



Technology Paper

Optimizing Storage for Extreme Environments—

EE25.2 Series™ Hard Drives, Flash Solid-State Drives and Standard 2.5-Inch Hard Drives

Introduction

Sophisticated electronic devices now permeate virtually every aspect of business and personal life, boasting communications and entertainment capabilities that until recently were the exclusive province of bulky desktop computer systems. Bringing remarkable power and compactness to a host of outdoor and mobile settings, these devices are the foundation of such diverse applications as:

- Automotive entertainment, navigation and data delivery systems
- Industrial PCs used for process monitoring and data acquisition
- Military field imaging and information systems
- Digital signage and advertising displays
- Mobile/portable medical equipment

Not surprisingly, these applications present daunting environmental challenges: severe temperatures (from sub-zero frost to sweltering heat), punishing vibration and shock, stifling humidity and extreme altitude. To survive in such grueling settings, system components must be purpose-built for ruggedness, durability and protection from hostile conditions. And this is particularly true for a critical element of outdoor and mobile systems: the storage device.

Standard 2.5-inch hard disk drives are designed to operate reliably in the relatively hospitable physical surroundings characteristic of laptop computer use: mild temperatures, stable humidity and only moderate levels of vibration. When deployed in the far more rigorous environments that typify outdoor and mobile storage, such laptop drives often suffer degraded reliability.

Flash solid-state drives certainly seem more promising, shrugging off the harsh conditions that compromise conventional laptop hard drive durability. But flash drives also offer write performance inferior to hard drives, limited capacity and sharply higher cost per GB. The solution? An innovative breed of storage device that combines superior hard-drive speed, storage capacity and economy with flash-rivaling ruggedness—in short, the Seagate® EE25.2 Series™ hard disk drive.

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Out of the Office (Way Out)

Office professionals and consumers alike have come to rely on the flexibility and mobility afforded by laptop computers. Conventional 2.5-inch laptop drives are specifically designed to offer the blend of capacity, durability and low power consumption such users demand.

Outdoor and mobile applications require this same suite of capabilities, but, the brutal environmental conditions typical of such applications pose challenges well outside the design brief of standard laptop drives. Whether in automotive, industrial or military storage settings, such drives encounter stresses that can cause premature failure:

- On a summer day, the GPS system inside a parked automobile can be exposed to interior temperatures in excess of 65°C, while winter could see that same car's interior drop to -20°C or lower. Furthermore, long-duration (11 ms) shock, such as the impact encountered by a drive mounted in a vehicle that hits a pothole, is far more punishing than the short-duration (2 ms) shock of a laptop falling from an office desk onto the floor.
- In factory environments, industrial process control (IPC) devices often run 24x7 and are routinely located within feet of powerful machine tools, dies and welding equipment. The excessive heat and vibration in such settings can quickly cause a standard laptop drive to malfunction.
- Military applications impose a demanding range of environmental stresses on hard drives, from scorching desert heat to punishing sub-zero cold at extreme elevation. In addition, military vehicles operating under such conditions often must negotiate rugged terrain that metes out far more shock and vibration than civilian roads and highways do.

In contrast to conventional 2.5-inch laptop drives, the Seagate EE25.2 Series hard drive is purpose-built to handle the temperature, vibration, shock, altitude and humidity extremes endemic to outdoor and mobile storage applications. Utilizing RunOn™ technology, a comprehensive feature suite that ensures reliable performance in punishing physical conditions, the EE25.2 Series drive sets new standards for hard drive ruggedness.

In spite of the obvious technical superiority of Seagate EE25 Series hard drives over conventional laptop hard drives, there are still those who would argue that flash solid-state drives are the preferable storage choice for extreme environments. A close examination of the facts suggests otherwise.

Flash Solid-State Disks: Beyond the Hype

As is often the case with new technologies, flash drives are currently riding a wave of critical approval and popular acceptance, fueled in large part by the many impressive claims made for flash relative to hard drives: lighter weight, lower power consumption, superior ruggedness and higher performance.

However, when viewed in the unforgiving light of real-world use, the theoretical benefits of flash drives lose much of their luster. For example, the strengths of flash drives quickly pale when one considers their staggering cost: from US\$500 to US\$1200 more than EE25.2 Series drives of comparable capacity.

To be sure, flash drives do indeed have a place in storage environments where fast random reads, low power consumption and extreme shock resistance take precedence over issues of capacity, read/write performance and cost. But for the vast majority of outdoor and mobile applications, flash drives are simply not the storage panacea they are made out to be.

Purpose-Built Edge: Seagate® EE25.2 Series™ Drive vs. Standard 2.5-Inch Hard Drive					
	Temperature (Operating, °C)	Vibration (5 to 500 Hz, Gs)	Shock (Operating, 2 ms/11 ms, Gs)	Altitude (M)	Annualized Failure Rate (AFR)
Seagate EE25.2 Series Drive	-30 to +85	2	300/150	-300/+5000	<0.5%
Standard 2.5-Inch Drive*	0 to +60	1	350/NA	-300/+3048	<0.6%

* Manufacturer's specifications for Seagate Momentus® 5400.3 drive

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Myth #1: Lighter Weight

Flash drives weigh far less than hard disk drives, enabling portable computer systems that are much lighter.

Fact: The Seagate EE25.2 Series drive weighs just over 50 grams (approximately two ounces) more than a Samsung 2.5-inch flash drive. But reviewing those figures in isolation doesn't tell the full story. For example, a Panasonic Toughbook 30 laptop computer weighs 8.4 pounds; in that context, the 2-ounce difference between the EE25.2 Series hard drive and the Samsung flash drive accounts for well under two percent of the system's weight, an insignificant amount.

