

DRAFT
PDS CD-DVD Media Test Summary
Mike Martin 3/28/07

"Playing a disc is not wholly deterministic, but is rather a statistical process." Clover Systems Manual

Overview.

The NASA Planetary Data System (PDS) has performed a preliminary evaluation of archival volumes written to CD and DVD media over the past 12 years at many different sites with a variety of hardware configurations. Twenty-one discs were selected for initial testing on CD and DVD-CATS systems at the National Institute of Standards and Technology (NIST) as well as being tested on a variety of commercial CD/DVD drives using freeware utilities (CD/DVD Speed and DVDIsaster).

Every disc failed the CATS scans on one parameter or another. Nearly every CD-R had bursts of errors at the very end of the disc which seemed to cause elevated values for average BLER and high numbers of E12, E22 and E32 errors. Several discs also had a similar burst of errors at the beginning. None of these bursts seem to affect the readability of the discs. Otherwise, the graphs of "I11R", "RN - Average" and "BLER - Average" look very good for all but one of the CD-R discs. All DVD discs also failed the CATS scans. All but one of the DVD's tested showed a spike in errors at the very end of the disc. This resulted in 1 POF being recorded for nearly every disc even though none of the discs showed any read errors when being copied with Windows utilities or scanned with DVDIsaster.

Every disc was also scanned multiple times using the "CD-DVD Speed" program (<http://www.cdspd2000.com/>). The Disc Quality scan was used to summarize C1/C2 errors (for CD's) and PI errors/PI failures (for DVD's). Each disc was tested on each of three drives. CD's were tested at 24X and 40X read speeds and DVD's were tested at 4X, 8X and 16X read speeds. There is more variability in the scan results than we would have expected. The average number of errors counted by the most sensitive drive is twice that of the least sensitive drive and the third drive is right in the middle. However, we feel that the scans still present a good picture of the overall quality of a disc.

The Disc Quality test does not check every sector on the disc, but only samples sectors. There is good correlation in the location of errors between scans on the same drive at different speeds but not between different drives. For example, a disc may show lots of errors ramping down from the beginning on one drive but lots of errors ramping up at the end on another. Also the average number of errors reported by different drives varies considerably, with the most sensitive drive reporting twice as many errors as the least sensitive drive.

Table 1 summarizes the attributes of the discs that were tested. Out of nine CD-R's tested, seven look stable, one is marginal and one disc is flawed and needs to be copied to new media. Out of nine DVD-R's tested, two look stable, four discs are marginal and three discs are flawed and need to be copied to new media. The one DVD+R disc that was tested is flawed. The two pressed discs (one CD-ROM and one DVD-ROM) tested good. We do not see any evidence of deterioration due to age. Many flawed discs show evidence that they were written improperly. All data on all discs was fully recoverable, though only by using multiple readers. Based on our research, we are contemplating a migration from CD-R and DVD-R archives to on-line storage systems with high-density (DLT) backup. This is due to dramatic cost reductions for on-line storage, the relatively low storage capacity of CD and DVD media, the difficulty of establishing a successful recording environment and the difficulty in ascertaining the quality of recorded media.

Disc Id	Volume ID	Media	Date	Vendor	Capacity	Size (MB)	Dye	Label	Recorder	Model	Quality
DISC01	CD_PA060	CD-R	03/03/00	MCC/Verbatim	74 min	534	Blue	Surface			Good
DISC02	MG_4564	CD-R	06/25/97		74 min	676	Green	Stick-on			Good
DISC03	CL_4020	CD-R	01/23/00	Kodak Japan	74 min	634	Gold	Surface			Good
DISC07	MGN_0038	CD-R	10/22/98	Kodak (gold)	74 min	625	Gold	Hub			Flawed
DISC08	VL_1001	CD-R	05/03/95	Taiyo Yuden	74 min	236	Green	Hub			Good
DISC09	VO_1101	CD-R	06/12/95	Yaiyo Yuden	74 min	674	Green	Hub			Scatched
DISC12	MGN_0017	CD-R	10/06/98	Kodak (gold)	74 min	642	Gold	Hub			Good
DISC20	GOMA_3009	CD-R	12/14/98	CMC Magnetics	74 min	671	Blue	Hub			Good
DISC21	HAL_0025	CD-R	09/19/00	CMC Magnetics	80 min	479	Blue	Hub			Marginal
DISC17	VG_1001	CD-ROM	11/12/92		N/A	556	N/A	Surface			Good
Disc Id	Volume ID	Media	Date	Vendor	Capacity	Size (MB)	Dye	Label	Recorder	Model	Quality
DISC04	DMGSC_1017	DVD-R	04/01/03	Verbatim	4.7 gig gen	906	N/A	Surface	Pioneer	DVR-104	Good
DISC05	NEROS_5001	DVD-R	01/15/04	Verbatim	4.7 gig gen	761	N/A	Stick-on	Pioneer	DVR-103	Marginal
DISC06	DMGSC_1018	DVD-R	10/01/03	Verbatim	4.7 gig gen	4,251	N/A	Surface	Pioneer	DVR-104	Marginal
DISC10	DMGSC_1016	DVD-R	04/01/03	MCC/Verbatim	4.7 gig gen	3,807	N/A	Surface	Pioneer	DVR-104	Marginal
DISC11	NCRUZ_3001	DVD-R	09/10/02	MCC/Pioneer	4.7 gig auth	3,945	N/A	Handwriting	Pioneer	DVR-103	Flawed
DISC14	LO3_HGH_RES_V1	DVD-R	06/29/05	MCC/Verbatim	4.7 gig gen	4,213	N/A	Surface	Pioneer	DVR-104	Marginal
DISC15	DMGSC_1036	DVD-R	10/01/04	MCC/Verbatim	4.7 gig 8X	3,940	N/A	Print on lacqu	Pioneer	DVR-104	Good
DISC16	MGN_9001	DVD-R	03/16/00	MCC/Pioneer	3.95 gig auth	2,876	N/A	Handwriting			Flawed
DISC19	CORFWS_0001	DVD-R	04/21/05	Princo	4.7 gig 4X	4,585	N/A	Stick-on	Pioneer	DVR-105	Flawed
DISC18	DMGSM_2001	DVD-ROM	05/31/01		N/A	4,227	N/A	Surface			Good
DISC13	DMGSC_1036	DVD+R	10/01/04	PVCR	Unknown	3,940	N/A	Stick-on	Pioneer	DVR-103	Flawed

Table 1. Media Test Summary

Test regimen.

CD and DVD CATS device. These are expensive test devices for evaluating CD (CATS SA3) and DVD (DVD+R Pro and DVD-R Pro) disc quality. Normally they are beyond the budget of end-users to procure and use. The National Institute of Standards and Technology has a number of test devices and volunteered to test some of our disc for this evaluation. Many of the CD discs show errors near the beginning and end of each disc (Figure 1). According to AudioDev, these are artifacts in the lead-in and lead-out areas of the discs and do not impact the quality of the disc. Nearly all the discs fail on some parameter or another, but it would be difficult to interpret the severity of the failures without a great deal of research. DISC11 and DISC16, but DVD-R for Authoring discs were not tested because there was no readily available setup for these types of discs.

