Myce Enterprise Class Solid State Storage Testing Methodology

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1 Introduction

This document describes the testing process and methodology established by Myce for its reviews of Enterprise class Solid State Storage (SSS) solutions.

All testing is performed on a Test, Validation, and Benchmarking System from OakGate Technology. We perform two sets of IO performance profiling tests, as standard:

1. The Storage Networking Industry Association ('SNIA') set of tests (using the mandatory parameters), as specified in the Storage Network Industry Association's (SNIA's) Solid State Storage (SSS) Performance Test Specification (PTS) Enterprise Version 1.0.

2. The Myce/OakGate Full Drive Characterisation set of tests.

If an SAS based drive supports dual port connection we will perform and publish results of all the tests run in single and dual port mode.

From time to time, we may also inject other performance related tests into reviews.

Myce plans to add Error Injection and Power Consumption testing in due course.

All standard tests performed by Myce are explained below.

We trust readers will find Myce's Enterprise Class Reviews to be the most comprehensive, and authoritative of their kind.

2 OakGate Test, Validation, and Benchmarking System

2.1 About OakGate Technology

OakGate Technology is a leading provider of test, validation, and benchmarking products and services to the storage industry. The company is a recognised leader in test and validation tools for Solid State Storage. OakGate's highly capable and flexible platforms support all popular storage protocols and are based on advanced, proprietary software, and industry standard hardware. The company also provides comprehensive test services. OakGate's products and services have been deployed by top tier component suppliers, drive manufacturers, and storage system OEMs. Based in Loomis, California, OakGate Technology was founded in 2008 by industry veterans from the storage and server industries.

2.2 Product Overview and Applications

All OakGate products offer a comprehensive set of features and are designed to deliver the highest performance. Customers use OakGate products during various phases of development, including silicon bring-up, firmware development, validation, Software Quality Assurance, Design Verification Testing (DVT), and Reliability Demonstration Testing (RDT). OEM customers often deploy OakGate products to conduct performance benchmarking and for qualification of products from different vendors.

OakGate provides fully configured, turnkey system platforms in desktop as well as rack-mount form factors. At the heart of OakGate systems is a powerful, proprietary software suite that runs on industry standard Linux servers. This software suite consists of a high performance driver and various layers that manage traffic generation, error injection, traffic analysis, and performance measurements. OakGate also provides companion "controller" software that can be installed on one or more Windows based laptops or desktops. The controller software incorporates a user friendly GUI with a comprehensive set of user controlled knobs.

Key features built into OakGate products:

- High performance, highly flexible traffic generation
- Extensive error injection capabilities
- Performance benchmarking and characterization
- Built-in protocol analyzer
- Customer programming via robust API
- Test automation
- Summary Report Generation
- Automated power cycling with data validation
- "Canned" test sequences, including JEDEC Endurance

OakGate products support all industry standard IO interfaces and protocols including:

- PCIe Gen 1, 2 and 3
- NVMe, SCSI Express/SOP, Customer specific drivers
- SAS (3/6/12G), SATA (3/6G), SATA Express/AHCI and Fibre Channel (4/8/16G)

Key benefits offered by OakGate products:

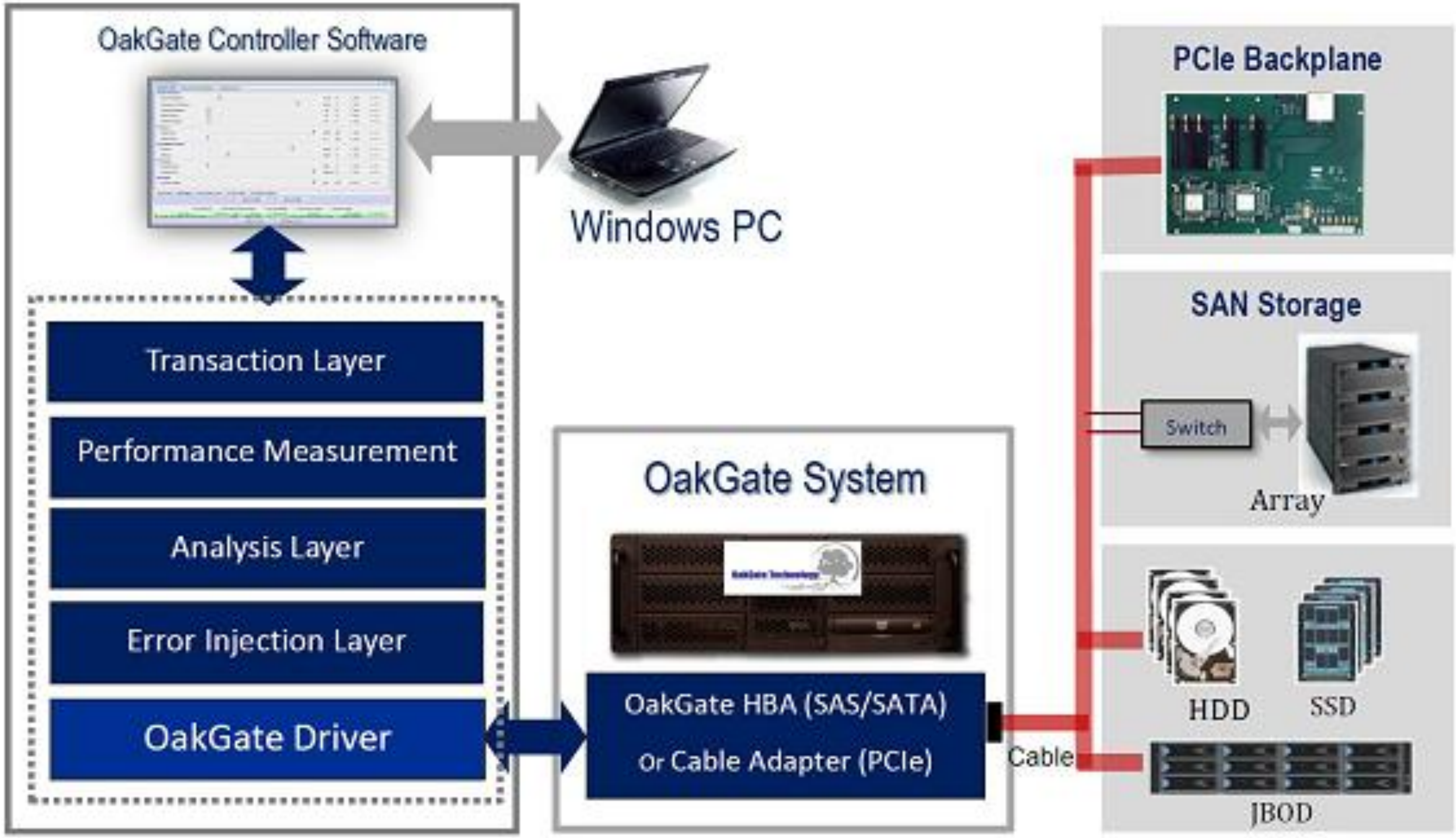
- Improved product coverage

- Fewer field defects
- Faster Time To Market
- Fewer acceptance iterations
- Faster test development
- Reduced capital equipment expenditure
- Integration with existing test environments

Further information can also be seen on OakGate's website.

Esther Spanjer, Director, SSD Technical Marketing at Smart Storage Systems, said, 'I am happy to commend Myce for their high level of professionalism and cooperation during the review process', Ms. Spanjer added, 'I wish them every success in their partnership with OakGate Technology and their initiative to provide authoritative performance reviews for the Enterprise Solid State Storage market'

2.3 OakGate Product Architecture



2.4 Product Images

Shown below are some pictures of the Myce OakGate Unit –

3 SNIA Testing

3.1 Background and Key Concepts

The Storage Networking Industry Association is a non-profit organisation, made up of some 400 member companies, spanning the global storage market. The members share a common goal to promote acceptance, deployment, and confidence in storage related architectures, systems, services, and technologies across IT and business communities.

The SNIA has launched several program initiatives in support of a specific goal to foster the growth and success of the market for SSS solutions. The SSS Technical Working Group ('SSS TWG') includes members from many of the world's leading SSS manufacturers as well as some leading US Universities. The SSS TWG is developing a performance test specification for SSS solutions, which will define the testing process, thus assuring consistent results and allowing fair product comparisons. The first version of the specification for Enterprise grade solutions has been published and can be found here – NCIA SSS PTS Enterprise V1.0.

I am delighted to tell you that the OakGate Test, Validation and Benchmarking System is delivered with a standard set of preconfigured tests that perform the mandatory SNIA enterprise tests, and that **Myce's SNIA tests faithfully follow the NCIA SSS PTS v1.0 standards.**

I extract some key test process concepts and a description of the common approach to test flows, from the SSS PTS –

Steady State

SSS devices that are Fresh Out of the Box (FOB), or in an equivalent state, typically exhibit a transient period of elevated performance, which evolves to a stable performance state relative to the workload being applied. This state is referred to as a Steady State.

It is important that the test data be gathered during a time window when the device is in Steady State, for two primary reasons:

1) To ensure that a device's initial performance (FOB or Purged) will not be reported as "typical", since this is transient behaviour and not a meaningful indicator of the drive's performance during the bulk of its operating life.

2) To enable Test Operators and reviewers to observe and understand trends. For example, oscillations around an average are "steady" in a sense, but might be a cause for concern.

Steady State may be verified:

- by inspection, after running a number of Rounds and examining the data;
- programmatically, during execution; or
- by any other method, as long as the attainment of Steady State is demonstrated and documented.

Purge

The purpose of the Purge process is to put the device in a consistent state prior to preconditioning and testing, and to facilitate clear demonstration of Steady State convergence behavior.

Purge shall be run prior to each preconditioning and testing cycle. If the device under test does not support any kind of Purge method, and the Test Operator chooses to run the PTS, the fact that Purge was not supported/run must be documented in the test report.

The Test Operator shall report whatever method of Purge was used (for example – SATA Secure Erase).

Preconditioning

The goal of preconditioning is to facilitate convergence to Steady State during the test itself.

The SSS PTS defines two types of preconditioning:

- Workload Independent Preconditioning; and,
- Workload Based Preconditioning

ActiveRange

It is desirable to be able to test the performance characteristics of workloads which issue IO across a wide range of the LBA space vs. those which issue IO across only a narrow range. To enable this, the SSS Performance Specification defines ActiveRange.

The test scripts define required and optional settings for ActiveRange.

Data Patterns

All tests shall be run with a random data pattern. The Test Operator may execute additional runs with non-random data patterns. If non-random data patterns are used, the Test Operator must report the data pattern.

Multiple Thread Guideline

If the Test Operator wishes to run a test using multiple Threads, it is recommended that OIO/Thread for all Threads be equal, so Total OIO is equal to (OIO/Thread) * (Thread Count). This will enable more direct comparisons.

Caching

All tests should be run with all volatile write caches disabled. The cache state shall be reported.

3.2 Overview of Common Test Flow

The tests in the SSS PTS use the same general steps and flow, described below -

SNIA General Test Flow

Basic Test Flow:

For Active Range = (the specified value:the specified value)

1) Purge the device
    Sata Secure Erase or equivalent

2) Run Workload Independent Preconditioning

3) Run Test (includes Workload basedpreconditioning):

    a) Set Test parameters (OIO/Thread, ThreadCount, data Pattern etc.) as specified in t he test script
    b) Run test loop until Steady State reached, ora maximum of 25 Rounds, Record data as specified for each test, for each round

4) Post process & plot the Rounds data:
    a) If Steady State is reached by Round x <= 25, where the MeasurementWindow is Round x-4 to x, the Test Operator shall:
        i) Plot Rounds x-4 to x, per 'Steady State Convergence Report'
        ii) Plot Rounds x-4 to x, per 'Steady State Verification Report'
        iii) Plot Rounds x-4 to x, per 'Measurement Plot'
    b) If Steady State is not reached by Round 25, the Test Operator shall either
        i) Continue at 3b until Steady state is reached, or
        ii) Stop at Round 25 and report per 4a (i-iii)

End For Active Range

End Basic Test Flow

Note: Steps (2) and (3) must each be run with no interruptions, and there must be no delay between Step (2) and Step (3), to maintain consistent test conditions for all devices.

Note: With respect to the reports in Step (4):

• The **Steady State Convergence Plot** shows general visual convergence to Steady State by plotting the dependent variable (IOPS, Throughput, etc.) for each Round.

• The **Steady State Verification Plot** shows, via either a graph or a table, that the device has reached Steady State as per definition 2.1.18, by examining dependent variable behaviour within the Measurement Window.

• The **Measurement Plot** is not one, but a set of, plots/reports, which summarize the test data in the Measurement Window, for the metric being measured.

• The content of these plots, and other test-specific reporting, is specified in each test.

The SSS PTS also defines Common Reporting Requirements as follows

3.3 Common Reporting Requirements

The following items, common to all tests, shall be included in the final test report. These items only need to be reported once in the test report. Test specific report items are defined in the relevant test sections themselves.

General

1. Test Date
2. Report Date
3. Test Operator name
4. Auditor name, if applicable
5. Test Specification Version

Test System Hardware

1. Manufacturer/Model #
2. CPU
3. DRAM
4. Host Bus Adapter
5. Primary Storage
6. Peripherals

Test System Software

1. Operating System Version

2. File System and Version
3. Test Software

Device Under Test

1. Manufacturer
2. Model Number
3. Serial Number
4. Firmware Revision
5. User Capacity
6. Interface/Speed
7. Form Factor (e.g. 2.5”)
8. Media Type (e.g. MLC NAND Flash)
9. Optional: Other major relevant features (e.g. NCQ, Hot plug, Sanitize support, etc.)

Now that these concepts are established let’s look at the specifications of the individual SNIA Tests that are performed by Myce, and examples of the reporting artefacts produced by the Myce/OakGate Enterprise Test Bench, that are included in our reviews.

