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# Life Time Test of Rewritable Mini Disc (MD) Media

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The lifetime test of optical media is discussed on the rewritable Mini Disc media for consumer use. The experiments were applying the method conventionally used for the data storage optical disc. Judging from some respects of the experimental results, the lifetime of the recording layer of rewritable MD media presently available in the market is deemed to be sufficiently long. In order to establish a measurement method to determine the reliability or lifetime of rewritable MD media, it is necessary to discuss the issues from view points except degradation of recording layer.

KEYWORDS: optical disc, life test, rewritable disc, MD media, survival probability, testing method, Arrhenius method, error rate

## 1. Introduction

When development of the optical disc began, it was assumed that the lifetime of the optical memory media would be extremely long and the reliability is high. In the draft documents for ISO standardization, this specification was clearly stipulated at the beginning.

In Japan, a working group was established within the domestic committee for ISO/TC97/SC23 and JIS committee to discuss media reliability. More than 10 years after the above activities began, a consensus was finally reached in the industry regarding specifications for the data storage optical disk.[1–5)]

However, the optical disk for consumer use has rarely been discussed in the public. Recently, interest in its reliability has been gradually increasing because of the wide-spread use of CD-ROM for computer memory, and reports of the reliability tests have begun to appear.[6)]

In this area, rewritable Mini Disc (MD), whose main application is recording/reproducing audio signals is rapidly becoming popular. Because of this , interest has begun to be shown in the reliability of this type as well.

The purpose of this study is to contribute to establishment of the standard reliability test for the rewritable MD media for consumer use. To this end, we evaluated the lifetime of the rewritable MD media by applying the method conventionally used for the data storage optical disk.

## 2. Experimental Procedure

The major factor which determines lifetime of data storage optical media is considered to be degradation of the recording film due to thermal diffusion. For measurement, the Arrhenius method has generally been used to determine the lifetime under the condition of an actual operating or storage environment and the equivalent activation energy is determined by measuring lifetime at more than 2 points under the acceleration condition including other accompanying factors.

Assuming that the above explanation is applicable to the rewritable MD media, we performed the test using Arrhenius method. Figure 1 shows the actual experimental procedure. We used 5 discs of 4 types obtained from 4 different manufacturers as test samples. For measurement , we picked 3 areas, the inner circumference, the middles circumference, and the outer circumference in order to evaluate the reliability of and time required for the measurement with respect to shelf life and archival life. Lifetime of the rewritable optical memory media is defined as a period during which the function continue under normal operation. There are two kinds of lifetime; one is shelf lifetime for the function of recording, another is archival lifetime for the function of holding the recorded information. The information is rightly recorded during the shelf lifetime and the information rightly reproduced during the archival lifetime.

Thus, total number of measuring areas per disk is 18 and, as 20 disks are used, total of 360 areas were used for measuring and the accuracy of the evaluation is assumed to be fairly high.

Figure 2 shows the environmental cycle of temperature and humidity. The process cycles shown in this figure correspond to Cycle P1, P2, P3$\cdots$ in Fig. 1. Since the discs are returned to the test environment after each measurement, we were careful to ensure the thermal shock would not be applied to the test discs.

To determine end of life, we used BLER (Block Error Rate) defined in the Standard for CDs (Compact Discs). A measurement is made at the worst point of average transfer in a specific time of 10 seconds.

A specific tester was designated for measurement and used until the series of the tests were completed. We also controlled the tester so as not to cause changes in its characteristics.

Table I shows the difference in the method proposed from that for the data storage optical disk. The biggest difference is that definition of the end of life is performed with BLER instead of BER (byte error rate).

We measured variation of BLER at temperatures of 70°C, 80°C exhibited by each of the 5 discs of 4 types.

