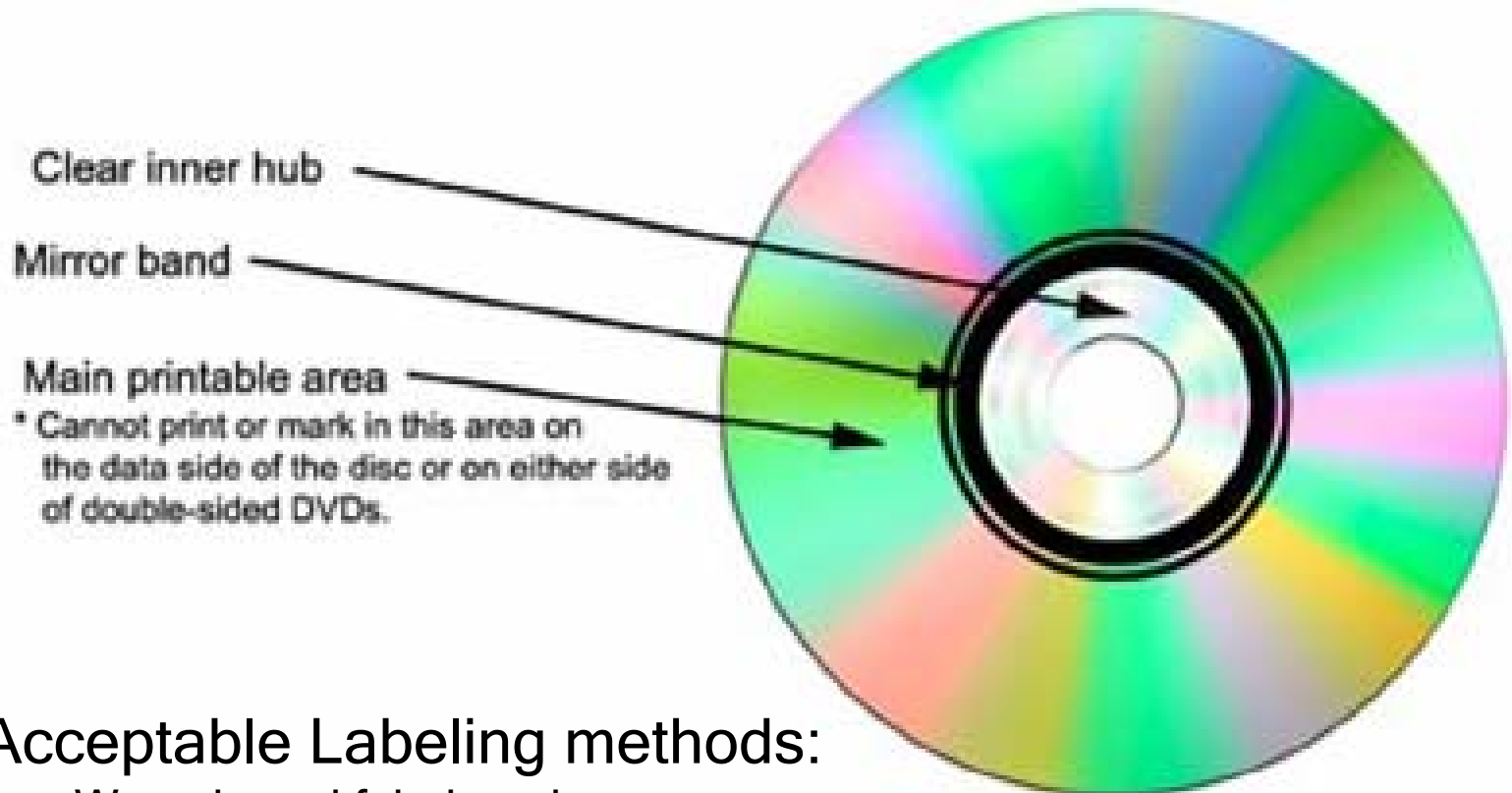
“Don'ts”*



1. Don't touch the surface of the disc.
2. ...Bend the disc.
3. ...Use adhesive labels.
4. ...Store discs horizontally for a long time (years).
5. ...Expose discs to extreme heat or high humidity.
6. ...Open a recordable optical disc package if you are not ready to record.

