Monitoring the Life Expectancy of Compact Discs

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Abstract: This report measures the condition of 125 CDs that are statistically selected from a collection of over 60,000 discs. This small sample was selected to demonstrate a testing program and to get some feeling as to the general condition of the discs in the collection. Using this small sample, a complete set of ISO measurements were performed. A CD-CATS system was used to perform such measurements. Based upon the findings of these initial tests of 125 CDs, a more detailed test of the complete collection may be recommended. In any case, it is the intent that, at a minimum, these tests be repeated using these same discs in a few years to determine if any and what kind of changes may occur. With these data, information regarding the life expectancy of the collection may be determined.

1. The collection

The Library of Congress (LC) has a large collection of audio CDs and the condition of these discs were never monitored. This small sampling test is to get some data as to the condition of the existing collection, and perhaps develop a baseline for future measurements.

The tester used by the Library of Congress was a CD-CATS system, configured with a 486 PC, printer, and software to output various reports. These reports consist of summary of each parameter measured, a list of each parameter out of specification, and tools to show surface presentations of certain parameter variations. It measures all the ISO parameters, in addition to the jitter and length deviation, which is becoming a significant indicator of errors.

The testing and monitoring program statistically selected a sample of 125 audio compact discs from the LC collection of over 60,000. This 60,000 number is only an estimate of the number in the collection, but a number that most could agree upon. Statistically speaking, a sample size of over 1000 disks would be needed in order to have a confidence level of over 95 %, if discs are normally distributed in defects. However, since we know that the disks are not purely distributive in defects, a successive estimate approach was used, projecting that the true error rate may be less than 5%, the sample size was reduced to 125 disks. This was felt to be a reasonable number of discs to test as a demonstrative testing and monitoring program. The next phase may increase this number to 1000.

2. The test parameters

The test results are grouped, by the CD CATS system, into three categories: static data, dynamic data, and the recommended length deviation and jitter data. Obviously, some of these parameters are of more interest than others in this testing and monitoring program. The parameters are listed below and their definitions and use of the terms are discussed in ISO/IEC 10149, *Data interchange on read-only 120 mm optical disks (CD-ROM).*

The static data includes: SLD (Start Lead In is the optical start of the tracks), SPD (Start of Program Diameter), MID (Maximum Information Diameter), SVY (Scanning Velocity), TRP

(Track Pitch), ECC (Eccentricity), DEV (Deviation), DEFL (Deflection), PP (Push Pull), PPC (calculated Push Pull), and XT (Cross Talk).

The dynamic test data consist of the following: BLER (Block Error Rate), E11, E21, E31, E12, E22, and E32 (error counts), I3, I11, I3R and I11R (reflective indicators), REF (Reflectivity), SYM (Symmetry), BERL (Burst Error Length), CRC (Cyclic Redundancy Check), RN (Radial Noise), BEGL (Burst Errors Greater than Limits), and E32TOT (total number of uncorrectable blocks present within the testing time).

The time interval data, which are not ISO specification, but important to monitor, are the length deviation and jitter. The length deviation is the length of each pit and land area as measured, and compared to the ideal pit and land lengths. The results are compared for each run length, 3T to 11T, (9 values) with variations preset for each run length. Jitter is measured individually for pit and land (3T ...11T), 9 times 2, or 18 measurements. Each pit and land is measured and then jitter is calculated statistically as a standard deviation, (18 more measurements) according to Philips specifications. This is done for the entire track of the disc. As can be imagined, a lot of data are generated for each disc.

The tester also generates an "OUT OF SPEC. LIST", based on the maximum value specified by the user of the CD CATS system. This is a useful reporting mechanism for flagging errors. Based on where the "maximum" value is set the list of errors may not really be errors, but levels outside the reporting boundary. Also, some discs generate numerous "errors" that are not real errors, but only transitions between recording sessions. This depends a lot on how the discs were initially formatted, recorded, and manufactured. Since these are not really errors, it is important, when analyzing the data to determine where the errors occurred. They may have nothing to do with the condition of the disc or the data.