## 3. Experimental Results

Figure 3 shows the variation in shelf life and archival life in 80°C environment. Because BLER variations in the archival life are small, we focused on shelf life in our analysis. We understand that the recording process is

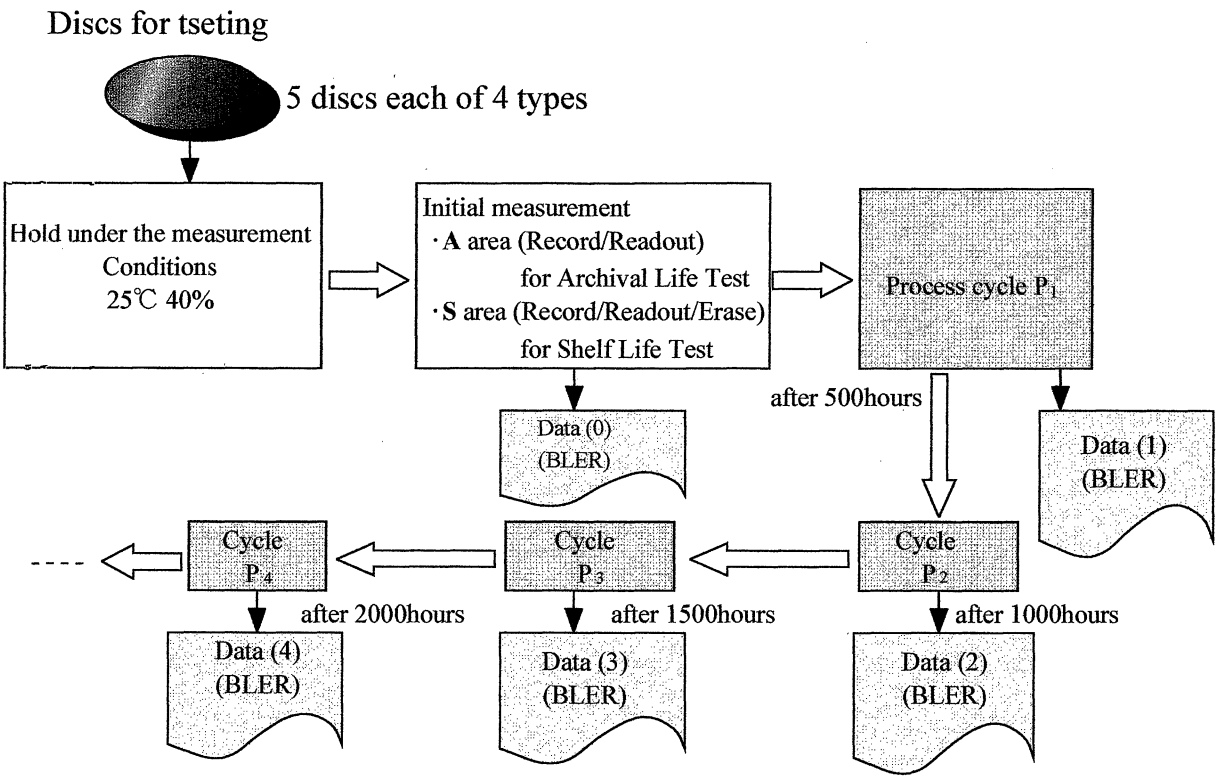



Fig. 1. Lifetime measurement procedure.

