Coughlin Associates

Improving Storage System Reliability with Western Digital's IsoVibe™ and ArticFlow™

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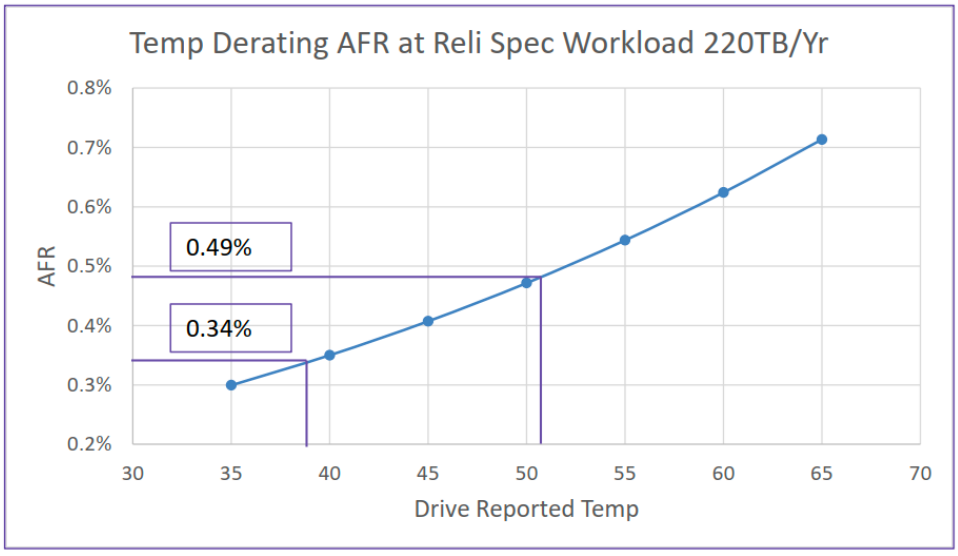
Introduction

There are many projections for accelerating data generation and storage growth over the next few years. This data growth will drive demand for economical digital storage. IDC has projected 175 zettabytes of content generated annually by 2025 with a few percent of this data, or the results of this data, destined for later use. The majority of the world's data is stored on hard disk drives. Storage systems used in enterprise and data center applications to store this information must be reliable to prevent loss of this valuable data.

At the same time, digital storage, like other information and communications technology infrastructure, must be energy efficient to meet worldwide goals for sustainability and reduced carbon emissions. The requirements for reliable higher storage capacity, with HDDs that consume less energy per byte, is encouraging clever approaches for using HDDs in storage system design. These approaches take energy efficiency and sustainability into mind. The HDD companies are working to meet the world's requirements for reliable, energy-efficient, and low-cost storage.

Importance of thermal control and vibration control in drive reliability

Higher temperatures accelerate hard disk drive failures. There is a formula called the Arrhenius equation that describes the acceleration of chemical reactions with increasing temperatures. The same exponential formula can be used to model the temperature dependence of device failure rates, such as for HDDs. The graph below shows results that might be expected for an HDD annual failure rate (AFR) as a function of HDD temperature for a workload of writing and reading 220TB in a year.



As shown on this graph, as the HDD temperature increases, the expected AFR of a collection of HDDs operating at this temperature increases.

Vibration within an HDD or induced from an external source can cause an HDD to take longer to write or read data because the vibration makes it harder for the heads in the HDD to stay on track while flying over the disks. The HDD heads have to do multiple tries to complete a write or read

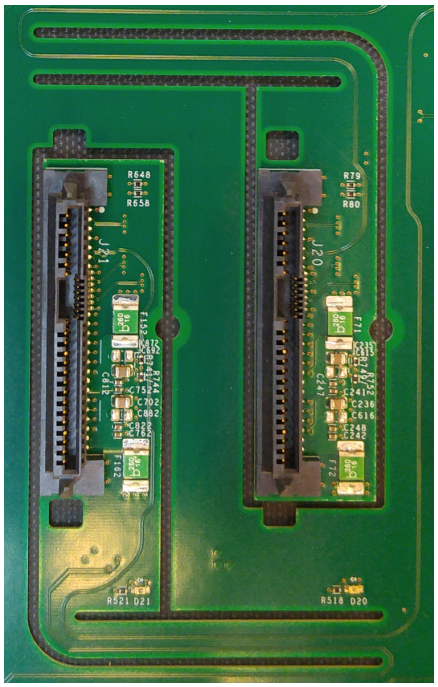
operation and this takes more time. Extreme vibration or shock can also cause the heads to bang into the disks and cause damage to the data on the disk. This could result in loss of data and decreasing HDD reliability.