7. Expose discs to extreme rapid temperature or humidity changes.
8. Expose CD-R or DVD-R/+R discs to prolonged sunlight or other sources of UV light.
9. Write or mark in the data area of the disc (area where the laser reads), especially with a ballpoint pen.
10. Clean in a circular direction around the disc.

Labeling Areas



Acceptable Labeling methods:

1. Water based felt-tipped pen
2. Thermal printer
3. Inkjet Printer
4. Silk screen printing

Preserving Forever ???

- NO PRODUCT is capable of preserving or archiving images, music, data, or videos for ever!!!
- Hard drives crash, hard copy and removable media can be damaged by environmental factors (light, heat, humidity, contamination) or by rough handling.
- Redundancy of storage is your best bet.
- Store your image, data, music, video, etc. in a computer, a backup hard drive, in hardcopy form and on the best removable media available (like the KODAK 24 karat Gold Preservation CD-R or DVD-R).
- Migrate to better removable media when new formats come along if current media will become obsolete or new media is superior for preserving/archiving.
- Preservation takes work, but is worth it!

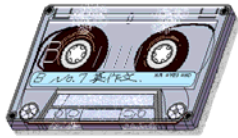
Optical Media
Storage Media



CD-R	CD-RW	DVD-R	DVD+R	DVD-RW
DVD+RW	DVD-RAM	CD-ROM/VCD	DVD-Video	Business Card CD-R

The Path of Storage Media

The Analogue Age



1972
Cassette Tape



1982
VHS



1985
Floppy Disk

A
U
D
I
O



1995
CDR

V
I
D
E
O



1995
CDR

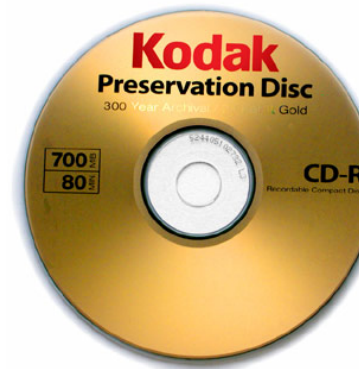
D
A
T
A



1995
CDR



DVDR
2002-



2006 KODAK 24K
Gold Preservation
CD- R and DVD-R

Data Storage Capability of Discs

Picture		VGA 640*480		1MP 1280*960		2MP 1600*1200		3MP 2048*1536		4MP 2304*1728		5MP 2560*1920		6MP 2816*2112	
Picture Size		Fine	Normal	Fine	Normal	Fine	Normal	Fine	Normal	Fine	Normal	Fine	Normal	Fine	Normal
DVD 4.7GB		24736	33567	6909	10213	4474	6712	3356	3915	2472	3130	2134	2609	1565	1955
CD 700MB		3684	4999	1029	1521	666	1000	500	583	368	466	318	389	233	291
MP3															
Memory Size of 4MB per Song	Q'ty of songs														
DVD 4.7GB	1128														
CD 700MB	168														
Video / Movie															
Memory Size GA/30fps/2mbps	Minutes														
DVD 4.7GB	282														
CD 700MB	42														

New Formats: Blue Ray HD-DVD

These new formats will initially have approx. 20GB data capacity but theoretically up to 80GB+.....opening the way for greater data storage in a simple, flexible, compact storage medium!

Thank you!

For a link to view the NIST Archiving guide, use URL below to view NIST's [“Care and Handling of CDs and DVDs—A Guide for Librarians and Archivists”](http://www.itl.nist.gov/div895/carefordisc/)

<http://www.itl.nist.gov/div895/carefordisc/>