CD-RECORDABLE MEDIA
IS PRICE THE ONLY PARAMETER?

(Extracts of surveys in this pdf are on Pages 9 - 13)

PRO **DISC** CD Systems Pty Ltd produces very high quality ***phthalocyanine*** based optical media for the Australian and export markets, from 50mb card size CD-R and 185mb mini CD-R to 4.7Gb DVD+R, DVD-R and 9.4Gb DVD-RAM. (DVD-RAM is a phase change technology).

A recent random survey of CD-R media available in Australia (commissioned by Sinclair Communications, W.A.) reveals just how much the key quality parameters vary from brand to brand, in some cases not even meeting the minimum ***Orange Book*** requirements.

Also of importance for every CD-R customer should be some knowledge about how the recorded or written CD-R will behave in the short, mid and long term, otherwise the whole process of transferring the content becomes an expensive waste of human and system resources.

Of course, the temptation for purchasing managers to 'save' up to AU$1.00 per disc (assuming that, incorrectly, all CD-Rs being 12cm diameter, shiny and digitally perfect, are the same!) becomes alluring indeed when many small to medium sized organisations are now burning thousands of CD-R discs annually.

However, that saving of say AU$1000 per annum palls into insignificance when whole libraries of digital imaging, financial records, corporate files and audio masters become at risk due to catastrophic failure of dye layer or contamination of reflective layer in poor quality CD-R media manufactured to a 'price point' design rather than a 'performance excellence' design.

The accompanying **CD-R Quality Survey** (page 4) gives some insight into the optical performance characteristics of 13 different brands *just after writing/recording* . But for a clearer understanding of what might occur in the *period following* (*from 1 day to 100 years*) take some time to read the three **Research Document Extracts** (pages 13, 16, 18) where the implications of selecting a CD-R employing lower cost ***cyanine*** or ***azo*** dyes are clearly demonstrated.

Kevin Bradley , National Library of Australia, President A.S.R.A. and Vice Chair, Technical Committee of International Association of Sound Archives wrote

**..It is quite possible to achieve better error readings with a CD-R of a specific dye type that may *not* be suitable for storage, than with a more stable disc type..

Drago Kunej , Slovenian Academy of Sciences and Arts wrote

..Disc C (***phthalocyanine*) tested extremely well. In the period when other kinds of discs were completely destroyed, the measured parameters on this disc remained unchanged..

Bernie Adams , Adams Magnetic Products, Inc, wrote

**..the range of quality, reliability and archiveability of CD-Rs is worse than Audio and Video Cassettes ever were. From pure junk to very very good, unfortunately it is not always apparent which is junk and which is good just by looking.....

**..not all CD-Rs are created equal and life expectancy can run from a couple of hours to 100+ years depending on the materials used in manufacturing process....

..The disc with ***Phthalocyanine* dye polymer had not degraded even after a total of 100+ hrs. For the UV exposure test..

Jerome L. Hartke , Media Sciences, Inc, wrote

**..Readability in a few drives does not confirm quality. Even reliance upon brand names can be ineffective unless each manufacturing location and product type is qualified and regularly monitored to assure consistency. Only in-depth testing can qualify media and assure interchange and longevity. The expense of such and effort is quickly repaid when recording processes flow smoothly and field failures are minimised. Establishment of a quality baseline enables further cost savings to be achieved by reducing the frequency of testing while maintaining a high level of confidence in the process..

Bibliography:

- CD-R Archiving: Case study of an interim media.
  Kevin Bradley, National Library of Australia, President A.S.R.A. and Vice Chair, Technical Committee of International Association of Sound Archives
  Paper presented at I.A.S.A., 2000 in Singapore

- Instability and Vulnerability of CD-R Carriers to Sunlight
  Drago Kunej, Institute of Ethnomusicology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts
  Paper presented at AES 20 th International Conference

- CD-Rs and How They Pertain to Evidentiary Use "Longevity of the Recorded Information" 7/12/2001

  Bernie Adams, Adams Magnetic Products, Inc.

  www.ampcass.com

- CD-R Media Survey ¯updated 22/05/2000

  Jerome L Hartke, Media Sciences, Inc.

www.mscience.com/survey.html

CD-R QUALITY SURVEY COMMISSIONED BY *SINCLAIR COMMUNICATIONS* (W.A.)

Test Drive: Sony CRX160S
Recording Speed: 8x

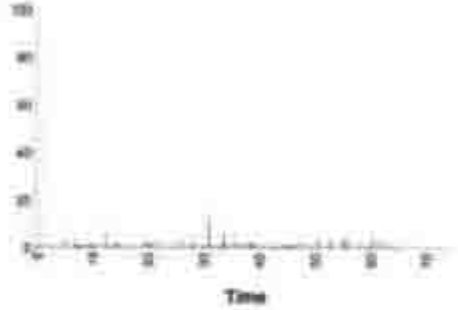
TABLE OF RESULTS — Key Parameters of Optical Performance — ☐ = CD CATS result for parameter