4 SNIA Test Set

4.1 SNIA IOPS Test

Here is the specification for the SNIA IOPS Test we perform, presented in the style adopted in the SSS PTS –

SNIA IOPS Test

For Active Range (0:100)

1) Purge the device

2) Workload Independent Preconditioning
    a) Thread Count = 32, Data Pattern = 100% Entropy
    b) Write 2 x User Capacity with 128K Sequential Writes

3) Set Test parameters and record for later reporting
    a) Write Cache = Disabled
    b) OIO/Thread = 1
    c) Thread Count = 32
    d) Data Pattern = 100% Entropy

4) Run the following test loop until Steady State is reached, or maximum of 25 Rounds:
    For (R/W Mix % = 100/0, 95/5, 65/35, 50/50, 35/65, 5/95, 0/100)
        For (Block Size = 1024K, 128K, 64K, 32K, 16K, 8K, 4K, 0.5K)
            Execute random IO, per (R/W Mix%, Block Size for 1 minute)

        Use IOPS (R/W Mix % = 0/100, Block Size = 4K) to detect Steady State

5) Process and plot the accumulated Rounds data

The rules for verification of the achievement of steady state are also specified in the SSS PTS, which I detail as follows –

IOPS - Steady State Determination

Steady State is determined by the Ave 4K Random Write IOPS from each round (the 'Round Value')

For the Round Values from the current round to current – 4 (the 'Measurement Window')

> Calculate the average of the Round Values (the Ave Measurement Window Value)
> Calculate the 'Allowed Range' as +/- 10% of the Ave Measurement Window Value
>
> Do all of the Round Values fall inside the Allowed Range?
> Is the slope of the best linear fit through the Round Values <= 10%?
>
> If the answers to both of these questions is Yes then Steady State is deemed to be achieved in the Measurement Window

Use the Ave Measurement Window Values to report

Some observations:

- The mandatory test requires the IO Range to be the full user capacity of the drive.

- Step 2 demands that the full user capacity must be written to twice with sequential writes. This step facilitates the achievement of steady state in the following step.

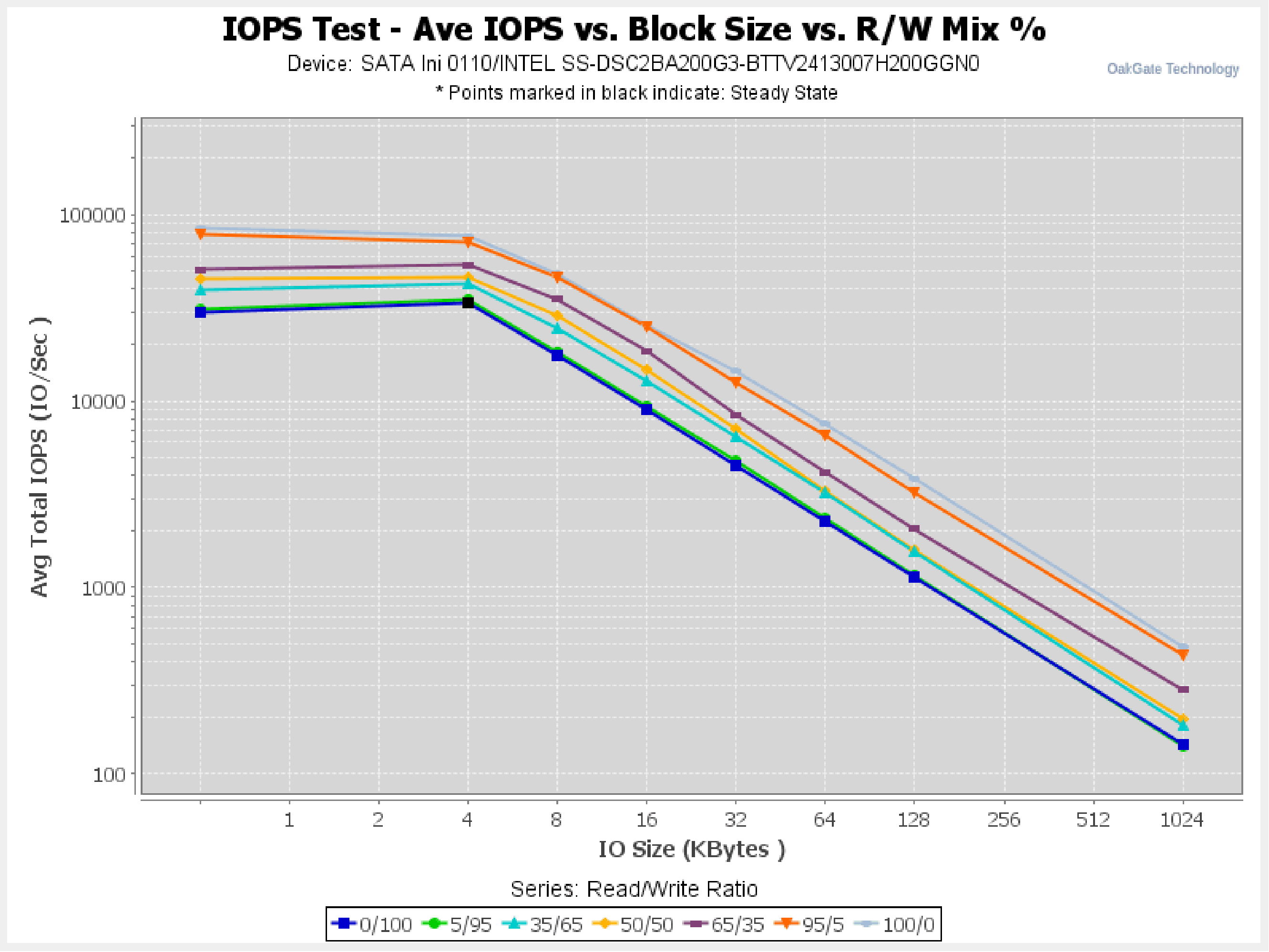
- Step 4 specifies that 56 combinations of Read/Write Mix% and Block Size should be run for 1 minute in each Round, and that each Round should be repeated 25 times, or until Steady State is reached. So potentially this test may run for 56 x 25 minutes – 23.3 hours. One of the challenges facing a tester is to detect the achievement of steady state. If you can't do that on the fly in this kind of test one's only option is to run all 25 rounds, then look back over the results to see when steady state was achieved, in order that one can then choose the correct measurement window to report upon (or to put it another way one will need to wait a day before reviewing the results). Fortunately for us the OakGate Test Bench very cleverly automates checking for the transition to steady state.

SNIA IOPS Test Reporting Artefacts

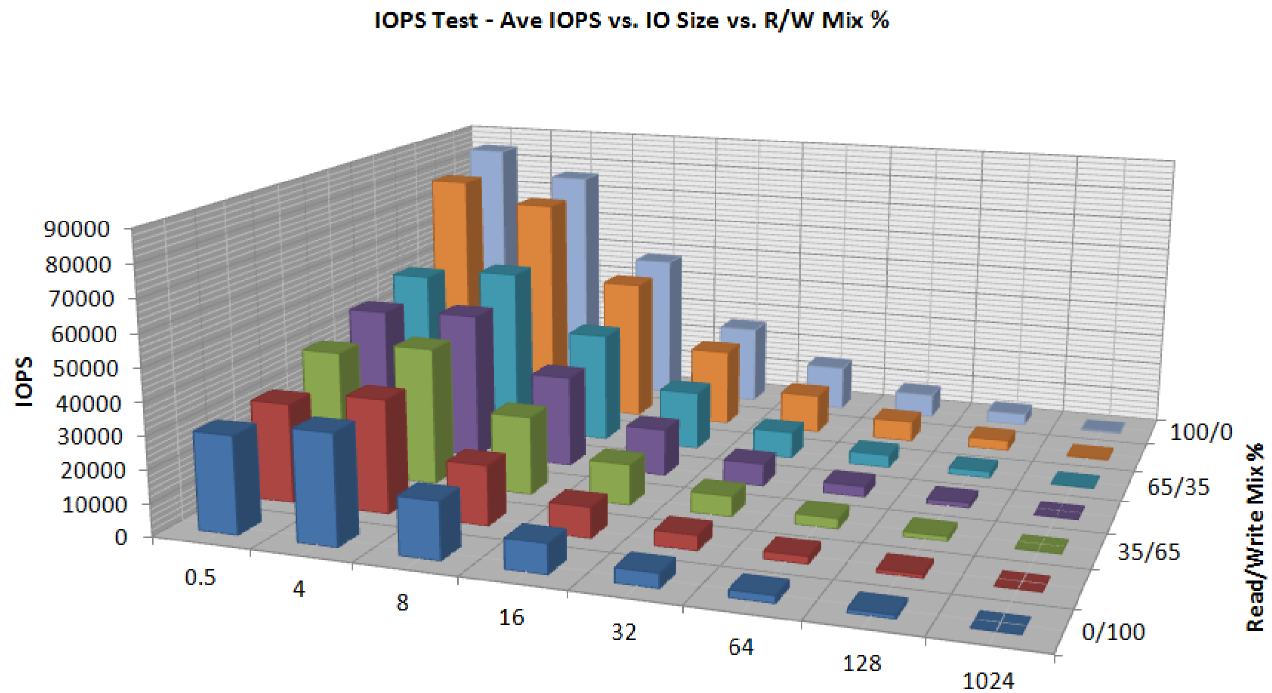
The SSS PTS defines the reports to be produced, but rather than run you through the requirements it is easier for me and you if I show you examples of the reporting artefacts that are automatically produced by the OakGate Test Bench and will be included in Myce's reviews, as I believe they accurately meet the requirements as specified in the SSS PTS.

IOPS Summary Report Page			
SNIA SSS PTS v1.0		Test Run Date:15 May 2013 17:52:24	
Test Parameters		SSS Solution under Test	
Purge Type	Secure Erase	Manufacturer	Intel
Active Range	0-100%	Model	SSD DC S3700
Queue Depth	32 IOs	Firmware	5DV1
Data Pattern	Entropy 100%	User Capacity	200GB
Write Cache	Disabled		
Workload Independent Preconditioning	Write 2 x User Capacity, 128K seq	Test Platform	
		Manufacturer	OakGate
		Motherboard	Asus
		CPU	Intel Core i5-3470 3.20GHz
		DRAM Type	DDR3
		DRAM Amount	8GB

Steady State Validation Table		
Item	Value	Max allowed
4K RNG/Slope	0.05 / 0.00%	0.2 / 10%
0/100 Steady State reached at	Round 5	N/A



IOPS Test - Ave IOPS vs. Block Size vs. R/W Mix %
Device: SATA Ini 0110/INTEL SS-DSC2BA200G3-BTTV2413007H200GGN0
OakGate Technology
* Points marked in black indicate: Steady State
Avg Total IOPS (IO/Sec)
100000
10000
1000
100
1
2
4
8
16
32
64
128
256
512
1024
IO Size (KBytes)
Series: Read/Write Ratio
0/100
5/95
35/65
50/50
65/35
95/5
100/0



	0.5	4	8	16	32	64	128	1024
0/100	29851.87	33885.13	17575.39	9019.9	4511.37	2262.84	1133.6	142.64
5/95	30827.79	35141.98	18410.84	9357.4	4768.93	2339.18	1164.33	141.15
35/65	38973.52	42888.32	24468.73	12763.34	6474.81	3225.46	1563.54	181.96
50/50	45131.07	46255.79	28921.54	14823.99	7049.37	3317.03	1602.55	194.9
65/35	50500.09	53609.9	35235.71	18589.67	8383.6	4157.3	2054.99	282.1
95/5	77975.63	71509.53	45954.9	24855.24	12479.6	6543.82	3251.01	433.22
100/0	84441.14	76240.21	47896.19	25738.04	14463.72	7524.29	3817.22	481.43

4.2 SNIA Write Saturation Test

Here is the specification for the SNIA Write Saturation Test we perform, presented in the style adopted in the SSS PTS –

SNIA Write Saturation Test

For Active Range (0:100)

1) Purge the device

2) Set Test parameters and record for later reporting
   - a) Write Cache = Disabled
   - b) OIO/Thread = 1
   - c) Thread Count = 32
   - d) Data Pattern = 100% Entropy
   - e) Read/Write % = 0/100, Block Size = 4K

4) Run the following test loop until 4 x User Capacity is written, or 24 hours, whichever is less
   Execute random IO, per (R/W Mix%, Block Size) for 1 minute
   Record Ave IOPS
   Record Max and Ave Latency

5) Process and plot the accumulated Rounds data

End For Active Range

Some observations:

- The mandatory test requires the IO Range to be the full user capacity of the drive (the full LBA).

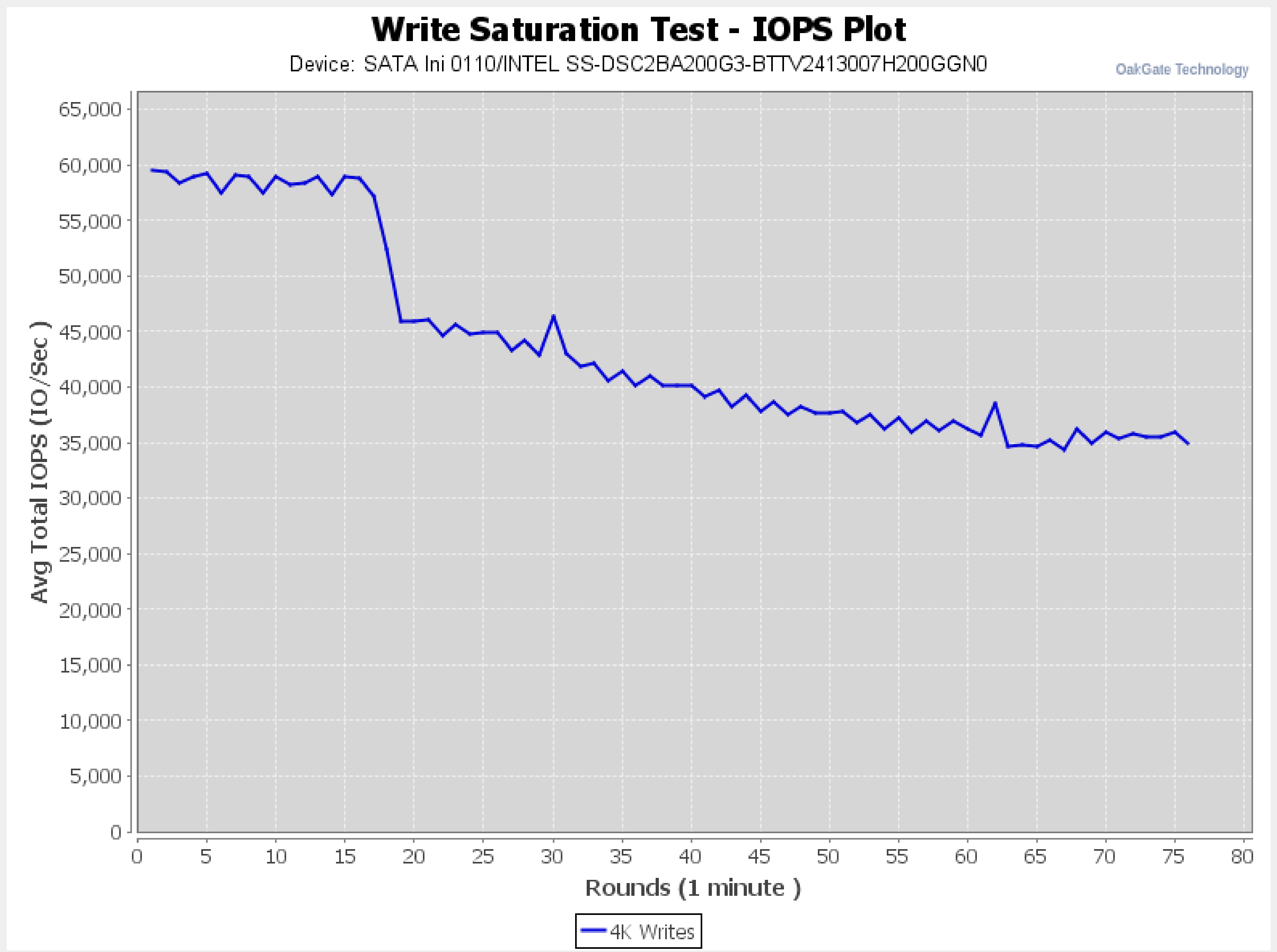
- Step 3 demands that the 1 minutes test rounds should be run for whichever is the lesser of the time it takes to write until 4 x User Capacity, or for 24 hours. Of course if one's test bench doesn't have the ability to detect that the time to write 4 x User Capacity occurs before 24 hours, one must run the test for at least 24 hours. Again, fortunately for us, the Okgate Test bench automatically detects that 4 x User Capacity has been hit