Bottom line: Overall system weight is virtually the same whether an EE25.2 Series drive or a 2.5-inch flash drive is employed.

Myth #2: Lower Power Consumption

Flash drives consume far less power than hard disk drives, enabling significantly longer battery life in portable computer systems.

Fact: Thanks to the power-saving features built into the Seagate EE25.2 Series drive, power use is only nominally higher than that of a 2.5-inch flash drive. More importantly, the storage device accounts for less than ten percent of total system power consumption. A system's video display and ASICs demand far more power and are thus the prime determinants of net system battery life.

Power Play: Seagate® EE25.2 Series™ Drive vs. Samsung Flash Drive		
	Seagate EE25.2 Series 2.5-Inch Drive (80 GB)*	Samsung 2.5-inch Flash Drive (16 GB)*
MobileMark Battery Life	PATA: 328 minutes SATA: 316 minutes	324 minutes

* Figures obtained at Seagate Technology, Longmont, Colorado, testing laboratory

Bottom line: System battery run time is virtually the same whether an EE25.2 Series drive or a 2.5-inch flash drive is employed.

Myth #3: Superior Ruggedness

Flash drives feature extraordinary tolerance to extreme environments, ensuring reliable system operation in even the harshest operating conditions.

Fact: Both the Seagate EE25.2 Series hard drive and the Samsung 2.5-inch flash drive can endure a broad range of temperatures as well as high levels of shock and vibration. To be sure, the Samsung flash drive's shock and vibration tolerance numbers are better, but in reality, such numbers are largely academic. In actual use, many other system components would likely fail long before the shock or vibration thresholds of the Samsung flash drive were approached, rendering such capabilities essentially overkill.

Tough Enough: Seagate® EE25.2 Series™ Drive vs. Samsung Flash Drive

	Seagate EE25.2 Series 2.5-Inch Drive	Samsung 2.5-inch Flash Drive*
Temperature (Operating, °C)	-30 to +85	-25 to +85
Vibration (Gs)	2 (5 to 500 Hz)	20 (10 to 2000 Hz)
Shock (Operating, Gs)	300 (2 ms)/150 (11 ms)	1500 (0.5 ms)

* Manufacturer's specifications for 2.5-inch flash drive

Bottom line: Projected real-world system reliability is virtually the same whether an EE25.2 Series drive or a 2.5-inch flash drive is employed.

Myth #4: Higher Performance

Flash drives deliver far higher performance than hard drives, enabling systems that more efficiently execute commands and process data.

Fact: Flash drives are indeed much faster than hard drives when randomly reading data, but that is an unrealistically narrow application model. By the same token, the Seagate EE25.2 Series drive is much faster than the flash drive when writing data. But in the real world, most extreme storage applications (such as military radar data updates and ruggedized laptops at construction sites) require frequent random reads and writes of data. Under such circumstances (80%R, 20%W), lab testing proves that the EE25.2 Series drive delivers performance virtually identical to that of a flash drive.

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Performance Reality Check: Seagate® EE25.2 Series™ Drive vs. Samsung Flash Drive			
Benchmark	Seagate EE25.2 Series 2.5-Inch Drive (80 GB)*	Samsung 2.5-inch Flash Drive (16 GB)*	Advantage
PCMark 04	3460	4800	Flash (+38%)
Sustained Sequential Reads (MB/s)	59	50	Hard Drive (+18%)
Sustained Sequential Writes (MB/s)	52	29	Hard Drive (+79%)
Random Reads, 8 KB (IOPS)	70	2450	Flash (+3500%)
Random Writes, 8 KB (IOPS)	112	23	Hard Drive (+487%)
Random Reads/Writes, 80%R, 20%W (IOPS)	79	80	None

* Figures obtained at Seagate Technology, Longmont, Colorado, testing laboratory

Bottom line: Depending on the use case, system throughput is virtually the same whether an EE25.2 Series drive or a 2.5-inch flash drive is employed.

Cost: The Ultimate Difference

Simply put, Seagate EE25.2 Series drives of any capacity boast far lower cost-per-GB than either 32-GB or 64-GB 2.5-inch flash drives. Specifically, the street price differential can range from US\$500 to over US\$1,200. While the flash drive's higher price is sobering when contemplating a single-unit purchase, it is positively staggering in the context of a trucking firm that wants to add 500 GPS units (each equipped with a drive) to its fleet.

Part of the flash drive's cost premium comes from its need to use more expensive single-level cell (SLC) flash memory to ensure satisfactory performance and a sufficient number of read/write cycles. Less expensive multi-level cell (MLC) flash memory is not practicable, as such memory requires more chips to meet a given capacity requirement, uses more power, is less tolerant of heat and cold, and enables only a fraction of the read/write cycles possible with SLC memory.

To put flash drive cost in a different perspective, *its price must drop by 50 percent every year until 2011* for it to be cost-competitive with hard drive storage (based on Seagate Technology projections). And the flash drive's reliance on more expensive SLC memory will make that ambitious goal even more difficult to attain.

Conclusion

The Seagate EE25 Series family of ruggedized disk drives represents a profound advance in hard drive durability and flexibility, enabling storage in a broad variety of extreme environments. Significantly more robust than standard 2.5-inch laptop drives, Seagate EE25.2 Series drives incorporate advanced engineering features while maintaining the remarkably low cost-per-GB that characterizes hard drive storage.

In theory, flash drives offer advantages in terms of weight, power consumption, ruggedness and performance. But in practice, these benefits are largely unrealized, overshadowed by the vast price penalty that flash drives impose. Bottom line? In real-world applications, the Seagate EE25.2 Series drive delivers comparable functionality at far lower cost.

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