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Technology**Paper**

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G-Force Protection

Introduction

As the world's largest manufacturer of disc drives, Seagate® is committed to providing best-in-class products by focusing on high-performance and reliability. Because reliability is of high concern to our customers, Seagate has always taken steps to ensure that our high-performance disc drives can withstand bumping or dropping during nonoperational shock events such as transportation or installation. Many components in the drive can be affected by nonoperational shock, including the spindle motor, heads, head arms and discs. Seagate has always taken a system approach to nonoperational shock by carefully designing all of these components to withstand shock events. As a company that strives for continuous improvement, Seagate has once again pushed the technology to improve the nonoperational shock specifications on its newest products. Seagate's high-performance Barracuda® 18LP/36/50 and Cheetah® 18LP/36 disc drives use advanced technology to provide customers with the most reliable product on the market today. This technology, called G-force protection (GFP), improves the nonoperational shock specification by as much as 40 percent.

Why is G-force protection needed?

When a disc drive is not operating but is being moved or installed into a cabinet, the drive may be bumped or knocked against a workbench or the PC cabinet. These incidents are called nonoperational shock events because the drive is not functioning when the bump or shock occurs. Bumping or dropping a drive may not cause visible damage to the outer case; however, components inside the drive may be damaged due to the shock. The four components that are most affected by nonoperational shock are the spindle motor, heads, head arms and discs. Damage to or failure of any of these components may result in data loss and reduced reliability. Through Seagate's ongoing research and testing, we have enhanced the technology of the spindle motor, heads, head arms and disc clamp in our high-performance products. These enhancements help to increase the drive's resistance to nonoperational shock events.

How is the spindle motor affected by shock?

Figure 1 shows the inside of a ball bearing. During a shock event, the bearing and the balls in the bearing may become damaged. The damage is caused when a shock event occurs that forces the ball and the race to press against each other, deforming the material of the race and the ball. Motor-bearing damage is detected by an increase in acoustics and can lead to motor failure. Larger balls in the bearing help prevent damage because there is more surface area contact to absorb a shock. The motor bearings in Seagate's Barracuda and Cheetah drives use one of the largest ball-bearing sizes in the industry for higher contact surface area to prevent race and ball damage when a shock event occurs.

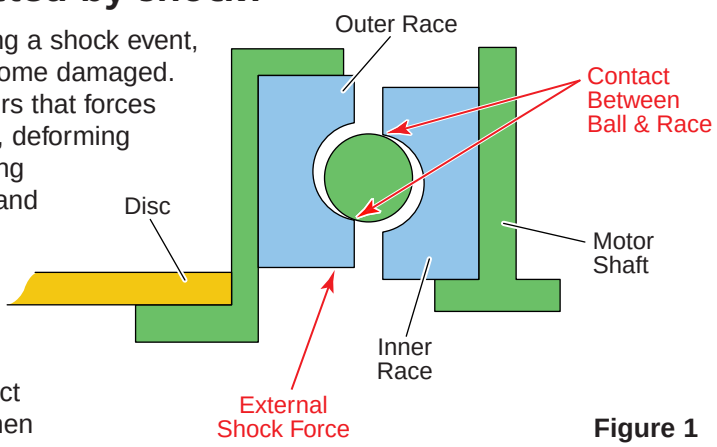

Figure 1

How are the heads, head arms and discs affected by shock?

Figure 2 shows the inside of a drive with the top cover removed. When the drive is not operating, the heads, flexure and head arms are at rest over the dedicated laser-textured landing zone on the disc. During a shock event, the heads may lift off of the discs and then slap back down onto the discs, called a head slap. As shown in Figure 3, head slaps may damage the disc and the head and may generate head or disc particles. These particles may become lodged under the head, resulting in data loss.