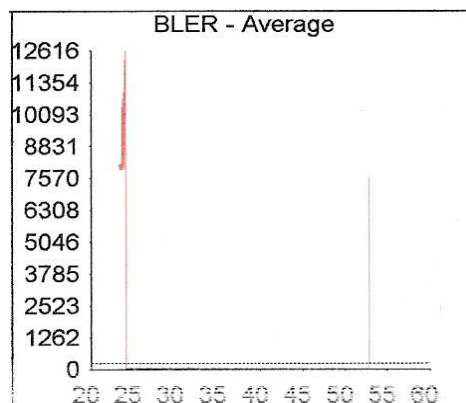


Figure 1. CD-CATS Scan with Errors in Lead-in/Lead-out Area

Disc copy. Windows Explorer was used to drag and drop the contents of each disc to a folder on hard disc and record the elapsed time that it took to copy the disc. For several of the discs it was obvious that the drive was

laboring and re-trying many times at certain points in the disc. All discs were copied successfully to hard disc on Windows XP without errors although two DVD-R discs (DISC11 and DISC16), both Pioneer media for authoring would not mount on the Samsung drive and had to be copied with the Hitachi drive.

DVDDisaster. This is a Windows program which will scan CD or DVD discs and check for read errors while also graphing the read speed. DVDDisaster can also be used to generate an error correction file from a good CD or DVD which can be used later to recover all data from a disc if the user should encounter errors. All disc were successfully scanned with DVDDisaster, however Disc11 failed on the Samsung drive but succeeded on the Hitachi reader and scans performed on Disc 13 failed on the Hitachi drive with unrecoverable read errors but succeeded on the Samsung drive. All the CD-R discs recorded on minicomputers by the Science Digital Data Preservation Task show a 512 byte block size in the volume table of contents which causes DVDDisaster to think there are four times too many sectors on the disc thus it shows erroneous sector read errors. Figure 1 shows a thumbnail view of all the DVDDisaster scans.

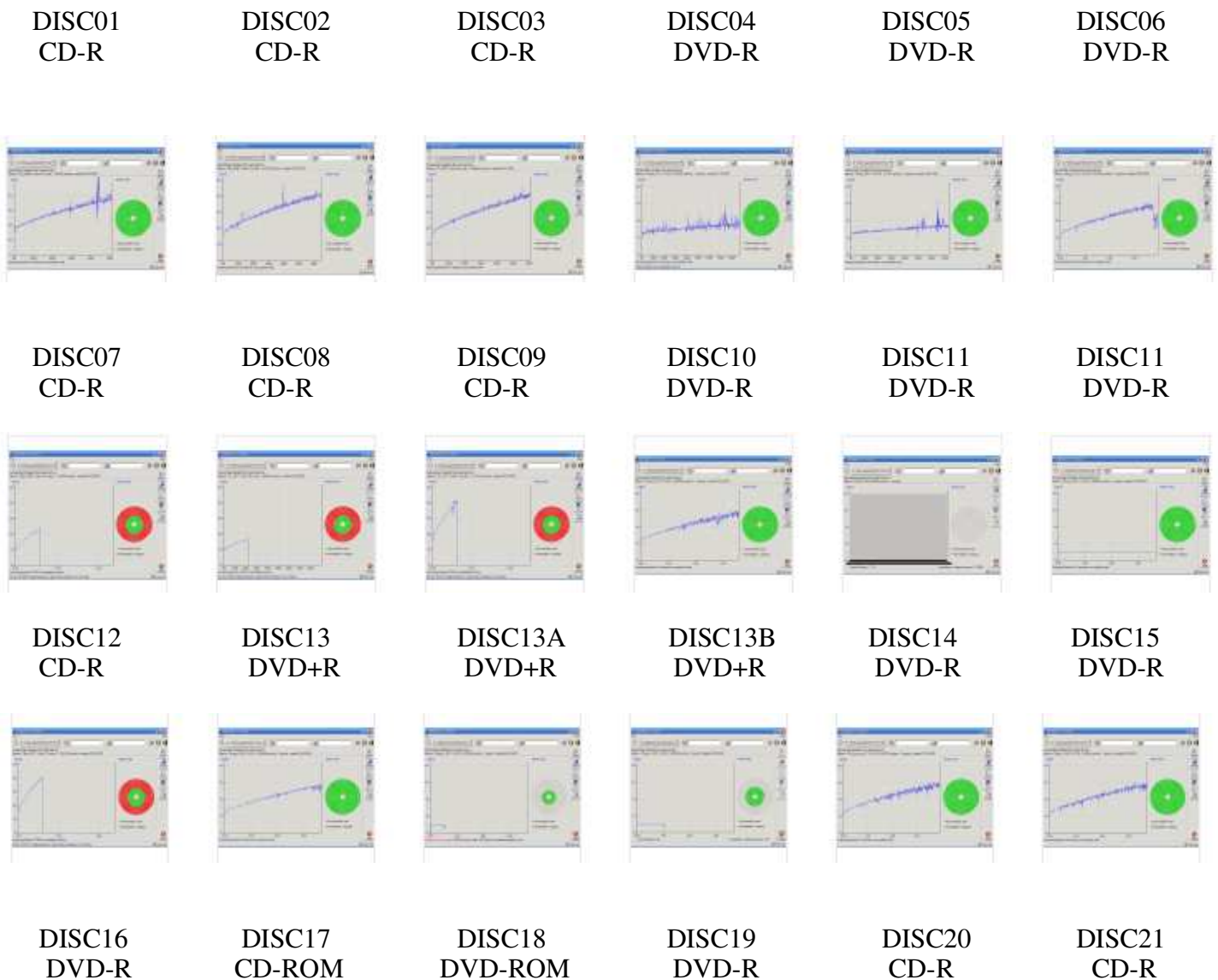


Figure 1 DVDDisaster scans for all discs

CD-DVD Speed. This is Windows program which provides numerous tests including benchmark, disk quality, disk info and scandisc. The program is not well documented and we do not understand its internal workings and the interpretation of some tests, in particular the distinction between scandisc read option vs scandisc error option. The disc quality test produces a graph of block errors (both C1 and C2) for CD's and a graph of parity

inner errors and parity inner failures for DVD media. There is an aspect of testing called scanning interval which can be 1ECC vs 8ECC. The LITE-ON and SONY drives use a 1ECC scanning interval while the NEC drive uses an 8ECC scanning interval. Our interpretation is that the 8ECC scanning interval requires that we divide the PIF errors for the NEC scans by 4 to get a value that is comparable to the PIF errors for the other drives. There was fairly good consistency between repeated tests with the same reader and disc. Scans done at different speeds with the same reader showed significant variations. Scans done at the same speed with different readers showed significant variations. In general the NEC reader seemed to report the highest number of errors with both CD and DVD media. Locations of areas with a high number of errors are generally consistent but spots with peak numbers of PIE errors or PIE failures are similar, but not by always identical. The Benchmark test shows a graph of rotations speed vs read speed while reading the disc. The Scandisc tests show a chart of locations of good, damaged and bad sectors on the disc. It is not clear how we interpret these charts and there seems to be great variation between sectors marked as damaged and bad between error and read scans with the same test setup and between all the scans at different read speeds and with different readers.

