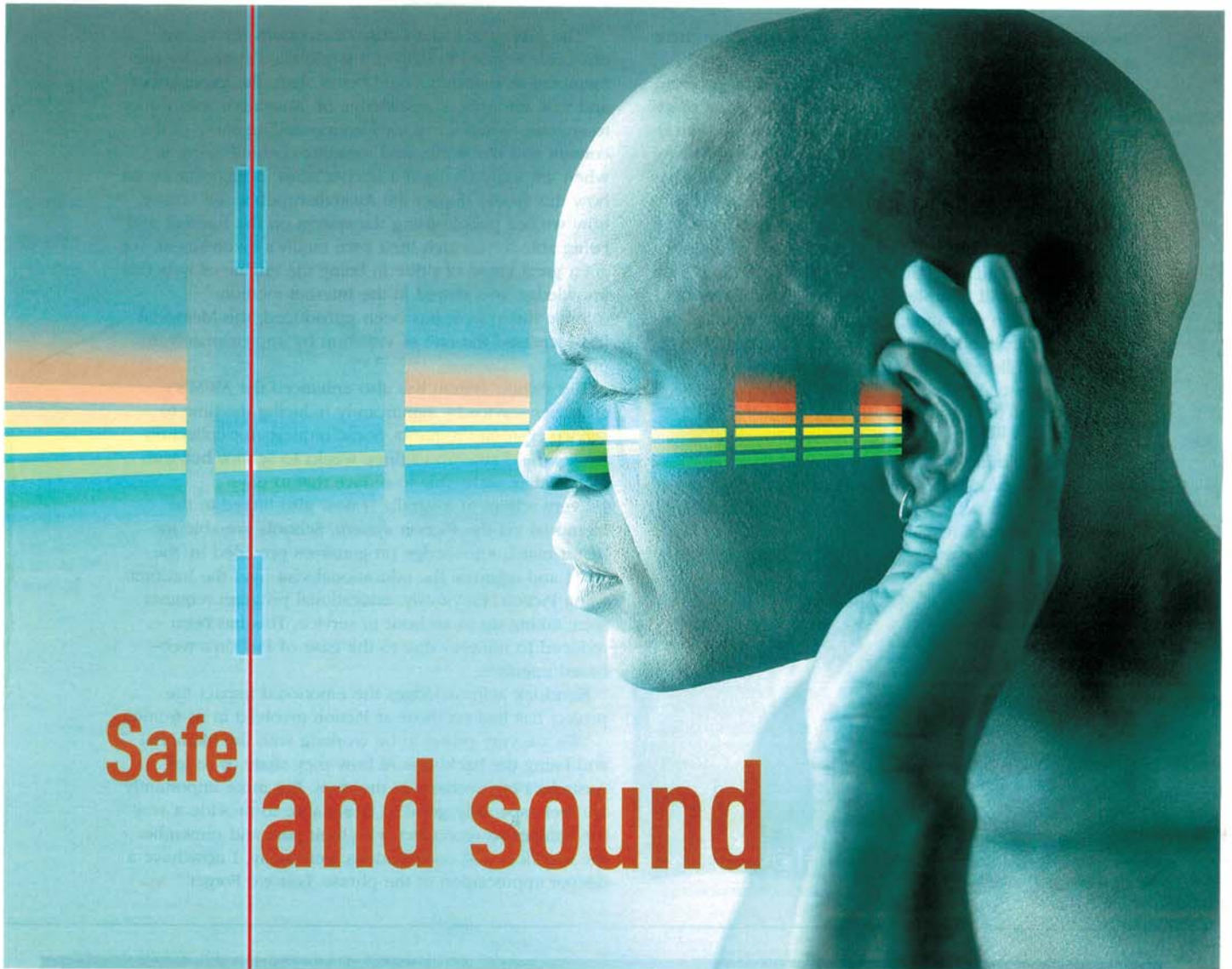


# FULL VERSION



## Safe and sound

### FEATURES

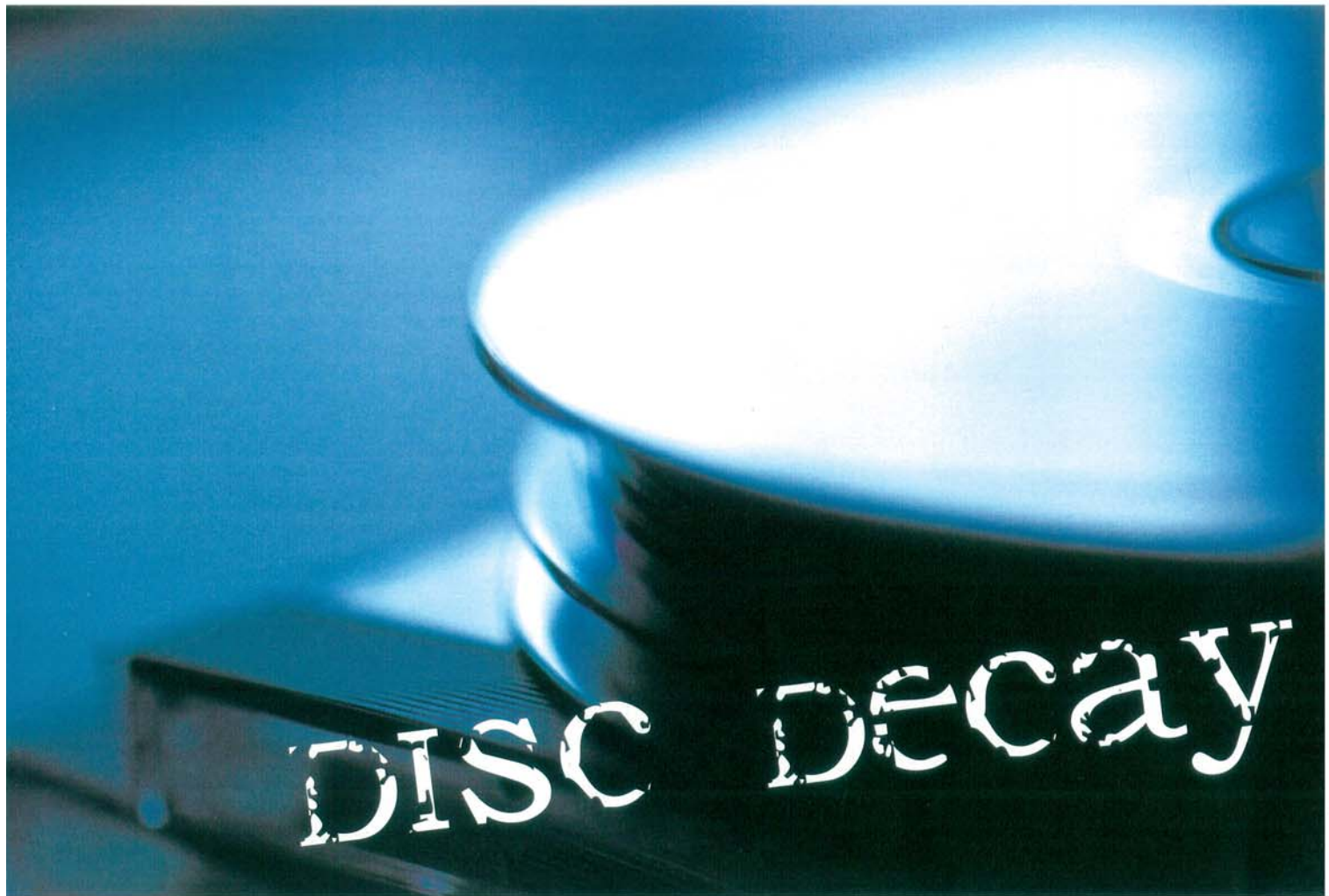


#### 54 Disc decay

Although all CD-Rs look the same, research and laboratory testing by some of the most prestigious archiving departments in Australia have proved that not all CD-Rs are equal. In fact, results show there are incredible differences in longevity.

### EDITORIAL

Many organisations put their faith in CD-Rs for archival purposes, but often little is known about the comparative quality of the discs available on the market, which is a very worrying scenario, for as IDM finds out from some of the foremost archivists in the country, the quality of the discs vary considerably. We offer an extensive insight into what to look for in your CD-Rs to make sure you're not left exposed by your data expiring years before its time.



**Although all CD-Rs look the same, research and laboratory testing by some of the most prestigious archiving departments in Australia have proved that not all CD-Rs are equal. In fact, results show there are incredible differences in original quality and longevity. Some record data well initially but deteriorate shortly afterwards, whereas others maintain stability over a number of years. Rodney Appleyard reports on the CD-Rs that have met the approval of the ABC, the National Library Australia, the National Archives of Australia and the State Library of Victoria, and the ones that did not make the grade.**

The proof is in the manufacturing of the CD-R. With so many makers of CD-Rs on the market, consumers usually do not think about the brand or type that they purchase. After all, most people think that if it fails, they can simply go out and buy another one, because they are so cheap.