SNIA Write Saturation Test Reporting Artefacts

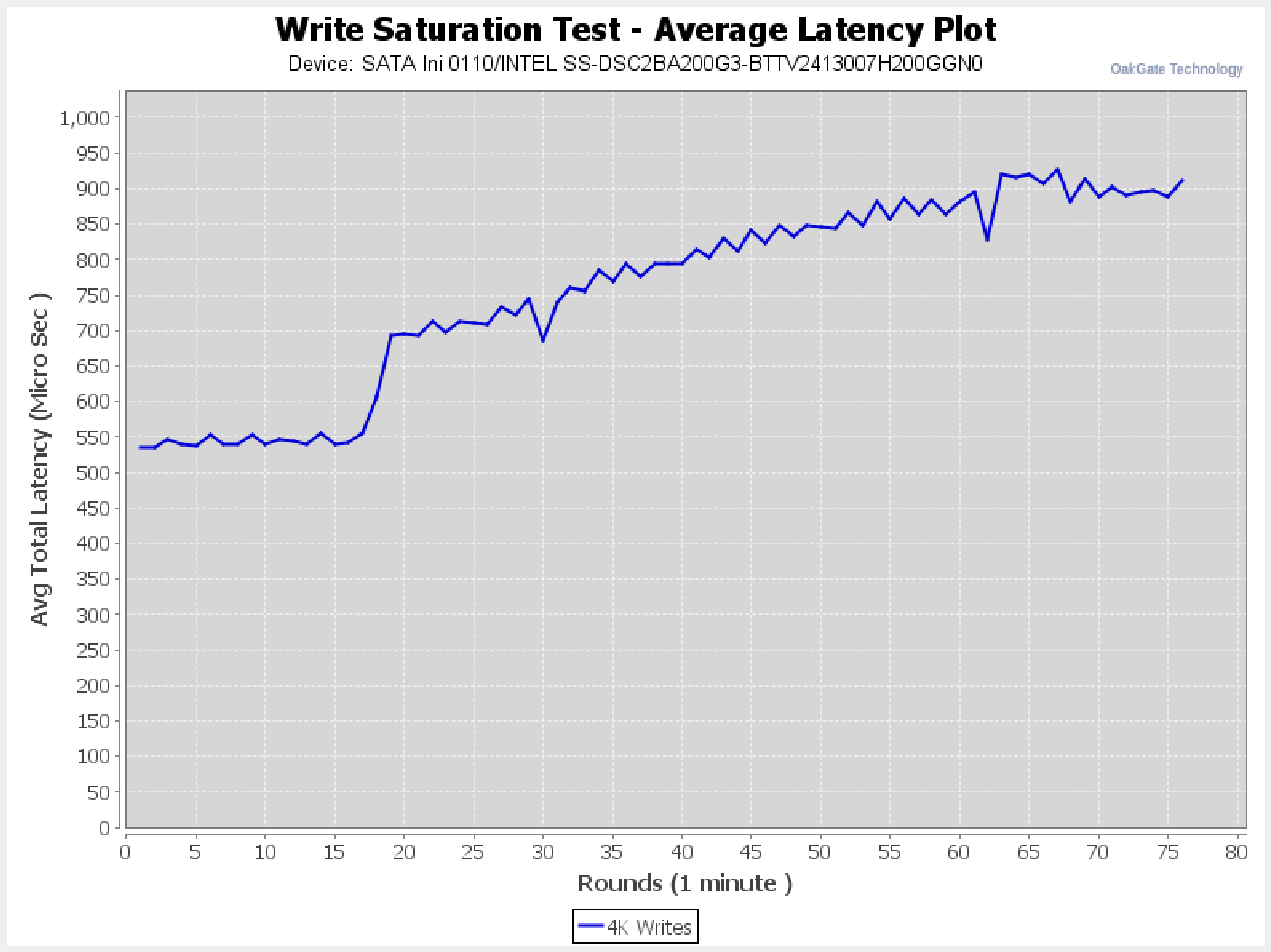
Once again it is easier for me and you if I show you examples of the reporting artefacts that are automatically produced by the OakGate Test Bench and will be included in Myce's reviews, which accurately meet the reporting requirements as specified in the SSS PTS.

Write Saturation
Summary Report Page

SNIA SSS PTS v1.0		Test Run Date:15 May 2013 17:52:24	
Test Parameters		SSS Solution under Test	
Purge Type	Secure Erase	Manufacturer	Intel
Active Range	0-100%	Model	SSD DC S3700
Queue Depth	32 IOs	Firmware	5DV1
Data Pattern	Entropy 100%	User Capacity	200GB
Write Cache	Disabled		
		Test Platform	
		Manufacturer	OakGate
		Motherboard	Asus
		CPU	Intel Core i5-3470 3.20GHz
		DRAM Type	DDR3
		DRAM Amount	8GB



Write Saturation Test - IOPS Plot
Device: SATA Ini 0110/INTEL SS-DSC2BA200G3-BTTV2413007H200GGN0
OakGate Technology
Avg Total IOPS (IO/Sec)
65,000
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Rounds (1 minute)
4K Writes


Write Saturation Test - Average Latency Plot
Device: SATA Ini 0110/INTEL SS-DSC2BA200G3-BTTV2413007H200GGN0
OakGate Technology
Avg Total Latency (Micro Sec)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Rounds (1 minute)
4K Writes

4.3 SNIA Throughput Test

Here is the specification for the SNIA Throughput Test we perform, presented in the style adopted in the SSS PTS -

```
                    SNIA Throughput Test

For Active Range (0:100)

For (Block Size = 1024K, 64K, 8K, 4K, 0.5K)

        1) Purge the device

        2) Set Test parameters and record for later reporting
                a) Write Cache = Disabled
                b) OIO/Thread = 1
                c) Thread Count = 32
                d) Data Pattern = 100% Entropy

        4) Run the following test loop until Steady State is achieved, or maximum 25 Rounds
                For (R/W Mix % = 100/0, 0/100)
                        Execute Sequential IO, per (R/W Mix%, Block Size) for 1 minute
                        Record Ave MB/s

                Use Ave MB/s (R/W Mix%, Block Size) to detect Steady State

End (For Block Size) loop

End For Active Range
```

The rules for verification of the achievement of steady state in step 3 are also specified, which I detail as follows –

Throughput - Steady State Determination

For each Blocksize

Steady State for Write Throughput is determined by the Ave Sequential Write MBs from each round (the 'Round Value')

For the Round Values from the current round to current – 4 (the 'Measurement Window')

Calculate the average of the Round Values (the Ave Measurement Window Value)
Calculate the 'Allowed Range' as +/- 10% of the Ave Measurement Window Value

Do all of the Round Values fall inside the Allowed Range?
Is the slope of the best linear fit through the Round Values <= 10%?

If the answers to both of these questions is Yes then Steady State is deemed to be achieved, for the specific block size, in the Measurement Window

Use the Ave Measurement Window Value to report

Steady State for Read Throughput is determined by the Ave Sequential Read MBs from each round (the 'Round Value')

For the Round Values from the current round to current – 4 (the 'Measurement Window')

Calculate the average of the Round Values (the Ave Measurement Window Value)
Calculate the 'Allowed Range' as +/- 10% of the Ave Measurement Window Value

Do all of the Round Values fall inside the Allowed Range?
Is the slope of the best linear fit through the Round Values <= 10%?

If the answers to both of these questions is Yes then Steady State is deemed to be achieved, for the specific block size, in the Measurement Window

Use the Ave Measurement Window Value to report

An observation:

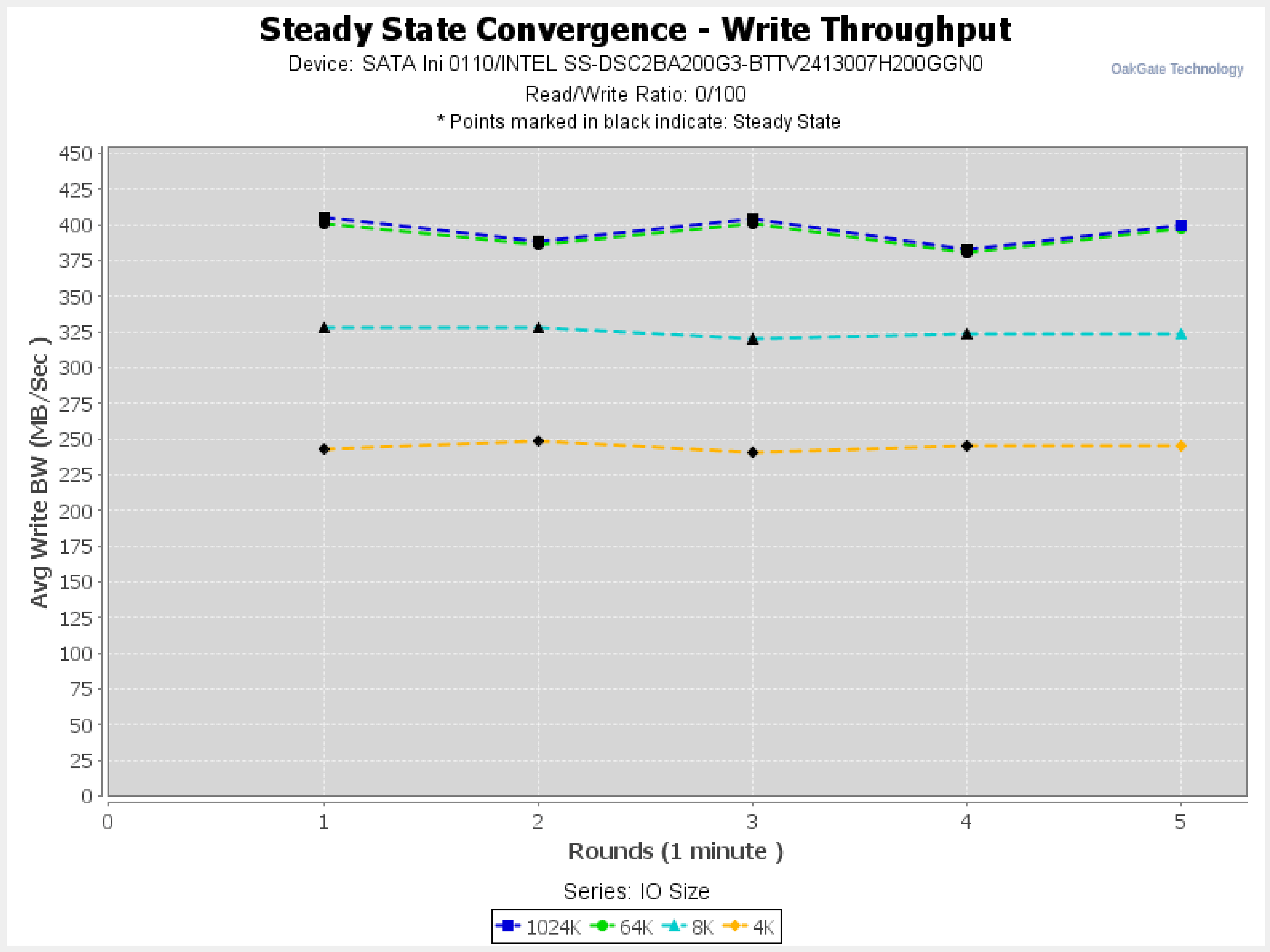
- Determining the achievement of Steady State is particularly complex in this test as it may be achieved at a different stage for each block size and at a different stage for read and write throughput – again, thankfully this is automated by the OakGate Test Bench.