High-density digital storage systems that include a number of HDDs in an array can suffer from different HDD temperatures across the array and vibration from adjacent HDDs can cause performance and reliability problems for HDDs in the array. This can lead to drive rebuilds or data loss. If an HDD array is designed to reduce operating temperatures for the HDDs and minimize vibration it will result in better performance, lower power consumption and a more trouble-free storage system.

Western Digital's IsoVibe and ArcticFlow

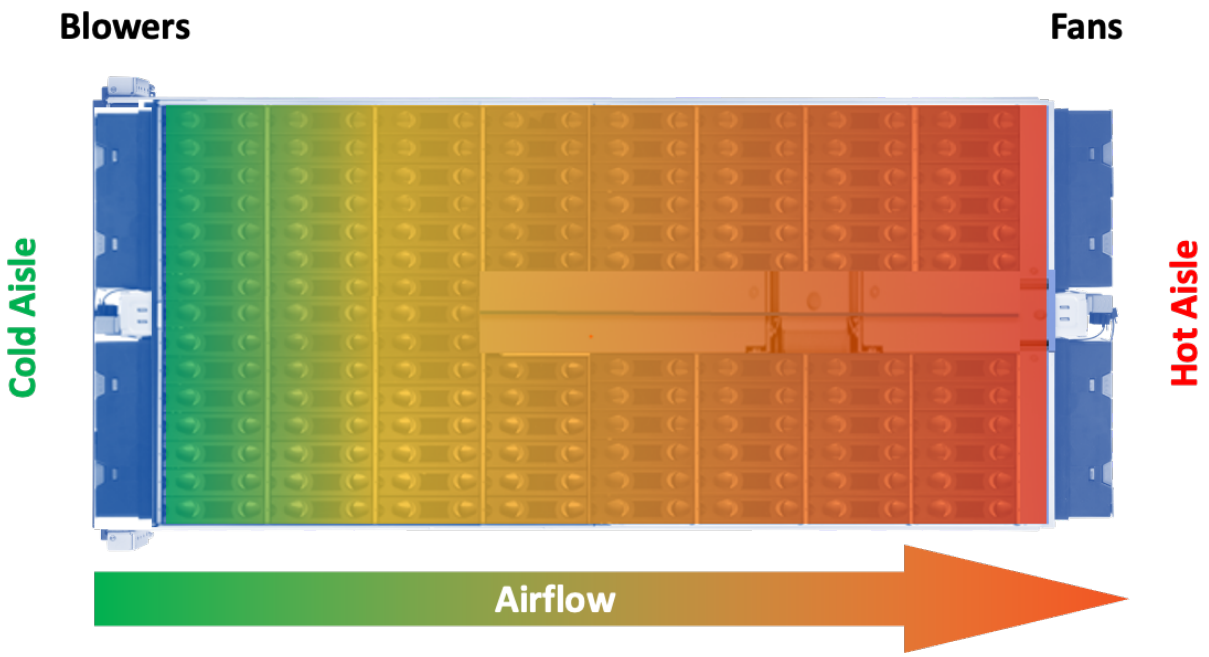
Western Digital has designed HDD storage arrays in its Ultrastar® Data60 and Data102 storage enclosures that reduce the impact of vibrations from HDDs and fans in the array with the company's patented IsoVibe technology. This platform also reduces the range and level of HDD temperatures with ArticFlow system cooling design.

The IsoVibe technology creates a flexible "suspension" in the storage array baseboard that HDDs are inserted into in the HDD array. These suspensions are created by the slots shown in the figure below.



The slots in the baseboard make it act as a suspension that reduces the transmission of vibrations from drives in the arrays, particularly between adjacent drives, by isolating the motion of the drives. The Ultrastar platform also uses vibration isolated fans to minimize this source of vibration. ArticFlow also reduces the vibration in the system by enabling the use of lower fan speeds, so the fans generate less vibration, and a side benefit is they use less power to cool the storage system.