RANK	CD-R BRAND	BLER AVG	BLER MAX	E22 MAX	REFLECTIVITY	WAWM MIN	REC. SURF COLOUR	DYE TYPE*
1	ProDisc Premium White Printable 74 +50yrs 209621423807 (TEST)	0.1	13	0	75	38.681	silver with aqua tint	Phthalocyanine (confirmed)
2	ProDisc Premium White Printable 74 +50yrs 015522110946 (CONTROL REFERENCE)	0.2	12	0	75	36.083	silver with aqua tint	Phthalocyanine (confirmed)
3	BASF 74 Digital Audio HC157M0515174 (TEST)	0.3	10	0	70	37.043	pale blue	Cyanine ?
4	ProDisc Dub 80 Utility CD-R Bulk Production Stock - Dub 80 (TEST)	1.0	25	0	73	37.066	silver with green/yellowtint	Modified Phthalocyanine (confirmed)
5	That's CD-R 80TY 700MB RV 6H251B0884680 (TEST)	0.3	12	0	68	32.472	pale green/blue	Cyanine (confirmed)
6	That's CD-R 80TY 700MB Taiyo Yuden 8L122K0250580 (TEST)	0.9	19	0	68	30.172	pale green/blue	Cyanine (confirmed)
7	HHB CD-R74 x1>x16 J507R5204252444D21 (TEST)	0.6	27	2	66	39.950	silver with green/yellowtint	Modified Phthalocyanine
8	Imation CD-R700 MB/80min x1>x48 5125GG271LH0480B3 (TEST)	2.1	24	5	67	35.357	silver with green/yellowtint	Cyanine ?
9	Sony CD-R 700MB Supremas x1>x40 FB0811F23F074A80 (TEST)	2.8	26	0	70	34.102	silver with pale blue/green tint	Cyanine ?
10	EMTEC CD-R 80 x1>x16 D3113GD1019081LH (TEST)	3.5	25	0	67	14.304	silver with green/yellowtint	Cyanine ?
11	Laser 80min Premium Gold up to x40 10-205151540-00 (TEST)	9.3	42	0	68	17.320	silver with green/yellowtint	Cyanine ?
12	TDK 74min White Printable x1>x16 J620K106308628B09 (TEST)	33.2	510	0	69	31.903	pale blue	Modified Cyanine
13	Verbatim CD-R 80 x1>x24 W2416L5130282 (TEST)	9.9	53	1	71	20.069	mid blue	Super Azo (confirmed)
14	Sony CD-R 700MB EB0504G21F305A80 (TEST)	378.6	1009	2	67	-3.627	aqua	Cyanine ?

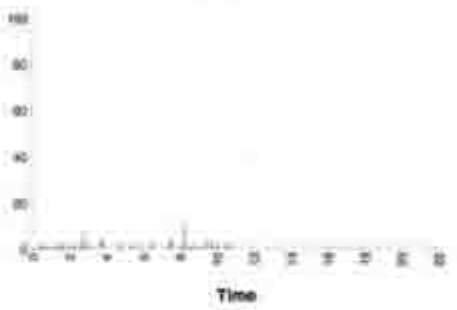
* DISCLAIMER: Some manufacturers do not disclose dye type - this column displays best estimate, and may not be accurate (if not shown as confirmed)

