



Iomega's Removable Rigid Disk Technology Delivers Estimated 30-Year Shelf Life for Reliable Backups and Archiving

***Design features and accelerated
testing are keys to 30-year shelf
life specification***

- Introduction**
- Designed for 30-Year Shelf Life**
- Technology Improvements**
- The Seal of Approval**
- Material Selection**
- Testing and Evaluation**
- Conclusion**
- Appendix**



Introduction

Iomega's revolutionary Removable Rigid Disk (RRD) technology provides the speed, reliability, and ease-of-use of a hard drive with the portability and expandability of tape and optical media. While based on standard hard drive components, the removable Iomega RRD disk contains only the magnetic media and spindle hub and motor for greater durability – all the sensitive drive heads and electronics remain in the drive itself. Both the drive and disks are sealed by a unique shutter mechanism designed to keep the heads and media in a virtual “clean room” environment. Advanced air filtration, automatic head cleaning, and robust two-stage error correction are employed to ensure high data integrity and reliability.

The Iomega® REV™ 35GB/90GB* drive system is the first of the company's RRD-based family of products. With its high speed, capacity, and removable media, the Iomega REV products are the ideal solution for desktop and server-level backup as well as high-capacity, portable storage applications.

This paper provides valuable insights into the fundamental design elements that are incorporated in RRD disk technology. It also details why this new storage solution is ideal for data-intensive applications that require extended storage life.

Designed For 30-Year Shelf Life

Iomega especially designed RRD technology to ensure long shelf life by identifying the likely causes of long-term media degradation and engineering the product to minimize their specific effects. Table 1 details five probable factors of long-term media degradation.

Table 1
Five probable factors of long-term media degradation

Factor	Description
1. Thermal stability and self-demagnetization	Long-standing concerns for most hard disk drives are thermal stability and self-demagnetization. As areal densities increase, concerns arise about the super-paramagnetic effect. A condition that occurs when the magnetic bit cells become so minute that it is possible for the magnetic cell to flip, the result is a loss of the information stored on the disk. This condition becomes increasingly prominent as temperatures rise.

* Compressed capacity assuming 2.6:1 data compression with “high” compression on Iomega Automatic Backup Pro software. Capacity may vary and is data and software dependent.

Factor	Description
2. Corrosion of the media, motor parts or connector	The most severe corrosion concern involves the media, because it could result in data loss. Media corrosion may lead to areas of the disk developing corrosive sites, which could result in data loss at that particular location. Corrosion of the motor parts may cause improper disk rotation or higher mechanical run-outs. In addition, corrosion at the motor connector might not allow for sufficient electrical conductivity to power the motor.
3. Particulate infiltration or contamination	Particulate infiltration can result in airborne contamination that either settles or otherwise deposits itself on the disk surface. This phenomenon could either create a site for possible corrosion or be a site for data loss due to excessive head-to-disk spacing when the disk is spinning and the head is "flying" over the particulate on the disk. If it is deposited on the inside of the cartridge or elsewhere, the possibility exists that the corrosion could be transferred to the disk during operation or handling.
4. Out-gassing	Out-gassing usually refers to release of detrimental vapor from the cartridge's internal parts or hard case over time, as well as the infiltration of detrimental external gasses. Out-gassing may cause deposition of detrimental films upon the disk. This film may subsequently lead to either a spacing loss or chemical reaction that may result in data loss.
5. Adhesive breakdown	Some components, such as the filter and desiccant inside each disk, are mounted with adhesives. There is a possibility that the adhesive might break down because of time, temperature or humidity, which could permit the filter and/or desiccant to loosen. In turn, this could cause rubbing or contact with the disk, which could generate sites of non-recoverable data.