However, the research and testing carried out by the above institutions, which are responsible for archiving and managing a vast array of precious holdings, has now paved the way forward for private sector enterprises and IT managers to follow suit and feel confident about using CD-Rs that are undoubtedly reliable and of a high quality. These CD-Rs have been tested to their limits in artificial handling and temperature environments but have still protected data despite the conditions. The other CD-Rs that have failed these tests have in the past cost companies large amounts of money and have damaged their ability to get on with day-to-day business due to the loss of data. These companies have also been exposed before to litigation over the loss of intellectual property.

Kevin Bradley, the manager of the National Library Australia's digital and audio preservation section, advises people not to go out and buy CD-Rs for archival purposes until they have done thorough research and testing on the particular product.

"We have carried out extensive testing on all different types of CD-Rs and have found there to be huge differences in quality, robustness and longevity. Some survive a lot better than others. Through our testing, we take pride in educating the public about the capabilities and shortcomings of CD-Rs.

"They are a risk to use for storage, but if they are managed in the correct manner, and comply with manufacturing standards, with a strict testing regime in place, they can be used adequately for archiving purposes. Although we cannot endorse a brand, there are incredible differences between standards currently on the market."

## **CD-R construction**

All CD-Rs should comply with the Philips Orange Book Standard (this is the set of specifications created by Philips and Sony to define the optical signal characteristics, physical arrangement, writing methods and testing conditions for CD-R discs) to provide the best guarantee of longevity and robustness. However, Bradley claims that some are made with cheaper material than others, resulting in very wide differences in price and quality.

Most of the disc is made up of polycarbonate (plastic) substrate. This provides the depth needed to maintain the laser focus on the metal and data layers. However an error will occur if there is anything inside or on this layer that prevents the laser from focusing on the data layer. For instance, fingerprints on the polycarbonate layer can cause the CD-R to seriously malfunction in reading back data.

The data layer is a dye that sits in between the polycarbonate substrate and the reflective layer. A laser beam burns pits and bumps into it, which are essentially ones and zeros. These pits and bumps contain the data on the disc, which can be read back by the laser.

There are four chemical formulae for the dye used on the data layer. These are: the Cyanine/light green/blue - which is low cost to make and is the most common and provides the lowest longevity; Phthalocyanine/transparent with a hint of green tint - this provides the highest longevity and is the second most common; Metallised azo/blue, which costs less to make, but is not as common and Formazan/light green, which is a combination of Cyanine and Phthalocyanine, costs less to make and also not as common.

A good dye will burn a clean "U" shaped pit, so the data is easy to read, instead of a "V" shaped pit, made by cheaper dyes used by manufacturers who produce budget quality CD-Rs. If the pit is not formed properly, timing errors can cause unreliable data readings.

A reflective layer is also put on top of the data layer. This is usually silver alloy, pure silver or gold. The purpose of this layer is to reflect the laser beam back to the laser photosensor in the laser head. Manufacturers who make better quality CD-Rs will use a thick layer of reflective coating, but those who make budget quality CD-Rs will vary this coating to match costing constraints. Gold is known to be the most robust, whereas pure silver and silver alloys are known to corrode more readily.

On top of this is a protective layer, which allows users to label the CD-R or write on them with ink. However, it is recommended that archiving users do not apply solvent based adhesive labels because they can damage the CD-R dye layer, making it unreadable by the laser.

Bradley says that the longevity of the CD-R relies heavily on the construction of the CD-R. "You can't pin down the long life to one parameter. It relates to a variety of different reasons, such as the reflective layers, the dyes used, the way it is burnt. 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 National Library 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 ageing tests revealed, all other parameters being equal, that the Phthalocyanine discs respond much better to artificial ageing."

## **CD-R testing**

Tests have revealed that CD-Rs which are made differently also respond in separate ways to harsh conditions. A study published last year by the Journal of Research of the National Institute of Standards and Technology, titled: "Stability Comparison of Recordable Optical Discs - A Study of Error Rates in Harsh Conditions", found that there are significant differences in the stability of recordable optical media from different manufacturers.

The main factors, which the study tested, involved the CD-Rs' responses to higher temperatures, humidity and light exposure. It found that higher temperatures and humidity caused the dye inside the CD-R to degrade and breakdown, making it more transparent, and therefore unreadable in areas. Light exposure was found to increase degradation of the dye too.