BLOCK ERROR (BLER) GRAPHS

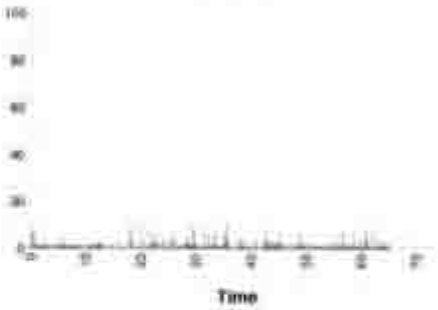
1. Prodisc Premium 50 + Yrs
BLER



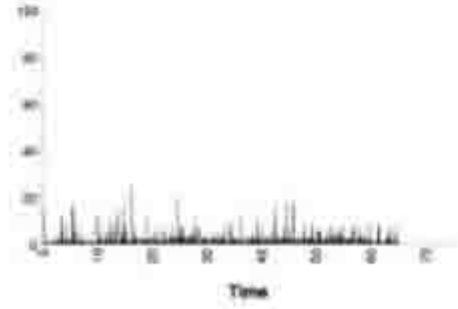
2. Prodisc Premium CONTROL
BLER



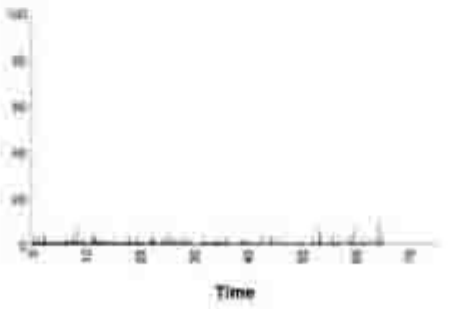
3. BASF 74 Digital Audio
BLER



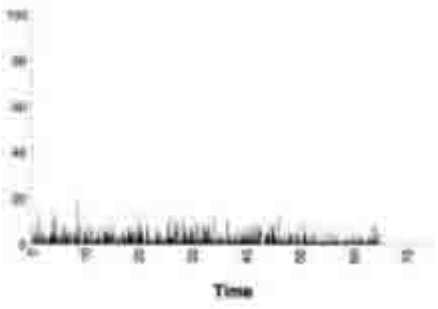
4. Prodisc DUB 80 Min Utility
BLER



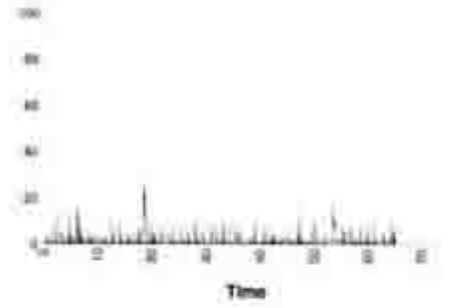
5. THAT'S CD-R 80TY 700Mb RV
BLER



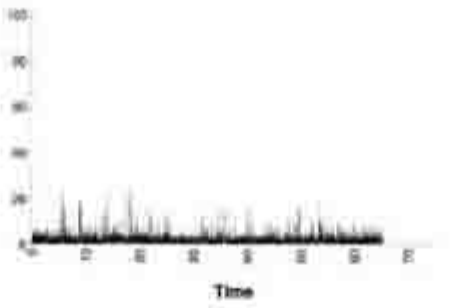
6. THAT'S CD-R 80TY Taiyo Yuden
BLER



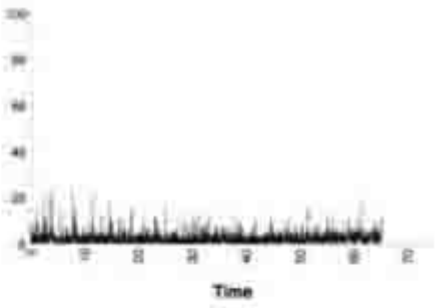
7. HHB CDR74 x1 - x16
BLER



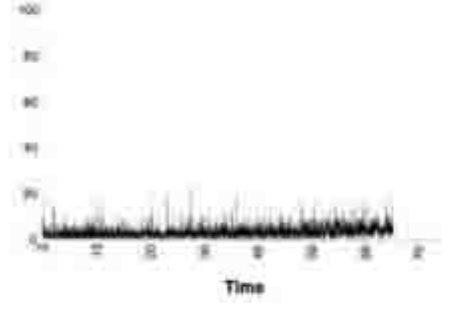
8. Imation CD-R700Mb 74Min
BLER



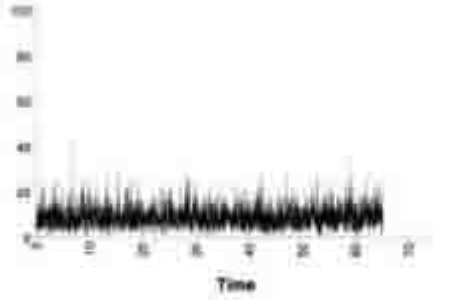
9. Sony CD-R 700Mb Supremas
BLER



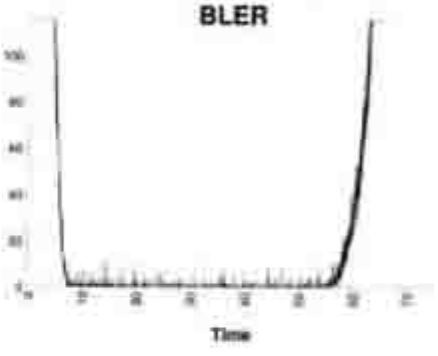
10. EMTEC CD-R 80 x1 - x16
BLER



11. LASER 80Min Premium Gold
BLER



12. TDK 74 Min White Printable
BLER



13. Verbatim CDR 80 x1-x24
BLER

14. Sony CD-R 700Mb
BLER

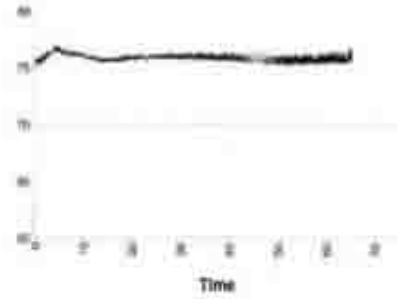
** Note the scale on the "14. Sony CD-R 700Mb" is NOT 0 - 100 Error BLER like all the others,

