Technical White Paper

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iomega

Drop Resiliency of the Removable Iomega® REV™ Disk

Test Results Show the Iomega REV Cartridge Design Can Survive Repeated 48-inch Drops

iomega REV™

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 explores the resiliency of the Iomega removable rigid disk (RRD) cartridge when dropped onto a hard surface. Included in this paper are areas of interest regarding potential damage for dropped cartridges, design considerations to guard against associated damage and information on actual drop testing of REV disks. Through both innovative engineering design and rigorous testing, Iomega has gone to great lengths to ensure that its REV disks meet or exceed expectations for disk resiliency within a normal usage environment.

Areas of Interest

The most important issue in cartridge drops typically is whether the cartridge still works after having been dropped. In other words, does the cartridge still insert and eject from the drive and can the information on the cartridge be retrieved?

The following are typical areas of interest regarding cartridge drops (listed in order of importance):

1. Disk slip (the mechanical shock of the drop causing the media to slip with respect to the motor hub);
2. Media damage;
3. Motor or bearing damage;
4. Damage to the cartridge shutter, shutter opening mechanism or cartridge sealing;
5. Damage to the cartridge shells or motor base-plate;
6. Pick up of contamination on the outside of the cartridge.

* 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.

Each area mentioned is explained in more detail below.

Disk Slip

Disk slip is the shifting of the centerline of the circular servo tracks (the information that the heads use to stay centered on a particular track of information) with respect to the motor rotational center-line. Normally, there is a slight clearance between the center hole of the media and the motor hub. This clearance is needed to allow assembly of the media onto the motor hub. Dropping a cartridge can cause a large enough mechanical shock in the media plane to cause the disk to overcome the preload that keeps the disk centered. This situation might cause the disk to shift and spin, causing a spinning eccentricity to the tracks to occur.

Among other things, this eccentricity causes a disturbance to the track-following servo. This disturbance is something the servo system must deal with in order for the heads to stay sufficiently centered on a given track of information. If a head is not sufficiently centered, the possibility increases that information might not be retrievable. The amount of slip depends on several factors: the initial clearance between the media hole and motor hub; the level and direction of the mechanical shock; the preload that holds the disk centered; and the mass of the disk. Since a cartridge drop can result in various orientations for the impact, a drop can result in mechanical shock in several different directions, not solely in the plane of the media. Therefore, not all drops result in disk slip.

Media Damage

Media damage results from the surface of the disk coming in contact with the inside of the cartridge during the drop with sufficient pressure to permanently mark or otherwise damage the disk. A permanent media defect might result in data loss at that location on the disk. The most likely scenario is the convex-shaped bending of the disk in the axis that is perpendicular to the plane of the disk resulting from an impact in that orientation. Due to the various orientations of the impact on a drop, not all drops result in media damage.

Motor or Bearing Damage

In a RRD system, the motor and spindle bearing are in the cartridge. If the mechanical impact of a drop results in motor or spindle bearing damage, the disk might not spin correctly. The results could include higher mechanical run-outs with subsequent additional servo disturbance, or damage to the motor that would cause erratic or no rotation. Furthermore, high damage levels may jeopardize information retrieval. Once again, there would be specific orientations for the impact in order to cause damage. Therefore, not all drops result in motor or bearing damage.

Shutter Damage

Damage to the cartridge shutter, and its related opening mechanisms in the cartridge, could prevent the cartridge from being inserted into the drive, or might further damage some aspect of the drive's shutter opening mechanism. Such damage might also prevent the cartridge shutter seal from adhering to the front of the cartridge, allowing an air path and airborne particulate to migrate into the media area of the cartridge. This particulate could settle or otherwise deposit itself on the surface of the disk, thereby causing a non-recoverable data error or head performance degradation when the head passes over the debris.

External Damage

Damage to the cartridge shell or motor base-plate is considered not as serious as the previously mentioned items. Permanent deformation of the plastic cartridge shell or motor base-plate would have to be large enough to prevent insertion or removal of the cartridge for these parts to fail as a barrier to airborne particulate infiltration. Mechanical position mis-registration is also a possibility, which could result in less than optimal performance and data reliability. The deformation of the base-plate would have to be large in key areas to cause serious concerns with cartridge mechanical position registration.

