Vancouver Response Center
T. 604.451.2727
Toll free T. 1.800.451.2727
F. 604.451.2713
Toll free T. 1.800.767.2736

Customer support email:
callcentre@creo.com

www.creo.com

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Philip Samaniego
Systems Engineer
T. +01.1.604.451.2700
F. +01.1.604.437.9891
philip.samaniego@creo.com

Data Archiving on CD and DVD

Comparison of Media and Software Packages

DVD and CD as storage media are gaining popularity among computer users due to their affordability and availability. They also offer the potential of portability between Macintosh® and Windows® due to standardized formats (ISO9660/Joliet in CDs and UDF in DVDs).

This white paper presents the results of tests carried out with Sony DRU-500A and Pioneer DVR-104 combination DVD/CD writers and various mastering and packet writing software. These tests are intended to show the complexities of using CD and DVD as media for archiving data.

Executive Summary

Are CD and DVD media appropriate for archiving data? What problems can be anticipated and what are the limitations of CD/DVD?

We recommend using tape for archiving data for the following reasons:

- Tape is more economical than DVD or CD, although DVD+R is not far behind.
- Tape capacity is more than 20 times that of DVD, so there will be fewer media to manage.
- Tape media can be managed using Windows 2000 Removable Storage Management. This is not possible with CD or DVD.
- Intermittent problems were encountered with CD/DVD as summarized in *Problems Encountered With CD/DVD on page* 2.
- Tape has a higher throughput than CD or DVD.

The test results showed that archiving data to CD or DVD might not be robust or reliable enough for industrial applications. Most concern is over the media becoming unreadable after the data is written. There were also instances where the files on the DVD were not visible from Windows Explorer.

Problems Encountered With CD/DVD

Below is a summary of the problems found in using CD and DVD for data archiving with various writing software packages. These problems may be due to the writing software, the DVD writer, or interactions between the two.

- Media becomes unreadable after write operation.
- Media becomes unreadable after they are ejected.
- Files with identical Unicode file names are allowed to co-exist in a folder.
- Most of the software does not copy alternate streams to the CD or DVD. This may be a problem with files containing resource forks.
- After files are written to disc, the files do not appear in Windows Explorer or in the output of a `dir` command issued from the command line. However, the file does appear if the file name is specified in the `dir` command (for example, `dir file.pdf`).
- Occasional system crashes.
- Portability between Macintosh and Windows and operating systems is inconsistent, and depends on the drive type, media type, operating system, and writing software used.

Comparing CD/DVD Media with AIT (Advanced Intelligent Tape) Media

Media	**Native capacity**	**Cost/GB**	**Write throughput (from specs)**
CD-R	650MB	C$1.50/GB	3.5MB/s (depending on drive/media)
CD-RW	650MB	C$3/GB	1.5MB/s (depending on drive/media)
DVD-R	4.3GB	C$2.30/GB	5.5MB/s (depending on drive/media)
DVD-RW	4.3GB	C$3/GB	2.7MB/s (depending on drive/media)
DVD+R	4.3GB	C$1.60/GB	3.3MB/s (depending on drive/media)
DVD+RW	4.3GB	C$3/GB	3.3MB/s (depending on drive/media)
AIT-2	50MB	C$2/GB	6MB/s
AIT-3	100GB	C$1.10/GB	12MB/s

Recommendations for Using CD or DVD

If you still want to archive using CD or DVD media, consider the following recommendations:

- You should extensively test the CD/DVD writer and writing software prior to relying on them for use in archiving data. This will allow you to assess any limitation they may have (Does it support named alternate streams? Can it be read in Macintosh and Windows OS? etc.).

- Data written onto the media should be verified before purging the original data from the online storage. This can be done manually, or if available, through the writing software.
- Each disc should be properly labeled and stored in its case.
- Use only branded media. Generic media may cost less, but quality may be substandard.
- Handle the media with care. Scratches or dirt on the media surface can render the disc unreadable.
- We do not recommend using a Prinergy server or Renderstation as the CD/DVD writing host for the following reasons:
  - Possibility of system crash due to writing software.
  - To avoid additional resource load. Depending on CD/DVD drive, writing software, interface configuration, etc., CPU usage may be high during CD/DVD writing. Use DMA mode if supported instead of PIO.
  - Possibility of CD or DVD writing becoming unsuccessful if the host is busy. This may be a problem with mastering software using older drives without buffer under run protection.