it is 0 - 450 Error BLER

REFLECTIVITY GRAPHS

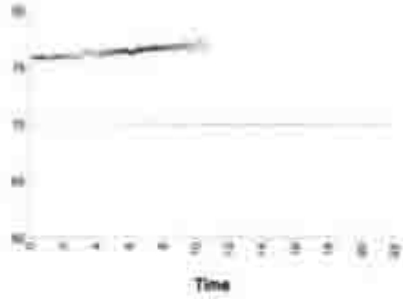
1. Prodisc Premium 50 + Yrs

REF



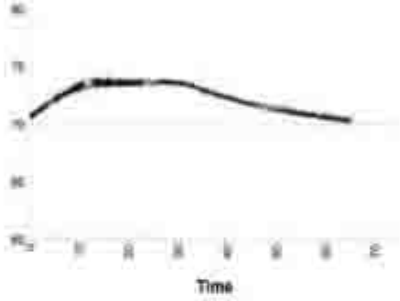
2. Prodisc Premium CONTROL

REF



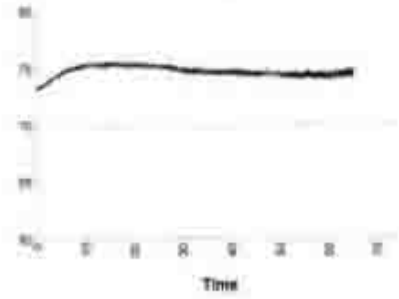
3. BASF 74 Digital Audio

REF



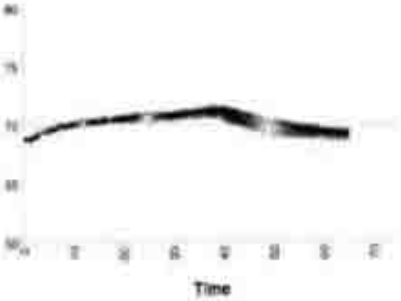
4. Prodisc DUB 80 Min Utility

REF



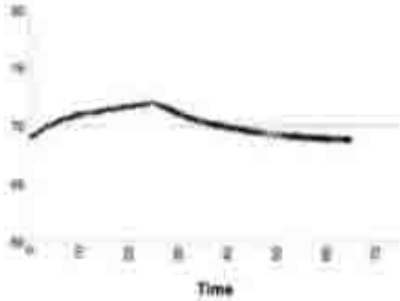
5. THAT'S CD-R 80TY 700Mb RV

REF



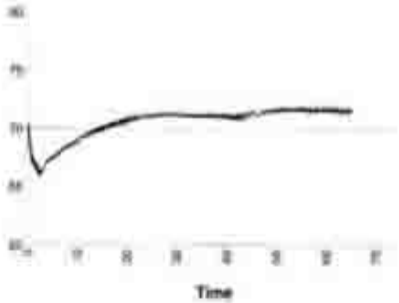
6. THAT'S CD-R 80TY Taivo Yuden

REF



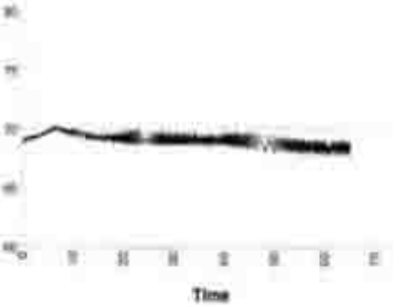
7. HHB CDR74 x1 - x16

REF



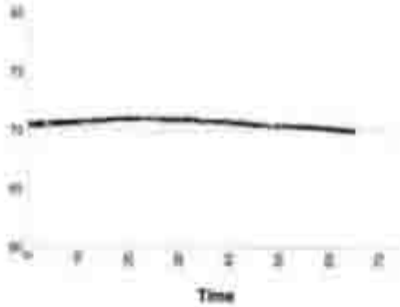
8. Imation CD-R700Mb 74Min

REF



9. Sony CD-R 700Mb Supremas

REF



10. EMTEC CD-R 80 x1 - x16

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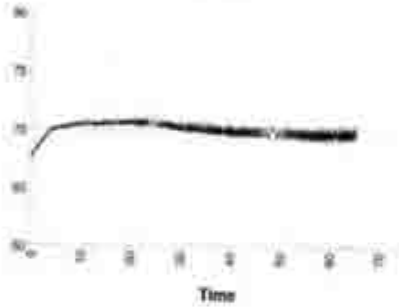
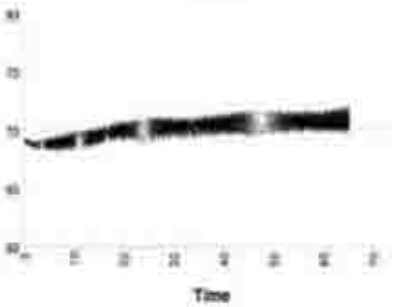


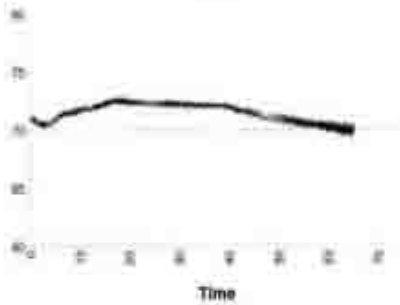
11. LASER 80Min Premium Gold

REF



12. TDK 74 Min White Printable

REF



13. Verbatim CDR 80 x1-x24

REF

14. Sony CD-R 700Mb

REF

** Note Scale is the same on all graphs, and is a percentage of light reflected back from the disc.

A BRIEF GUIDE TO KEY PARAMETERS OF OPTICAL PERFORMANCE

BLER

BLOCK ERROR RATE is a measurement of the number of blocks of data that have at least one occurrence of erroneous data (E11 + E21 + E31). BLER is quantified as the rate of errors per second. The specification level is set to 220 errors per second, although for CD-ROM use, a better specification is an average of no more than 50 errors per second, and maximum peak level 100 errors per second. BLER is critical because the errors need to be kept at the minimum to insure data integrity.

E22

E22 is a two-symbol correctable error in the second decoder (C 2) caused either by one big error or a very high degree of cluster errors. If E22 exists at all, the disc is approaching uncorrectable errors, and there is not much margin of error left to the user. A CD-ROM disc containing a maximum of 15 E22 errors would be unacceptable even though it is correctable, because the information is so valuable.

REFLECTIVITY

Reflectivity is a measurement of the ability of a CD-R to bounce the reflected light, including the information data, back to the laser pickup in the reading CD drive or CD player. While the Orange Book specification requires a minimum of 65%, most CD-R users now expect their recorded discs to perform as well as a manufactured (pressed) disc. To achieve this performance parallel requires a reflectivity of 75% or more which will also improve the overall accuracy of the information read back, and enhances the performance of older drives or players in which the efficiency of the pickup laser diodes may have been impacted by age. This is particularly important at the beginning of a disc, when the laser pickup is first identifying the Table Of Contents and other data. Reflectivity is calibrated with a good reference disc and is used for detection of reflection variations and normalization of I3R and I11R.
REF = I top = I mirror * 0.95 for aluminium

WAWM

WAWM is an acronym for ' Weighted Average Window Margin' and is a measurement of 36 different time interval data values, including all pit and land jitter measurements together with all pit and land length deviations. A compression algorithm then compresses the 36 values into one value and one graph.
So what is WAWM and why is it so important? It all goes back to the earliest days of the Red Book when the best measure of the quality was Block Error Rate (BLER). BLER is an effective measure for detecting physical defects which can cause data errors on the disc. But there is another source or class of errors that is much more subtle, the so-called "*soft errors"* . *Soft errors* occur because of some kind of noise or overall degradation in the quality of the signal being reflected from the disc. As manufacturers push their processes to the limits, the overall signal quality can be compromised. This kind of signal quality degradation is not detected by BLER measures until it is too late. *Soft errors* are the main reason why some discs play on some drives but not other drives. *Jitter and Time Deviation* were added to the Red and Orange Books in recent years and are useful in measuring the grey scale which leads to the sudden onset of high BLER. If you have ever tried to quickly read the *Time Interval Data* section, you will appreciate the difficulty in interpreting the quality of the disc based on these numbers. This is where a simplified WAWM is most informative.

The greater the WAWM, the better the disc

The *soft errors* mentioned above can come from a number of different sources but mainly from *high jitter*, or *high time deviation*, or a combination of both. It turns out that most systems can tolerate one or the other, but the combination is often disastrous. Furthermore, the decoder chips inside the players don't really care about individual pit or land lengths or jitter values. The decoder chips are only interested in whether or not a transition from pit to land, or land to pit, has occurred during a clock cycle. WAWM converts the 36 *Time Interval Data* values into a prediction of how reliably these transitions can be detected inside the player. The greater the WAWM, the better the detection process can work.

About *PRO*DISC CD-R Technology

Physical Description:

- A CD-R is a disc with a diameter of 120mm and a thickness of 1.2mm. The central hole, used to centre the CD-R has a diameter of 15mm.
- The disc is made of polycarbonate, a material with greater mechanical stability and higher temperature resistance than regular plastics.
- A stack ring 0.27mm high protects the CD-R®s when they are stacked on top of each other

Components of a CD-R

- Substrate

  The polycarbonate disc is the basic component of a CD-R. It has a very important role as you will notice when reading the section about the manufacturing process (moulding).