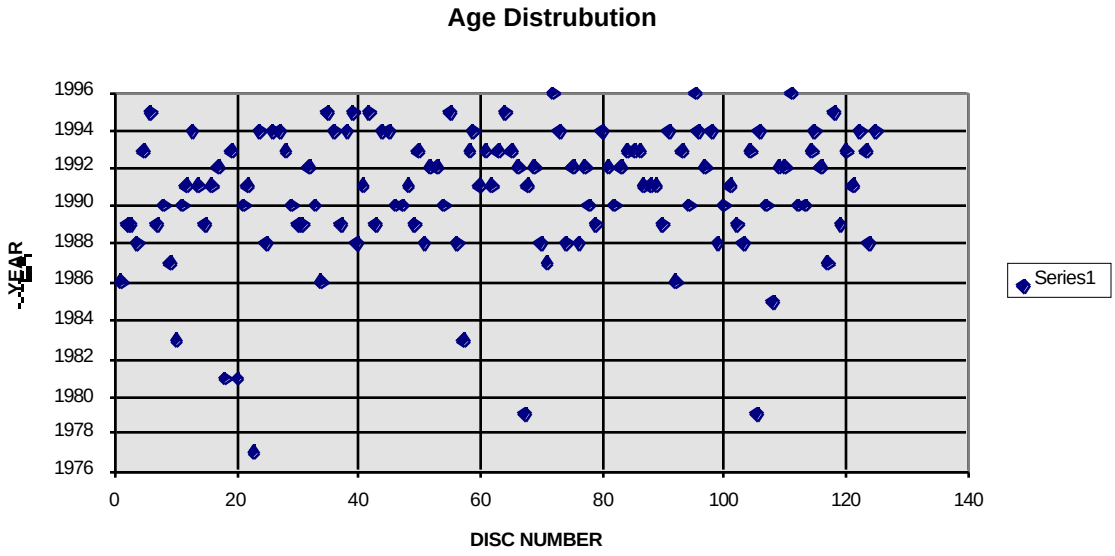

Figure 1. Scatter plot of age distribution.

3. Some test data

The test data have been collected for all the selected 125 discs. The full spectrum of errors has been tabulated for analysis, but are not included in this brief paper. However, a number of scatter plots are provided to present the range of certain parameter.

The Figure 1, represents the 125-disc sample in terms of the age. Since the sample of the test was statistically derived, it is hoped that this scatter plot does indeed represent the age distribution of the CD collection. Each disc is identified by a disc number, which is attached to the jewel case of the CD. It is hoped that the CD can be retrieved at a later date and repeated measurements made.

In looking at the data in the scatter plot, it can be seen that the age distribution ranges from 1977, disc number 23, to 1996 where there are 3 discs in the sample, disc numbers 72, 95, and 111.

It is often interesting or useful to look at specific parameters over the entire surface of the disc. The CD CATS system provides a surface presentation tool to look at how a parameter value may vary over the surface of the disc. This report does not include such presentations, but using the surface presentation of the BLER, for example, it can be used to correlate the variations of levels BLER (max.) with any other parameter, such as the E32 error. This is a useful mapping tool, but performed visually on a CRT.

Figure 2 shows the scatter plot of the maximum Block Error Rate (BLER). Except for the four discs with a BLER over 200, the data are very acceptable. These discs are disc numbers 18, 59, 80, and 93. Most CDs manufactured currently are exhibiting BLERs around 5 or less.