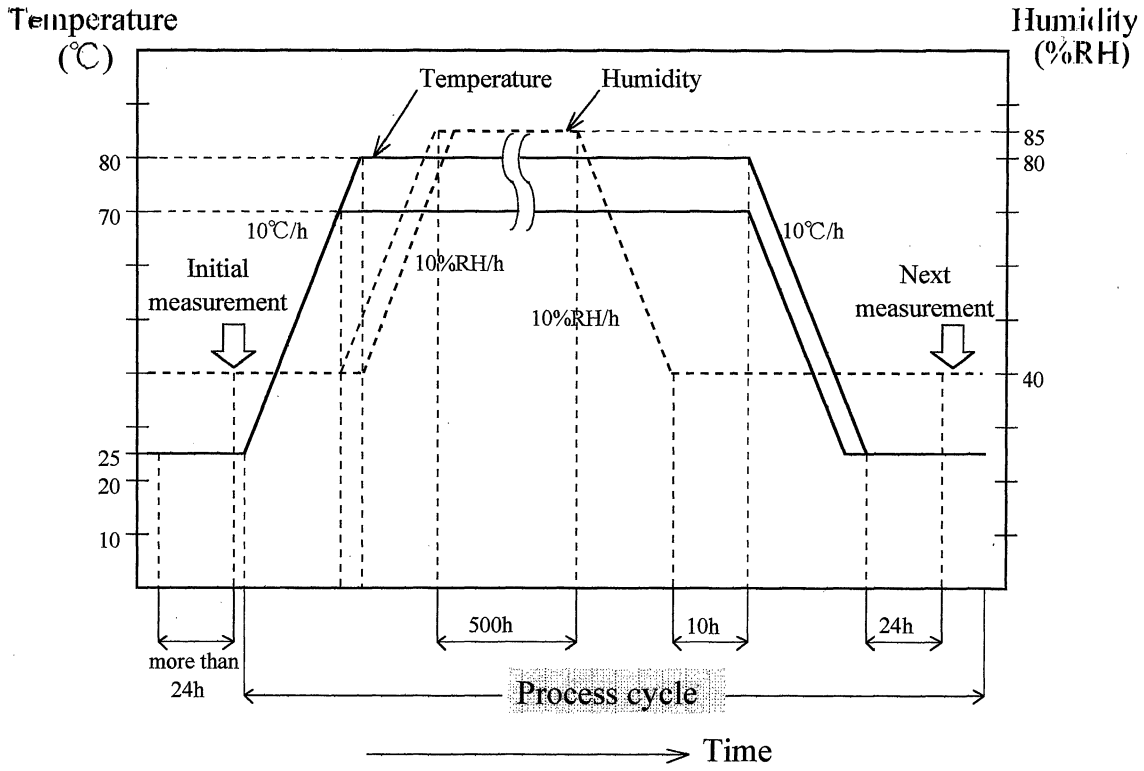
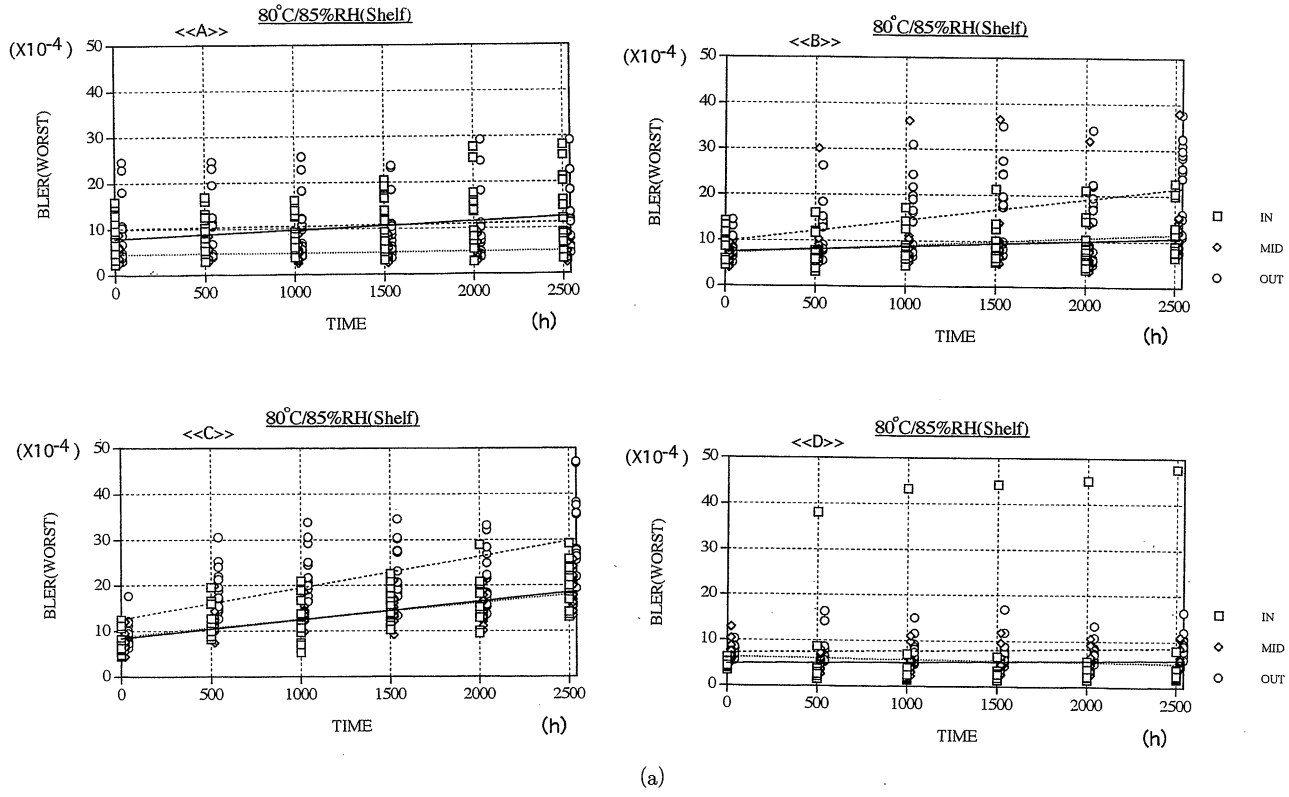