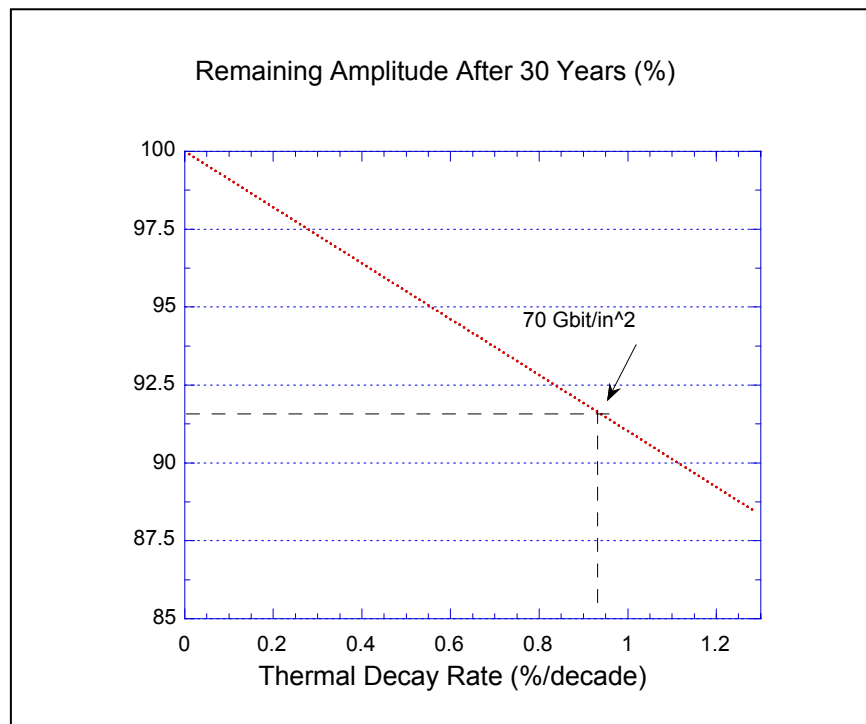
Utilizing the latest magnetic disk media technology, innovative engineering of the disk seal and air filtration mechanisms, and careful selection of case materials and adhesives, Iomega's RRD technology provides an effective solution to the common concerns regarding long-term storage of digital media.

Technology Improvements For Extended Thermal and Magnetic Stability

Iomega's RRD technology uses the latest, standard, off-the-shelf hard disk media. Methods for improving the thermal stability of media in high-capacity hard disk drives (HDDs) are well-known. When applied appropriately, they permit HDDs to enjoy continual capacity increases while maintaining or improving reliability. Iomega partners with industry-pioneering magnetic media suppliers that design and manufacture disk media with characteristics for minimal signal degradation, while maintaining exceptional areal density and an impressively low rate of thermal decay (the percent loss of amplitude per decade).

Analysis of data reveals that the thermal decay rates should be less than one percent per decade, which suggests signal loss of less than nine percent after 30 years (refer to Figure 1). This low thermal decay rate was observed in a detrimental thermal environment of 70 degrees Celsius or 158 degrees Fahrenheit. Thus, disk storage at temperatures more typical to real-life conditions, such as room temperature, should not cause any significant degradation of signal loss due to thermal instability.

Figure 1
30-year Amplitude vs. Thermal Decay Rate (70°C)



The susceptibility of the REV cartridge to stray external magnetic fields is also low. The REV product uses high coercivity (4500 gauss), high density, hard disk drive, magnetic film media. The use of higher

coercivity media means higher magnetic fields are required to reverse or degrade the recorded information. The stability of the recorded information is therefore high.

The Seal of Approval – Protection from Corrosion & External Contamination

Most of the remaining areas of concern, including corrosion, particulate infiltration and out-gassing, can be successfully mitigated by ensuring high-quality sealing of all RRD disk cartridges and drives.

Iomega's RRD cartridges employ a labyrinth-type seal design, which features multiple seals for a very effective barrier to outside contaminants. The sealing mechanism of the RRD disk is specifically designed so moisture and other contaminants are blocked from entering the cartridge, resulting in high resistance to corrosion and guarding against the potentially adverse effects of airborne particulate and infiltration of detrimental external gasses.

Because no seal is perfect, RRD incorporates a charcoal desiccant inside each cartridge to provide additional protection from moisture, corrosion and out-gassing. The disk design also includes a robust recirculation filter on each cartridge to filter the air inside the cartridge each time the disk spins, effectively removing any airborne contaminants that make it past the cartridge seal.

Material Selection for Component Stability

The issue of out-gassing from internal cartridge parts is addressed by careful selection of the cartridge material and superior cartridge design.

To prevent issues of adhesive breakdown, Iomega also sets its RRD cartridges apart by using only high-quality, HDD-approved adhesive for the desiccant and filter. This adhesive exhibits excellent adhesion even to difficult substrates and is the same product used in HDD manufacturing, including use on liquid crystal polymer plastics. In addition, the adhesive is rated for continuous 80 degrees Celsius conditions.

Testing and Evaluation

An accelerated testing methodology is required to complete 30-plus years of RRD cartridge shelf life testing. Accelerated testing requires that some assumptions be made to determine whether the test design is adequate.

Appendix A below defines the acceleration factor assumptions for corrosion and adhesive adherence. The results include a temperature acceleration factor of 32 and humidity acceleration factor of about 20. This means a successful test of two to three weeks at such an accelerated state (80 degrees Celsius with a relative humidity of 80 percent) parallels a 30-year shelf life in typical real-life media storage conditions. The testing environment is non-condensing.