- Dye

  The polycarbonate disc is covered by an organic dye where the recorded information data is stored. The dye will decompose under the effects of the heat generated by a writing or recording laser beam (wavelength of 780-790 nanometers). The dye blackens during this process and the information carrying pits are created.

Gold or Silver

- A gold or silver reflective layer is applied under a vacuum. This layer reflects the laser beam when reading the CD. For economic reasons, silver has gradually replaced gold so as to reduce the cost of the end product as well as increase the reflectivity.

  Nevertheless, CD-R®s with silver rather than gold layers have a shorter lifespan.

Lacquer:

- A layer of lacquer is applied to cover the gold or silver completely. It goes beyond the edges and centre of the disc in order to prevent any peeling (as the layer of gold or silver tends to peel easily and humidity and atmospheric pollutants might therefore infiltrate). This layer is baked under ultra-violet light for two seconds.

Anti-Scratch Coat

- A highly scratch resistant protective layer produced for *PRO* **DISC** is applied to the lacquer which makes the medium more resistant to scratches.

Inkjet Printable Surface

- All *PRO* **DISC** Premium CD-R®s have an extra high resolution printable layer providing matte gold, platinum or white surfaces allowing for *Direct to Disc* Inkjet colour printing of graphics, photographs and text.

See

- *Slovenian Academy of Science/Arts - Research Document Extracts*
- *National Library of Australia - Research Document Extracts*

Organic Dyes used in *PRO* DISC CD-R®s

- Phthalocyanine

All CD-R discs incorporate a photosensitive dye layer where your data is stored. This is the layer that gets deformed or burned when you write to the disc. This dye layer is where your data or music is stored in the form of pits which are oblong areas that are discoloured by the writer. These pits are read by the laser pickup in the drive or player and ultimately transformed into the 1s and 0s that make up your digital information (data and music look the same to the laser pickup). ***The accuracy of the stored information and the reliability of future reading cycles is directly affected by how this dye reacts. That's why the dye quality is so critically important.***

See

- *Slovenian Academy of Science/Arts - Research Documents Extracts*

Phthalocyanine (tha-lo-cy-a-neen), which displays as a silver/aqua appearance on *PRO* **DISC** Premium White and Platinum and a gold/transparent appearance on a *PRO* **DISC** Super Archive Gold, dye has several advantages over others:

1. More responsive to the writing laser so cleaner, better defined pits are created
2. Longest lifetime of any photosensitive dye
3. More transparent, contributing to *PRO* **DISC** 's very high reflectivity

See

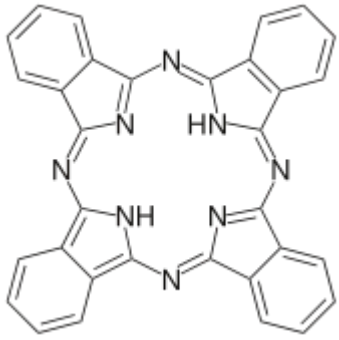
- *Quality Survey*

What does this mean for you? **Cleaner pits** means fewer errors. **Higher reflectivity** means better compatibility among readers. **Longer life** , 50 years or more for *PRO* **DISC** Premium White and Platinum and 100 years or more for *PRO* **DISC** Super Archive Gold

See

- *National Library of Australia - Research Document Extracts*

Phthalocyanine Molecule



Skeletal Model

Ball and stick model

Contrary to the two other types of dye with ***linear molecular*** structure, Phthalocyanine has an ***annular structure*** , thus offering the benefit of increased structural robustness by forming a strong and extremely stable chemical bond.

Other Organic Dyes

- Cyanine

  These CD-R discs have a green recording surface, and include an organic dye based on Cyanine. Their quality is variable, and they have a shorter lifespan than CD-R's using Phthalocyanine-based dye. Light reflection is lower, given the colour of the dye, and the burning is less accurate.

See

- *Slovenian Academy of Science/Arts - Research Document Extracts*
- *National Library of Australia - Research Document Extracts*

- Metal Azo

  The CD-R's made with metal azo have a blue or pale blue recording surface, and use a silver reflective layer, which gives good reflectivity despite the colour of the organic dye. Like Cyanine, the dye is less stable than the Phthalocyanine, has a higher BLER rate when recording, and consequently a shorter lifespan.

See

- *Slovenian Academy of Science/Arts - Research Document Extracts*
- *National Library of Australia - Research Document Extracts*

CD-R Dyes: How to Tell What's What

All CDs contain a reflective layer that allows a laser to bounce off the CD and be read by the laser pickup in your CD-ROM drive or CD player. The ones and zeros are coded into the dye layer of the disc and are ultimately transformed into the data or music that you are storing. Many metals are suitable for use as a reflective layer, although only three have been in widespread use for CDs (mostly because of cost). Aluminium is used for CD-ROM, CD-Audio (manufactured, play-only discs) etc. Gold and Silver are currently being used for CD-R.

Much of the recent confusion started when silver CD-R's with reflective layers were first introduced, changing the apparent colour of the dye. Cyanine (blue) dye appears green on gold media and blue on silver media. Phthalocyanine dye appears transparent on gold media, but light aqua on silver media. The term *Gold on Gold* (*PRO* **DISC** Super Archive Gold) is used because the disc appears gold on both recording surface and top surface .

These are the three types of dye currently in use for CD-R media:

Name	Pronunciation	Actual colour	Common names
Phthalocyanine*	thalo-sy-a-neen	Very light green	gold dye, gold on silver, silver on silver
Cyanine	sy-a-neen	Blue	Blue dye, green dye
Azo**	ay-zo	Very deep blue	dark green, dark blue

Silver vs Gold - Which is Better?