The graphs on the next page illustrate the Disc Quality scans done for all discs at 40X speed for CD media and 8X speed for DVD media for the three readers. The program was set to automatically scale the y-axis so some plots that should look very similar do not.

CD-DVD Speed Disc Quality graphs for all discs from each reader (LITE-ON, NEC, SONY).



DISC15
DVD-R

DISC16
DVD-R

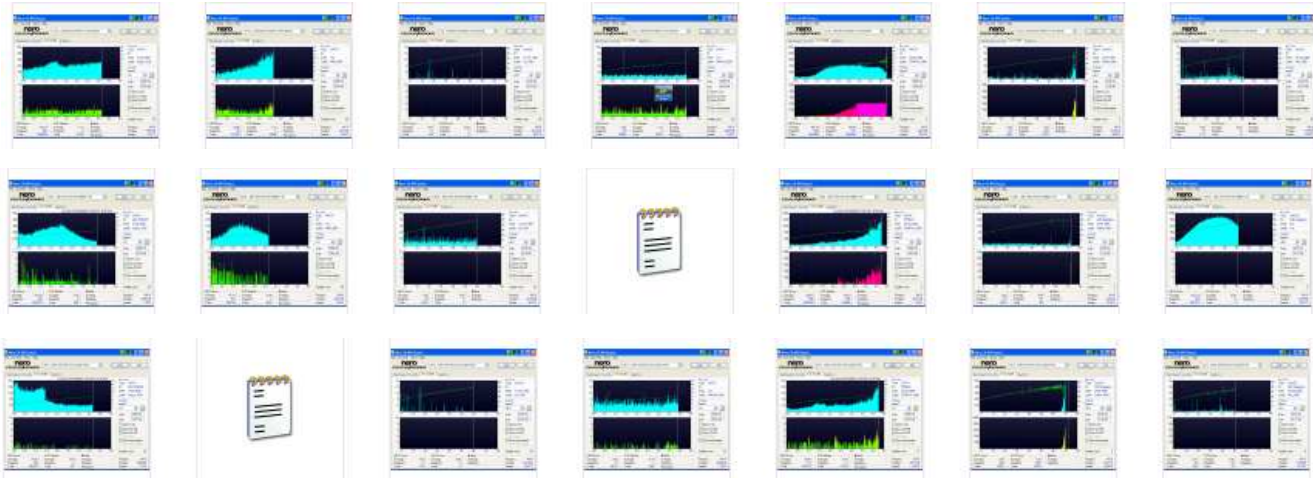
DISC17
CD-ROM

DISC18
DVD-ROM

DISC19
DVD-R

DISC20
CD-R

DISC21
CD-R



The following figures present the LITE-ON Data Quality scans done at low speed (4X DVD/24X CD) vs higher speeds (8X DVD/40X CD). The scans are fairly consistent but the magnitude of errors can be quite different. Note for DISC01 (CD_R) and DISC03 (CD-R) the number of errors detected by the higher speed scan is much greater than the lower speed scan, however for DISC10 (DVD-R) and DISC18 (DVD-R) the reverse is true.