The discs were monitored via an industry standard laboratory CD-R analyser: The CD CATS SA3 Advanced, which measured all the CD disc parameters, including BLER (block error rates - the number of data blocks per second that contain detectable errors), E32 errors (means that errors can't be corrected), jitter, and other timing errors, according to the optical disc industry standards.

A random selection of CD-Rs from the commercial market were chosen for testing, and most of them returned error rates due to increased temperature, humidity and light.

However, the CD-Rs which employed the Phthalocyanine dye and silver reflective layer, or the Phthalocyanine dye and gold reflective layer (which is an even better combination) were much more stable than all the other CD-Rs tested. CD-Rs using these elements were also considerably stronger than other CD-Rs in surviving extreme stress conditions, reporting much lower jitter and E32 rates, leading the survey to report that CD-Rs made with this quality are much more likely to be suitable for long-term storage of important digital data.

This survey discovered that these media types will protect data for many years and are therefore suitable for archival applications. It reported that the formulation and quality of the dye is the most important factor in terms of maintaining the readability of the data.

David Wickert, Managing Director of ProDisc Systems (Australia), which specialises in the production of archive grade CD-Rs to these specifications, talks about how important it is for people who buy CD-Rs to know about the quality of manufacturing and ongoing testing before they purchase any products for archiving or mastering applications.

"It has been proven that a CD-R that is manufactured to ISO standards (meaning the discs can be read by many operating systems), employing the very highest quality Phthalocyanine dye, and the very highest grade gold reflective layer, can last for 200-300 years. That's because gold doesn't oxidise and the Phthalocyanine dye itself is very stable and doesn't fade."

**"We have carried out extensive testing on all different types of CD-Rs and have found there to be huge differences in quality, robustness and longevity. Some survive a lot better than others. Through our testing, we take pride in educating the public about the capabilities and shortcomings of CD-Rs."**

**KEVIN BRADLEY, THE MANAGER OF THE NATIONAL LIBRARY AUSTRALIA'S DIGITAL AND AUDIO PRESERVATION SECTION.**

The Phthalocyanine dye, used by ProDisc, is an exclusive Mitsui product that has been patented since 1993. It has been proven to deliver outstanding performance for speed of record, compatibility and extended longevity up to 300 years.

"Our main focus is to provide the finest of CD-Rs for any organisation that needs to archive for years to come. To guarantee this, we believe that every part of the manufacturing process must be carefully monitored, and the finished product subjected to rigorous quality control methods before it can be used. You can't maintain the high standards of product performance that we provide without having the commitment to provide the very highest level of quality control."

Wickert says that organisations actually request ProDisc to carry out CDCATS testing for them, because they do not have access to industrial or laboratory quality control systems. He provides an example here of the difference between discs on the market.

"We've done tests with different CD-Rs on exactly the same drive, on the same day in a climate controlled environment, within one hour of recording, and found that one disc reported a BLER 0.1 rate, (ProDisc Premium White), and another disc had a BLER rate of 580. Specifications point out that the BLER rate should never ever exceed 220."

"It is difficult to comprehend how educated professional CD-R users can expect an obviously budget (CD-R) product to offer reliable short term quality, let alone mid to long term archival performance for their organisation."

"Whilst massive improvements in manufacturing, economy of scale factors (mostly due to the rapid uptake of CD-R over the last decade) have contributed to a dynamic price spiral, it is worth bearing in mind that very high quality raw materials and strict process engineering and laboratory quality control procedures still have to be factored in when producing quality CD-R products such as the ProDisc archival range."

"All of the scientific reports published over the last 6-7 years worldwide on CD-R quality and aging reach the same conclusion: Build the disc with proven, stable recordable dye and nonoxidising reflective layer components, whilst ensuring excellence in Orange Book performance via CDCATS testing regimes and the resulting CD-R disc will always outperform."

Kevin Bradley, from the National Library Australia, backs this up. "The CD-R manufacturing has become 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 smaller manufacturers 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 and 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.”

Glen McFarlane, the sales and operations manager for imaging bureau, microview solutions, has had first hand experience of cheap CD-Rs that do not make the grade.

“It’s a false economy buying cheap CD-Rs to backup data. In the past, we use to use cheap CD-Rs which ended up failing constantly and reporting error messages. Our customers used to send the faulty discs back to us, and in the end it was too time consuming re-writing the data on the media which kept constantly breaking down.”