Q. What is the difference between gold and silver CD-R?
A. All CD-R media incorporates a reflective layer that allows the reader to see the data that is digitally stored on the disc. *PRO* **DISC** Premium White Printable and Premium Platinum Printable have a reflective layer manufactured from 99.1% pure silver & *PRO* **DISC** Super Archive Gold discs are manufactured with a 99.9% pure gold reflective layer. -- the real stuff!

Q. Is gold better for one purpose than another (and vice versa)? As far as can be established, the urban legend is that gold lasts longer but silver is better quality. Is that accurate?

A. *PRO* **DISC** Super Archive (Gold Layer) and Premium White/Platinum (Silver Layer) are manufactured to the same very high standards, but there are some differences in performance and lifetime. ***We estimate the lifetime of our Premium White/Platinum CD-R's to be 50 years or more & our Super Archive Gold CD-R's to be 100 years or more.*** Many government organisations use the Super Archive Gold for archival applications to ensure the longest life possible, together with the very best mechanical and optical performance.

See

- *Quality Survey*

Why *PRO*DISC CD-R?

Compatibility

PRO*DISC CD-R is the highest quality both in mechanical/optical and in proven very long term reliability** (*See National Library of Australia ¯Research Document Extracts*) and the most universally compatible in the industry. Not all CD drives and CD Players are created equal. Although drive manufacturers need to conform to a basic set of CD-R standards for manufacturing, there are subtle differences in how well the laser pickup is able to handle the reflected signals from CDs. *PRO* **DISC *Premium CD-R media has the highest reflectivity in the industry (*See Quality Survey*), which improves the accuracy of the player read-back and ensures performance from older drives and players.

For many years now, most leading drive manufacturers have used high quality Phthalocyanine CD-R discs as a reference for developing and testing of their products. This is a further compatibility benefit when using *PRO* **DISC** Premium CD-R discs as our competitors often need to change their dye formulations with solvents and other additives to accommodate different writing speeds and/or improve resistance to UV light and heat.

See

- *Slovenian Academy of Science/Arts - Research Document Extracts*
- *National Library of Australia - Research Document Extracts*

*PRO***DISC** CD-R exhibits extremely consistent signal performance across the entire disc. Because of *PRO* **DISC** 's attention to detail, our moulding process results in discs that are flatter than the competition.

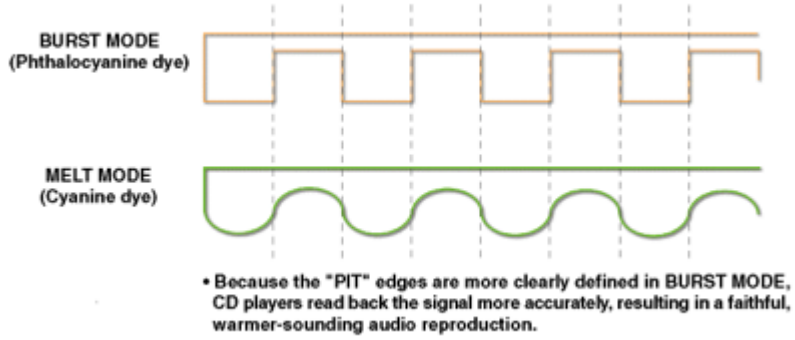
While all discs are very slightly warped, if they are warped beyond a certain tolerance, drives and players can have problems during playback. Temperature variations in different office/studio/system configurations can cause discs to warp more than usual, so it helps to start out with the flattest disc possible.

More sensitive to the writing laser

When you burn a CD-R, your writer creates pits in the dye layer that make up the 0's and 1's for digital recording. *PRO* **DISC** ☜ Phthalocyanine dye reacts more quickly to the writing laser than other dyes. Because our dye reacts in a **burst** mode instead of a **melt** mode as with other dyes, sharper pit edges are created (see diagram below). These sharper edges are easier for CD drives and CD players to read, so faster and more accurate reading is possible together with more fidelity in audio reproduction.

Burst Mode (Phthalocyanine dye)

Melt Mode (Cyanine dye)



Naturally resistant to damage from UV light (ie. Sunlight)

CD-ROMs and Audio CDs are now expected to perform in all manners of portable, vehicular and marine environments. ***PRO*DISC's Phthalocyanine dye is more resistant to UV light than dyes used by our competitors.** While other dyes are very reactive to UV light unless stabilizers are added, *PRO* **DISC** dye is naturally stable, so no additives are required. This means that once your data files and audio tracks are saved to a *PRO* **DISC** Premium CD-R, **you can be sure to use it for a long time to come**

See

- Slovenian Academy of Science/Arts Research Document Extracts

Heat Resistance
The advantages of a naturally stable dye don't end with UV resistance. *PRO* **DISC** CD-R's are also more resistant to damage from heat sources, whether natural or man-made. For instance, in a motor vehicle the ambient temperature in summer can reach very high temperatures and added to the heat that is generated in the player itself, you come up with a thermal combination that can be very hostile or deadly to CD-R media produced with other dyes. Even the darker colour of our competitors dyes contributes to the amount of heat absorbed by the disc.

Extracts from:

CD-R Archiving: Case study of an interim media.

Kevin Bradley
National Library of Australia

Presented at I.A.S.A., 2000 in Singapore

**..With its potential for pristine replication tempered by the possibility of catastrophic loss, the digital archive has been an earnestly debated issue in the world of sound archiving..

**..Like any other archival technology, the CD-R has technical issues that must be addressed to ensure that the original recordings exploit the full potential of the recording technology and to ensure that they have an appropriate archival life..

**..In this area of speciality the NLA is responsible for preserving the largest oral history, folklore and social history collection in Australia comprising some 33,000 hours of unique items vital to documenting Australian cultural heritage,

**..There are three components to the CD-R archival system; the technical database/ description, the CD writing system and the CD testing system. All parts of the system are integral to the overall outcome..

**..Jacob Trock's paper at JTS supported the proposition that errors are an adequate indication of faults in a CD-R, but that those errors are caused by a number of different problems that cannot be distinguished by a simple error tester. In other words, an error checker is adequate for the identification of problems, but for a full scale analyser is necessary to understand the problem's cause..