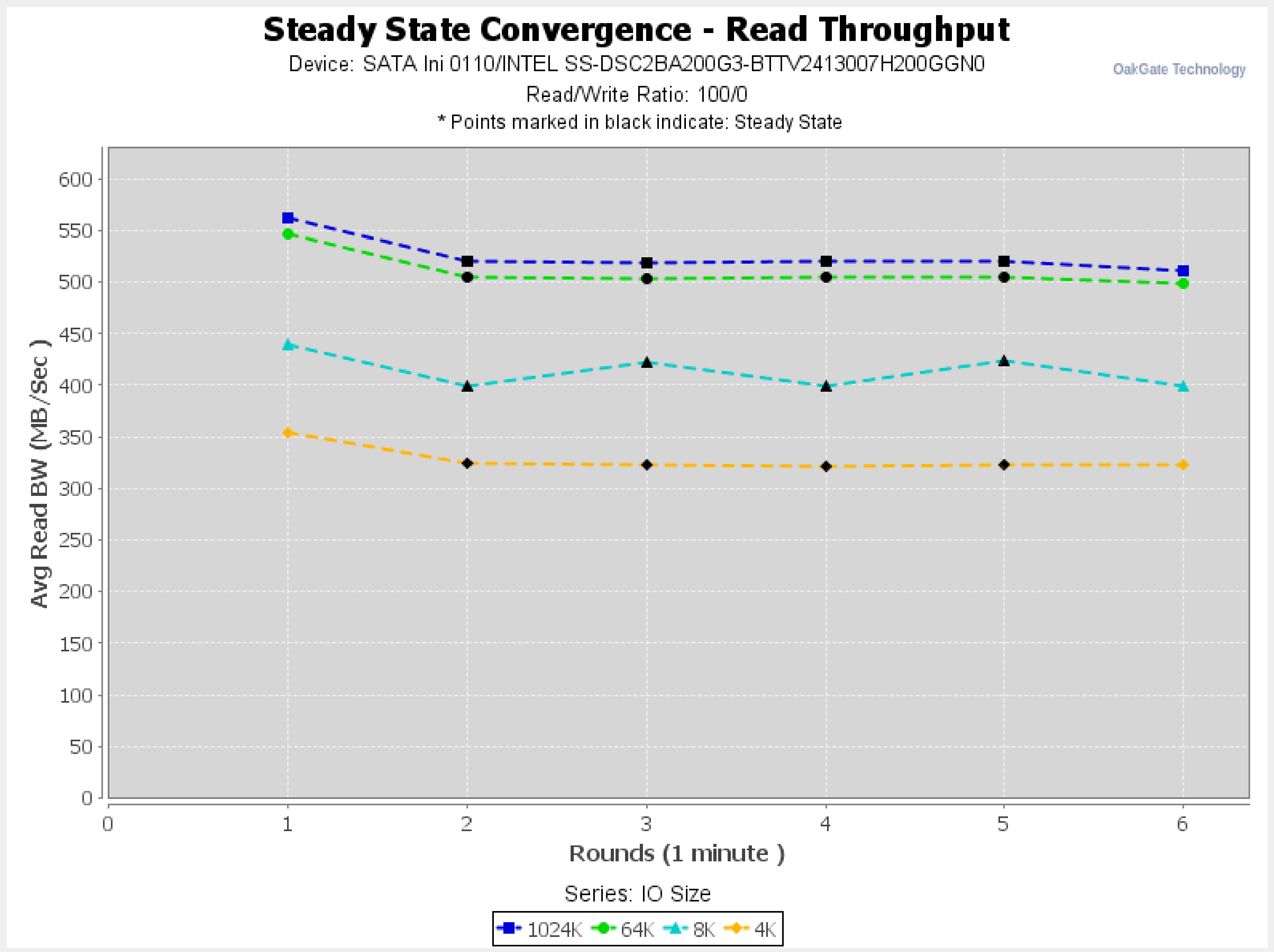
SNIA Throughput Test Reporting Artefacts

And, once again, it is easier for me and you if I show you examples of the reporting artefacts that are automatically produced by the OakGate Test Bench and will be included in Myce's reviews, which accurately meet the requirements as specified in the SSS PTS –

Throughput Summary Report Page			
SNIA SSS PTS v1.0		Test Run Date:15 May 2013 17:52:24	
Test Parameters		SSS Solution under Test	
Purge Type	Secure Erase	Manufacturer	Intel
Active Range	0-100%	Model	SSD DC S3700
Queue Depth	32 IOs	Firmware	5DV1
Data Pattern	Entropy 100%	User Capacity	200GB
Write Cache	Disabled		
		Test Platform	
		Manufacturer	OakGate
		Motherboard	Asus
		CPU	Intel Core i5-3470 3.20GHz
		DRAM Type	DDR3
		DRAM Amount	8GB

Steady State Validation Table			
SNIA SSS PTS v1.0		Test Run Date:15 May 2013 17:52:24	
0/100	Round Achieved	Value	Max Allowed
4K RNG/Slope	5	0.03/0.00%	0.20/10%
8K RNG/Slope	5	0.03/0.00%	0.20/10%
64K RNG/Slope	5	0.05/0.00%	0.20/10%
1024K RNG/Slope	5	0.06/0.00%	0.20/10%
100/0	Round Achieved	Value	Max Allowed
4K RNG/Slope	6	0.01/0.00%	0.20/10%
8K RNG/Slope	6	0.06/0.00%	0.20/10%
64K RNG/Slope	6	0.01/0.00%	0.20/10%
1024K RNG/Slope	6	0.02/0.00%	0.20/10%


Steady State Convergence - Write Throughput
Device: SATA Ini 0110/INTEL SS-DSC2BA200G3-BTTV2413007H200GGN0
Read/Write Ratio: 0/100
* Points marked in black indicate: Steady State
OakGate Technology
Avg Write BW (MB/Sec)
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
0
1
2
3
4
5
Rounds (1 minute)
Series: IO Size
1024K
64K
8K
4K



myce
OakGate Technology

Measurement Window Summary Data Table			
SNIA SSS PTS v1.0		Test Run Date:15 May 2013 17:52:24	
		Average MB/s	
Block Size		0/100 (Reads)	100/0 (Writes)
4K		244.85	323.52
8K		324.56	408.51
64K		393.14	503.34
1024K		396.04	518.27

4.4 SNIA Latency Test

Here is the specification for the SNIA Latency Test we perform, presented in the style adopted in the SSS PTS –

SNIA Latency Test

For Active Range (0:100)

1) Purge the device

2) Workload Independent Preconditioning

3) Set Test parameters and record for later reporting
   - a) Write Cache = Disabled
   - b) OIO/Thread = 1
   - c) Thread Count = 32
   - d) Data Pattern = 100% Entropy

4) Run the following test loop until Steady State is reached, or maximum of 25 Rounds

   For (R/W Mix % = 100/0, 65/35, 0/100)

      For (Block Size = 8K, 4K, 0.5K)

         Execute random IO, per (R/W Mix%, Block Size) for 1 minute

         Record Max and Ave Latency (R/W Mix %, Block Size)

   Use Ave Latency (R/W Mix % = 0/100, Block Size= 4K) to detect Steady State

5) Process and plot the accumulated Rounds data

End For Active Range

The rules for verification of the achievement of steady state in step 4 are also specified, which I detail as follows –

Latency - Steady State Determination

Steady State is determined by the Ave 4K Random Write Latency from each round (the 'Round Value')

For the Round Values from the current round to current – 4 (the 'Measurement Window')

Calculate the average of the Round Values (the Ave Measurement Window Value)
Calculate the 'Allowed Range' as +/- 10% of the Ave Measurement Window Value

Do all of the Round Values fall inside the Allowed Range?
Is the slope of the best linear fit through the Round Values <= 10%?

If the answers to both of these questions is Yes then Steady State is deemed to be achieved in the Measurement Window

Use the Ave Measurement Window Values to report

An observation:

Step 4 specifies that each combination Read Write mix and Blocksize must be run for 1 minute in each Round and that each Round should be repeated 25 times, or until Steady State is reached. As you may have come to expect by now - the OakGate Test Bench very cleverly automates checking for the transition to steady state.

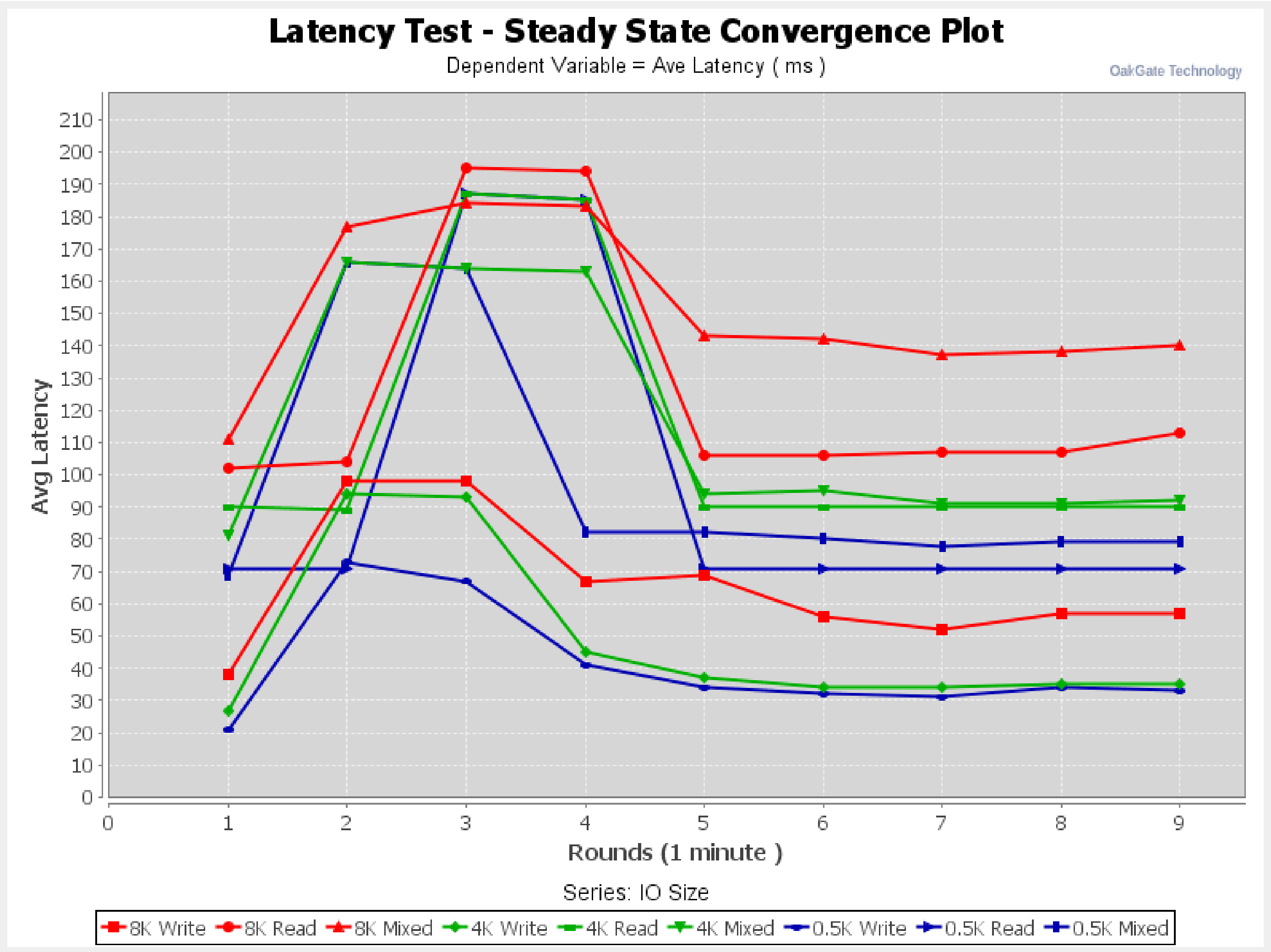
SNIA Latency Test Reporting Artefacts

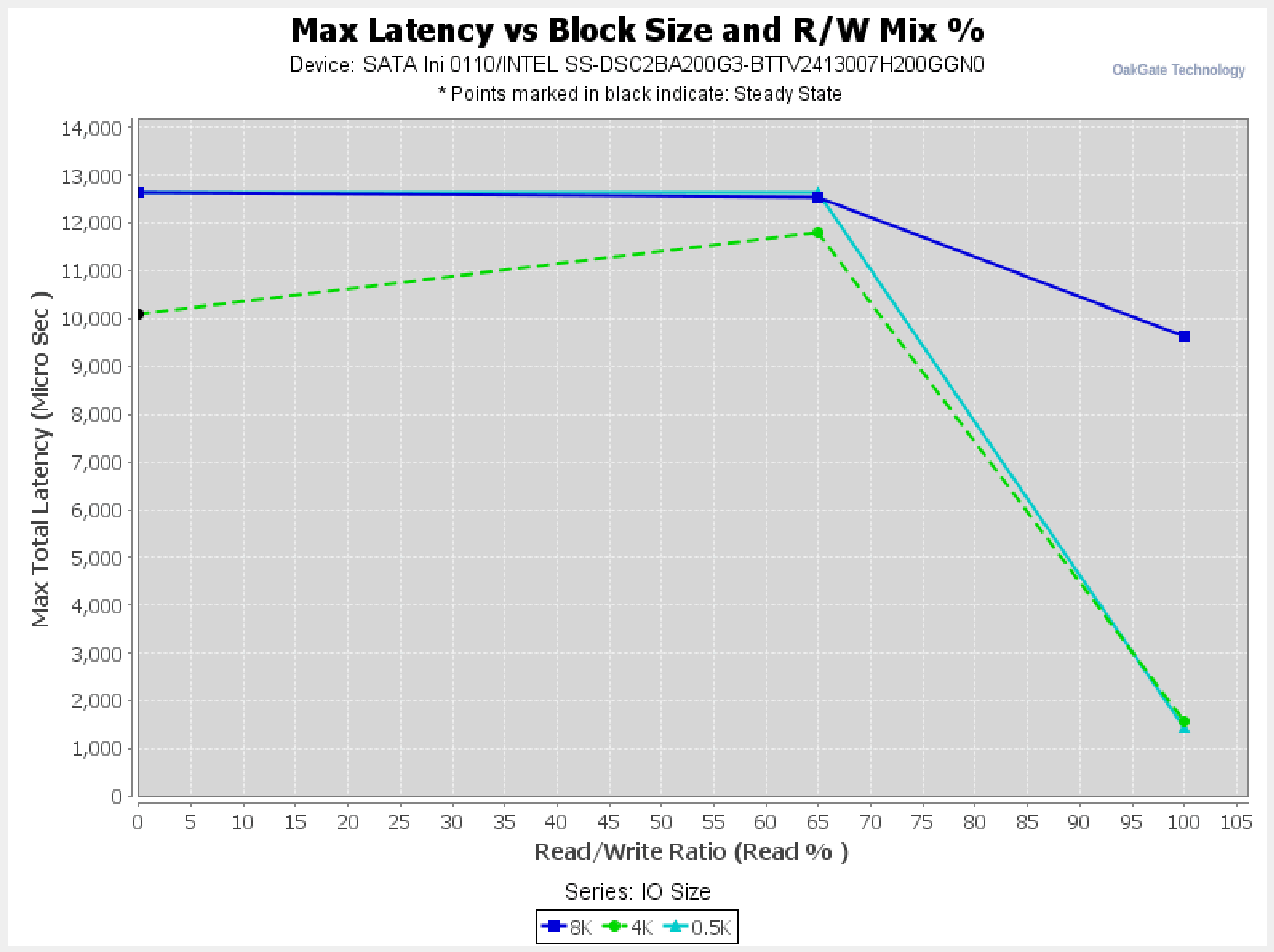
And, once again, it is easier for me and you if I show you examples of the reporting artefacts that are automatically produced by the OakGate Test Bench and will appear in Myce’s reviews, which accurately meet the requirements as specified in the SSS PTS –