“We now use CD-Rs which have been tried and tested rigorously, and they have not failed us once, they use gold media, which is an 18 carat gold reflective layer and can last for 50 years. We are soon going to upgrade to a CD-R which uses a 24 carat gold reflective layer, which will last longer than my lifetime. Our customers are very with the CD-Rs we use now, so they should be even pleased with the new ones we have planned.”

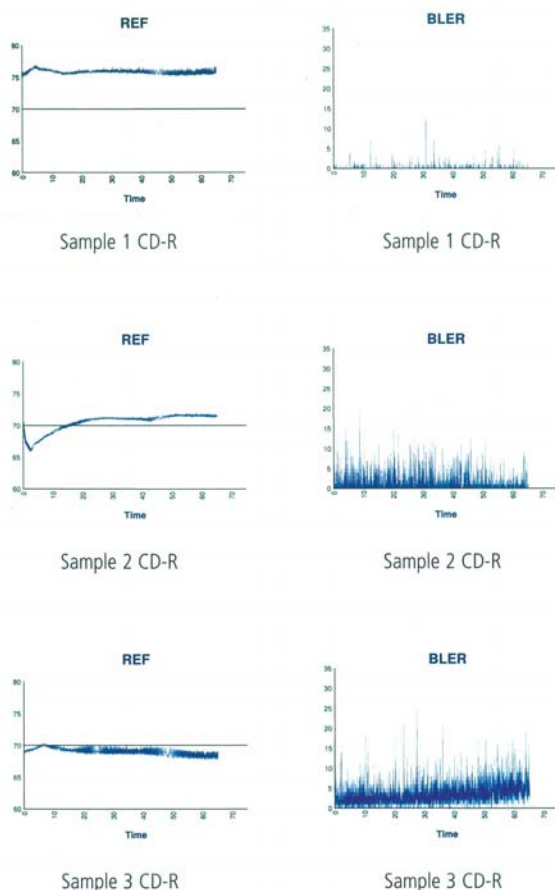
## Working in practice

CD-Rs of this quality have been used in very high profile institutions in Australia, which depend on high quality archival media to protect very important data.

The ABC, The National Australia Archives, The State Library of Victoria and The National Library Australia have all used CDRs after carrying out thorough checks and tests over the quality of the media.

Malcolm Pollard, a video operator at ABC, was a part of a major project a few years ago which involved transferring music video files onto CD-Rs to make it easier for producers to preview music videos for production on the television station.

These graphs illustrate the differences in quality between some discs.  
Results from CD-R analysis: The CD CATS SA3 Advanced



REF – Reflective  
High reflectivity is associated with high performance discs.  
BLER – Block Error Rate  
Low Blers are associated with high performance discs.

“We started transferring them in 1996, and currently have about 18,000 music video clips on CD. We did extensive testing and research before deciding to choose ProDisc CD-Rs to archive our collection.”

“I had heard horror stories beforehand about other CD-Rs losing their gold layers and blowing up the drives of a PC so I was wary about which manufacturer to go with. This told me that some were made much more robust than others.

“We tested the ProDisc CD-Rs to make sure they worked, before ordering a huge batch of them. They passed all the tests and so far we have not had a single problem with the CD-Rs, We handle them with care, which is important too, and we have been able to archive important data on them now for nearly 10 years.

This rigorous testing regime was also adopted at the National Archives of Australia, which is currently converting speeches by Australian Prime Ministers from tape recordings onto CD-Rs. The first phase has involved the conversion of the Hon Paul Keating’s speeches. The second phase has included the Hon Gough Whitlam’s speeches. Copying of other sound recordings is still in progress.

Robyn Gamble, the preservation project manager for the National Archives of Australia, says that adequate care and handling helps to sustain the shelf life of the CD-Rs.

“We burn three CD-R copies of each tape. One for the public and researchers to listen to, one to sit in the repository for backup purposes, and another is preserved in secure storage.”

“We do extensive quality checking with CD-Rs. Each time we have copied data across, we have double checked discs to make sure the content is transferred across properly. We look at error rates, failure rates and any sign that any data is missing, or any sign of trouble in playing the information back.”

“If we find any glitches, we burn it again. I expect cheap CD-Rs to breakdown at a faster rate, but with more expensive, reputable brands, like the one we use, we would expect those discs to last for a long time into the future, although we are not sure for how long exactly.”

Gerard Kleist, the audio/video preservation manager, adds. “You have to make sure you use good drives when you burn CD-Rs. Do not burn at a high-speed. The difference between a good CD-R brand and a bad one can be similar to the difference between VHS and Betacam. The cheaper CD-Rs will be more popular, but of course the more expensive ones will hopefully have a longer lifespan, and will provide better quality recording.”