DISC01
CD-R

DISC02
CD-R

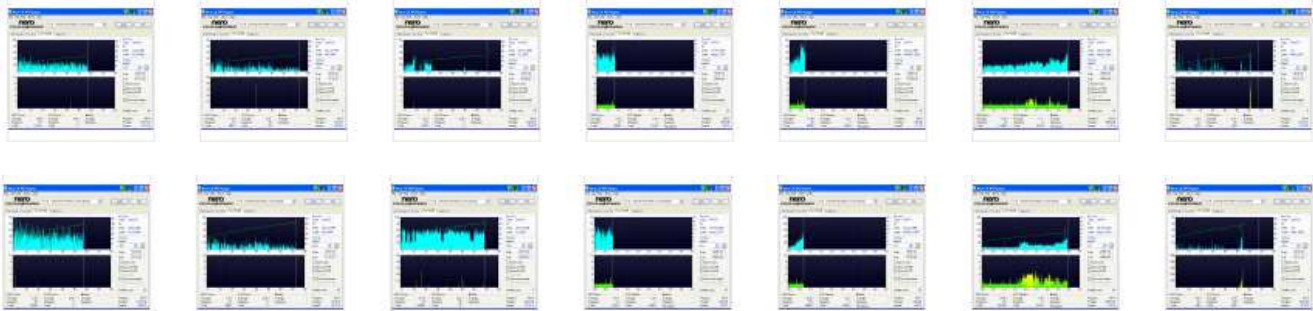
DISC03
CD-R

DISC04
DVD-R

DISC05
DVD-R

DISC06
DVD-R

DISC07
CD-R



DISC08
CD-R

DISC09
CD-R

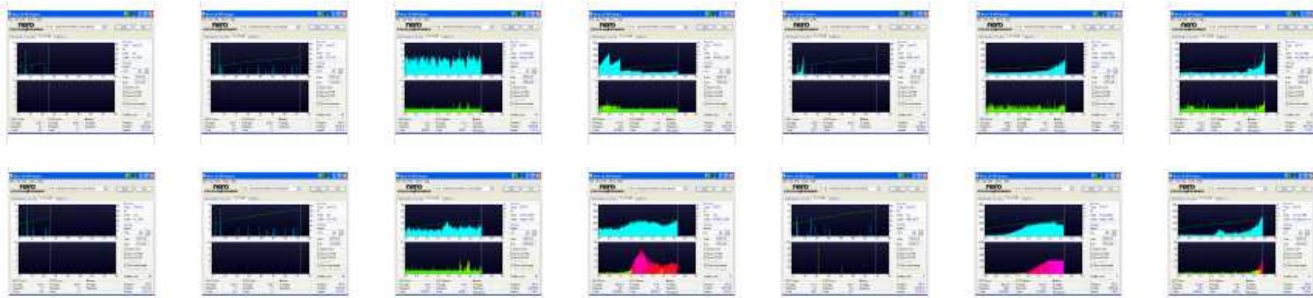
DISC10
DVD-R

DISC11
DVD-R

DISC12
CD-R

DISC13
DVD+R

DISC14
DVD-R



DISC15
DVD-R

DISC16
DVD-R

DISC17
CD-ROM

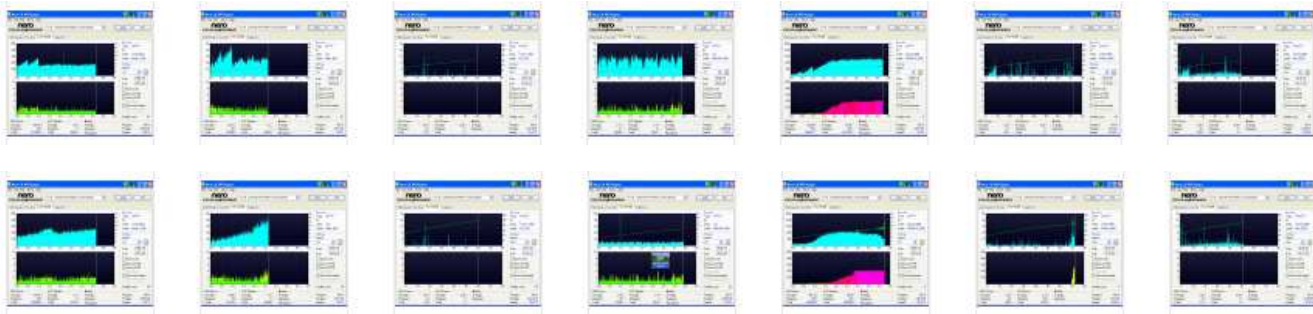
DISC18
DVD-ROM

DISC19
DVD-R

DISC20
CD-R

DISC21
CD-R





Evaluation of CD/DVD Speed scans results.

Table 2 shows the correlation values (CORREL function) for scans done on the three drives at various speeds for nine CD-Rs. Disc07 could not be scanned on some drives and was excluded. Line 1 shows the correlation for scans done on the LITE-ON drive at 24X vs 40X. There is a strong correlation for the values of Maximum C1 errors, but nothing else. For the most part there is not much correlation for the CD-R scans. We hypothesize that this is due to the low sampling rate used by CD Speed, possibly only 3 percent of blocks on the disc are tested. We are still investigating this issue.

Drive(s)	Speed	CD Tests			Max C2	Avg C2	Tot C2
		Max C1	Avg C1	Tot C1			
LITEON	24Xvs40X	0.87	0.40	0.41	-0.19	-0.13	-0.14
SONY	24Xvs40X	-0.27	0.98	0.98	-0.44	-0.44	-0.44
NEC	24Xvs40X	0.82	1.00	1.00	0.14	-0.02	-0.01
SONYvsNEC	24X	-0.19	-0.13	-0.13	-0.18	-0.18	-0.19
SONYvsNEC	40X	0.51	-0.15	-0.17	-0.30	-0.19	-0.30
LITEONvsSONY	24X	-0.29	0.86	0.81	-0.08	-0.11	-0.08
LITEONvsSONY	40X	0.35	0.08	0.03	0.37	0.32	0.39
LITEONvsNEC	24X	0.49	-0.12	-0.13	-0.12	-0.18	-0.12
LITEONvsNEC	40X	0.68	-0.16	-0.16	0.89	0.99	0.99

Table 2. Correlation values for scans done on CD-R media

Table 3 shows the correlation values for eight DVD-R discs (Disc19 was excluded due to very high error rates). The LITE-ON drive does not scan at 16X so only the 4X and 8X scans are compared. These scans seem to evaluate nearly 100 percent of the contents of the disc so we would expect to see a better correlation. The LITE-ON and SONY scans on lines 1 and 2 show a high degree of correlation between results for scans at 4X vs 8X as do the NEC 5Xvs8X values on line 5. Note that most of the correlations which include 16X scans do not correlate as well. The LITE-ON vs SONY scans on the last two lines of the chart also correlate fairly well. Our conclusion is that scans can be done at either 4X or 8X, but should not be done at 16X.

Drive(s)	Speed	DVD Tests					
		Max PI	Avg PI	Tot PI	Max PIF	Avg PIF	Tot PIF
LITEON	4Xvs8X	0.85	0.95	0.85	0.95	0.96	0.73
SONY	4Xvs8X	0.97	0.91	0.93	0.71	0.82	0.88
SONY	4Xvs16X	0.26	0.52	0.74	0	0.77	0.91
SONY	8Xvs16X	0.19	0.33	0.54	0.25	0.65	0.98
NEC	5Xvs8X	0.86	0.71	0.81	0.76	0.83	0.84
NEC	5Xvs16X	0.19	0.10	0.28	0.50	-0.18	-0.07
NEC	8Xvs16X	-0.09	-0.02	0.07	-0.05	0.06	0.23
SONYvsNEC	4X5X	0.37	0.17	0.38	0.52	-0.03	0.10
SONYvsNEC	8X	0.03	0.14	0.28	0.23	0.04	0.04
SONYvsNEC	16X	-0.06	-0.03	0.59	-0.23	-0.34	-0.02
LITEONvsNEC	4X5X	0.73	0.83	0.87	0.73	0.14	0.44
LITEONvsNEC	8X	0.74	0.41	0.46	0.40	-0.18	0.10
LITEONvsSONY	4X	0.84	0.52	0.62	0.52	0.75	0.45
LITEONvsSONY	8X	0.53	0.89	0.95	0.90	-0.25	-0.04

Table 3. Correlation values for scans done on DVD-R media

The next set of graphs show the values of Maximum Parity Inner Errors and Maximum Parity Inner Failures for the nine DVD-R discs. The first two graphs are for scans at 4X (5X for the NEC drive) and the second two for 8X. The limit for PI errors is 280 and the limit for PI failures is 4. The maximum values are important to monitor because a single read-error on a disc can be disastrous even if 99.99 percent of the disc is good. Figure 1 indicates potential problems indicated by the NEC drive for discs DISC05, 11, 14, 15 and 19. The LITE-ON drive corroborates the problems with DISC11, 15 and 19. The SONY shows high values for these three discs, but only over the limit for DISC19. Figure 2 shows a similar pattern except that DISC05 and 15 look fine on the NEC scan. Note that there is a very good correlation of values for PIF for the LITE-ON and SONY scans. Figure 3 and Figure 4 shows Maximum PIEs and PIFs at 8X. These show more divergence in values between drives at the 8X speed vs the 4X speed that was used in Figures 1 and 2. NOTE: The Maximum PIF values for the NEC drive (which uses an 8ECC sampling interval) have been divided by 4 so that they can be compared to the values for the LITE-ON and SONY drives (which use a 1ECC sampling interval).