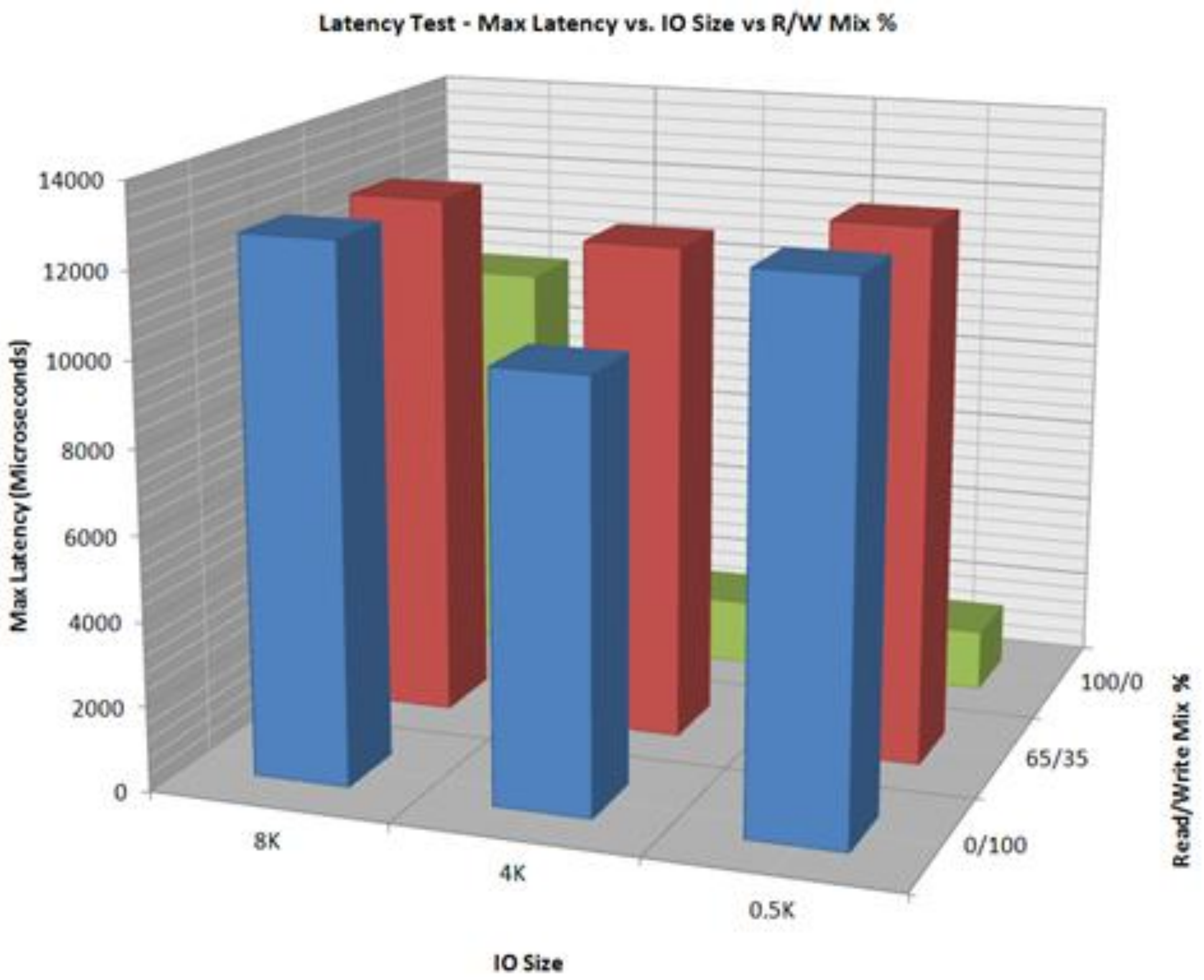
Latency Summary Report Page			
SNIA SSS PTS v1.0		Test Run Date:15 May 2013 17:52:24	
Test Parameters		SSS Solution under Test	
Purge Type	Secure Erase	Manufacturer	Intel
Active Range	0-100%	Model	SSD DC S3700
Queue Depth	1 IOs	Firmware	5DV1
Data Pattern	Entropy 100%	User Capacity	200GB
Write Cache	Disabled		
Workload Indepenent Preconditioning	Write 2xUser Capacity 128K Seq	Test Platform	
		Manufacturer	OakGate
		Motherboard	Asus
		CPU	Intel Core i5-3470 3.20GHz
		DRAM Type	DDR3
		DRAM Amount	8GB

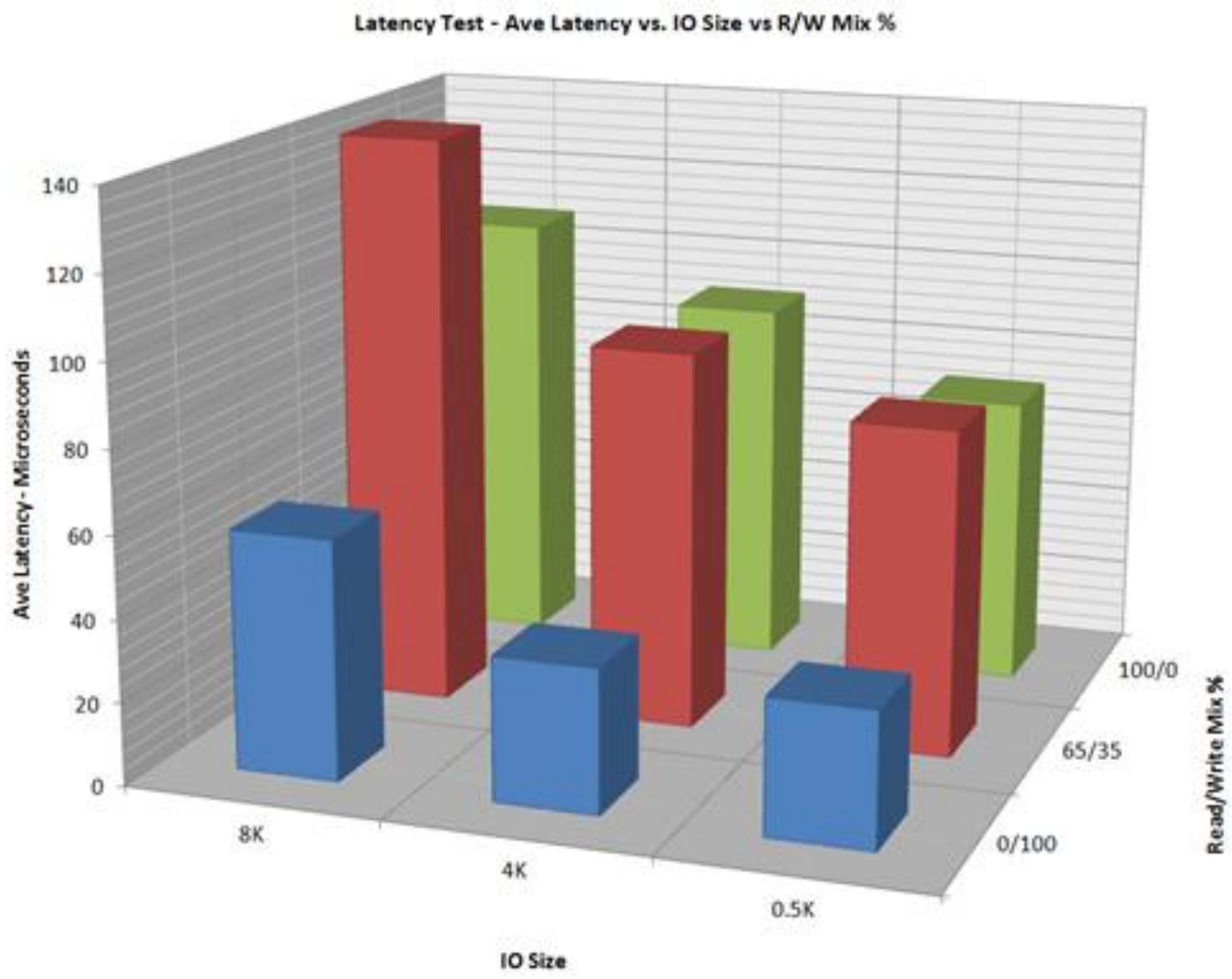
Latency Rounds Data

		Average Latency			Maximum Latency		
Round	Block Size	100/0	65/35	0/100	100/0	65/35	100/0
5	8K	0.11	0.14	0.07	8.44	11.84	9.20
5	4K	0.09	0.09	0.04	0.74	10.34	5.69
5	0.5K	0.07	0.08	0.03	0.92	12.53	11.65
6	8K	0.11	0.14	0.06	9.63	11.18	8.47
6	4K	0.09	0.10	0.03	0.92	10.80	5.88
6	0.5K	0.07	0.08	0.03	1.42	10.66	7.83
7	8K	0.11	0.14	0.05	1.45	12.55	12.65
7	4K	0.09	0.09	0.03	1.16	11.80	5.62
7	0.5K	0.07	0.08	0.03	1.25	10.67	7.05
8	8K	0.11	0.14	0.06	1.41	11.65	9.36
8	4K	0.09	0.09	0.04	1.32	9.82	10.10
8	0.5K	0.07	0.08	0.03	1.35	12.65	6.13
9	8K	0.11	0.14	0.06	7.19	11.93	8.07
9	4K	0.09	0.09	0.04	1.58	11.31	9.81
9	0.5K	0.07	0.08	0.03	1.45	10.71	12.66


Latency Test - Steady State Convergence Plot
Dependent Variable = Ave Latency (ms)
OakGate Technology
Avg Latency
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
Rounds (1 minute)
Series: IO Size
8K Write
8K Read
8K Mixed
4K Write
4K Read
4K Mixed
0.5K Write
0.5K Read
0.5K Mixed


Max Latency vs Block Size and R/W Mix %
Device: SATA Ini 0110/INTEL SS-DSC2BA200G3-BTTV2413007H200GGN0
* Points marked in black indicate: Steady State
OakGate Technology
Max Total Latency (Micro Sec)
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105
Read/Write Ratio (Read %)
Series: IO Size
8K
4K
0.5K


Latency Test - Max Latency vs. IO Size vs R/W Mix %
Max Latency (Microseconds)
14000
12000
10000
8000
6000
4000
2000
0
8K
4K
0.5K
IO Size
100/0
65/35
0/100
Read/Write Mix %


Latency Test - Ave Latency vs. IO Size vs R/W Mix %
Ave Latency - Microseconds
140
120
100
80
60
40
20
0
8K
4K
0.5K
IO Size
100/0
65/35
0/100
Read/Write Mix %

5 Myce/OakGate Full Characterisation Test Set - Background

I think readers will agree that the SNIA SSS PTS Enterprise Version 1.0 specifies a comprehensive set of tests. However, we feel that they fall somewhat short of illustrating the full character of a drive for our readers.

Therefore we also run an additional set of tests so that we are confident we provide a fuller characterisation. Credit for the design and implementation of these additional tests goes to Bob Weisickle and his team at OakGate. Myce is delighted to be able to capitalise on OakGate's extensive experience in the storage industry. We would welcome feedback from readers and manufacturers if you feel we should add other forms of performance testing.

We introduce our additional test set as follows:

5.1 Myce/OakGate 4K Read and Write Latency Tests

Continuing with the style adopted in the SNIA SSS PTS here are the specifications for our 4K Read and Write Latency Tests –

Myce / OakGate 4K Read Latency Test

For Active Range (0:100)

1) Purge the device

2) Preconditioning
   a) Queue Depth = 32, Data pattern = 0 Fill
   b) 4K Random Writes for 2 hours

4) Run the following test loop

   For IOPS = 1,000 to 120,000 in steps of 1000
      Execute 4K Random Reads, Queue Depth = 32, for 2 minutes
      Record Ave Read IOPS, Ave Read Latency, Max Read Latency

5) Process and plot the accumulated Rounds data

End For Active Range

Myce / OakGate 4K Write Test

For Active Range (0:100)

1) Purge the device

2) Preconditioning
   a) Queue Depth = 32, Data pattern = 0 Fill
   b) 4K Random Writes for 2 hours

4) Run the following test loop

   For IOPS = 1,000 to 120,000 in steps of 1000
      Execute 4K Random Writes, Queue Depth = 32, for 2 minutes
      Record Ave Write IOPS, Ave Write Latency, Max Write Latency

