# Safe Archiving Operation Using International Guidelines and High Capacity BD-R

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## Abstract

*Digital data is expanding amazingly throughout the world. Each organization, despite their size, or even individuals are facing issues of how to develop effective solutions to store the data safely by achieving both its method and data accessibility. Generally, the necessary factors to be considered for selecting a method and proper media are; capacity, authenticity, security, long-term storage stability, format obsolescence risk, accessibility, and the frequency and accuracy of data migration. Ideally, the solutions shall be recommended by international standards or alike that define safe operation of archiving starting from selecting the proper media to migration, which can give users great benefits.*

*This paper clarifies the suitability of optical disk formats for archiving, particularly of BD-R, and challenges the said issues by discussing the relation between the format and the safety standards that support long term storage.*

## 1. Introduction

In recent years, online information exchange has been established in daily life, and digital data such as animation, images, and text data has been increasing with the dissemination of digital equipment. More information, such as GPS and POS data, from various sensors and terminals has accumulated every day. According to a certain investigative agency, the volume of information is expected to increase dramatically from 130 exabytes in 2005 to 40,000 exabytes in 2020.

Such a large quantity of generated data creates new beneficial information by being temporarily stored and actively accessed for processing, handling, and editing. During this process, unnecessary data will be disposed of and necessary data will be stored for a long time (archived) in accordance with access frequency.

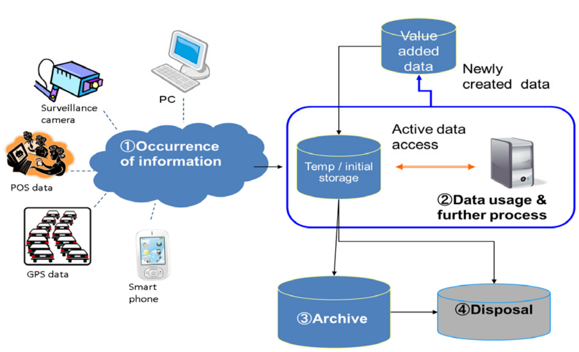


*Figure 1. Information life cycle.*

For archiving digital data, authenticity (non-writeable and non-deletable), confidentiality (function of access management), visual readability (function of displaying digital data), and retrievability (function of retrieving data) need to be secured in general.

In addition, cost efficiency, security, and disaster resistance are important elements for long-term storage of digital data. Table 1 compares optical disks, HDD, and magnetic tape LTO.

**Table 1. Comparison of data media.**

| | OPTICAL DISC | HDD | Magnetic Tape LTO6 |
|---|---|---|---|
| Capacity | BDR-DL: 50 GB<br>BDR-TL: 100 GB | 4 TB | 6.25 TB |
| Transfer Rate [MB/s] | 18 | 200 | 400 |
| Random Access [msec] | 200 | 10 | 8000 |
| Life Time [year] | 30 | 5 | 10 |
| Energy Consumption | Best | Poor | Better |
| Security | Best (Write Once) | Poor | Better |
| Disaster management | Best | Poor | Poor |

From the aspect of cost efficiency, it is desirable to control the migration frequency and complexity, as well as minimizing the consumption of energy such as electric power during the storage period using recordable media with a longer service life.

From the aspect of security, it is necessary to protect data by preventing data deletion through misoperation, tampering, and incursion by viruses or hackers.

From the aspect of disaster resistance, it is important to be able to easily read the digital data affected by a natural disaster.

Table 1 indicates that optical disks are a promising candidate for long-term storage of digital data. The details of the potential for optical disk technology to enable long-term storage of digital data are discussed below.

## 2. Validity of optical disks for long-term storage

It should be noted in advance that optical disks meet all the basic requirements for digital data storage, namely authenticity, confidentiality, visual readability, and retrievability.

(1) Cost efficiency

Every recordable medium deteriorates with age and requires refresh migration to transfer the data to a new recordable medium in order to store digital data for a long time.

■ Migration frequency and life of storage media

Figures 2 and 3 compare the relationship between the service life and cost efficiency of recordable media in the case of storing data generated every year and disposing of the data 10 years later for digital data with a storage period required by law.