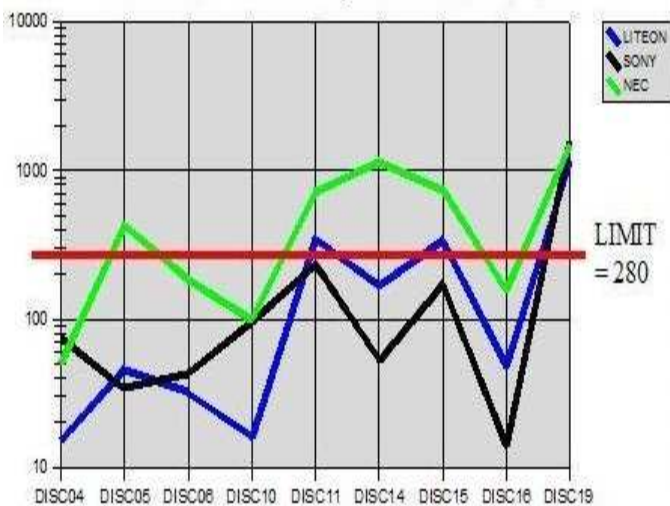


Figure 1. Maximum Parity Inner Errors @ 4X

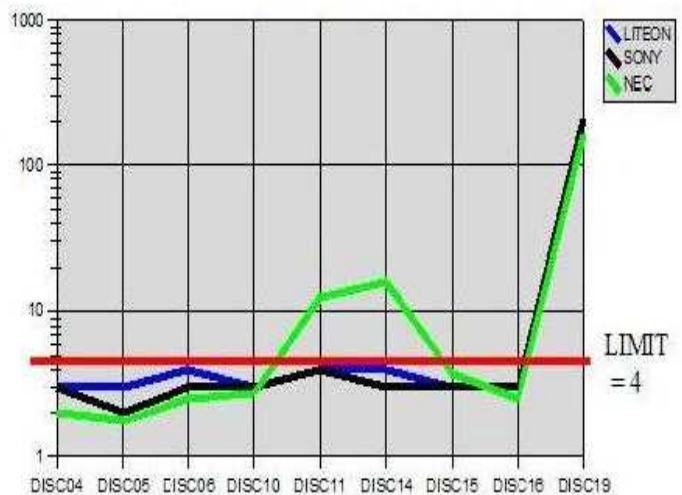


Figure 2. Maximum Parity Inner Failures @ 4X

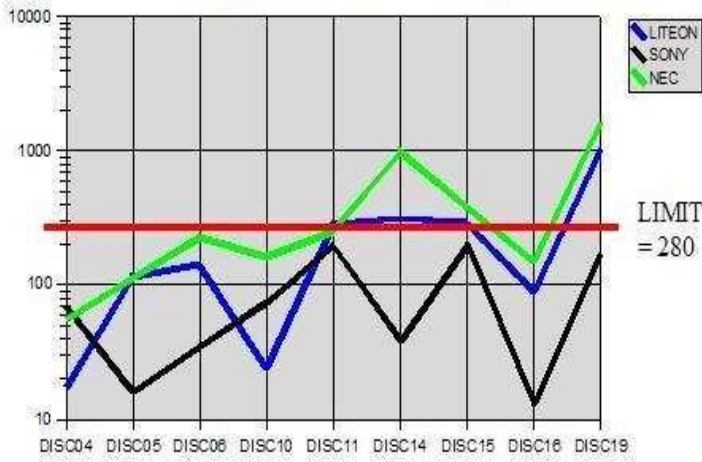


Figure 3. Maximum Parity Inner Errors @ 8X

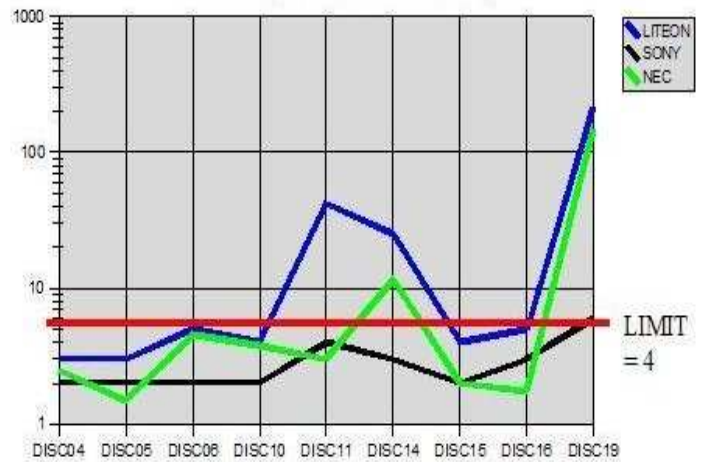


Figure 4. Maximum Parity Inner Failures @ 8X

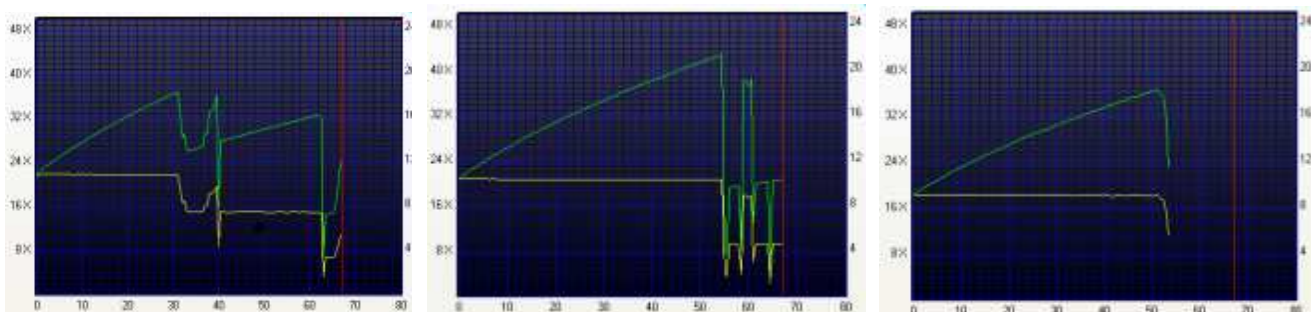
CD Analysis

DISC01. Seven year old Verbatim blue colored Azo CD-R disc (59024E2115041) with printing on disc surface, written at USGS. Shows bursts of errors at the beginning and end on CATS scan, probably before and after the recorded area. Looks fine in most of the CD-Speed and DVDDisaster tests. Infinadyne reports: "The post-gap for this disc is either missing or invalid. 0 trailing sectors found."

DISC02. Ten year old green colored Cyanine CD-R disc (DD5A10244674) with printed stick-on circular label, written by Geosciences. Shows bursts of errors at the beginning and end on CATS scan, probably before and after the recorded area. Took a little longer to copy than other CD's. Looks fine in most of the CD-Speed and DVDDisaster tests. Infinadyne reports: "The mastering program for this disc did not place version numbers (";1") after the filenames. A properly written post-gap was found for this track."