5) Process and plot the accumulated Rounds data

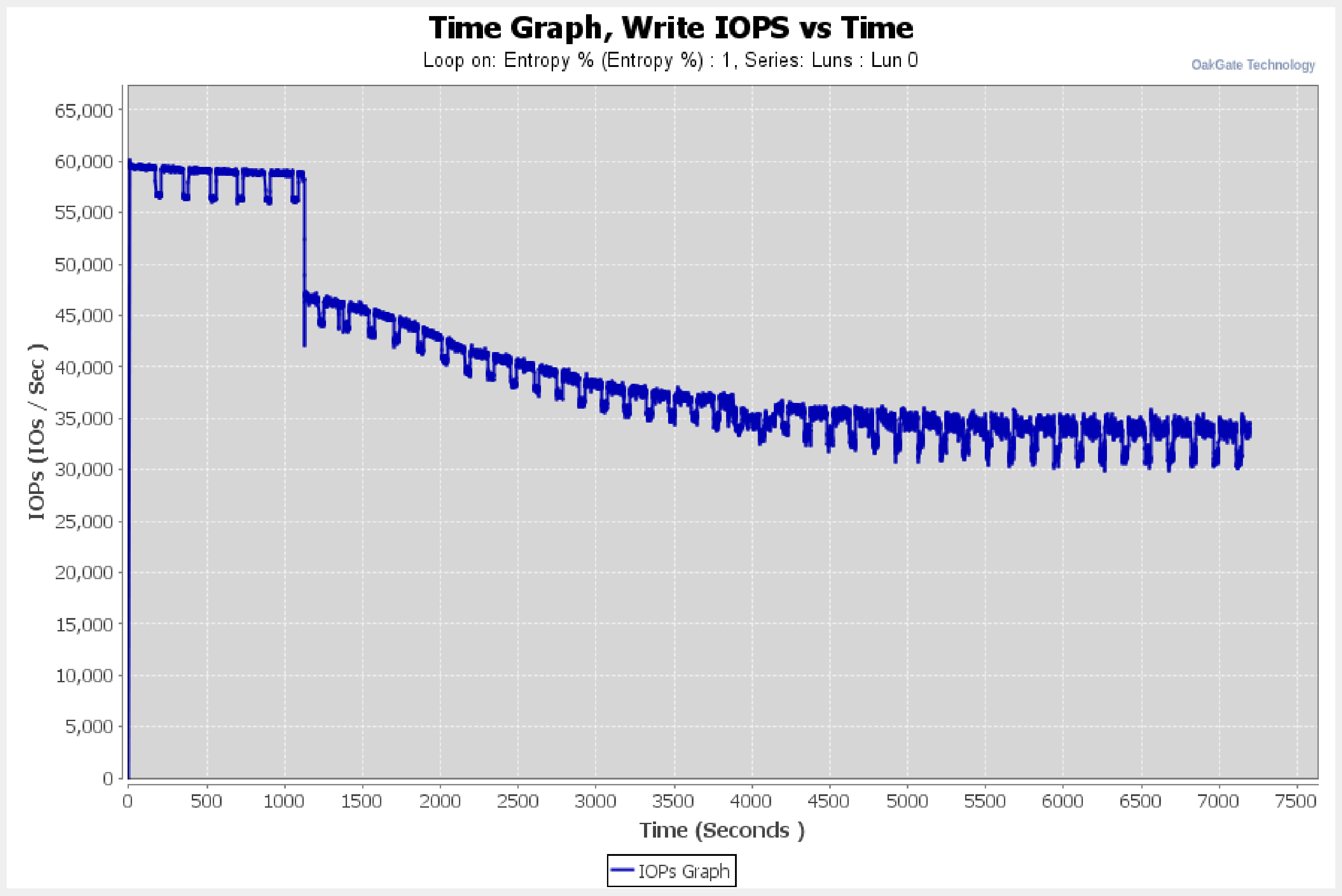
End For Active Range

These are very interesting tests as they increase the level of IO demand and record the drive's response to that demand. To visualise it, the tests increase the level of IOPS demand along the X axis whilst recording the drives response along the Y axis. Thus the results allow readers to judge how the drive would respond to the level of demand experienced in a specific environment.

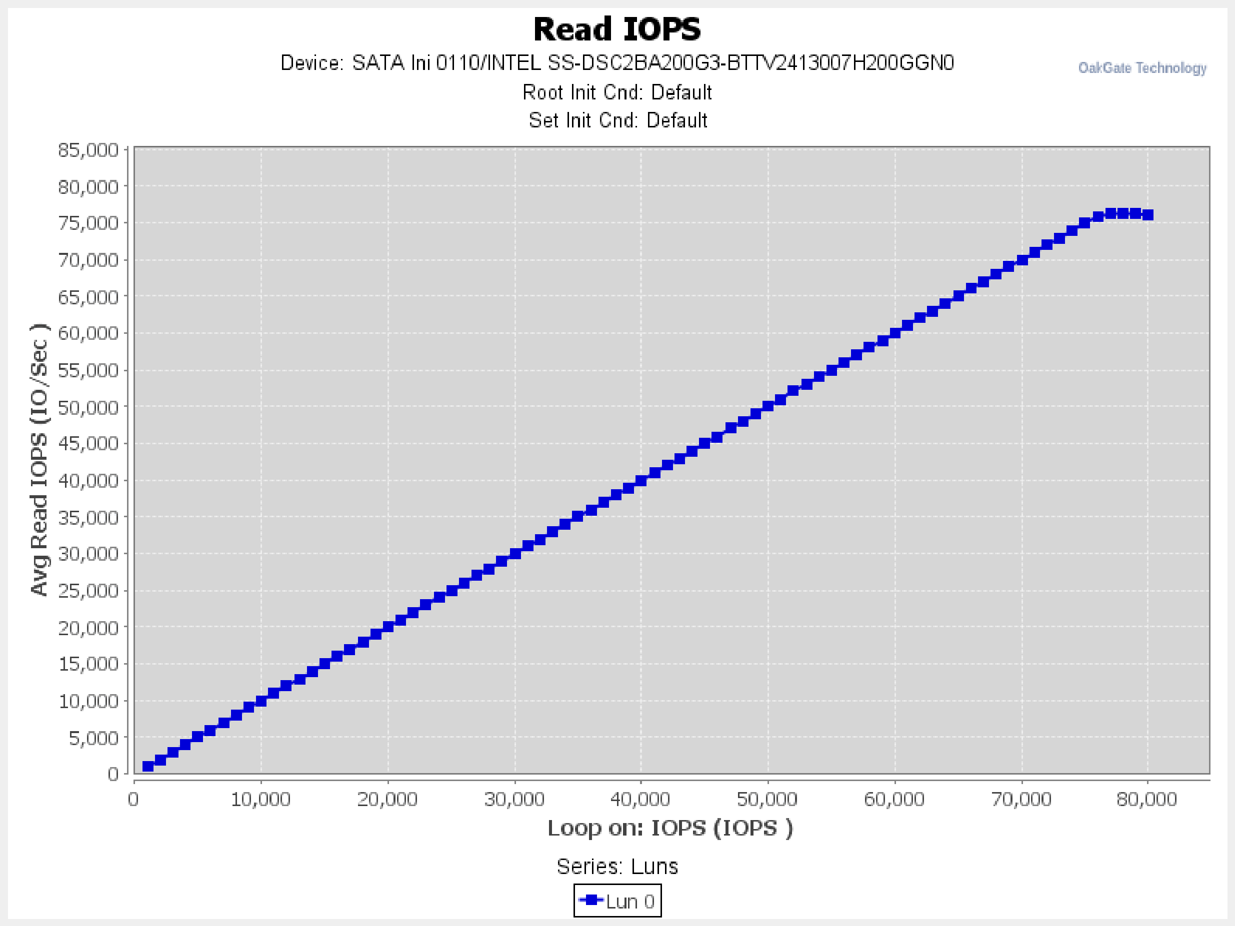
Myce/OakGate 4K Read and Write Latency Tests Reporting Artefacts

Here are examples of the reporting artefacts, automatically produced by the OakGate Test Unit, that Myce publishes –

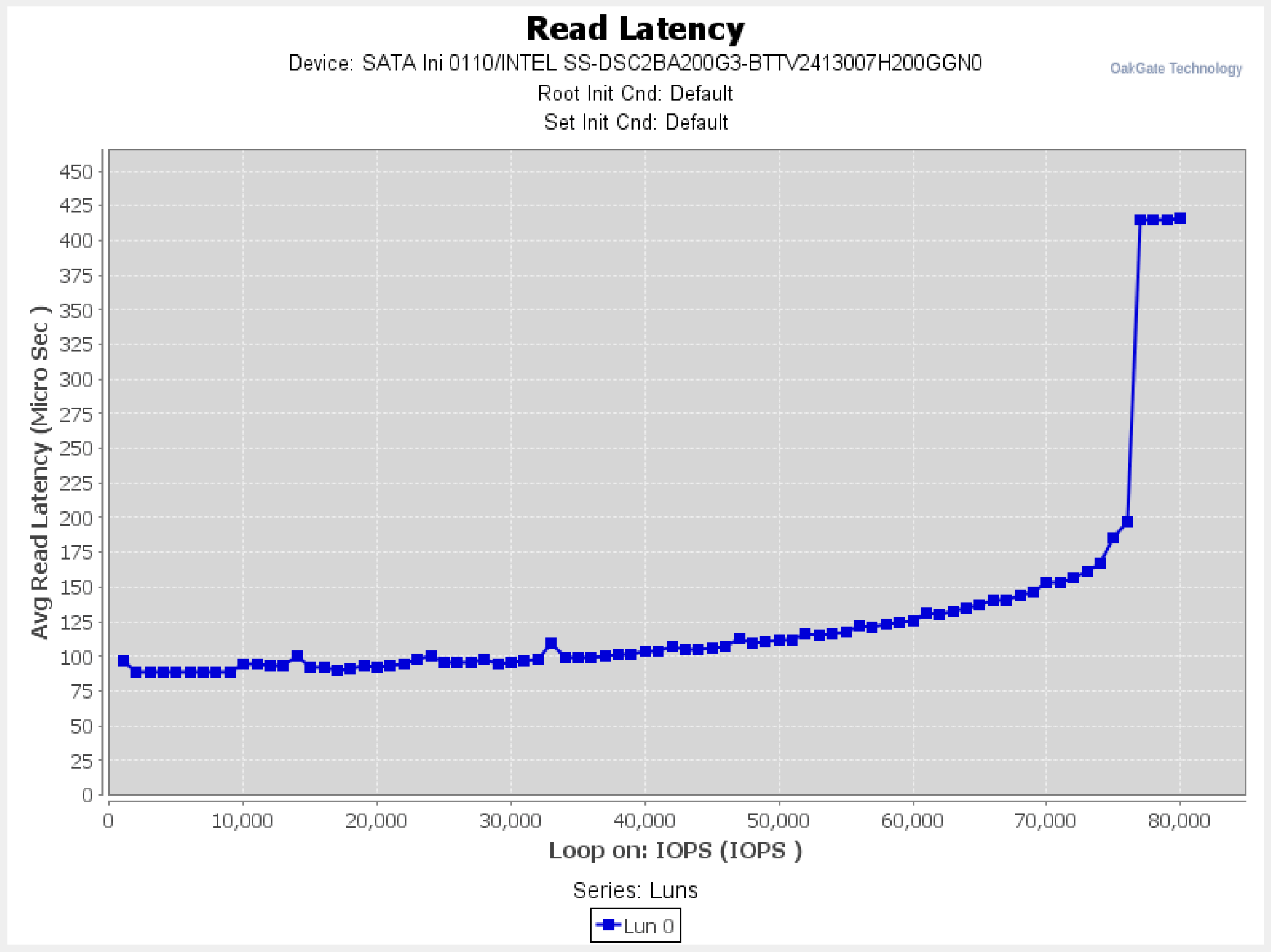
Firstly, this is an example showing the performance against time during the preconditioning step of the read test -


Time Graph, Write IOPS vs Time
Loop on: Entropy % (Entropy %) : 1, Series: Luns : Lun 0
OakGate Technology
IOPs (IOs / Sec)
65,000
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
Time (Seconds)
IOPs Graph