**..Since the system went into full production in March 1996, we have preserved nearly 6,000 hours of material onto CD-R. When, in the next 12 months, the NLA moves towards a digital mass store, the transfer from CD-R to storage can be automated using an appropriate CD jukebox and a digital acquisition system..

**..Any digital archiving practice must also incorporate adequate testing at all stages in the process. This is especially so with CD-R where constant attention to blank media, recording systems and storage conditions is necessary to ensure appropriate archival life..

**..The CD CATS, while an extremely expensive piece of equipment, nonetheless complies with, and tests, all aspects of a CDs performance defined in the standard, and has, in addition, developed some other parameters that highlight possible problems that are not defined in the standard, particularly in the area of blank CD testing. A device that carries out full analytical tests enables the determination to cause of failure, be it the media, the writing devices, the storage, or damage..

**..The CD-R manufacturing industry has become, of late, a market place driven by narrow profit margins and large quantities. CD-R manufacturing equipment has become, smaller, less expensive and more self-contained. As a consequence there are many more small manufactures of CD-Rs with minimal experience producing CD-Rs for the low cost market. Many of what appear to be reputable brands may turn out to have been manufactured by a second party and repackaged for sale. A CD-R manufacturer can manipulate the dye, reflective layer ad the now expensive polycarbonate components to reduce price or control quality. And with pricing so tight, the flexibility to dispose of rejected CD-Rs is less available, instead of which they are often sold as lower cost items..

**..[We have defined the standards we expect the CD-Rs to perform at, and test discs, and similarly expect our supplier to carry out tests, to ensure that performance standard is met]..

**..The link between media and writing equipment has often been discussed and manufacturers and independent analysts alike have published charts that document the relationship. Our testing has certainly supported this view..

**..Low initial errors are important in the life expectancy carrier. Artificial aging and testing carried out at the NLA supports the view expressed in a paper at the recent JTS that initial error rate has an exponential influence on the life of the carrier..

**..Applying only increased temperature and humidity has produced reasonably inconclusive results and take inordinately long periods of time. We have instead applied an approach described by Dr Masatoshi Yanagimachi of Mitsui, whereby the CDs are cycled through a range of temperatures, described as 'softening' and then exposed to high levels of calibrated light (150 lux) and measured at short regular intervals..

**..At the stage of initially writing a CD-R, the dye type is not the only factor that needs to be considered, the combination of components, construction and writer all play a part in determining the quality of the resultant CD. It is quite possible to achieve better error readings with a CD-R of a specific dye type that may not be suitable for storage, than with a more stable disc type. So the dye type is only one aspect that needs to be considered when selecting a CD-R..

**..The NLA has primarily used the Phthalocyanine discs, though for a period the low error rate achievable with the metal stabilised AZO resulted in the use of that disc. However, the accelerated aging tests revealed, all other parameters being equal, that the phthalocyanine discs respond better to artificial aging..

**..The lack of error increases in CD-Rs in storage over the past 5 years is an important and encouraging result. There is little doubt that the discs are in fact undergoing some level of chemical decay, however, the effects of that degradation have yet to impact on increased faults in the disc themselves..

**..The use of CD-Rs at the NLA can be considered a success as some 6,000 hours of material has been copied to a reliable digital format and will be transferred in a reliable and automated fashion..

**..Jitter is the variation of the data from ideal clock time. It is basically an issue of timing. It may incorporate program jitter, or the jitter caused by pit variation on a CD. Excessive jitter translates into errors, which may or may not be correctable, depending on the severity. More importantly, or at least more commonly, intermediate level jitter may be associated with degradation of the aural signal. In other words, if jitter is present at the digital to analogue converter through which you listen to the CD, it is possible to hear the effect. Jitter has been a concern amongst the CD mastering and manufacturing industry who have noted that a copy of a manufactured CD made in a recording studio may sound better than the original..

**..Vigilance is the price of digital archiving. The only way to know the condition of a digital collection is constant and comprehensive testing. This cannot be stated too strongly, no collection using CD-R as an archival carrier should be without a reliable CD tester. The error correction capability of CD replay equipment will mask all audible effects of degradation until the errors are well into the uncorrectable region. When this point is reached, all subsequent copies are irreversibly flawed. On the other hand, a comprehensive testing regime allows for best possible planning of preservation strategies by acting on the known, objective and measurable parameters that digital archiving make possible..

**..Testing is also an integral part of the creation process. CD writing is a process that has inherent risks and must be checked at the creation stage. Error measurements, as well as creating a benchmark for future testing, will enable the detection of problems as they occur. This need for constant checking and calibration should have been a part of any analogue archiving scheme, however, the penalty for not testing in the digital domain is not just loss of quality, but also loss of data..

**..Likewise the burner is also a critical point and must be checked and calibrated regularly. After a specified period the laser must also be replaced..

**..CD-R is potentially a useful and functional part of the audio archive, providing that tight tolerances are applied and comprehensive error measuring is undertaken. The Library's experience in the use of this material has been positive, though we have not ignored the possible problems. Instead, we have attempted to gain the potential benefits by managing the risks..

Extracts from:

CD-R MEDIA SURVEY

Jerome L. Hartke, Media Sciences, Inc
www.mscience.com/survey.html

**..Failures for other discs increased from 33% in 1998 to an alarming 60% in 2000, mostly in high radial tracking and jitter..

**..Falling prices, new suppliers, conflicting vendor claims, and silver - green - gold - blue alternatives present a bewildering matrix to CD-R buyers requiring both high quality and low cost. since readability in a few drives or the absence of coasters are not effective quality indicators. Costly and embarrassing field failures are often the result..

**..Since drive standards do not exist, readability is not an indicator of disc quality because various read drives can respond differently to media defects. Only conformance to disc standards provides confidence in readability and interchange..