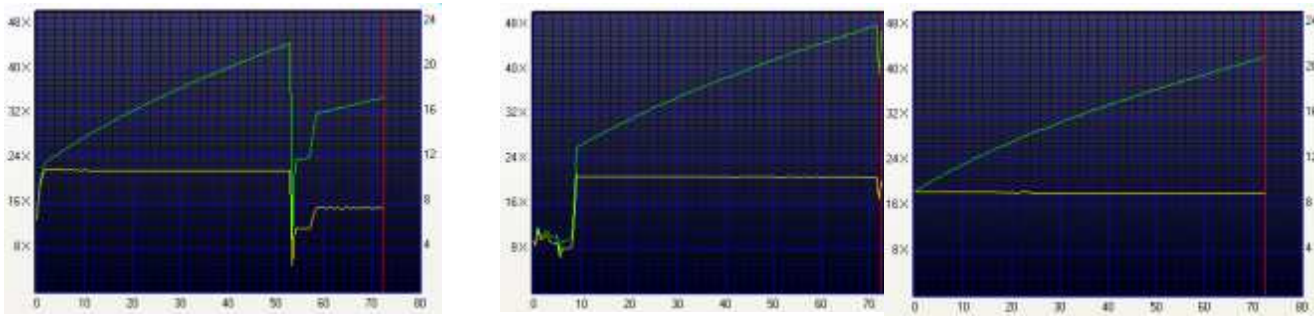
DISC03. Seven year old Kodak gold colored Phthalocyanine CD-R disc (9307 3303 4604) with printing (some color) on disc surface written at USGS. Shows a single burst of errors at the end on CATS scan, probably after the recorded area. Very low block error rate of 5.7. Looks fine in most of the CD-Speed and DVDDisaster tests. Infinadyne reports: "The post-gap for this disc is either missing or invalid. 0 trailing sectors found."

DISC07. Nine year old gold colored Phthalocyanine CD-R disc (5071 1622 2509 - K01036) with no labeling written by the SDDPT task. This disc shows lots of burst errors on the Cats scan at the beginning of the disc, and a single line at the end. The radial noise graph shows a large increase in radial noise just before the middle of the disc. This disc took a long time (six minutes) to copy. CD-Speed tests failed on the LITE-ON drive at 24X and 40X and the NEC and SONY drives at 40X in the region of 58 to 60 minutes. The 24X tests on NEC and SONY readers look fairly good. This disc uses 512 for the sector size in the Volume Table of Contents (VTOC) which causes CD-Speed scandisc tests to fail and DVDDisaster to think the disc is longer than it actually is, thus providing misleading results. Note the benchmark graphs by the three readers (LITE-ON, NEC, SONY) for this disc:



DISC08. Twelve year old green colored Cyanine CD-R disc (TK4A1 7866Q74) written on SDDPD Kodak writer with no labeling written by the SDDPT task. Took about four minutes to copy, which is very slow for a short (220 meg) disc. This disc shows a fairly low BLER on the CATS scan. Tests generally looked good. This disc uses 512 for the sector size in the Volume Table of Contents (VTOC) which causes CD-Speed scandisc tests to fail and DVDisaster to think the disc is longer than it actually is, thus providing misleading results.

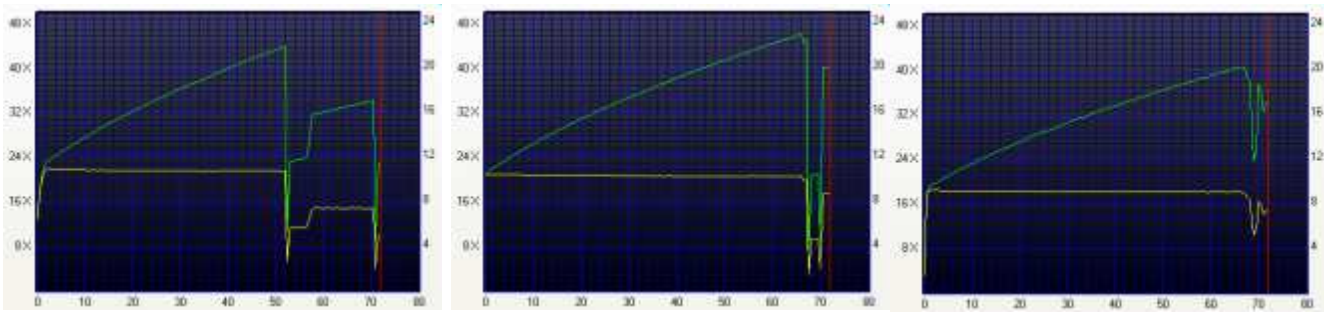
DISC09. Twelve year old green colored Cyanine CD-R disc (TK4A1 7272Q74) written on SDDPD Kodak writer with no labeling written by the SDDPT task. Took about five minutes to copy, slower than normal. This disc is physically damaged, with a cut or scratch running from the inside (VTOC area) to the outside of the disc on the top side. In some cases this disc could not be mounted by Windows XP and showed up as an empty disc. The Infanadyne program said "vtoc damaged, had to go to sector 26 for vtoc". It is not known when this damage occurred. The CATS scan shows some bursts of errors at the beginning and a single burst error at the end. The CD-Speed tests look fine. This disc uses 512 for the sector size in the Volume Table of Contents (VTOC) which causes CD-Speed scandisc tests to fail and DVDisaster to think the disc is longer than it actually is, thus providing misleading results. Note the benchmark scans (LITE-ON, NEC and SONY) which show a lot of trouble near the beginning on both LITE-ON and NEC readers, and some problems at 50 minutes with the LITE-ON reader but neither of the others.



DISC12. Nine year old gold colored Phthalocyanine Kodak CD-R disc (6326 3141 1436) with no labeling written by the SDDPT task. Took about five minutes to copy, slower than normal. The Infanadyne program said "vtoc not found in right place, found in sector 20; some files may not be intact, buffer underrun". The CATS scan shows a single burst error at the end of volume, but the block error rate is good. The CD-Speed tests look fine. This disc uses 512 for the sector size in the Volume Table of Contents (VTOC) which causes CD-Speed scandisc tests to fail and DVDisaster to think the disc is longer than it actually is, thus providing misleading results. For some reason it appears that scandisc (Sony 24X) worked on this disc which is an anomaly.

DISC17. Four year old CD-ROM (CDRM-1051920). Took 8 minutes to copy, much slower than would be expected. The CATS scan shows an average BLER of 6.4 with just one spike in errors at the end of disc. The CD-Speed and DVDisaster scans look fine.

DISC20. Nine year old blue colored Azo CMC Magnetics CD-R disc (D2107CK2222287) with no labeling written by PPI node. Took four minutes to copy, slower than normal. There is a tiny scratch near the outside edge of the disc. The DVDisaster scan shows a significant drop in read speed at this point, though no unreadable sectors. There lots of problems around 68 - 70 minutes at 40X causing failure of CD-Speed Disc Quality test. These problems do not show up on the CATS scan (average BLER 7.2) or CD-Speed at 24X. Note the benchmark graphs by the three readers (LITE-ON, NEC, SONY) for this disc:



DISC21. Seven year old blue colored Azo 80 min CD-R disc (KFLH0148, BB110DK29353112LH) with no labeling written by PPI node. Took four minutes to copy, which is slow for a disc that is only 2/3 full. Failed CATS scan and looked very bad for the part of the disc that was tested (BLER > 7000). Looked good on DVDDisaster scan and most CD-Speed tests. However, on the NEC reader it shows error rates an order of magnitude higher than any other disc tested.

