OPEN COMPOSABLE COMPATIBILITY LAB

Ultrastar DC SN655 — 15.36TB SSD Test Results

The Third Party Test Results for the Ultrastar DC SN655 are based on a comprehensive evaluation to ensure compatibility, performance, and reliability performed by the Open Composable Compatibility Lab (OCCL). The assessment covers basic interoperability and specialized workload performance using industry-standard benchmarking tools.

For more information related OCCL, see: https://www.opencomposable.com/.

Drive Details

Drive	Ultrastar DC SN655[1]
Form Factor	U.3 15mm
Interface	PCIe Gen4, NVMe 1.4
Security	SE
Power	16W, 20W (Default)
Power Idle	< 8W
Part Number	WUS5EA1A1ESP7E1

The following table displays the status and results of the testing of a specific device. The four columns represent specific configurations which progressively increase in terms of complexity in the following order: Local benchmark x1 > Data24 x1 > Data24 x8 > Data24 x24. All devices will start with the Local x1 and Data24 x1. Poor performance or interoperability issues in any configuration can eliminate the device from further consideration. The individual tests are consistent with general industry practices and reporting. Western Digital's OpenFlex Data24 NVMe™-oF Storage Platform extends the high performance of NVMe flash to shared storage. The storage platform provides low-latency sharing of NVMe SSDs over a high-performance Ethernet fabric to deliver similar performance to locally attached NVMe SSDs.

For additional information on Western Digital's OpenFlex Data24 NVMe-oF Storage Platform, see: https://www.westerndigital.com/products/data-center-platforms/openflex-data24-nvme-of-platform?sku=1ES2380.

Ultrastar DC SN655 15.36TB Top Line Performance

Test Description	Local x1	Data24 x1	Data24 x8[2]	Data24 x24
Read Bandwidth (128KB) MB/s	6,772	6,988	—	132,417
Write Bandwidth (128KB) MB/s	3,738	3,722	—	85,366
Random Read (4KB)K IOPS	1,116	1,122	—	27,019
Random Write (4KB) K IOPS	128	128	—	3,104
Random Mixed (4KB) K IOPS	289	288	—	10,365
4K Random Write Latency (µs)	8.75	19.70	—	20.40
4K Random Read Latency (µs)	86.40	93.10	—	94.40
4K Random Write 4-9s µs	36.10	37.00	—	35.70
4K Random Read 4-9s µs	220.00	229.00	—	238.00

[1] The Ultrastar DC SN655 SSD is available from SanDisk at: https://shop.sandisk.com/en-sg/products/ssd/internal-ssd/ultrastar-dc-sn655-nvme-ssd?sku=0TS2508.

[2] The "—" indicates that configuration has not been tested. This is generally due a lack of drive availability or the benchmark being non applicable.

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The following table displays tests 2-4 normalized to test 1 (Local x1), the percentages in tests 2-4 should generally increase with more complex and larger configurations. The two QoS values (4-9s) by there stocastic behavior can have significant variability.

Ultrastar DC SN655 15.36TB Normalized to Local x1 Top Line Performance

Test Description	Local x1	Data24 x1	Data24 x8[2]	Data24 x24
Read Bandwidth (128KB) MB/s	100%	103%	—	1955%
Write Bandwidth (128KB) MB/s	100%	100%	—	2283%
Random Read (4KB)K IOPS	100%	100%	—	2420%
Random Write (4KB) K IOPS	100%	100%	—	2429%
Random Mixed (4KB) K IOPS	100%	100%	—	3586%
4K Random Write Latency (µs)	100%	225%	—	233%
4K Random Read Latency (µs)	100%	108%	—	109%
4K Random Write 4-9s µs	100%	102%	—	99%
4K Random Read 4-9s µs	100%	104%	—	108%

Coefficients of Variation (CoV) are a standard statistical measure that are directly comparable to other CoVs as opposed to Standard Deviations (SD) that can only be compared if the mean is the same for two sets of data. CoV = SD/MEAN. NAND storage has a higher variability than DRAM, for example, that is highly consistent. NAND is a noise technology that has higher error rates than most solid state memory. Each manufacturing process has its own baseline error rate. These error rates are based on one second intervals provided by standard monitoring tools like iosstat.

Ultrastar DC SN655 15.36TB CoV Analysis

Test Description	Local x1	Data24 x1	Data24 x8[3]	Data24 x24
Read Bandwidth (128KB) MB/s	.003%	.08%	—	.078%
Write Bandwidth (128KB) MB/s	.024%	.42%	—	7.88%
Random Read (4KB)K IOPS	.0006%	.008%	—	.015%
Random Write (4KB) K IOPS	2.71%	.134%	—	.055%
Random Mixed (4KB) K IOPS	.062%	.065%	—	.0524%
4K Random Write Latency (µs)	3.56%	,054%	—	1.46%
4K Random Read Latency (µs)	.5%	.23%	—	.168%
4K Random Write 4-9s µs	0%	.653%	—	.203%
4K Random Read 4-9s µs	.76%	1.12%	—	6.8%

[2,3] The "—" indicates that configuration has not been tested. This is generally due a lack of drive availability or the benchmark being non applicable.