For example, recordable media with a service life of three years, as shown in Figure 2, requires three migrations for 10 years of storage. This type of media requires migration in the fourth year and data storage operation that includes the data generated during that year. From the seventh year onward, the second migration for the first-year data and the first migration for the fourth-year data will be required as well as data storage operation for three years required every year.

Recordable media with a service life of 10 years, as shown in Figure 3, dispenses with migration until data disposal after ten years, and the data storage operation is completed with one-year data storage every year. Thus recordable media with a service life of 10 years is significantly advantageous in terms of operation costs and complexity.

It has been shown that data storage using recordable media with a longer service life is economical in terms of preparation of new recordable media required for migration and operation for data storage alone.

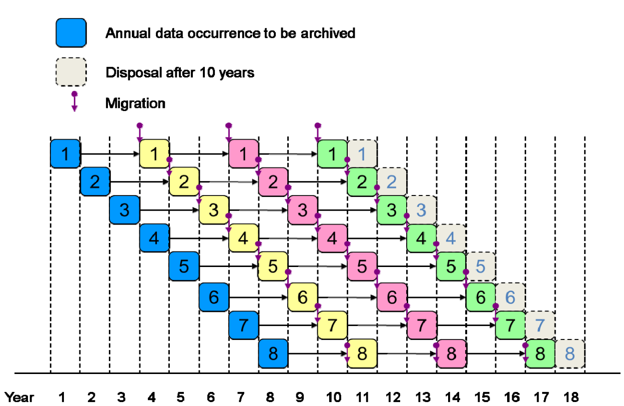


*Figure 2. Data storage using recordable media with longevity of three years.*

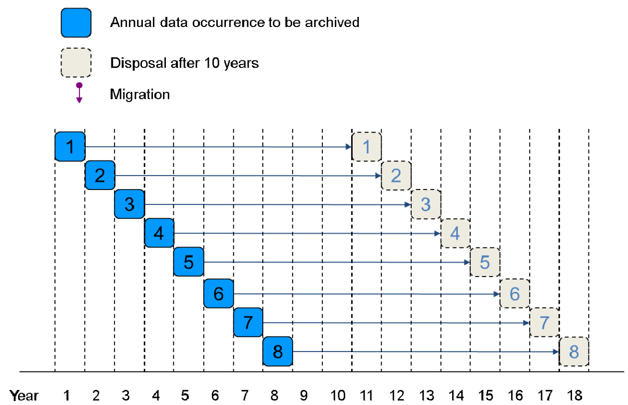


*Figure 3. Data storage using recordable media with longevity of 10 years.*

■ Estimated service life of optical disks

As discussed above, as the volume of digital data increases remarkably, complexity in migration will increase. The roles played by optical disks in such circumstances are discussed below.

For the service life of optical disks, test methods for DVDs and CDs are defined by international life test standards ISO/IEC10995 and ISO/IEC16963. Test methods for BDs are also expected to be standardized within this year.

**Table 2. International standard life test methods for optical disks**

| Format | DVD-R, DVD+R<br>DVD-RW, DVD+RW | BD Recordable disk<br>BD Rewritable disk |
|---|---|---|
| Standard | ISO/IEC 10995:2011<br>ISO/IEC 16963:2011 | To be published |

Failure in optical disks is defined as "a lack of digital data recoverability from playback signals; a time point where a certain level of error rate is generated during long-time storage under general storage conditions due to a physical factor generated from aged deterioration of the features of the recording film and so on" and the physical factor is considered to follow the reaction kinetics of chemical changes. In this case, a life estimation test can be performed with accelerated temperature and humidity stresses. ISO/IEC10995 estimates the service life as a 95% confidence interval lower limit obtained from the simplified Eyring equation in storage conditions with an ambient air temperature of 25℃ and a relative humidity of 50% with a probability of survival of 95%.

The service life under specific storage conditions (temperature 25℃, relative humidity 50%) can be estimated from the simplified Eyring equation (1) with logarithmic mean values of down time for each specimen obtained by giving the temperature and humidity stresses to the specimens under the conditions as shown in Table 3.