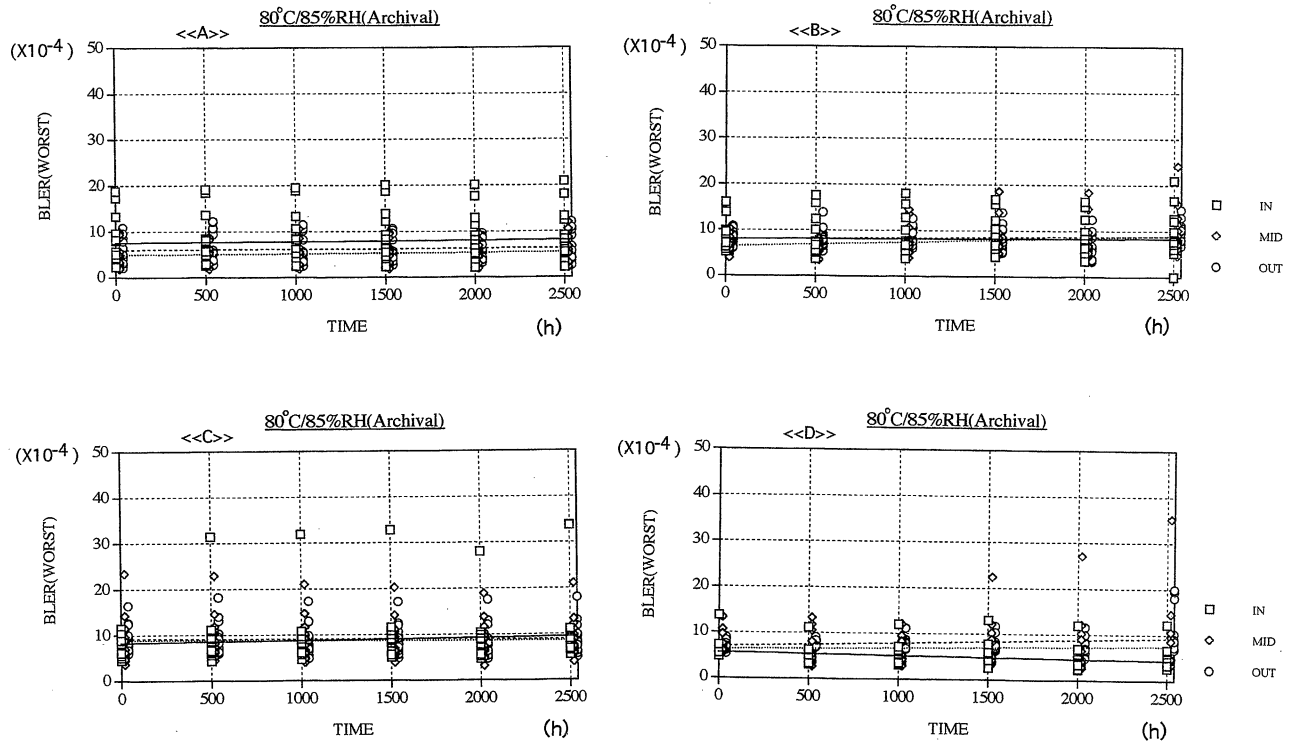

Fig. 2. Climatic condition cycle (temperature and humidity).

added to each measurement and this causes the shelf life to be shorter than archival life.