Two Types of CD/DVD Writing Software

The two main types of CD/DVD writing software are:

- Packet writing software
- Mastering or authoring software

Packet writing software allows the CD and DVD media to be used like a floppy diskette. Files can be copied, deleted, dragged-and-dropped, or created on the fly. Some packet writing software allows the disc to be ejected then reinserted later on so that files can be added, deleted, or modified.

Mastering software (or authoring software) writes files to the media sequentially. The files to be written must be compiled through a graphical user interface (GUI), and when all the files are in place, the operator can choose to write all the files to the disc at one time. When writing is finished, the files on the media can no longer be altered. Most mastering software allows creation of a disc image and copying of a disc. This is useful when more than one copy of a compilation is needed.

Packet Writing Software Tested

- WriteDVD version 4.1.3 beta (Software Architects)
- DirectCD version 5.3.4.21 (Roxio)
- InCD version 3.5.22.0 (Ahead)
- DLA version 3.58 build 350B57a (Veritas/Stomp)

Mastering/Authoring Software Tested

- Nero Burning ROM version 5.5.10.15 (Ahead)
- Easy CD Creator version. 5.3.4.21 (Roxio)
- RecordNow version 4.5 (Veritas/Stomp)
- MAC (OSX) authoring software (using Pioneer DVR-104 DVD-RW)

Test Results

Portability Between Windows 2000 and Macintosh

There is no media/software combination that produced media that is readable on all server/workstation platforms. This limitation poses a minor inconvenience that can be worked-around by reading the media on a compatible server/workstation platform and accessing the files through the network.

Readability tests were conducted for each software and media combination. The machines used to read the test media are:

- DELL PowerEdge 2600
- DELL PowerEdge 4600
- DELL Optiplex GX260XT
- DELL PowerEdge 6400
- DELL PowerEdge 2400
- MAC G4 OSX 10.2.3
- MAC G4 OSX 10.2.0

The test results are shown in the following tables:

Software (OS)	Read with Windows 2000?					
	CD-R	**CD-RW**	**DVD-R**	**DVD-RW**	**DVD+R**	**DVD+RW**
Packet writing eoftware						
SAI WriteDVD! (W2K SP3)	**Yes** CDFS/UDF	**Yes** CDFS/UDF	Not Tested	**No** UDF Needs UDF Reader (ReadDVD!)	**Yes** UDF	**No** UDF Needs UDF Reader (ReadDVD!)
Roxio DirectCD (W2K SP3)	**Yes** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	**Some*** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF
Nero InCD (W2K SP3)	N/A**	**Yes** FS_UDF	N/A	**Yes** FS_UDF	N/A	**Yes** FS_UDF
DLA (W2K SP3)	Can't Format	**Yes** UDF	Can't Format	**Yes** UDF	Can't Format	**Yes** UDF
Mastering/authoring software						
Ahead Nero (W2K SP3)	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	Not Tested	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet
Roxio Easy CD Creator (W2K SP3)	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	Not Tested	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet
Record Now (W2K SP3)	**Yes** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	Not Tested	**Yes** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF
MAC Authoring Software (OSX 10.2.3)	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	**No**	**No**	N/A	N/A

Software (OS)	Read with Macintosh?					
	CD-R	**CD-RW**	**DVD-R**	**DVD-RW**	**DVD+R**	**DVD+RW**
Packet writing software						
SAI WriteDVD! (W2K SP3)	**Yes** CDFS/UDF	**Yes** CDFS/UDF	Not Tested	**No** UDF Not tested with UDF Reader (ReadDVD!)	**No** UDF Not tested with UDF Reader (ReadDVD!)	**No** UDF Not tested with UDF Reader (ReadDVD!)
Roxio DirectCD (W2K SP3)	**No** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	**Some** CDFS, Joliet, UDF	**Some** CDFS, Joliet, UDF	**Some** CDFS, Joliet, UDF	**No** CDFS, Joliet, UDF
Nero InCD (W2K SP3)	N/A	**Yes** FS_UDF	N/A	**Yes** FS_UDF	N/A	**Some** FS_UDF
DLA (W2K SP3)	Can't Format	**Yes** UDF	Can't Format	**Yes** UDF	Can't Format	**No** UDF
Mastering/authoring software						
Ahead Nero (W2K SP3)	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	Not Tested	**Yes** CDFS, Joliet	**No** CDFS, Joliet	**Some** CDFS, Joliet
Roxio Easy CD Creator (W2K SP3)	**Some** CDFS, Joliet	**Yes** CDFS, Joliet	Not Tested	**No** CDFS, Joliet	**No** CDFS, Joliet	**Some** CDFS, Joliet
Record Now (W2K SP3)	**No** CDFS, Joliet, UDF	**Yes** CDFS, Joliet, UDF	Not Tested	**No** CDFS, Joliet, UDF	**No** CDFS, Joliet, UDF	**No** CDFS, Joliet, UDF
MAC Authoring Software (OSX 10.2.3)	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	**Yes** CDFS, Joliet	N/A	N/A

* - *Some* means media is readable in some machines but not in all.