The simplified Eyring equation is expressed as follows:

$$Ln(t) = \ln(A) + \Delta H / kT + B \times RH \quad (1)$$

t: kinetic constant; A: pre-exponential factor; ⊿H: activation energy; k: Boltzmann's constant; T: absolute temperature; B: exponent constant for relative humidity; RH: relative humidity

**Table 3. Temperature/humidity stress conditions in ISO/IEC10995**

| Test Number | Test Stress Condition | | Number of Specimens | Incubation Curation | Time Completed |
|---|---|---|---|---|---|
| | Temp ℃ | %RH | | Hours | Hours |
| 1 | 85 | 85 | 20 | 100-250 | 650 |
| 2 | 85 | 70 | 20 | 100-250 | 1150 |
| 3 | 65 | 85 | 30 | 100-250 | 2100 |
| 4 | 70 | 75 | 20 | 100-250 | 2500 |

Use of an optical disk with an estimated service life of 30 years or longer as per the international standard life test is significantly economical and advantageous, especially for storage of data with lower access frequency, and can be said to be highly effective for efficiency pursuit by simplification of migration, as shown in figure 3.

■ Storage environment

Recommended storage conditions are a temperature of 5℃ to 30℃ and a relative humidity of 15% to 80%, and thus no special conditions are required. Recommended long-term storage conditions are a temperature of 5℃ to 30℃ and a relative humidity of 15% to 80%, and an optimum storage facility with consideration given to security and disasters as discussed below is desired.

(2) Security

A write-once optical disk does not allow tampering by data rewriting and hence ensures authenticity, whereas unnecessary data needs to be completely disposed of for deletion. Incomplete data disposal may cause information leakage and thus poses a high risk. Optical disks can be considered highly secure media in that the data contained in them can be completely disposed of by destroying them physically with a shredder.

For the risk of data loss from smuggling, information leakage can be prevented by storing the optical disks in a safe place. Offline storage is highly secure partly because it serves to prevent viral infection and illegal computer access by a malicious third party network.

(3) Disaster resistance

Since data loss from a natural disaster is mostly caused by water invasion to recording media, ease of data recovery is required. Optical disks become readable by being washed and dried.

While playback equipment may be disabled by water invasion because it is an electronic device, the data is readable from the optical disk after water invasion using normal playback equipment. However, in the case that an electronic device and the recordable medium are integrated into one, as in HDDs, data recovery is difficult and the data may not be readable. Thus, optical disks can be considered highly disaster-resistant recordable media because they are independent of the electronic playback equipment.

## 3. Operation of long-term storage using optical disks

The international standard for data migration, ISO/IEC29121:2009, defines the operation of long-term preservation methods for DVD optical disks. The international standard also describes guidelines for initial characterization and periodical characterization required for long-term storage. The JIS Z6017 standard was revised with BDs added. The international standard ISO/IEC29121:2009 is also expected to add BDs in the near future

(1) Preparation of a data storage disk

A data storage disk is prepared by recording data into a managed optical medium using a managed drive. While a disk managed for appropriate long-term storage will reduce the risk of aged deterioration, the error rate itself also depends on the compatibility with the writing drive and the drive’s condition. Accordingly, in order to minimize the two risks, both the medium and the drive to be used need to be managed for long-term storage. Later, the recording status should be verified using a playback inspection drive. The recording status is classified into Level 1—Acceptable Status and Level 2—Status Requiring Measures as shown in Table 4. In the case of Status Requiring Measures, a data storage disk should be prepared by repeating recording of the data onto a new medium until a storage disk in Level 1—Acceptable Status is completed.