DVD Analysis

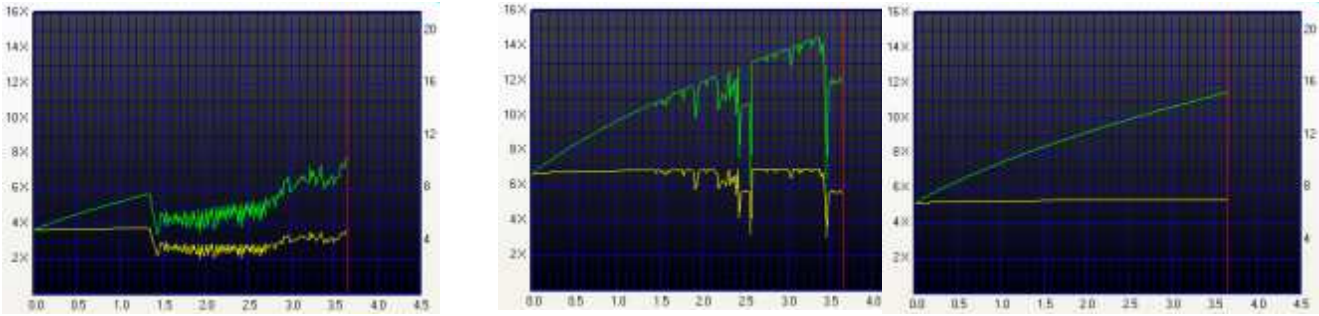
DISC04. Four year old blue colored DVD-R for General Verbatim disc (4.7 GB) with printing on disc surface written by USGS. The disc copies in 7 minutes (900 MB). The CATS scan shows a blip at the end of disc. This disc tests fine with DVDDisaster, and with CD/DVD Speed in several test setups, but fails the scantest read test on the LITE-ON and SONY readers at 4X at the end of the disc.

DISC05. Three year old blue colored DVD-R for General Verbatim disc (4.7 GB) with stickon printed label written by SBN with Pioneer DVR-103 recorder. The disc copies in 5 minutes (760 MB). This disc looks bad on the CATS scan, with a pattern of errors that shows up on several discs written on Pioneer recorders. This disc tests fine with DVDDisaster, and shows a moderate number of errors in CD/DVD Speed tests.

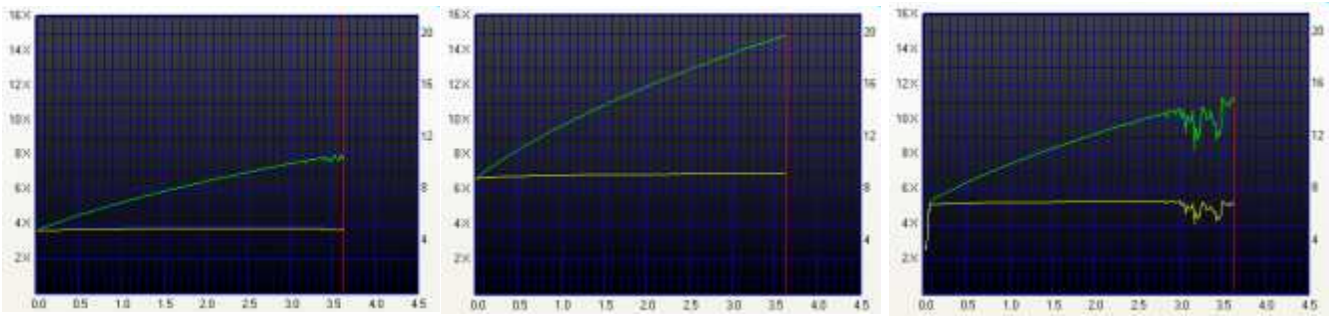
DISC06. DMGSC_1018. Four year old blue colored DVD-R for General Verbatim disc (4.7 GB) with printing on disc surface written by USGS on DVR-104 recorder. The disc copies in 30 minutes (4.25 GB). The CATS scan shows higher PI Sum 8 values near the end of disc and a blip at the end of disc. This disc tests fine with DVDDisaster, but shows a moderate number of errors in CD/DVD Speed tests.

DISC10. DMGSC_1016. Four year old blue colored DVD-R for General Verbatim disc (4.7 GB) with printing on disc surface written by USGS on DVR-104 recorder. The disc copies in 24 minutes (3.8 GB). The CATS scan stops about 1/4 of the way through the disc. This disc tests fine with DVDDisaster, and with CD/DVD Speed in all the test setups.

DISC11. NICRUZ_3001. Five year old blue colored Pioneer DVD-R for Authoring disc (4.7 GB) with a printable surface with handwritten labeling written at Small Bodies node. This disc shows up as a blank disc on my TSSC drive but was OK on another older DVD reader. The disc took 2 hours to copy (3.7 GB) seeming to labor on every file starting with folder nicru1_2002. The disc speed on DVDDisaster was 2X throughout, presumably being read in constant linear velocity mode instead of constant angular velocity. There is no CATS scan for this disc because NIST didn't have the set-up information for DVD-R for Authoring discs. The CD-DVD Speed scans look fairly good, but the benchmark scans on LITE-ON and NEC readers show some trouble reading the disc.



DISC13. Two year old blue colored DVD+R disc (WJ111350D2 4RG5S-0001) with printed stickon label on disc surface written by Malin SSS on Pioneer DVR-103 recorder. Someone has written "UNREADABLE" at the top of the disc. The CATS scan ended before half way through disc and showed characteristics of being written on Pioneer DVR recorder (lots of PI Sum 8 errors). The disc took 13 minutes to copy (3.9 GB). DVDDisaster scanned fine on TSST recorder, but failed on GD-2500 reader at about 1 GB into the disc. The CD-DVD Speed scans are mixed with some looking fine, but many showing lots of errors. The SONY drive failed to do Disc Quality and Report scans at any speed. Note the benchmark scan which shows a reduced read speed for the LITE-ON drive, normal scan for the NEC reader and problems reading the disc near the end with the SONY reader, which eventually failed with an uncorrectable error.



DISC14. Two year old blue colored Verbatim DVD-R for General disc (4.7 GB) with printing on disc surface written by USGS on DVR-104 recorder. The CATS scan shows a high number of errors at the end of the recorded area. The DVDDisaster scan looks good. CD-DVD Speed shows lots of errors near the very end of the recorded area with the LITE-ON and NEC drives but not the SONY drive.