** - *N/A* means not supported.

Named Alternate Streams

The only software tested that writes named alternate streams to the CD and DVD is the Macintosh authoring software. The resource forks in Macintosh OS use named alternate streams. NTFS supports named alternate streams, but, when the file is copied to a CD or DVD using a Windows 2000 host, that information is stripped off. Therefore, when the files on the CD or DVD are viewed or opened on a Macintosh, the Macintosh may not recognize which application to use to open the file.

Packet Writing Software

WriteDVD! (Software Architects)

WriteDVD! requires the CD and DVD media to be formatted before use. After formatting, the media will be ready for file operations just like a floppy or hard drive.

WriteDVD! does not have its own GUI. File operations are done through Windows Explorer.

WriteDVD! handles write-once media differently from rewriteable media. When formatted by WriteDVD!, rewriteable media allows on-the-fly drag and drop functionality. It behaves like a floppy or a hard drive. The media can be ejected and then reinserted later so that files can be added, deleted, or modified.

When WriteDVD! formats a write-once media, it creates a virtual disc on the hard drive. When a file operation is done on the DVD/CD writer, that operation actually happens on the virtual disc. No data is written on the media. Once the compilation is complete, WriteDVD! can be invoked to burn the data onto the disc.

Format and Write Performance

Media type	Quick format	Full format	Write throughput
CD-R	Not Selectable	19 seconds	1.7 MB/s
CD-RW (4x)	1:13 minutes	21 minutes	0.47 MB/s
DVD-R	Not Selectable	3 seconds	0.54 MB/s
DVD-RW	45 seconds	1:20 minutes	0.81 MB/s
DVD+R	Not Selectable	4 seconds	4 MB/s
DVD+RW	3:24 minutes	3:57 minutes	1 MB/s

Advantages

- Easy to install
- Easy to use
- Supports file names with Unicode characters
- Supports long file names (up to 127 characters)
- With additional software (ReadDVD), software architects claim that CD and DVD written with WriteDVD! should be readable from any Macintosh or Windows (provided they have the right drive).

Disadvantages

- Sometimes a DVD+RW became unreadable after being ejected.
- ExperieOne time the DVD+RW became unreadable after several copy and erase operations.
- Files with identical file names were allowed to co-exist in a folder. This was with Unicode file names.
- Experienced system crash while trying to open a file from a CD-RW.
- Named alternate streams are not supported.
- Write-once media are closed once ejected. No data can be added or modified on the media.

- Several times files did not appear in Windows Explorer when discs were full. Files could also not be listed using `dir` at a command prompt. If the file name is specified in the `dir` command (for example, `dir file.pdf`), the file is listed fine.
- System freezes from time to time while writing to CD-RW. CPU usage was low. Other media were fine.

DirectCD (Roxio)

DirectCD is one of the most widely used packet writing software applications. DirectCD requires the CD or DVD media to be formatted before use. After formatting, the media is ready for file operations just like a floppy or hard drive.

DirectCD handles write-once and rewriteable media in the same manner. The user has the option to either close the media or leave it open when ejected. When the media is closed, no further write file operations can be performed. When the media is left open, additional write operations can be done. Closing the media allows read compatibility for more drives.

Files can be erased in write-once media, but space occupied by those files is not recovered.

File operations are done from Window Explorer. DirectCD has a GUI for disc operations, such as erase or format, and also for configuring the software.

Format and Write Performance

Media type	Quick format	Full format	Write throughput
CD-R	40 seconds (Quick/Full selection are grayed out)		2 MB/s
CD-RW (4x)	34 seconds (preformatted)	33 minutes	0.14 MB/s
DVD-R	30 seconds (Quick/Full selection are grayed out)		1.8 MB/s
DVD-RW	47 seconds (preformatted)	1:42:30 hours	1.3 MB/s
DVD+R	27 seconds (Quick/Full selection are grayed out)		2.4 MB/s
DVD+RW	1:07 minutes*	Not Selectable	2.5 MB/s

* When DVD+RW was ejected right after formatting, it took another 90 seconds before the DVD was actually ejected.

