Climatic factors influence research on optical CD-Rs

Sergey Nedev, Vladimir Kamenov
Technical University, Sofia, Bulgaria, e-mail: s_nedev@tu-sofia.bg, Technical University, Sofia, Bulgaria, e-mail: vladokamenov@tu-sofia.bg

Abstract: *The quality of recorded data onto optical computer discs is determined by the quantity of read errors after the data has been burned. The influence of the environment, in which the recorded CDs are stored, can lead to such errors. The consequences of CDs and DVDs storage in sub-zero temperatures are not well studied. Continued exposure to bright sunlight can significantly increase the deterioration degree of the recording layer in recordable optical (CD-R) discs. The present paper describes an investigation of the influence of several environmental parameters on recordable optical discs.*
Keywords: *CD-R, read errors, climatic parameters, testing.*

1. INTRODUCTION

The compact disc (Compact Disc, CD, and CD-ROM) is an optical media for data storage. It is made of polycarbonate with thickness of 1.2 mm, layers with thin layer of aluminum and protective coating.

The data on disc is recorded in a helix shaped path using so called pits, formed in the aluminum layer. Each pit has the following dimensions: around 125nm depth and around 500nm width. The length of the pit varies from 850nm to 3.5µm. The distance between adjacent paths of the helix is 1.5µm.

The data on disc is read using laser beam with wavelength 780nm, which passes though the polycarbonate layer, reflects from the aluminum layer and finally is captured by a photodiode. The laser beam forms a spot on the reflective layer with 1,5µm diameter. The places on this layer, where there are no pits are called lands. The light from the laser, when falling onto a land is reflected and captured by the photodiode. If the light falls on a pit, it exhibits interference with the reflected light coming from the surrounding land and as a result no light is reflected back to the receiver.

2. FACTORS INFLUENCING THE LONGETIVETY OF RECODED OPTICAL DISCS

The next captions describe the influence of various environmental parameters on recorded optical discs.

2.1. Temperature and humidity

Optical discs are quite resilient when stored in a wide range of temperatures and humid conditions, but still these conditions have negative influence on them and this can lead to loss of recorded data.

2.2. Exposure to sunlight

2.2.1. Effect of sunlight exposure on recordable optical discs

Prolonged exposure to direct sunlight and other sources of ultraviolet light can significantly increase the deterioration degree of the recording layer in recordable (type-R) optical discs. Depending on the deterioration degree there can be read errors when the disc is red from a laser beam.

The most probable reason for type-R discs damage from direct sunlight exposure is that it overheats the pigment recording layer. Large portion of the ultraviolet spectrum of sunlight can be filtered with ordinary glass. Higher wavelengths of infrared light can pass through the glass and generate heat in the disc itself.

2.2.2. Effect of sunlight exposure on CD-RW, DVD-RW, DVD + RW and DVD- RAM discs

Sunlight has minimal effect on RW and RAM discs, because the recording layer, used in these discs is not sensitive to light. It is however influenced by heat. The recording in these discs is made with heat, generated by intensive laser beam. The heating of RW or RAM discs, caused by direct sunlight will accelerate the deterioration process in the recording layer. The recording layer in RW and RAM discs is deteriorated faster that the layer in R discs.

2.3. Organic solvents

Contact with such solvents should be avoided as they will melt the protective polycarbonate, making it opaque and thus the disc will become useless.

2.4. Magnetism, x-rays, microwaves and radiation

Magnetism has no effect at all on CDs or DVDs. Exposure to x-rays does not damage the optical discs. Microwaves like those in a microwave oven will destroy the disc, because it contains metal alloys.

3. OPTICAL DISCS DAMAGES AND RECORDING ERRORS CLASSIFICATION

The main disadvantages of optical laser discs are the loss of data, caused by mechanical contact or the recording errors, during burning of discs.

The recording quality is determined by the number of read errors during reading of the recorded disc. CDs use techniques called redundancy and interleaving, called cross-interleave Reed-Solomon code – CIRC, in order to eliminate the effects of errors on the disc.

The presence of additional circuits for error discovery and correction is the key difference between audio CD players and CD-ROM devices. CD-ROM devices cannot tolerate any inaccuracies. Every data bit has to be exactly red. That is why in CD-ROMs, significant additional (error correcting code) ECC data, except the user data, is stored. The ECC code can correct many of the smaller read errors, thus improving reliability and accuracy to acceptable levels, required for data storage.

CIRC consists of two levels of error correction (they are detected by two decoders): C1 and C2. These two levels can detect errors designated by labels E11, E21, E31, E12, E22 and E32.