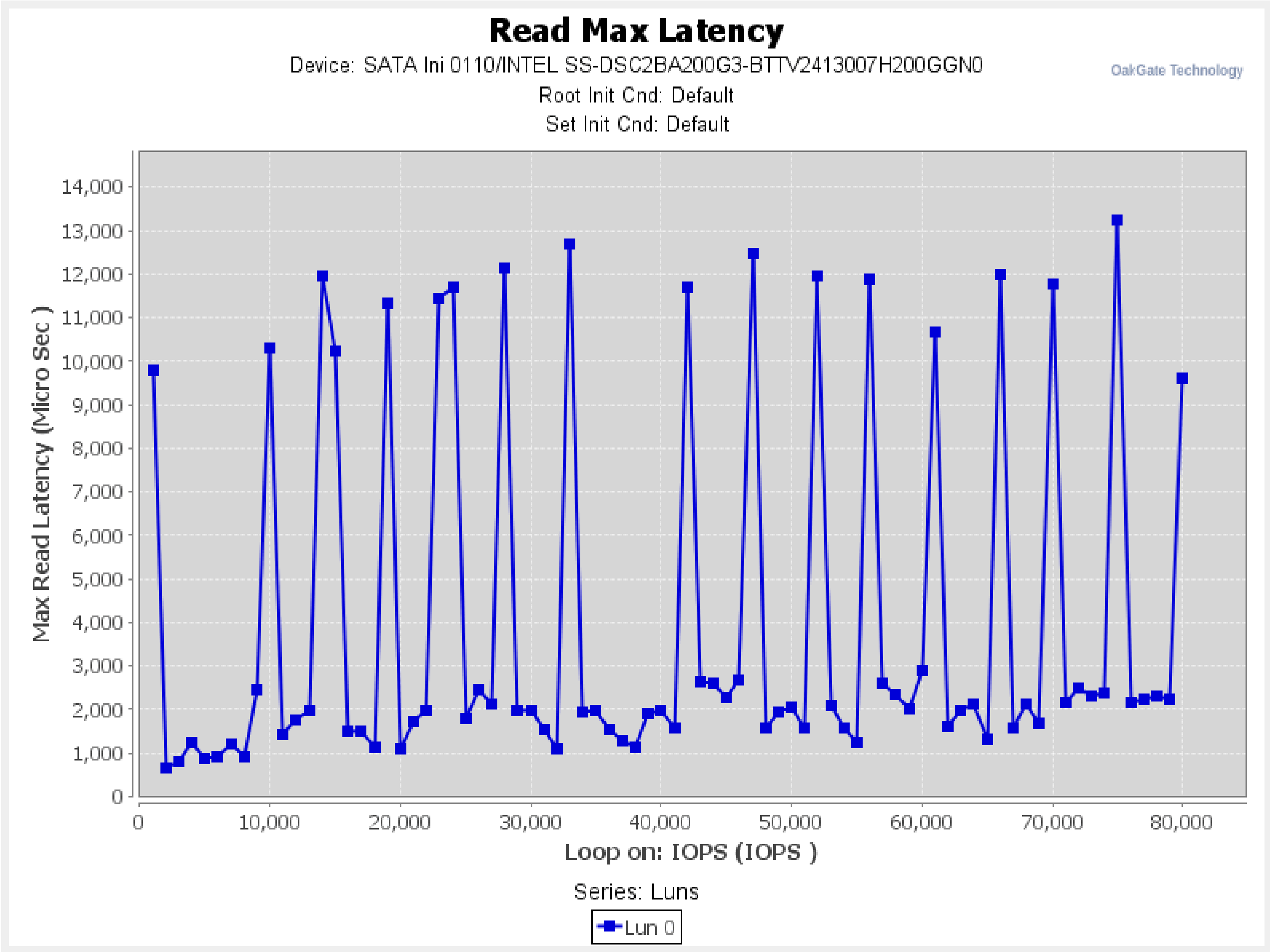
4K Latency Read Test



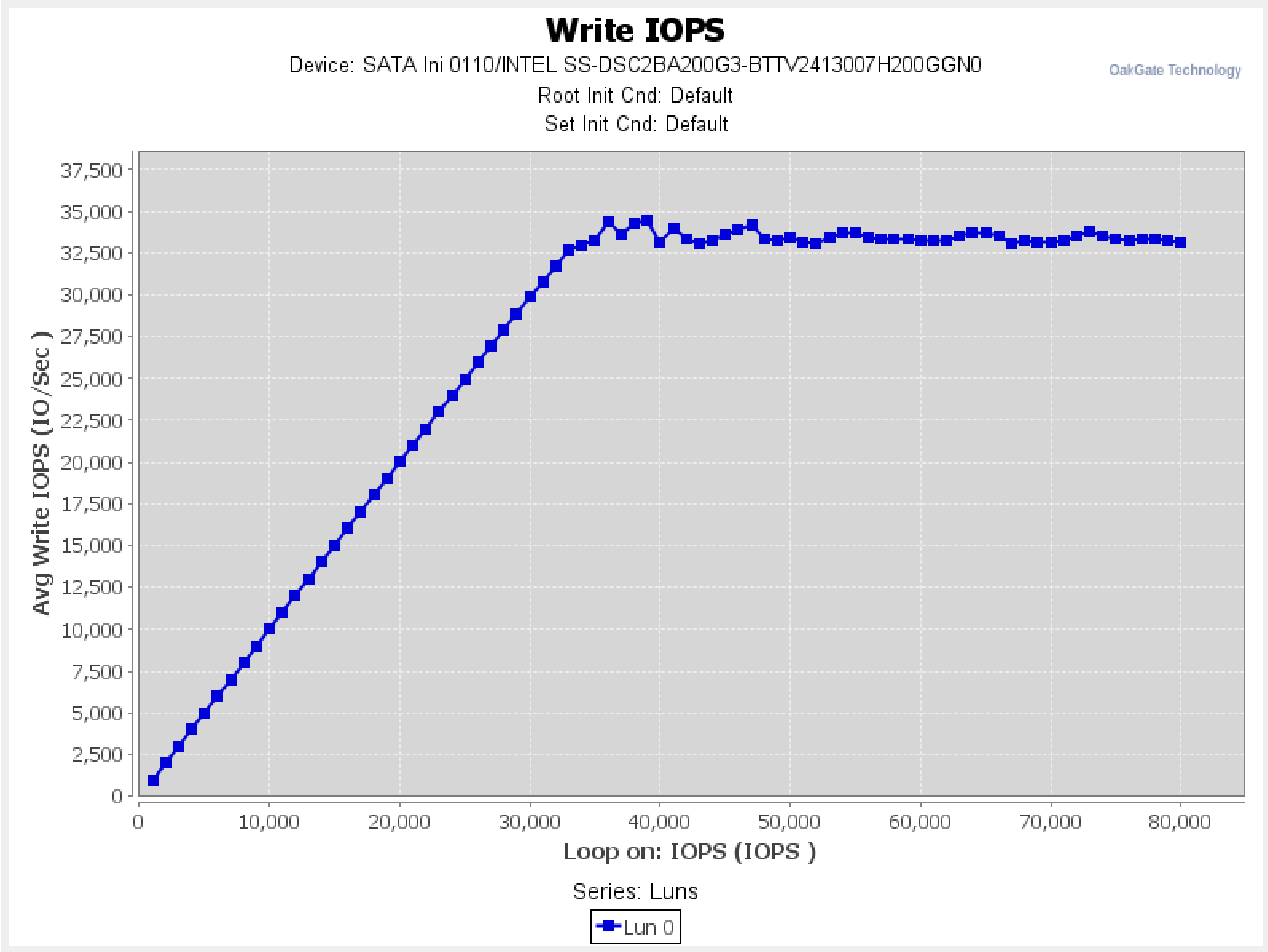
4K Latency Read Test



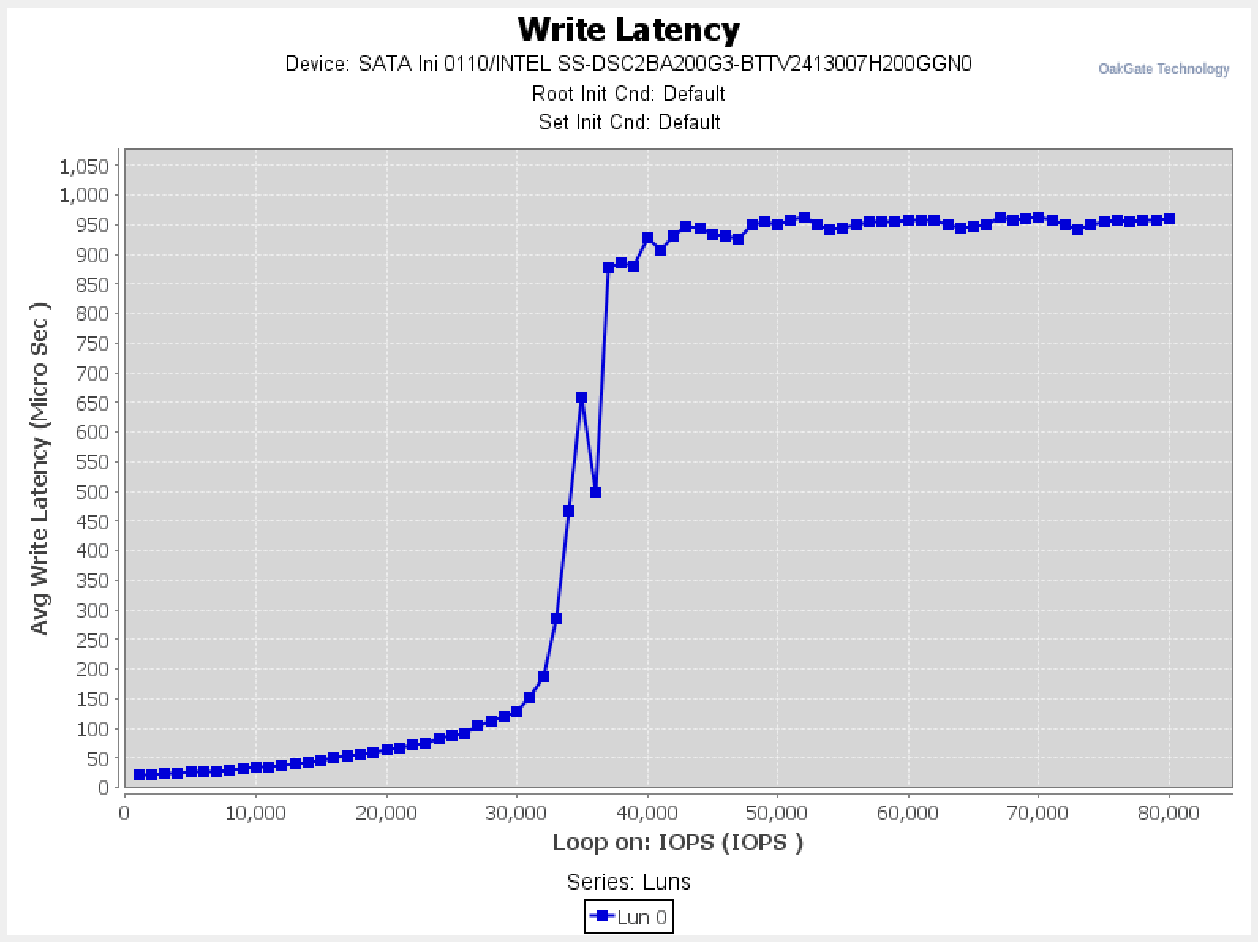
4K Latency Read Test



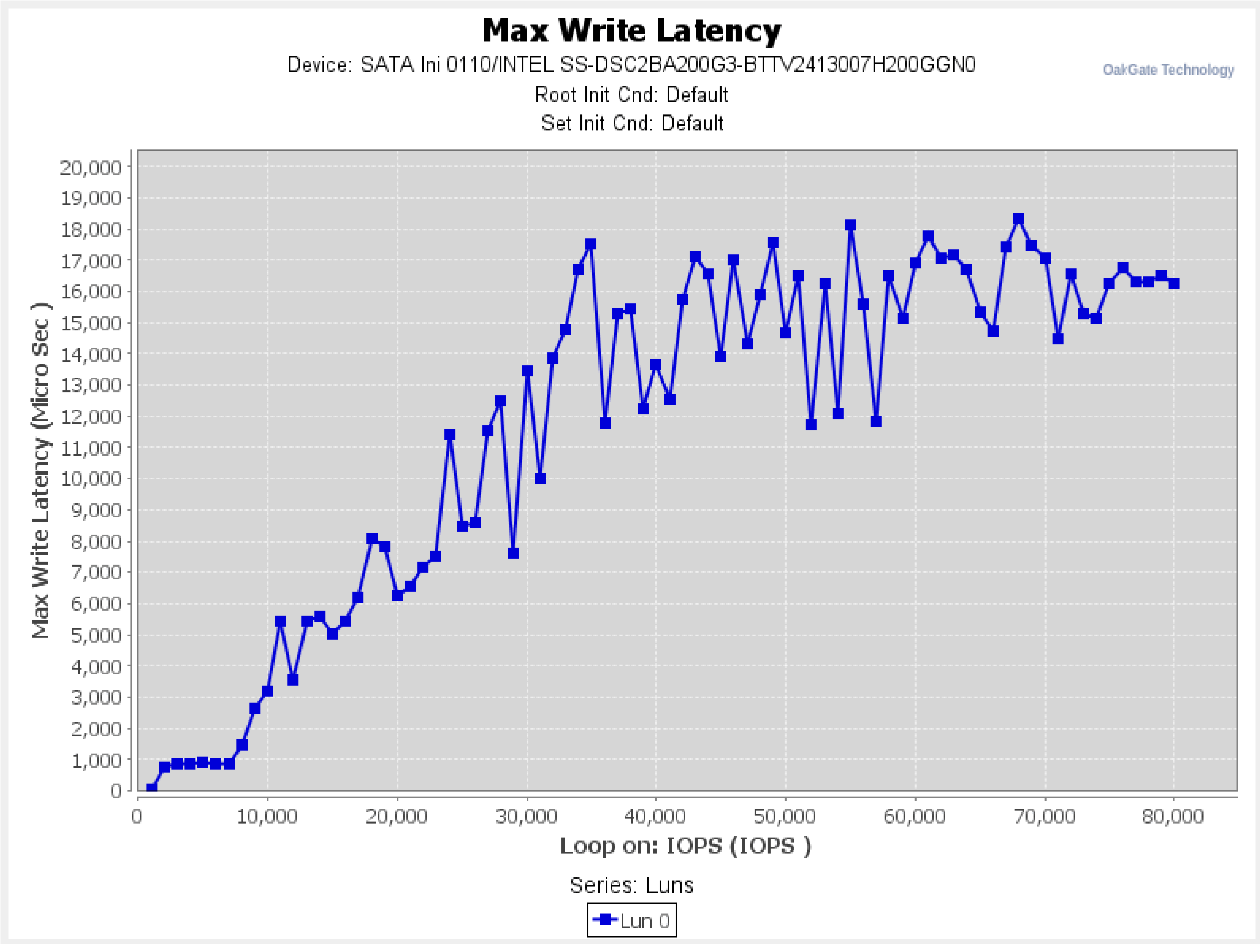
4K Latency Write Test



4K Latency Write Test



4K Latency Write Test



5.2 Myce/OakGate Reads and Writes Tests

Continuing with the style adopted in the SNIA SSS PTS here is the specification for our Reads and Writes Tests -

Myce / OakGate Reads Writes Tests

For Active Range (0:100)

1) Purge the device

2) Preconditioning
- a) Queue Depth = 32, Data pattern = 0 Fill
- b) 4K Random Writes for 2 hours

3) Random Reads
- For Queue Depth (4, 8, 16, 32, 64, 128)
  - For Block Size (0.5K, 1K, 2K, 4K, 8K, 16K, 32K)
    - Execute Random Reads for 5 minutes
    - Record Ave Read IOPS, Ave Read MBs, Ave Read Latency

4) Random Writes
- For Queue Depth (4, 8, 16, 32, 64, 128)
  - For Block Size (0.5K, 1K, 2K, 4K, 8K, 16K, 32K)
    - Execute Random Writes for 5 minutes
    - Record Ave Write IOPS, Ave Write MBs, Ave Write Latency

5) Sequential Reads
- For Queue Depth (4, 8, 16, 32, 64, 128)
  - For Block Size (0.5K, 1K, 2K, 4K, 8K, 16K, 32K)
    - Execute Sequential Reads for 5 minutes
    - Record Ave Read IOPS, Ave Read MBs, Ave Read Latency