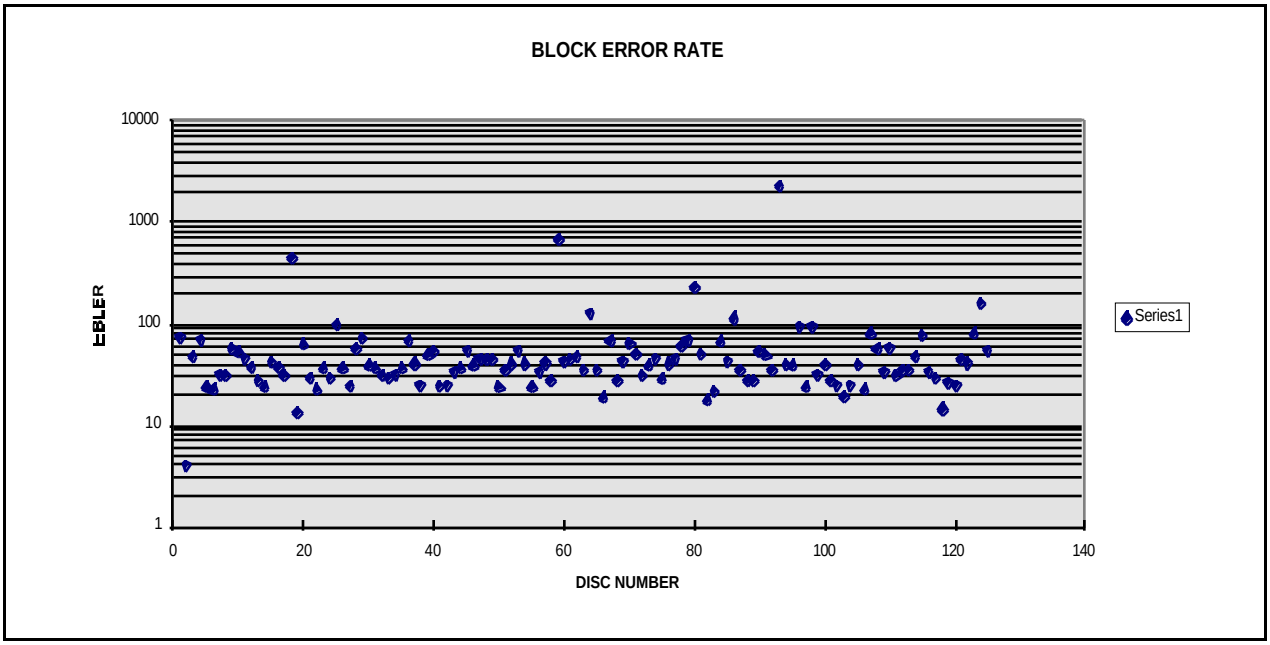

Figure 2. Scatter plot of Block Error Rate (BLER).

A closer look at the BLER for these discs show some interesting findings. The location of the BLER (max.) is shown along with the total playing time of the disc.

Disc number	BLER (max.)	Location time	BLER (av.)	Total playing time
18	444	55’ 43’’	67	56’ 07’’
59	1737	00’ 04’’	65	63’ 52’’
80	228	50’ 32’’	4	73’ 10’’
93	2304	41’ 11’’	1837	72’ 47’’

Often, it is said that errors occur near the end or edge of the disc. This is true for three out of the four discs that had BLER above 200. The BLER (av.) level is also too high for discs number 93. However, all these discs also had E32 errors, often near the location of the BLER (max.).

A closer look at the E32 error, which means an uncorrectable error, is in the following table. Discs 57 and 64 had acceptable BLER levels, but exhibited E32 errors. For Disc 57, the pit jitters were out of specification and for disc 64 both the land and pit jitters was out of specification.

Disc number	BLER (max.) at Location time	E32 at Location time	Total playing time
18	444 at 55’ 43’’	3 at 55’ 54’’	56’ 07’’
57	41 at 43’ 20’’	1 at 42’ 52’’	49’ 40’’
59	1737 at 00’ 04’’	20 at 00’ 07’’	63’ 52’’
64	127 at 25’ 04’’	317 at 25’ 04’’	64’ 52’’
80	228 at 50’ 32’’	409 at 50’ 32’’	73’ 10’’
93	2304 at 41’ 11’’	4 at 26’ 11’’	72’ 47’’

There are many other parameters to investigate, but is out of the scope of this short paper. Reflectivity is a critical factor and varies by types of substrates and reflective layers. Noise is also an important key parameters that will be later investigated.

4. Some conclusions

This report provides only the first, baseline testing of a small, 125, sample of discs. The monitoring and investigation of the CD collection will be an ongoing, low level, low priority, and low budget operation. Eventually, the entire collection should be monitored, not just a small sample.

First of all, it is probably desirable to increase the size of the sample, since certain assumptions were made to come up with a small sample size of only 125 discs as the first effort. The size should be increased to 1000 discs, for starts. In the sample of 125 discs there were 5 discs with one or more E32 errors. Since these are all audio discs, one cannot “hear” the “error”, but nevertheless there is a measurable data error.

Secondly, the sample that is now measured should be monitored for any indication of deterioration. We have no such real life deterioration data, and coming back to these same discs every 3 to 5 years will be important and a significant contribution to the study of the life of CDs.

And finally, there should probably be a systematic procedure to continue randomly sampling the entire collection to find deteriorating discs. Should such a disc be found, a copy of it should be made. We have not yet progressed to that point.