Tests on the RRD cartridges have been conducted at this elevated temperature and relative humidity for more than 17 days at an elevation of about 4,500 feet, indicative of 33.6 years under the noted assumptions. The results revealed neither significant change in data reliability or evidence of disk corrosion (after automated, microscopic, total surface scans of the disk).

Conclusion

Based on conclusions drawn from extensive testing, product pedigree, improved implementation, new design considerations and insistence on using only top-quality components, Iomega believes that its new RRD disk technology should offer a reliable shelf life of at least 30 years. With Iomega's REV disks and drives, users can be confident that their valuable data will be there when they need it, even if it is years or decades later.

#

This information is to be considered preliminary and subject to change. Please be aware that Iomega makes no commitment to update or revise this document in the future, and does not imply any representation, guarantee, or warranty by this document. This document does not create any contractual rights.

Appendix A – Development of Accelerated Testing Factors

Assume no interaction between the relative humidity (R.H.) and temperature; that is, each term is an accelerating factor in its own right[†].

Also assume that the accelerating factor for temperature is a factor of 2 for each increase of 10°C[‡].

Also assume that the R.H. accelerating effect is only proportional to the ratios of specific humidities. Specific humidity is the ratio of mass of moisture per mass of dry air, also known as the humidity ratio (H.R.). So this accelerating factor is simply the ratio of the mass of moisture during test to the mass of moisture during storage[§].

Assume a realistic media storage environment is 30°C (86°F) and 85 percent R.H.** , and the test storage environment is 80°C (176°F) and 80 percent R.H over a weeklong period. Under these conditions, the temperature accelerating factor (TAF) of the test environment is 32, and is calculated as follows:

$$TAF = 2^{\left(\frac{80^{\circ}C - 30^{\circ}C}{10^{\circ}C}\right)} = 32 .$$

The humidity ratio at the realistic media storage environment (30°C and 85 percent R.H.) is calculated from the following formula, where B is the barometric pressure, pv is the vapor pressure at the temperature, and RH is the relative humidity:

$$\begin{aligned} HR_{30} &= \frac{pv_{30}}{1.608 \cdot (B - pv_{30})} \cdot RH = \left(\frac{0.61518 \cdot psi}{1.608 \cdot (14.6960 \cdot psi - 0.61518 \cdot psi)} \right) \cdot 0.85 \\ &= 0.023094 \text{ at sea level} \\ & (= 0.028022 \text{ at 5000 feet}) . \end{aligned}$$

And for the test environment (80°C and 80 percent R.H.),

$$\begin{aligned} HR_{80} &= \frac{pv_{80}}{1.608 \cdot (B - pv_{80})} \cdot RH = \left(\frac{6.8690 \cdot psi}{1.608 \cdot (14.696 \cdot psi - 6.8690 \cdot psi)} \right) \cdot 0.80 \\ &= 0.436618 \text{ at sea level} \\ & (= 0.638649 \text{ at 5000 feet}) . \end{aligned}$$

The moisture accelerating factors (MAF) at sea level and at 5,000 feet above sea level are calculated as:

[†] A conservative assumption as H₂O is usually more reactive at higher temperatures.

[‡] Familiar rule-of-thumb for chemical reactions ([Engineering Design Handbook: Design for Reliability](#))

[§] Twice as much moisture allows for double the reaction.

** A conservative assumption as this appears to be on the high-end of real-life media storage environments.

$$MAF = \frac{HR_{80}}{HR_{30}} = \frac{0.436618}{0.023094} = 18.906123 \text{ at sea level}$$

$$\left(= \frac{0.638649}{0.028022} = 22.790986 \text{ at 5000 feet} \right) .$$

Thus, one week of exposure under accelerated testing conditions (80°C and 80 percent R.H.) is calculated to be equivalent to a storage period under realistic conditions (30°C and 85 percent R.H) of 11.6 years at sea level or 14.03 years at 5,000 feet:

$$1 \text{ week test period}_{(80^{\circ}\text{C}, 80\% \text{ R.H.})} \cdot TAF \cdot MAF \cdot (1 \text{ year} / 52 \text{ weeks})$$

$$= 1 \times 32 \times 18.906123 \div 52 = 11.6 \text{ test years}_{(30^{\circ}\text{C}, 85\% \text{ R.H.})} \text{ at sea level}$$

$$(= 1 \times 32 \times 22.790986 \div 52 = 14.03 \text{ test years}_{(30^{\circ}\text{C}, 85\% \text{ R.H.})} \text{ at 5000 feet}) .$$