Figure 4 shows the frequency distribution curve obtained in the measuring areas by setting BLER on the vertical axis according to the above data. In order to avoid complications, we have shown only the three curves, at the start, 1,000 h later and 2,500 h later, in the figure. That the horizontal axis (BLER) is logarithm. This results in a curve which is close to the normal distribution and facilitates later statistic analysis.




(a)




(b)

Fig. 3. Change of BLER for 4 types of disc (a) Shelf life test (b) Archival life test.

## 4. Discussion

We continued hereafter our evaluation of the lifetime of Disk Type C, considerable degradation of which , as shown in Fig. 4, may be considered to be the worst case result.

As far as Fig. 3 is concerned, it is difficult to predict lifetime after 2,500 h. Therefore it is necessary to continue the experiment to determine the end of life.

However, in many experimental results for the magneto-optical disc, the equivalent activation energy is within the range of 0.8–1.0 eV.[6] For example, in the

Table I. Test conditions for lifetime measurement.

| | ISO/IEC data storage disk | MD disk (this experimnt) |
|---|---|---|
| ***Climatic accelerating conditions*** | | |
| •temperature | 2–3 points ((60), 70 and 80°C) | ← 70 and 80°C |
| •humidity | 80–95% relative humidity | ← 85%RH |
| •testing term (definition end of life) | Time until BERs degrade at life end normally 2,000–6,000 hours (end of life: BER $= 5 \times 10^{-4}$) | time until BLERs degrade at end of life (end of life: BER $= 3 \times 10^{-2}$) |
| ***Testing conditions*** | | |
| •drive for BER measurement | the specific drive | the specific tester |
| •pattern of recording data | including 3T pattern (minimum mark pitch in the 2–7 RLL code) | EFM random signal |
| •number of disks under test | 5 or 10 sides of disks | 5 sides of discs (each 4 Types) |
| •recording test area | 100 tracks on each of inner, middle and outer areas of the disks | each of COH (192) cluster (see below*) |
| •measurement operation | archival test and shelf test are simultaneously | ← (same as the left) |

*inner 040H–100H cluster: read/write (shelf)
140H–200H cluster: read (archival)
middle 340H–400H cluster: read (archival)
440H–500H cluster: write/read (shelf)
outer 640H–700H cluster: read (archival)
740H–800H cluster: write/read (shelf)