Kleist reiterates the importance of handling the CD-Rs properly. He insists that CD-Rs should be protected from high humidity, high temperatures, poor handling and should be stored somewhere very secure. He believes that the life of a CD-R can be maintained with this kind of care and attention.

However, Gamble does strongly believe that if a CD-R breaks down regardless of proper care and handling, the blame could lie at the door of the manufacturer.

"If it fails, it could be the fault of the manufacturer. From our experience, cheaper CD-Rs generally cause more error rates. If you spend a bit more money on a more expensive disc, you get much better results in terms of archiving. I've come to this conclusion having observed people who use cheaper CD-Rs around the office, which have stopped working so early on."

But, it is not just about the brand of CD-R you use. Their experience has found that using cheap CD-RW drives can also lead to increased error rates, regardless of the disc you use.

The project is still in progress, and both Gamble and Kleist expect them to be archived on the CD-Rs for the next five years at least, before the data is migrated to a digital repository. But they are not so worried about the data being lost on the CD-Rs, if a better storage facility will be available to contain more information.

They are confident that with the right make of CD-R kept in the best conditions, with multiple backups, and constant testing, their data will be secure for many years to come.

Peter McGrath, the digital preservation specialist at the State Library of Victoria, looks after the CD-Rs just as well, and agrees that the CD-Rs will protect the data for as long as is necessary. In fact, he believes that the CD-Rs he is currently using to store ABC music played on the radio in the early part of the century will outlast his lifetime and the hardware currently used to play the information.

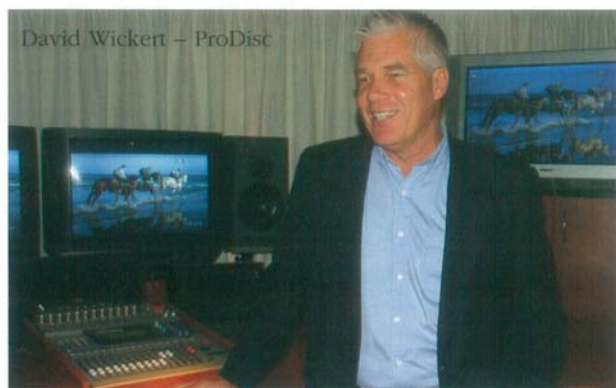
"We have recorded thousands of records from ABC's early radio broadcasts onto CD-R so that historians and researchers can have easy access to the music. It is hard to say how long the data will be safely stored on the CD-Rs for, but it is not seen as a permanent concept.

"This is purely because the technology changes so fast. For instance, the 5 1/2 floppy disc did not last very long. It is virtually obsolete now. Before choosing ProDiscs CD-Rs, we consulted with other institutions based on the standard they had implemented within their organisations. We followed their guidelines for good quality control with thorough testing."

McGrath says that he has had plenty of experience with other media over the last 10 years, and he has witnessed the use of other CD-R types in a negative manner. According to him, some vendors would use labels, which deteriorated the CD-Rs over time.

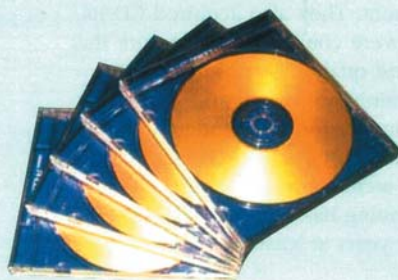
"Other CD-Rs used to have constant errors. For instance, clients used to send us CDs which just would not be readable in our drives. But after watching ProDisc's succeed through artificial testing, we knew we could trust this brand. Some people say that discs such as these will last for 100 years. I won't be concerned about that because things move on quickly and I won't be surprised if the CDRs outlast the hardware used to run them."

These major institutions have proved that essential information can be contained safely on CD-Rs for long periods of time, with little, if any causes for concern over years, if they are handled and treated with respect. Prior research and testing of the CD-R brand was also a key concern for these institutions too. They made sure that they could hold up well in different temperatures, humidity and under an artificial environment. They also acquired CD-Rs after finding out how they were constructed, to ensure that the products were of the best quality. Overall, it seems clear that all CD-Rs are certainly not equal, and it certainly is a case of getting what you pay for. The tendency to rush out and buy the cheapest CD-R on the market will obviously deliver the worst archiving results, but a CD-R that stands up to artificial testing has the capability of looking after data for many years at least.



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