Advantages

- Easy to use
- Supports file names with Unicode characters
- Supports long file names (up to 127 characters)
- Allows write-once media to be ejected without closing the media
- Includes a Repair option to repair unreadable media

Disadvantages

- Experienced Blue Screen after ejecting and reinserting CD-RW

- One time, files would not appear in Windows Explorer. They also couldn't be listed by `dir` in a command prompt. If the file name is specified in the `dir` command (for example, `dir file.pdf`), the file is listed fine.
- Formatting a new DVD-RW took a long time (1hour 42 minutes 30 seconds).
- Named alternate streams are not supported.

InCD (Nero)

InCD only supports rewriteable CD and DVDs. InCD requires CD and DVD media to be formatted before use. After formatting, the media is ready for file operations, like a floppy or hard drive.

InCD can be configured to automatically verify data after writing, but this setting increases the writing time.

File operations are done from Window Explorer.

Format and Write Performance

Media type	Quick format	Full format	Write throughput
CD-R	Not supported		
CD-RW (4x)	Not Tested	21 minutes format 5 minutes registering bad sectors	0.5 MB/s
DVD-R	Not Supported		
DVD-RW	10 seconds (preformatted)	1:02:30 hours format 57:03 minutes registering bad sectors	1.3 MB/s
DVD+R	Not Supported		
DVD+RW	8 seconds	1:12 minutes	3.1 MB/s

Advantages

- Easy to use
- Supports file names with Unicode characters
- Supports long file names (up to 127 characters)
- Provides an option to verify written data

Disadvantages

- InCD crashes when trying to copy files with alternate streams
- Formatting a new DVD-RW took a long time (2 hours)
- Named alternate streams are not supported
- Write-once media are not supported

DLA (Veritas/Stomp)

DLA (Direct Letter Access) only works with rewriteable CD and DVD media.

DLA requires the CD and DVD media to be formatted before use. After formatting, the media is ready for file operations, just like a floppy or hard drive.

DLA provides the option to close the media (called Make Compatible). When the media is closed, no further write file operations can be performed. Closing the media will allow read compatibility for more drives.

File operations are done from Window Explorer. DLA configuration can be accessed from the CD/DVD drive properties page.

Format and Write Performance

Media type	Quick format	Full format	Write throughput
CD-R	Not supported		
CD-RW (4x)	21 seconds	23 minutes	0.5 MB/s
DVD-R	Not Supported		
DVD-RW	8 seconds	38 seconds	1.3 MB/s
DVD+R	Not Supported		
DVD+RW	42 seconds	1:07 minutes	3.2 MB/s

Advantages

- Easy to use
- Supports file names with Unicode characters
- Supports long file names (up to 127 characters)

Disadvantages

- Named alternate streams are not supported
- Write-once media are not supported

Mastering or Authoring Software

Nero Burning ROM (Ahead)

Nero is one of the most popular mastering software applications, and has many features. Going through the configuration settings can be a bit intimidating, although the default settings worked fine. It offers a wizard, which simplifies the CD and DVD writing processes.

Nero can be configured to automatically verify data after writing, but this setting increases the writing time.

Nero comes bundled with InCD, a CD/DVD label creator, and some CD/DVD diagnostic tools.

Erase and Write Performance

Media type	Quick erase	Full erase	Write throughput
CD-R	N/A	N/A	1.6MB/s
CD-RW (4x)	1:10 minutes	20 minutes	0.5 MB/s
DVD-R	Not Tested		
DVD-RW	2 minutes	58 minutes	0.6 MB/s
DVD+R	N/A	N/A	0.6 MB/s
DVD+RW	12 seconds	25 minutes	2.6 MB/s

Advantages

- Lots of features.
- Frequent updates from Ahead to support new drives.
- Can select between ISO9660, Joliet, or UDF.
- Provides an option to verify media after write completion.

Disadvantages

- Named alternate streams are not supported
- File names are limited to 64 characters
- Unicode file names were converted to 8.3 format

Easy CD Creator (Roxio)

Easy CD Creator is another popular mastering software application. It is simple to use and comes bundled with DirectCD, an audio player, a CD/DVD label creator, and so on.