3.1. First level errors C1

E11, E21 and E31 errors are discovered on the first level of correction and are called C1 errors. The discovery of E11 error means that there is a presence of one incorrectly decoded symbol (byte) on C1 level. The discovery of E21 error means two incorrect bytes, E31 – three incorrect bytes. After the errors are discovered they are corrected. C1 level can correct E11 and E21. E31 error cannot be corrected on C1 level and it is submitted for correction to the second level.

3.2. Second level errors C2

E12, E22 and E32 errors are discovered on the second level of correction and are called C2 errors. The discovery of E12 error means that there is a one symbol error, which can be corrected in the second decoder. E22 designates the presence of a two symbol correctable by the second decoder error. Since this error comes close to the uncorrectable errors, they should not be present in the recorded disc. E32 error designates the presence of an uncorrectable in the second decoder error (unreadable data). E32 errors should not be present and tolerated.

3.3. BLER

The BLER (Block Error Rate) abbreviation designates the frequency of data blocks which contain wrong symbols discovered on C1 layer (first decoder). The BLER parameter can be used to assess the overall quality of the disc recording. Compared to their BLER index, optical discs can be divided in 5 quality groups.

4. EXPERIMENTAL RESEARCH SETUP AND TEST RESULTS

4.1. Software used for conducting the tests

The research used two brands of optical discs: EMTEC and i·b@se. The disc type and capacities are CD-R, 700MB, 80 min., maximum record speed 52x. The quality of the recorded data is examined, when the discs are subjected to prolonged exposure to high and long temperatures and strong sunlight.

In order to prepare the discs for subsequent testing, they have to be specially recorded as test discs by the corresponding diagnostics software. Nero CD/DVD Speed v.4.7.7.16 was chosen for the tests. The most important parameters from the analysis software are the C1/C2 errors, found on CDs. The number of C1 errors usually does not affect playback or data reading, and is considered more like a indicator for possible disc damage and inability of future data reproduction. The conducted test used the "disc quality" tab in the test software.

4.2. Test results

Tab. 1 – disc 1 EMTEC, heated to temperatures of 100°C, 150°C and 200°C for 60 min.

Test type	C1 errors	C2 errors	Jitter	Scanning Statistics
Control test with normal environmental conditions	Maximum: 20 Average: 0.41 Total: 1912	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4428 Average scanning interval: 1.08sec Glitches removed: 0
100°C test for 60 minutes	Maximum: 20 Average: 0.41 Total: 1945	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4428 Average scanning interval: 1.08sec Glitches removed: 0
150°C test for 60 minute	Maximum: 22 Average: 0.47 Total: 2247	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 8859 Average scanning interval: 2.17sec Glitches removed: 0
200°C test for 60 minute	Maximum: 39 Average: 1.00 Total: 4809	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4430 Average scanning interval: 1.08sec Glitches removed: 0

Tab. 2 – disc 1 i·b@se, heated to temperatures of 100°C, 150°C and 200°C for 60 min.

Test type	C1 errors	C2 errors	Jitter:	Scanning Statistics
Control test with normal environmental conditions	Maximum: 18 Average: 0.22 Total: 1047	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4428 Average scanning interval:1.08sec Glitches removed: 0
100°C test for 60 minutes	Maximum: 20 Average: 0.23 Total: 1094	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4426 Average scanning interval:1.08sec Glitches removed: 0
150°C test for 60 minutes	Maximum: 22 Average: 0.47 Total: 2247	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 8859 Average scanning interval:2.17sec Glitches removed: 0
200°C test for 60 minute	Maximum: 18 Average: 0.28 Total: 1351	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4427 Average scanning interval:1.08sec Glitches removed: 0

Tab. 3 – disc 2 EMTEC, cooled to temperature of -18°C, with different continuity

Test type	C1 errors	C2 errors	Jitter:	Scanning Statistics
Control test with normal environmental conditions	Maximum: 23 Average: 0.56 Total: 2676	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4429 Average scanning interval: 1.08sec Glitches removed: 0
-18°C test for 24 hours	Maximum: 28 Average: 0.61 Total: 2918	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4423 Average scanning interval: 1.08sec Glitches removed: 0
-18°C test for 5 days	Maximum: 31 Average: 0.93 Total: 4463	Maximum: 0 Average: 0.00 Total: 0	n/a	Elapsed time: 4:31 Number of samples: 4426 Average scanning interval: 1.08sec Glitches removed: 0
-18°C test for 15 days	Maximum: 28 Average: 1.00 Total: 4784	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4357 Average scanning interval: 1.10sec Glitches removed: 0
-18°C test for 20 days	Maximum: 27 Average: 1.03 Total: 4921	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4429 Average scanning interval: 1.08sec Glitches removed: 0