DISC15. Two year old blue colored Verbatim DVD-R for General 8X disc (4.7 GB) with printing on the discs laquer surface. The disc took 14 minutes to copy (4.7 GB). The CATS scan shows a single PI Sum 8 blip at the end of disc and asymmetry drops below limit near end of disc. This disc tests fine with DVDDisaster, but shows a fairly high number of errors in CD/DVD Speed tests.

DISC16. Seven year old blue colored Pioneer DVD-R for Authoring disc (3.95 GB) with printable label with handwritten label written by DDL. 2.9 GB on disc. The CATS scan was not done on this disc. The DVDDisaster scan was done on the GD-2500 reader because the disc appeared as a blank disc on the TSST drive. The scan looks fine but only reads at 2X speed. CD-DVD Speed scans look good but the SONY drive could not scan this disc.

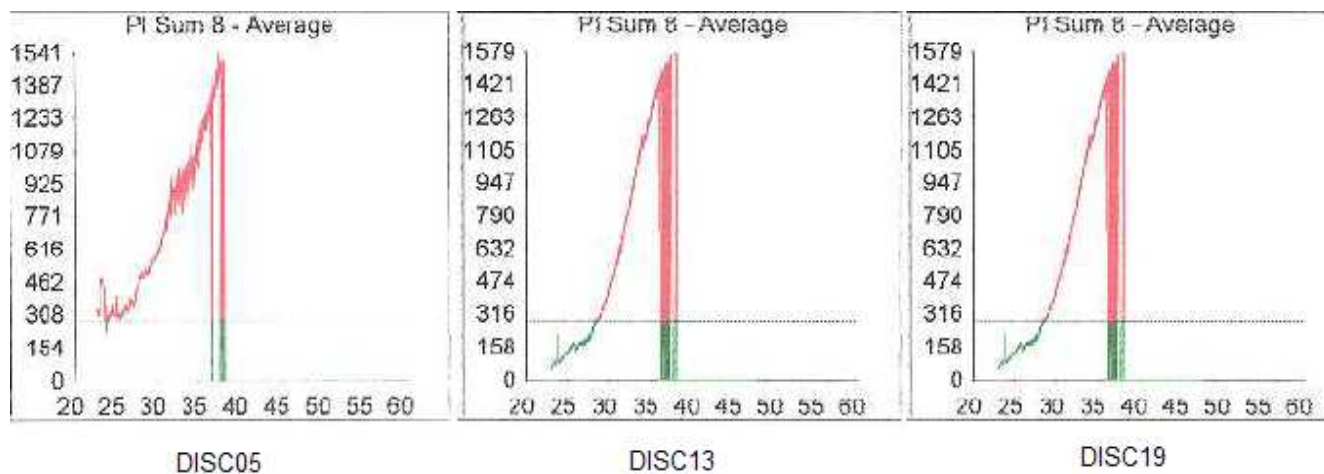
DISC18. Six year old DVD-ROM. This disc looks good in all the tests.

DISC19. Two year old blue colored Princo DVD-R 4X disc (4.7 GB) with stickon printed label written by PPI on Pioneer DVR-105. The disc took 28 minutes to copy (4.4 GB). The CATS scan failed about one half way through the disc. DVDDisaster experienced a slowdown reading near the end of disc. The CD-DVD Speed LITE-ON and SONY Benchmarks failed with an unrecoverable error at 2.8 GB. Several other CD-DVD Speed tests failed. Note the benchmark scans on LITE-ON, NEC and SONY drives. The SONY scan looks good but it failed with an uncorrectable error at the end.

Conclusions

The CD CATS scans test a lot of physical parameters for the discs, they don't seem to add much to the DVDDisaster and CD-DVD Speed tests that can be performed on any Windows computer with a DVD reader. In general scanning should be done initially at 4X. It would be useful to have a few benchmark discs with known characteristics that could be used to calibrate the test capabilities of any PDS test setup. Once we are comfortable with a test setup, bulk scanning can probably be done at 8X.

Several DVD recordable discs show the same characteristic error pattern near the middle of the disc on the CATS scans (see below). These error patterns show up in the CD-DVD Speed Disc Quality scans but do not seem as severe. The discs are DISC05 (NIEROS_5001, written by the Small Bodies node), DISC13 (DMGSC_1036, a DVD+R disc written by Malin Space Science Systems), DISC14 (lo3_high_res_v1, written by USGS-Flagstaff) and DISC19 (CORPWS_0001, written at the University of Iowa). We recommend additional testing of discs written by these facilities.



More than half of the discs that were tested show enough errors that it would probably be wise to copy them to new media. In particular DISC05, DISC07, DISC11, DISC13, DISC16 and DISC19 should be copied to media. Despite problems with many of the discs, all the data was copied to hard disk, though multiple readers had to be used for some discs.

Recommendations

1. Review the hardware, software and media setup at each node and recommend upgrades to improve performance.
2. Evaluate the feasibility of migrating all existing physical media archives to a higher density media (high capacity hard disk drive or DLT or both).
3. Perform additional scans on suspect media categories (Small Bodies, Malin SSS, U of Iowa, USGS Flagstaff) and refresh suspect discs.
4. Establish a media testing procedure utilizing the CD-DVD Speed program for use at the PDS nodes, including providing a benchmark disc to calibrate the drive(s) used for testing.
5. Establish an inventory of all recorded media at all nodes (can be central or distributed) including media characteristics (vendor, record speed, recorder, software) and media test data (disc quality info and scans) for all recorded volumes.
6. Test every disc when recorded and test samples of newly recorded media at intervals of 1 month, 1 year and 3 years.
7. Some thought should be given to testing more pressed discs (CD-ROMs and DVD-ROMs) at some point, however the handful of discs that have been tested look very good (even our oldest PDS Science Sampler CD-ROMs look extremely good).
8. Every data file on every volume should have an external checksum for validation. The internal checksums

computed on most imaging files are essentially useless since we don't (seem to) have a tool to automatically verify volumes that have them.

APPENDIX 1. Hardware used for the tests.

Discs were scanned using CD CATS SA3 and DVD DVD+R Pro and DVD-R Pro devices by the National Institute of Standards and Technology (NIST). Disc copies and DVD disaster scans were carried out using a Toshiba Samsung TS-H552L CD/DVD recorder and Hitachi GD-2500 CD/DVD reader. Each disc was also tested using CD-DVD Speed program at the Planetary Plasma Interactions (PPI) Node on three different CD-DVD drives, a LITE-ON LTD163 CD/DVD reader, a NEC ND3550A CD/DVD recorder and SONY DW-Q120A CD/DVD recorder.

APPENDIX 2. Discussion of CD and DVD Error Correction

Please refer to the "PxScan/PxView Manual" at <http://www.alexander-noe.com/cdvd/px/pxscanview.pdf> for a nice summary of CD and DVD error values.