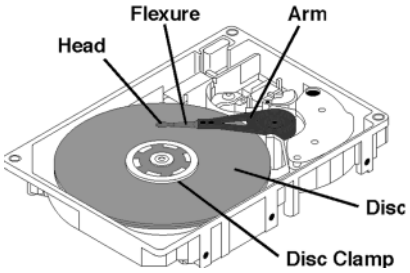

Figure 2

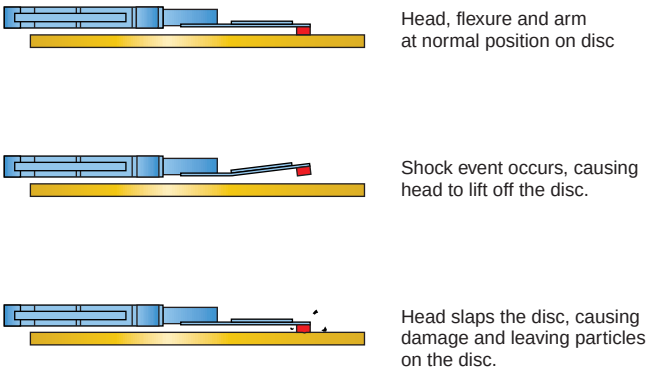

Figure 3

Damage to the head and the disc occurs when these two components contact each other. If a shock event occurs, but the head does not come in contact with the disc, no damage results. To avoid the occurrence of a head slap, the following improvements have been made on the new Barracuda and Cheetah disc drives:

- Reduced the mass of the head
- Reduced the size of the head
- Increased the clearance between the head suspension and the disc
- Increased the clearance between the head arm and the disc

By reducing the size and mass of the head and increasing the clearance between the head and the disc, there is less chance for the head to touch the disc during a shock event. These improvements increased the amount of nonoperational shock the new Barracuda and Cheetah drives can withstand before damage occurs.

Disc slip is another problem that can result from a shock event. The disc clamp shown in Figure 2 is designed to squeeze the discs with a certain amount of force to avoid slippage if a shock event occurs. Without the proper amount of force applied to the disc pack, one or more discs may slip out of alignment during a shock event. This slippage results in an increase in vibration and acoustics and a decrease in performance because the servo system has to work harder to keep the heads over track-center. The disc clamp used on the new Barracuda and Cheetah drives was improved by a change in geometry and an increase in the amount of force applied to the disc pack. These improvements, and the fact that Seagate monitors the amount of force applied to the clamp, increase the amount of shock the disc pack can withstand before disc slippage occurs.

Due to our careful monitoring, disc slip is quite rare. However, if disc slip occurs from a shock, Seagate's Barracuda and Cheetah drives have always had the capability to recover without losing the ability to read and write to the disc. This recovery capability is called once per revolution compensation (OPR). The servo system uses OPR to look at how much the disc has shifted out of alignment and applies a correction to be certain the head is over the track. Through our continuous improvement, we have doubled the disc slip recovery capability on our newest families of Barracuda and Cheetah drives to ensure their reliability.

Conclusion

Because we live in an imperfect world, accidents such as bumping or dropping a disc drive may happen. These unfortunate events, called shock events, may result in failure of a component, loss of data or a decrease in performance. Seagate strives for continuous improvement and, as a result of ongoing research and testing, has developed a design technique to improve the shock threshold of its new families of Barracuda and Cheetah drives, called G-force protection. Because Seagate saw the need to take an overall system approach to shock protection, GFP focuses on improvements to the spindle motor, heads, head arms and disc clamp. GFP increases the shock threshold by as much as 30 percent on the Barracuda 18LP/36/50 and 40 percent on the Cheetah 18LP/36. The following table shows a summary of the features and benefits associated with GFP.

GFP Features	GFP Benefits
Spindle motor: • Uses one of the largest ball-bearing sizes in the industry	• Prevents motor-bearing damage.
Heads and head arms: • Reduced the mass of the head • Reduced the size of the head • Increased the clearance between the head suspension and the disc • Increased the clearance between the head arm and the disc	• Prevents disc damage due to contact between the head arm and disc. • Prevents disc damage due to head slaps.
Disc clamp: • Improved the geometry • Increased the force applied to the disc pack	• Prevents discs from slipping on spindle motor. • Ensures low vibration and low acoustics. • Ensures optimal data throughput.
Once per revolution compensation (OPR): • Doubled disc slip recover capability	• Extends the nonoperating shock threshold by ensuring that the drive can continue to read and write if a disc slip occur**.**

By incorporating GFP on Seagate's new Barracuda 18LP/36/50 and Cheetah 18LP/36 drives, we are providing our customers with the most reliable drives on the market today

GFP
The Protection You Need
For Access to the Data You Want