Contamination

After a drop of a cartridge to the floor or other dirty environment, debris or particulate contamination could accumulate on its exterior. This debris might be transmitted into the drive during a subsequent insertion, thus increasing the potential for debris to migrate into the media area. This, in turn, could result in non-recoverable data errors or head performance degradation when the head passes over the debris.

Removable Rigid Disk Cartridge Implementation

Successfully designing a RRD cartridge to withstand drops requires addressing these significant areas of concern. The following explanation summarizes different methods for eliminating or mitigating problems through careful RRD technology design.

Disk slip has been addressed through close attention to the preload and mechanical clearances of the media to the motor hub. Using a single, 2.5-inch disk rather than dual platters or a larger diameter lowers the mass of the media on the motor hub, which results in less potential for disk slip. Additionally, the plastic shell of the cartridge is designed to permit some elastic/plastic deformation, which reduces the magnitude of the mechanical shock that the disk/hub might otherwise experience from a drop.

Media damage is addressed by keeping areas that have the potential to contact the disk surface sufficiently removed from the disk surface. Likewise, sharp edges or corners that concentrate stress forces on the disk surface have been rounded to minimize their effect. Due to the convex bending shape of the disk on impacts, the most likely area of contact on the disk surface is the media's edge. Iomega has designed the heads so they engage or disengage sufficiently away from the edge of the disk, so the risk is lowered in this regard as well.

Motor or bearing damage is addressed by using a typical 2.5-inch hard disk drive (HDD) motor and spindle bearing. These HDDs are designed for portable computer applications so they have been developed with an extra degree of resiliency. As a result, RRD drives and 2.5-inch HDDs use fluid dynamic bearings (FDBs), which reduce the potential for bearing damage. Ball bearing-type spindle bearings have relatively higher contact stresses at the ball-to-race interface (than is present with a FDB), which results in reduced device resiliency.

For Iomega, shutter damage was a special area of design focus. Several design iterations were initiated that led to tremendous improvements in shutter resiliency. Modifications, such as a gusset-like indent in the bent corner of the shutter and capturing the end of the shutter pivot, have sufficiently addressed this important area. Repeated testing has verified the effectiveness of these modifications.

Shell or base-plate damage is addressed by using materials that are resistant to brittleness or impact damage. In addition, the plastic shell extends beyond the base-plate so in the event of a drop, the shells are the predominant contact surface with the floor.

Debris pick-up is addressed by the sealing mechanism implemented between the drive and cartridge upon insertion. The front face of the cartridge underneath the shutter mates with a seal in the drive, thereby creating a chamber from the clean area of the drive to the clean area inside the cartridge. Debris on the exterior of the shells should remain outside this chamber. Any debris that enters the chamber, either through leaks or as the shutter is opened, should be purged by two re-circulation filters inside the cartridge as the disk spins.

Testing and Evaluation

The evaluation of cartridge resiliency generally involves some level of testing. Since a typical cartridge drop would occur from a desk onto the floor, and as most desktops are 30 inches or so above the floor, Iomega chose this height as a starting point for testing purposes. An industrial carpet was chosen for the contact surface since it is prevalent in offices and also represents a surface that is reasonably contaminated with debris. A successful test of 30-inch drops onto industrial carpeting is used as an indication of the survivability of a REV disk in a drop situation.

Actual testing was conducted not only at the 30-inch drop level (using a REV cartridge without its storage case) onto industrial carpet, but also at 48-inch and 24-inch heights. Sixty cartridges were tested, dropping each cartridge three times, with at least one drop attempted onto the shutter. The cartridges were characterized both prior to, and after, the series of drops. A successful result was characterized as showing neither significant change in data reliability or evidence of damage to the motor, bearing, shutter, shells or base plate, and insertion and ejection of the cartridges from the drive without problem. Successful results were obtained at all three drop heights.

In a few rare cases, some damage was noted to the shutter for "square-on" drops on to a particular shutter corner. However, based on over 100 drop tests, the chances of a square-on drop were roughly determined to occur about one out of every hundred drops.

Conclusion

Testing of the REV design reinforces the conclusion that the cartridge is capable of surviving repeated 48-inch drops onto a carpeted surface. It is suggested, however, that the storage case be used whenever transporting or storing the cartridge. This should provide another level of protection against damage or contamination in the event that a cartridge inadvertently drops. Iomega believes that the REV drive exceeds most resiliency expectations and can withstand most drops without affecting the disks adversely.

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