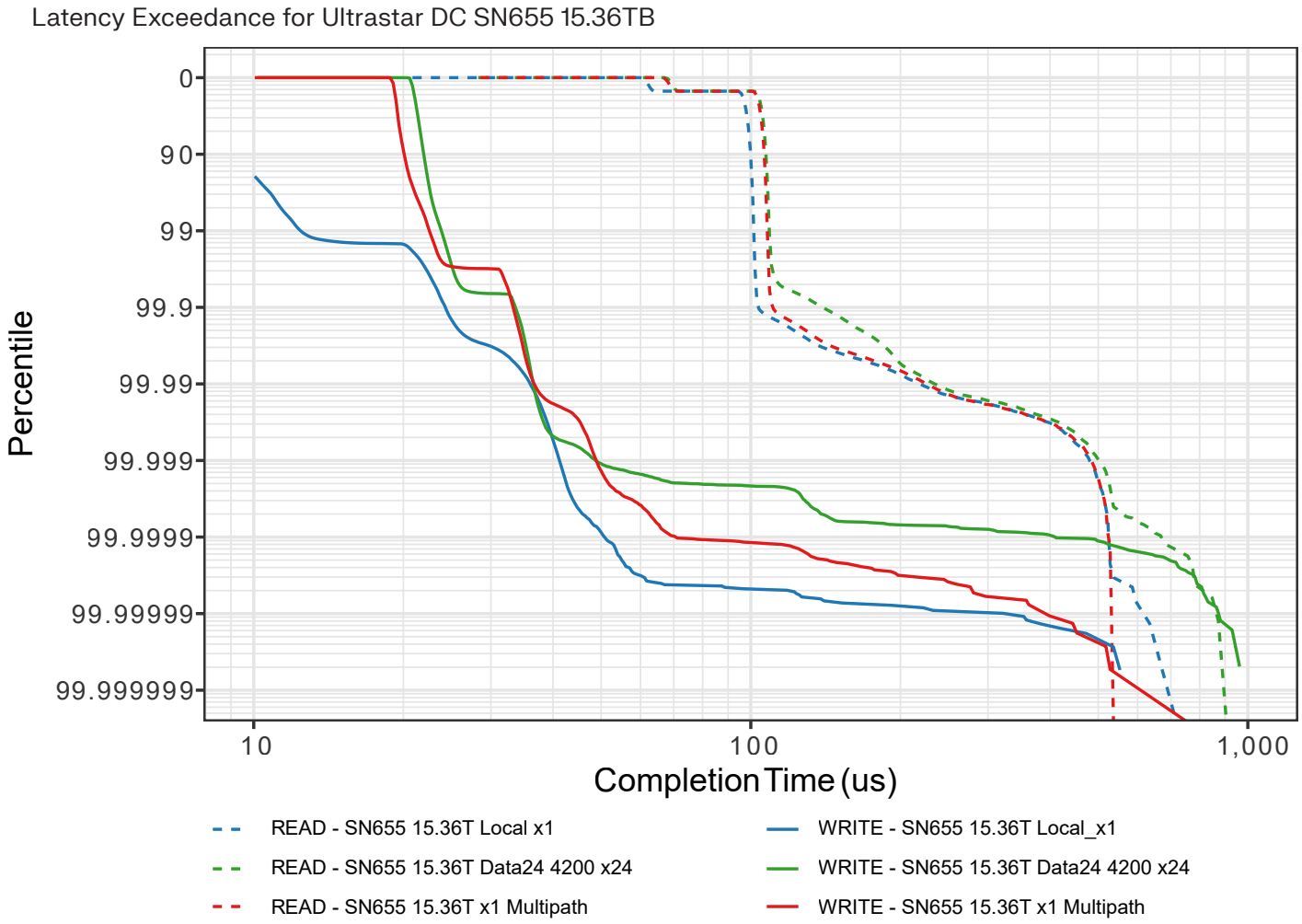
Western Digital SN655 SSD Test Results

Additional Observations

The following pivot chart displays a unique performance consideration with the OpenFlex Data24. With the same test environment, the smaller block (32K) test outperforms the larger block (128K) by about 30%. Typically, larger blocks provide increased performance until bottlenecks are encountered. This behavior has been identified as an interaction between the Data24's RapidFlex NVMe-oF Controllers - A2000 and the SSDs.

Exceedance Chart

The following charts contain the technical and most accurate information. Exceedance charts are typically used for only single drive, single process, queue depth one analysis as in the following example. The chart is the most fundamental measurement of SSD or disk performance as it shows the minimum latency as well as the expected error rate and latency for the device under test. These results are often referred to as the "number of nines". For example, "4-9s" shows the latency or response time for 9999 of 10000 IOs. The number of IOs grows exponentially with the increase in the number of nines. This chart shows for 6-9s that the best performer for random writes is the solid blue line at approximately 50 us. Random writes are faster than random reads, because random writes are cached in the asynchronous write buffer and are periodically written to the underlying NAND media. Exceedance charts can be run and compared as long as all tests were run on similar systems using the same workload.



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