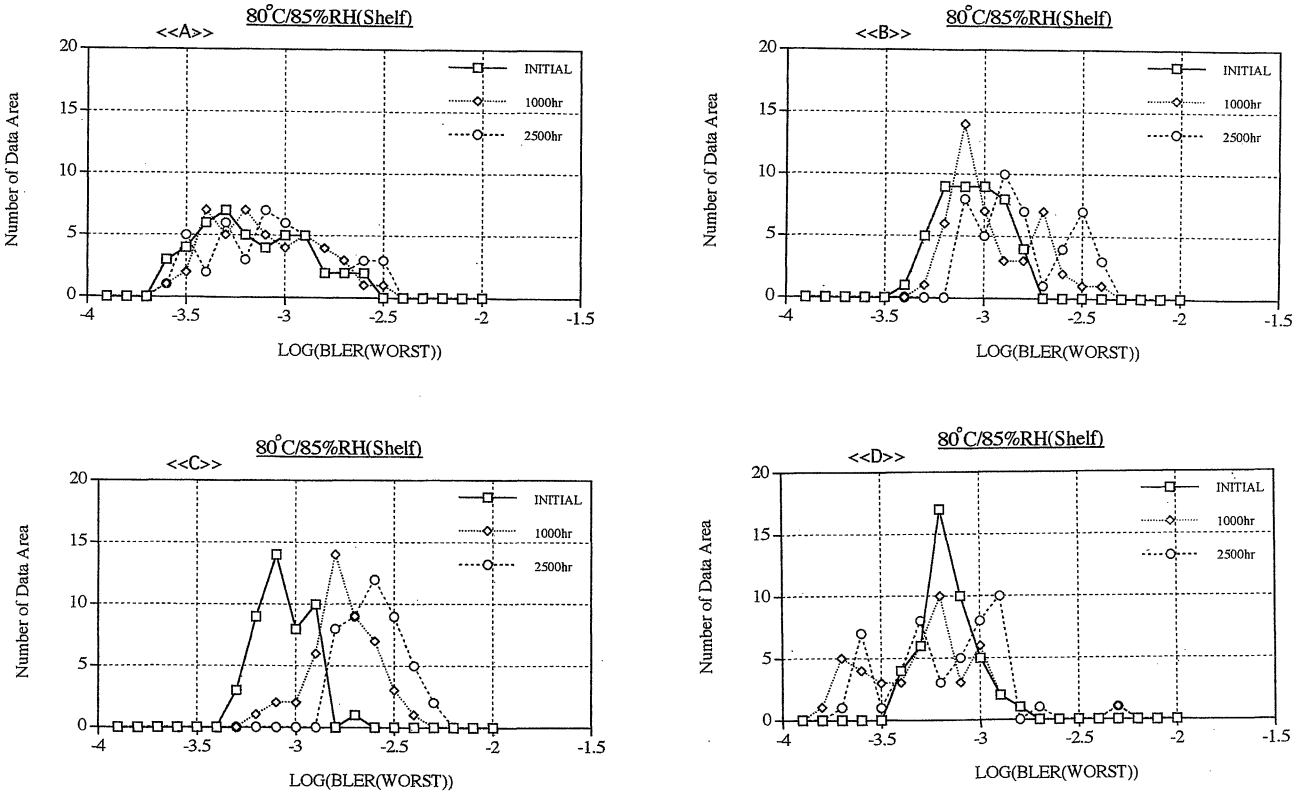



Fig. 4. BLER frequency distribution after holding under acceleration conditions.

test results for the 3.5-inch magneto-optical disk with its structure similar to that of MD media, it is approximately 1 eV.[7] Because life does not end at the point of 2,500 h, the Arrehnius plot for the MD media should be drawn in the zone above the broken line shown in Fig. 5, where the equivalent activation energy is assumed to be 1 eV. Therefore, we speculate that the lifetime of rewritable MD media has considerably longer than that of the data storage magneto-optical media. We consider, however, that this is largely due to differences in definition of lifetime and is not because reliability of the media has been improved.

Further more, the probability factor must be considered when determining the end of life. Here, we determined the standard deviation ($\sigma$) by approximating the frequency distribution curve shown in Fig. 4 to the normal distribution, defined the BLER accommodating frequency integrals within 99% as 99% survival limit and showed it on the time axis as in Fig. 6. Here, setting logarithmic vertical axis allows us to produce a good straight line. On the basis of extrapolation, the shelf life of Disk Type C should be less than approximately 7,000 h 80°C, as is plotted in Fig. 5.

From the above, we can speculate that lifetime of the recording layer of the rewritable MD media currently available in the market is sufficiently long. Reliability test method for the rewritable MD media should be further studied from the point of view of analysis of another major factors such as issues caused by contact with a magnetic head.