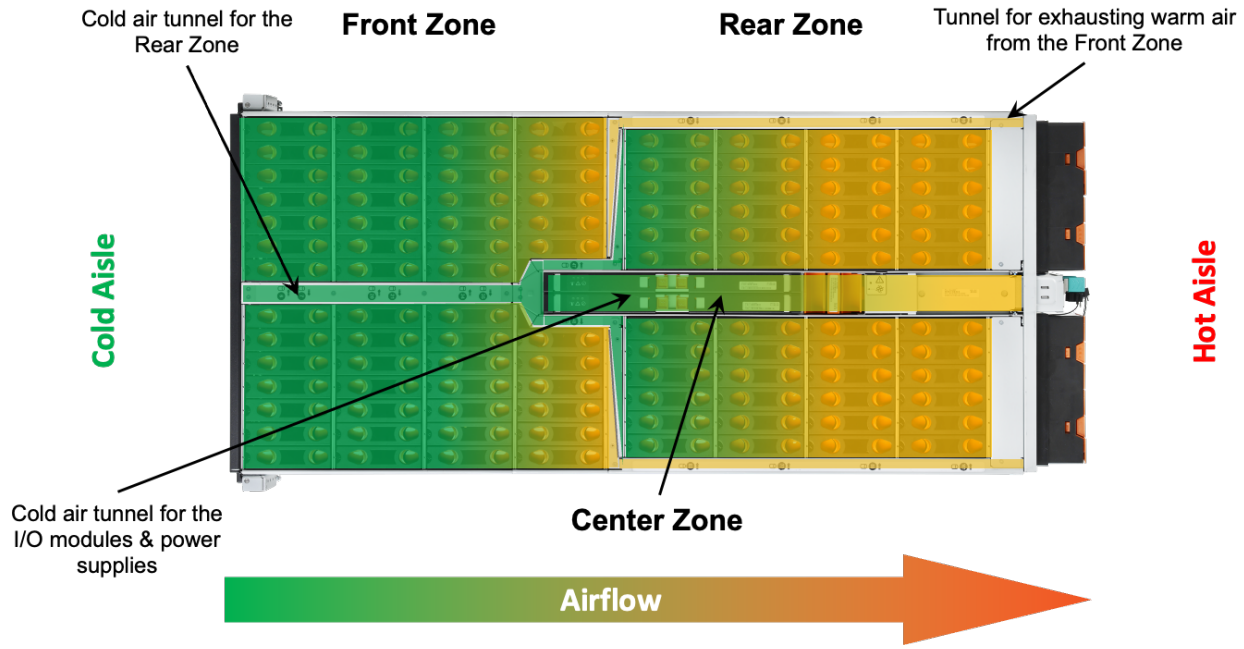
The figure below illustrates the challenges maintaining low, uniform temperatures in dense HDD shelves. The green areas contain cooler HDDs and as the color progresses towards red, the HDD temperatures rise.



With blowers to push air into the storage shelf from the cold aisle and fans to pull the air out of the shelves into the hot aisle, the drives nearest to the blowers stay cooler, but the drives farther from the blowers get hotter as the air flowing through the shelf gets hotter and don't pull as much heat from the HDDs.

Storage system designers can try to compensate for the non-uniform HDD temperatures by adding additional blowers to increase the airflow across the HDDs but this results in higher power requirements, higher noise levels and higher vibration experienced by the HDDs, resulting in system performance degradation. Also, as the earlier chart showed that drive failure rates increase with higher HDD temperatures, the hotter drives in this storage system will fail sooner, impacting overall storage system reliability.

Western Digital's Ultrastar Data60 and Data102 platforms are different than the storage system shown above. As shown in the figure below, the Ultrastar HDD enclosure divides the HDDs into two thermal zones using innovative airflow management. These two thermal zones can be independently cooled, keeping the HDDs cooler.