**Table 4.Initial Quality Standard.**

| Condition of disk | | BD Recordable disk<br>BD Rewritable disk |
|---|---|---|
| Level | | < Error rate status ><br>RSER<br>Burst error |
| 1 | Good | Lower than $3.5\times10^{-4}$<br>and<br>Lower than 800 byte |
| 2 | To be migrated / refreshed | Higher than $3.5\times10^{-4}$<br>and ／or<br>Higher than 800 byte |
| Standard | | ISO/IEC : to be published<br>JIS Z 6017 : existing |

(2) Periodic quality inspection

A periodic quality inspection should be conducted to verify the recording status with a storage period of five years as a guideline. The recording status verified by the periodic quality inspection is classified into Level 1—Acceptable Status, Level 2—

Status Requiring Measures within One Year, Level 3—Status Requiring Measures Immediately as shown in Table 5.

At status Level 2 and Level 3, the disk will be cleaned and then a new disk will be created in accordance with the "preparation of a data storage disk" procedure above. A new storage disk needs to be created within one year at Level 2 status, while a new storage disk needs to be created immediately at Level 3 status. After re-creation of the storage disk, quality inspection is repeated to verify the recording status, with a storage period of five years as a guideline until the storage time is completed.

**Table 5. Periodic quality inspection standard**

| Level | Condition of disk | BD Recordable disk<br>BD Rewritable disk<br>< Error rate status ><br>RSER<br>Burst error |
|---|---|---|
| 1 | Good | Lower than $5.0\times10^{-4}$<br>and<br>Lower than 1,200 byte |
| 2 | To be migrated / refreshed in a year | Higher than $5.0\times10^{-4}$ /<br>Lower than $1.0\times10^{-3}$<br>and ／or<br>Higher than 1,200 byte /<br>Lower than 1,900 byte |
| 3 | To be migrated / refreshed immediately | Higher than $1.0\times10^{-3}$<br>and ／or<br>Higher than 1,900 byte |
| | Standard | ISO/IEC : to be published<br>JIS Z 6017 : existing |

Figure 4 shows a flow series from preparation of a long-term storage disk to the periodic quality inspection and finally to disposal after completion of the storage period. Data for which no storage period is defined will be stored with periodic quality inspection repeated every five years as a guideline.

## 4. Proposal for use of optical disks according to data amount, application, and scale

The operation of long-term storage of digital data discussed so far is classified into small-scale archiving and medium- to large-scale archiving according to the amount of data to be stored.

For small-scale archiving, we propose that several storage disks be prepared year by year for documents with no legally required storage period. Except for long-term storage periods, storage periods are mostly defined as approximately 30 years, with others defined as 10 years, 7 years, 3 years, and 1 year.

Figure 5 shows a proposal for small-scale archiving. In this proposal, a data storage disk is prepared using a managed optical drive and will be stored for every storage period. Data can be stored without migration until the storage period is completed. This can be done by using an optical disk with a service life of 30 years or more proven by a life test pursuant to the international standard and by conducting a periodic quality inspection every five years as a guideline.