Tab. 4 – disc 2 i·b@se, cooled to temperature of -18°C, with different continuity

Test type	C1 errors	C2 errors	Jitter:	Scanning Statistics
Control test with normal environmental conditions	Maximum: 16 Average: 0.29 Total: 1374	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4428 Average scanning interval: 1.08sec Glitches removed: 0
-18°C test for 10 days	Maximum: 16 Average: 0.31 Total: 1465	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4428 Average scanning interval: 1.08sec Glitches removed: 0
-18°C test for 15 days	Maximum: 29 Average: 0.66 Total: 3147	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4428 Average scanning interval: 1.08sec Glitches removed: 0

Tab. 5 – disc 3 EMTEC, subjected to direct sunlight for different lengths of time

Test type	C1 errors	C2 errors	Jitter:	Scanning Statistics
Control test with normal environmental conditions	Maximum: 25 Average: 0.70 Total: 3336	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4430 Average scanning interval: 1.08sec Glitches removed: 0
5 days test	Maximum: 44 Average: 1.72 Total: 8269	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 8854 Average scanning interval: 2.17sec Glitches removed: 0
10 days test	Maximum: 61 Average: 2.80 Total: 13413	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4423 Average scanning interval: 1.08sec Glitches removed: 0
15 days test	Maximum: 65 Average: 5.01 Total: 24009	Maximum: 14 Average: 0.01 Total: 31	n/a	Number of samples: 8859 Average scanning interval: 2.17sec Glitches removed: 0
25 days test [1]	Maximum: 55 Average: 5.23 Total: 25076	Maximum: 6 Average: 0.00 Total: 14	n/a	Number of samples: 8854 Average scanning interval: 2.17sec Glitches removed: 0
30 days test	Maximum: 60 Average: 5.68 Total: 27234	Maximum: 7 Average: 0.00 Total: 11	n/a	Number of samples: 4429 Average scanning interval: 1.08sec Glitches removed: 0

[1] During testing of EMTEC disc for 25 days, C2 errors were observed for the first time under the influence of environmental factors.

Tab. 6 – disc 3 i·b@se, subjected to direct sunlight for different lengths of time

Test type	C1 errors	C2 errors	Jitter:	Scanning Statistics
Control test with normal environmental conditions	Maximum: 15 Average: 0.20 Total: 971	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 8857 Average scanning interval: 2.17sec Glitches removed: 0
10 days test	Maximum: 36 Average: 1.66 Total: 7954	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 4429 Average scanning interval: 1.08sec Glitches removed: 0
15 days test	Maximum: 53 Average: 2.53 Total: 12112	Maximum: 0 Average: 0.00 Total: 0	n/a	Number of samples: 13279 Average scanning interval: 3.25sec Glitches removed: 0

5. RESULTS ANALYSIS AND CONCLUSIONS

The first tested environmental parameter is high temperature. The research determined that increasing the temperature at which the recorded test discs are stored leads to increased read errors. It was also determined that the length of exposure determines the quantity of read errors – more exposure leads to more errors. Exposure to temperatures over 100°C leads to fast increase of read errors, but even exposure to temperatures over 200°C for 60 minutes does not influence disc operation. This shows that computer optical –R discs are resilient enough to temperature exposure in everyday life. The temperature limit where discs begun to deform becoming unreadable was 220°C

The second environmental parameter is low temperature. The research determined that optical –R discs are more resilient to low temperatures than to high temperatures. The discs were tested after exposure to -18°C temperature. The exposure for 20-25 days lead to read error increase, but serious problems permitting the recorded data to be red were not encountered.

The third environmental parameter investigated was the exposure to direct sunlight for prolonged periods of time. This research encountered the most read errors. The tests determined even C2, which however are fixable and thus no fatal damage was detected. The rate of read errors increase suggests that given enough prolonged exposure to direct sunlight will lead to a stage at which the discs will be irreversibly damaged and the recorded information will be lost.

The conclusion is that the tested environmental parameters on different brand of optical computer –R discs affect the expensive ones as well as the cheaper ones.

Premium brands exhibit lower rates of deterioration when subjected to environmental factors, but nevertheless they can also be damaged given enough time.

6. REFERENCES

[1] http://www.digitalfaq.com/guides/media/dvd-tests.htm - Test the Quality of CD Media
[2] http://dvd-r.ru - CD-R discs and technology inside
[3] http://www.cdmasteringservices.com - digital Errors And CD Quality