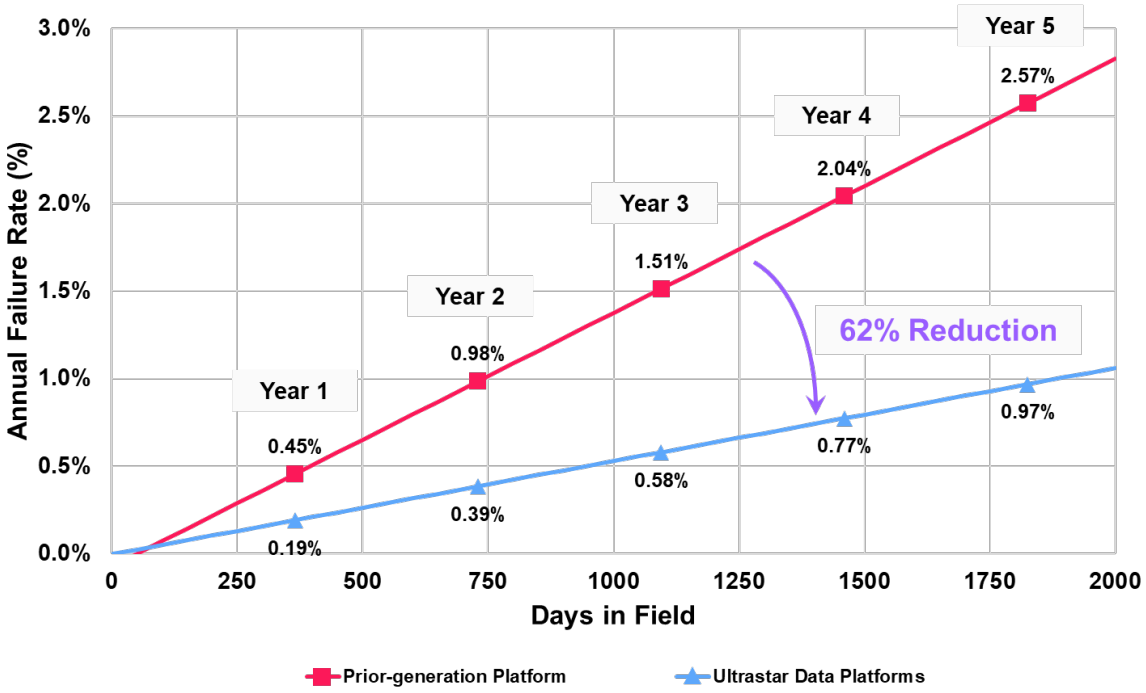


Warmed air from the first zone is ducted away from the second zone so the second zone drives aren't heated by that warm air. Cool air is drawn into the center of the enclosure from the cold aisle to cool the second zone HDDs. As a consequence of having two HDD cooling zones, overall HDD temperatures are cooler and more uniform leading to lower HDD failure rates. There is also a dedicated third cooling zone to channel fresh air to the I/O modules and power supplies.

This approach also allows lower fan speeds to maintain cooling and thus reduces power consumption, noise and fan vibrations. For large HDD enclosures the loss of a few HDDs to provide the additional air ducting is more than compensated by greater drive life and storage system reliability.

By implementing IsoVibe and ArticFlow into Ultrastar Data storage platforms, Western Digital was able to improve overall storage system reliability compared to older storage systems that didn't include these innovations. The figure below shows annual return rates (ARRs) for HDDs in the prior storage system design compared to those in the newer Ultrastar Data storage platforms.

Annual return rates are generally directly related to drive failure rates. The Western Digital Ultrastar Data storage platforms had a 62% reduction in HDD returns out to 1,800 days in the field compared to the older technology. This is a significant improvement in storage system reliability.



In addition to ArcticFlow and IsoVibe, the Ultrastar Data60 and Data102 platforms deliver other unique usability and serviceability features for systems at scale providing more reliable storage, including:

- Tool-less Customer Replaceable Units (CRUs) and Field Replaceable Units (FRUs) with cold aisle service for HDDs and I/O Modules (IOMs).
- Bulk packaging options to reduce shipping and freight cost.
- Rack-mounted Top Cover to eliminate top cover damage and loss.
- Cable Management Arm (CMA) with simple, snap-in baskets, supporting copper and active optical cables, for quick and easy service.
- Resource Manager, an in-band monitoring and management application for Western Digital storage platforms.

Resource Manager provides a consolidated monitoring dashboard that supports the Data60 and Data102 platforms. It is a GUI-based intuitive tool that provides in-band real-time monitoring and management running on Windows or Linux®. It provides platform health at-a-glance including drive monitoring and provides zoning and alerts based upon sensor threshold readings.

Summary and Conclusions

HDD failure rates increase with the temperature of the HDDs. Controlling the temperature of the HDDs in an HDD storage system can improve the overall storage system reliability. Likewise, reducing the vibration from adjacent HDDs and storage system cooling fans can improve system performance and reliability.

Improving Storage System Reliability with Western Digital's IsoVibe™ and ArticFlow™

Western Digital's latest Ultrastar Data storage system platforms incorporate technologies that reduce HDD temperatures and storage system vibrations. The ArticFlow technology breaks the storage system into three thermal zones with separate airflows to keep from overheating the HDDs, I/O modules and power supplies. The company's IsoVibe system isolates the individual HDDs vibrations, so they don't impact adjacent HDDs. In addition, ArticFlow allows using lower fan speeds and thus reducing storage system vibration, reducing noise, and reducing storage system power requirements.

Due to these improvements, the Ultrastar storage system return rates are 62% better than the previous generation storage systems that didn't include these features. ArticFlow and IsoVibe provide more sustainable and performant, higher reliability, and lower noise storage systems.

About the Author

Tom Coughlin, President, Coughlin Associates is a digital storage analyst and business and technology consultant. He has over 40 years in the data storage industry with engineering and senior management positions at several companies. Coughlin Associates consults, publishes books and market and technology reports (including *The Media and Entertainment Storage Report and an Emerging Memory Report),* and puts on digital storage-oriented events. He is a regular storage and memory contributor for forbes.com and M&E organization websites. He is an IEEE Fellow, IEEE President Elect in 2023, Past-President of IEEE-USA, Past Director of IEEE Region 6 and is also active with the Storage Networking Industry Association (SNIA) and the Society of Motion Pictures and Television Engineers (SMPTE). For more information on Tom Coughlin and his publications and activities go to https://tomcoughlin.com.

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