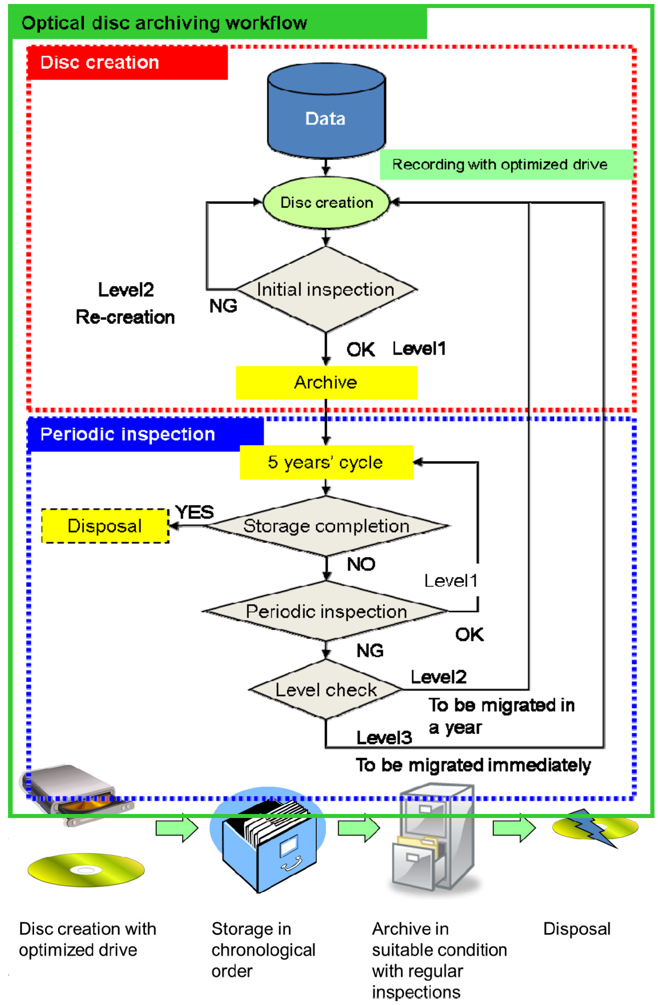


*Figure 5. Proposal for small-scale type archiving*

In the proposal for medium- to large-scale archiving, a storage disk for a data center device with several optical disks mounted needs to be prepared automatically as the data amount is larger than small-scale archiving. It is efficient to conduct periodic quality inspections automatically as well as store the data automatically in a cartridge.

Figure 6 shows a proposal for medium- to large-scale archiving. As discussed so far, for the storage site, it is desirable to store the data offline by disconnecting the storage media from the network and to store the data in a place with security management against outside intrusion.

In addition to the previous proposals for archiving according to the amount of data, consideration should also be given to the risk of data loss from formatting long-term data storage.

For example, in the case of an LTO, while compatibility in playback is ensured between LTOs with a gap of two generations, the generation advances approximately every three years, and the data will not be compatible for playback over four generations, as a simple calculation. Migration will be required by 12 years later.

The service life of LTOs is considered to be approximately 10 years, including the risk of data loss from formatting.

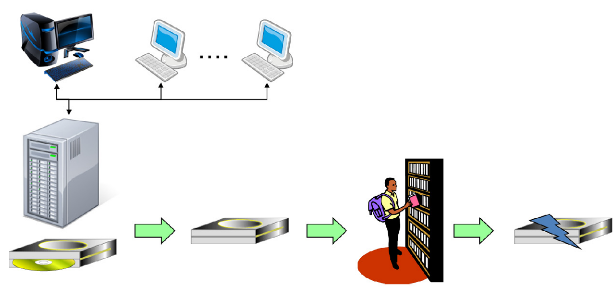


*Figure 6. Proposal for medium- to large-scale archiving.*

Optical disk playback equipment, which can playback CDs, DVDs, and BDs, has disseminated worldwide and advanced quite far, with compatibility in playback ensured. One of the major SNS started looking into the possibility of BD-R library system. The long service life of optical disks contributes to reducing the risk of data loss from formatting.

The increase in storage capacity of optical disks is left for further study, but it is expected to enable long-term data storage for 30 years or longer without migration with playback compatibility maintained.

## 5. Conclusion

This paper outlined that optical disks have the potential for cost efficiency, security, and disaster resistance. These are factors required for long-term storage, as well as storage factors for digital data, namely authenticity, confidentiality, visual readability, and retrievability. In terms of the operational aspect of long-term storage, international standards and quality criteria have already been established for DVDs, and BDs are also expected to be standardized.

Searchable digital data will become intellectual property that produces new value. We propose the use of optical disks to aid in the cold storage of digital data, which is expected to increase in volume more and more in the future, as well as cross-media storage and long-term storage of highly confidential data.

## References

[1] JIS for "Document Management—Long-Term Preservation for Electronic Imaging Documents" was revised (JIS Z 6017). Ministry of Economy, Trade and Industry, September 20, 2013.
[2] Japan Image and Information Management Association (JIIMA), "Blu-Ray DiscTM Inspection Standard for Long-Term Storage of Digital Documents and Handling Guidelines."
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## Author Biography

*Masatoshi "Max" Inui is President for JVC Advanced Media USA and Europe. He has been focusing on optical media business particularly for professional storage market in Europe and America for over 10 years.*