**..Quality can be established and maintained only through in-depth testing using properly calibrated equipment and trained personnel..

**..Reliance only upon pass/fail tests, or upon qualitative tests such as readability, often results in misleading results and erroneous conclusions..

**..although heat, humidity, sunlight, and chemicals may degrade CD-R quality. Experience indicates that longevity is best attained by assuring high initial quality. Discs can then be stored under the proper conditions with confidence that they will always be readable in any system of reasonable quality..

**..Intensity of the reflected laser beam as measured by Itop is important to readability. Reflectivity is affected by both the type and thickness of metallization and by attenuation in the dye layer..

**..Marginally high results are not uncommon, but very high values can result from pre-groove or dye problems, and such discs may be readable in some drives but not in others..

**..Excessive noise caused by defects can disrupt the radial servo of a write or read drive, resulting in unpredictable errors..

**..Weak signals predict readability problems, especially if subsequent dust or scratches degrade the entrance surface of the disc..

**..Asymmetry evaluates the match between the dye layer and OPC, and also evaluates the radial uniformity of the dye..

**..Error-free data recovery requires that tolerances be maintained in the time intervals between mark-land transitions. Deficiencies usually result from either pre-groove or dye problems, and are a frequent cause of media failure..

**..Test results clearly indicated that all discs were not alike, even if their colours were similar. Cost pressures have resulted in a broad matrix of stampers, dyes, metallizations, and processes. Quality is primarily determined by efforts at the manufacturing facility..

**.. Readability in a few drives does not confirm quality. Even reliance upon brand names can be ineffective unless each manufacturing location and product type is qualified and regularly monitored to assure consistency. Only in-depth testing can qualify media and assure interchange and longevity. The expense of such and effort is quickly repaid when recording processes flow smoothly and field failures are minimised. Establishment of a quality baseline enables further cost savings to be achieved by reducing the frequency of testing while maintaining a high level of confidence in the process.

Extracts from:

Instability And Vulnerability of CD-R Carriers to Sunlight

Drago Kunej
Institute of Ethnomusicology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts

**..Many audio and audiovisual archives use the CD-R medium as temporary target medium for the transfer of analog recordings. Smaller audio archives, and research audio archives in particular, are usually inadequately aware of the vulnerability of CD-Rs and do not place enough importance upon the correct manner of storage and handling of digital carriers. It is the aim of this paper to draw attention to the vulnerability of CD-R carriers to sunlight and to emphasize that an inadequate choice of a disc, careless handling and storage, and inadequate testing can quickly jeopardize previously recorded archival material or even lead to its loss.

**..The institute of Ethnomusicology therefore performed a simple experiment whose aim was to demonstrate the susceptibility of CD-Rs to sunlight. Already known from technical literature (i.e. [1]), this sensitivity to sunlight might present a serious difficulty which tends to be greatly underestimated when CD-Rs are being handled or put in storage, The experiment takes into account everyday, realistic and thoroughly possible circumstances found in scientific research institutions with audiovisual archives. .. **..Discs A are inexpensive multipurpose CD-Rs with the cyanine dye and a silver reflective layer. Due to poor manufacture, or maybe due to insufficient compatibility with our CD burner, even the very first measuring revealed a comparatively high average BLER (around 30.0),

**.. Discs D are discs of the same kind and with equal characteristics as the discs A, but made by a different manufacturer. There were used for the test repeated in 2001 since the discs A were no longer in the market. With the average BLER around 1.1, in the course of the first measuring they turned to be much better that the discs A.

**.. Discs E were the so-called 'gold' discs with the phthalocyanine dye and a gold reflective layer, in a more expensive price range, and for different usages. The first testing indicated the lowest average BLER of all the discs tested (around 0.3); likewise, the other tested parameters were among the best as well..

**..According to our measurements, the peak BLER and the average BLER first increased as the time of exposure increased, but when they reached a certain limit they started to decrease despite the fact that the disc was still exposed to light and that its general condition started to deteriorate. Among the more 'damaged' CD-Rs other parameters such as the BERL and the E32, were therefore better indicators of the general condition of the disc.
Several months of monitoring and measuring the discs revealed that some of them were very susceptible to sunlight and the conditions to which they were exposed. Taking into account the different areas in which they were placed, the manner in which they were exposed, and their different brands, the results varied considerably....

****.. 4.3 CD-Rs Exposed to Direct Sunlight**
Exposed to this kind of light, the discs turned out to be at their most sensitive and vulnerable, and the differences between individual discs became pronounced. Since due to extremely rapid changes some of the discs could not be measured often enough , they manifested pronounced and swift changes of error conditions. Especially marked was the change occurring on the discs that had been exposed with their recorded side facing upward....

***.. 4.3.1 Recorded Side Facing Upward*
Disc A exhibited extreme vulnerability to such exposure. Even after 20 days the average BLER increased from 17 to 1664 and the total E32 count from 139 to 6.800,000 (see Fig. 7 and Fig. 8, curve A0. The disc was very difficult to play, and the recorded music was almost unrecognisable. Five days later the disc was completely destroyed, the CD player could not recognize it, and instead of playing it the player sent the "No Disc" message....

**..The measuring was repeated on disc D in April 2001. Despite the fact that the changes on this disc occurred more slowly, this disc exhibited similar results as disc A (see Fig. 7 and Fig. 8, curve D). After a thirty-day exposure the peak BLER and the average BLER exceeded the limit of 220, and six days later there were clearly audible errors when the disc was being played. After a fifty-day exposure the disc was completely destroyed....

**..Disc C tested extremely well. In the period when other kinds of discs were completely destroyed, the measured parameters on this disc remained unchanged (see Fig.7 ad Fig. 8, curve C). Only after almost a year of exposure its average BLER started to increase, has lately became increasingly obvious, and is still on the rise....

**..Disc E also tested fairly well. It has bee exposed only since April 2001, but after more that 70 days it displays only a slight increase of the average BLER from 0.3 to 3.3; other parameters remain unchanged.