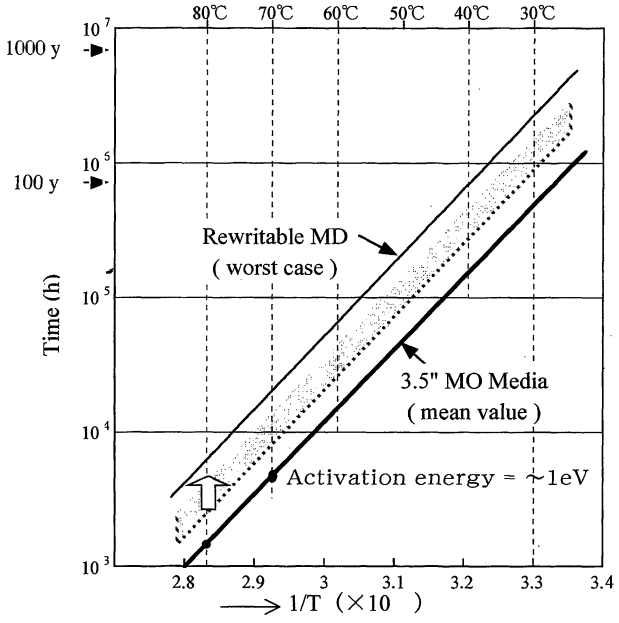



Fig. 5. Lifetime estimation by Arrhenius method.

## 5. Conclusion

We have measured the lifetime of the rewritable type MD applying the measuring method used for the data storage optical disk.

It is considered that life of the recording film of the rewritable MD media currently available in the market is extremely long. This is mainly attributable to specification of a MD system design regarding the life as consumer use.

The survival probability as survival limit should be introduced as a parameter for assuming the lifetime. We have proposed the method of determining the lifetime from the dispersion coefficient by approximating the error rate frequency distribution curve to the regular distribution.

For the media whose life is expected to be extremely long, we have proposed the method of determining lifetime in the acceleration environment on the linear extrapolation of the chemical reaction velocity assumed by the primary approximation.

The sliding magnetic head may cause problems in evaluating the general reliability of the rewritable MD media. Requirement for repeated recording and magnetic field modulation with a high output laser beam should be taken into consideration rather than lifetime of the recording layer.

## Acknowledgements

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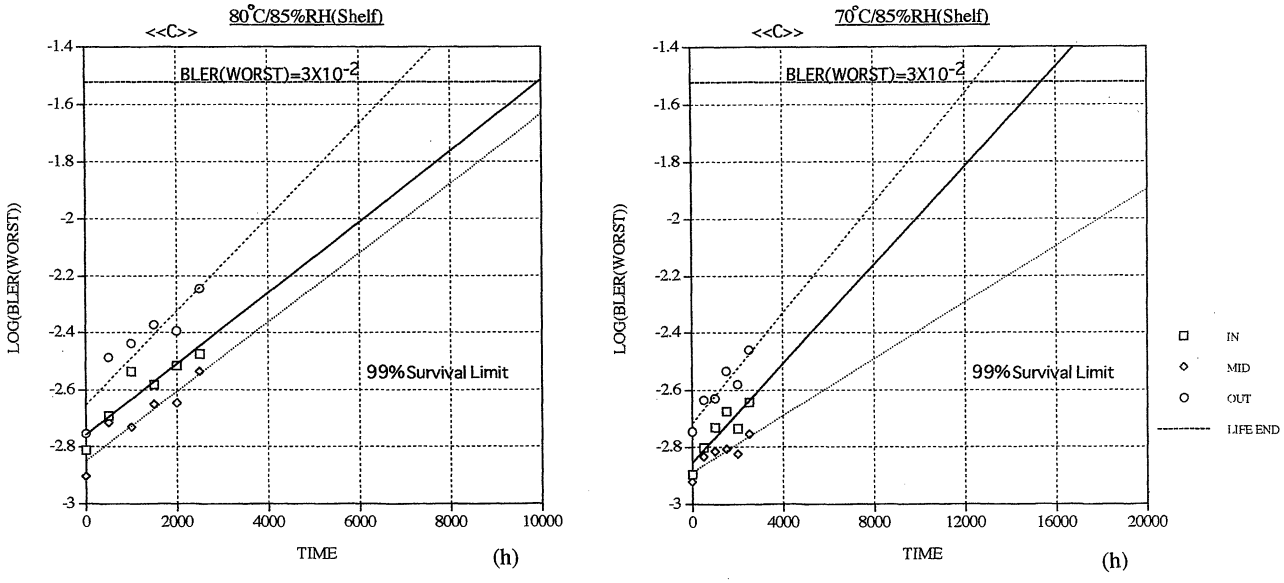


Fig. 6. Estimation of end of life.

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