Erase and Write Performance

Media type	Quick erase	Full erase	Write throughput
CD-R	N/A	N/A	1.6MB/s
CD-RW (4x)	45 seconds	20 minutes	0.5 MB/s
DVD-R	Not Tested		

DVD-RW	2:10 minutes	Not Tested	1.2 MB/s
DVD+R	N/A	N/A	3.2 MB/s
DVD+RW	30 seconds	Not Tested	3.1 MB/s

Advantages

- Easy to use
- Supports long file names (up to 127 characters)
- Can select between ISO9660, Joliet, or UDF
- Provides an option to verify media after write completion

Disadvantages

- Named alternate streams are not supported
- Some files with Unicode file names were not copied

RecordNow (Veritas/Stomp)

RecordNow is easy to use and provides wizards to guide first time users. It comes bundled with DLA packet writing software.

Erase and Write Performance

Media type	Erase	Write throughput
CD-R	N/A	1.5 MB/s
CD-RW (4x)	1:12 minutes	0.5 MB/s
DVD-R	Not Tested	
DVD-RW	2:15 minutes	0.3 MB/s
DVD+R	N/A	0.8 MB/s
DVD+RW	10s	1.2 MB/s

Advantages

- Simple and easy to use
- Provides an option to verify media after write completion

Disadvantages

- Named alternate streams are not supported
- File names are limited to 110 characters
- Some files with Unicode file names were not copied.

Macintosh OSX Authoring Software

This is the software that comes with a Macintosh G4 with DVD writer. The compilation of the files to be written is done in Finder. When a blank CD or DVD is inserted, a virtual disc is created on the hard drive. When a file

operation is done on the DVD writer, that operation actually happens on the virtual disc. No data is written on the media. Once the compilation is complete, the user can invoke the burn process. The media is verified automatically after it is written.

Rewriteable media are erased using the Disk Utility.

Erase and Write Performance

Media Type	Erase	Write Throughput (verify time not included)
CD-R	N/A	0.9 MB/s
CD-RW (4x)	1 minutes	0.4 MB/s
DVD-R	N/A	0.6 MB/s
DVD-RW	1:50 minutes	0.3 MB/s
DVD+R	Not supported by drive	
DVD+RW	Not supported by drive	

Advantages

- Easy to use
- Supports long file names (up to 127 characters)
- Supports named alternate streams
- Verifies media after write completion
- Supports Unicode file names

Disadvantages

- Disc has to be in the drive while compiling the files and folders. The DVD drive is not useable while compiling.

Test Setup

PC hardware	DELL GX260XT; 1x3GHz CPU; 1GB RAM, W2K Pro SP3
DVD writer	Sony DRU-500A; F/W: 1.0d; 8 MB buffer; DVD+/-R/RW, CD-R/RW
Macintosh hardware	Macintosh G4, 2x1.2GHz CPU, 512 MB RAM, OSX 10.2.3
DVD writer	Pioneer DVR-104; 2 MB buffer, DVD-R/RW, CD-R/RW
Media Used	CD-R—Princo CD-RW—Memorex Platinum 4x DVD+R—Generic DVD+RW—Sony and HP 2.4x DVD-R—Verbatim DataLifePlus 2x DVD-RW—Verbatim DataLifePlus
CD/DVD writing software	WriteDVD! version 4.1.3 beta (Software Architects) DirectCD version. 5.3.4.21 (Roxio) InCD version 3.5.22.0 (Ahead) DLA version 3.58 build 350B57a (Veritas) Nero Burning ROM version 5.5.10.15 (Ahead) Easy CD Creator version 5.3.4.21 (Roxio) RecordNow version 4.5 (Veritas) Macintosh OSX authoring software (using Pioneer DVR-104)
Other software used	Nero infoTool CopyFile.exe—written by Henry Chan. Software that is used to create or copy files. Genfile.exe—written by Henry Chan. Generates files with file names containing 65536 Unicode characters. StreamRead—written by Bruce Cowan. Software that lists the alternate streams in a file. VolInfo—written by Bruce Cowan. Software that lists file system information.

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Creo is a world leader in solutions for the graphic arts industry. Core product lines include image capture systems; inkjet proofers; thermal imaging devices for films, plates and proofs; professional color and copydot scanning systems; and workflow management software. Creo is also an Original Equipment Manufacture supplier of on-press imaging technology, components for digital presses, and color servers for high-speed, print-on-demand digital printers.

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Philip Samaniego
Systems Engineer
T. +01.1.604.451.2700
F. +01.1.604.437.9891
philip.samaniego@creo.com