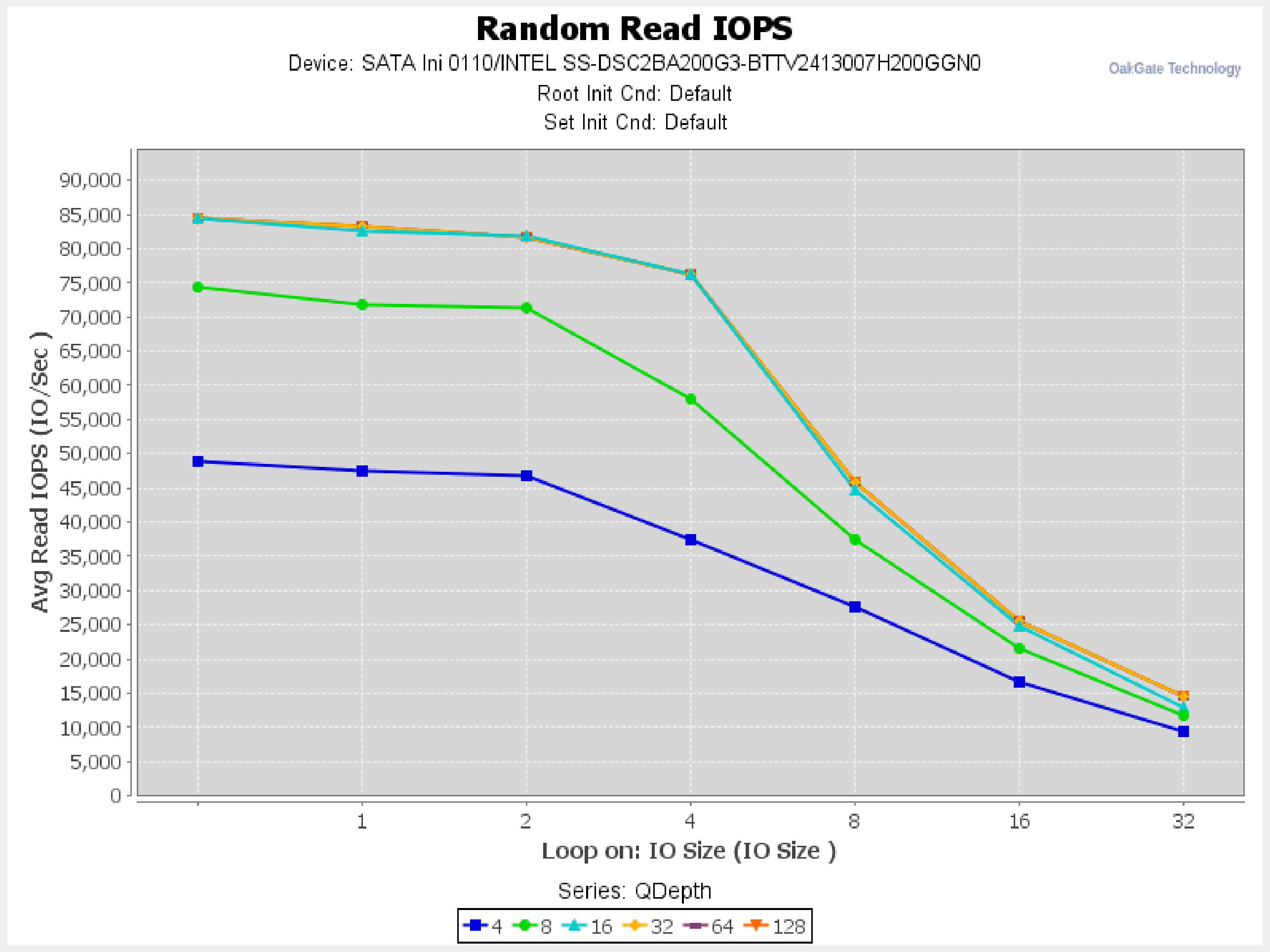
6) Sequential Writes
- For Queue Depth (4, 8, 16, 32, 64, 128)
  - For Block Size (0.5K, 1K, 2K, 4K, 8K, 16K, 32K)
    - Execute Sequential Writes for 5 minutes
    - Record Ave Write IOPS, Ave Write MBs, Ave Write Latency

End For Active Range

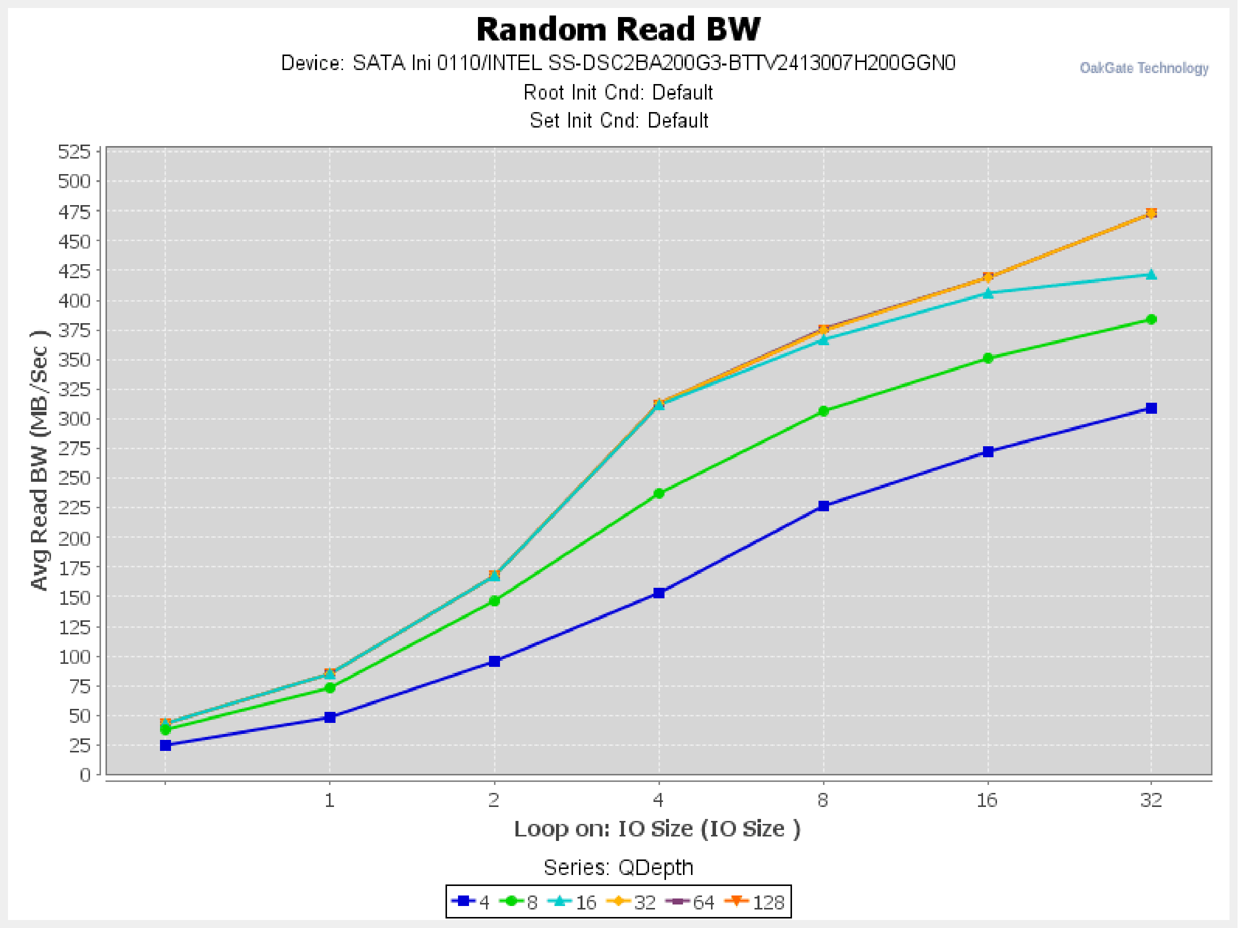
Myce/OakGate Reads and Writes Tests Reporting Artefacts

Here are examples of the Reporting Artefacts, automatically produced by the OakGate Test Unit, that Myce publishes –

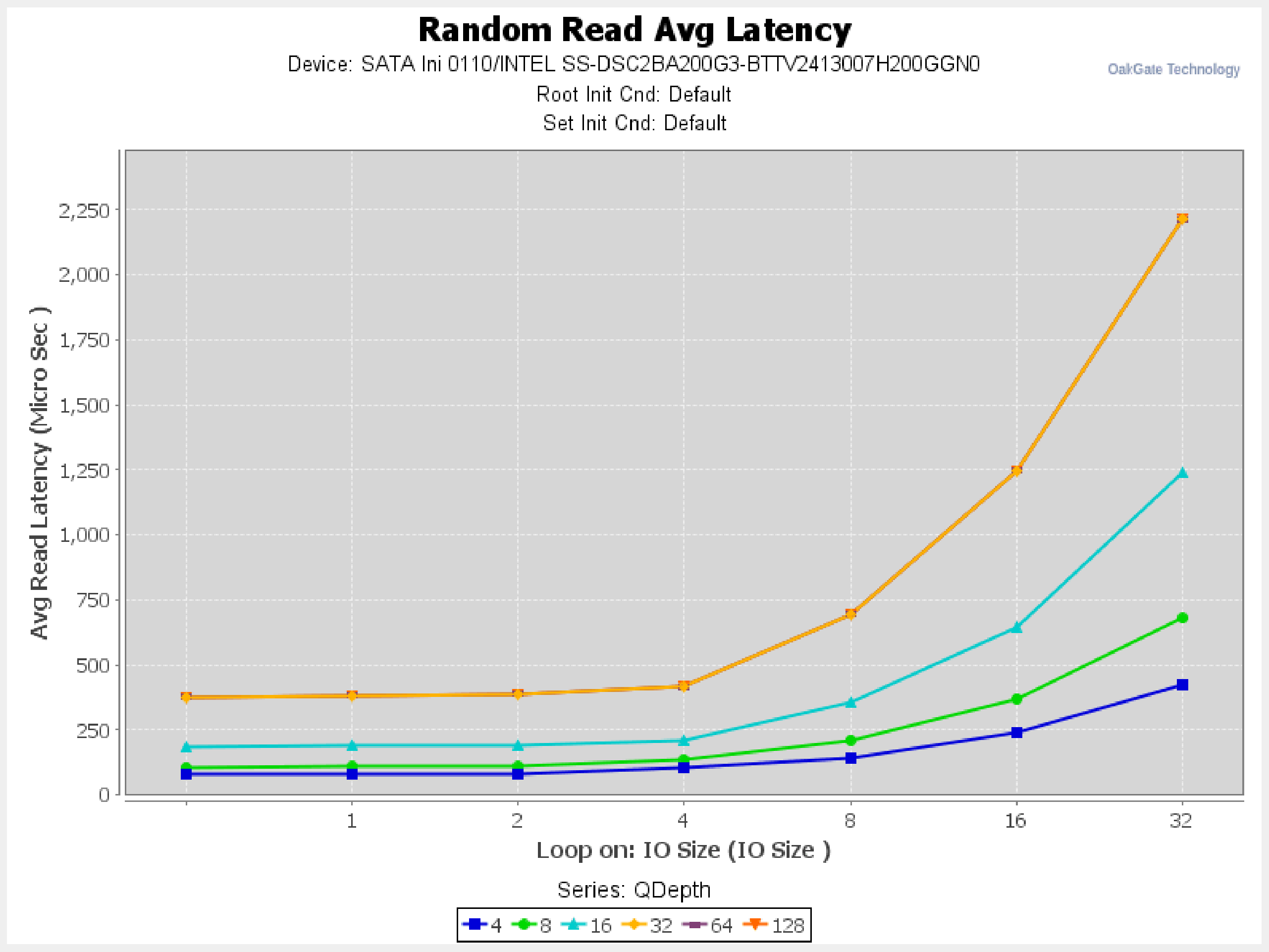
Random Reads



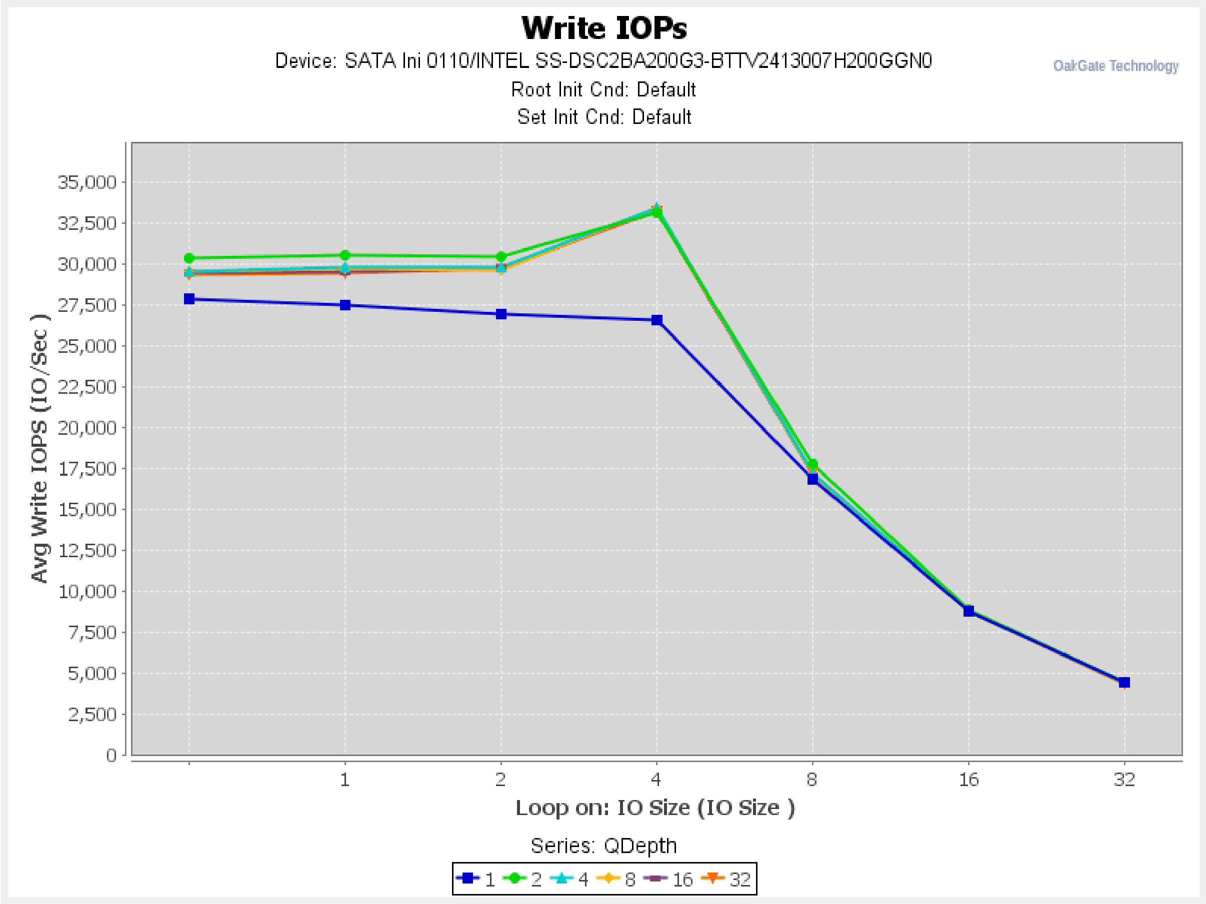
Random Reads



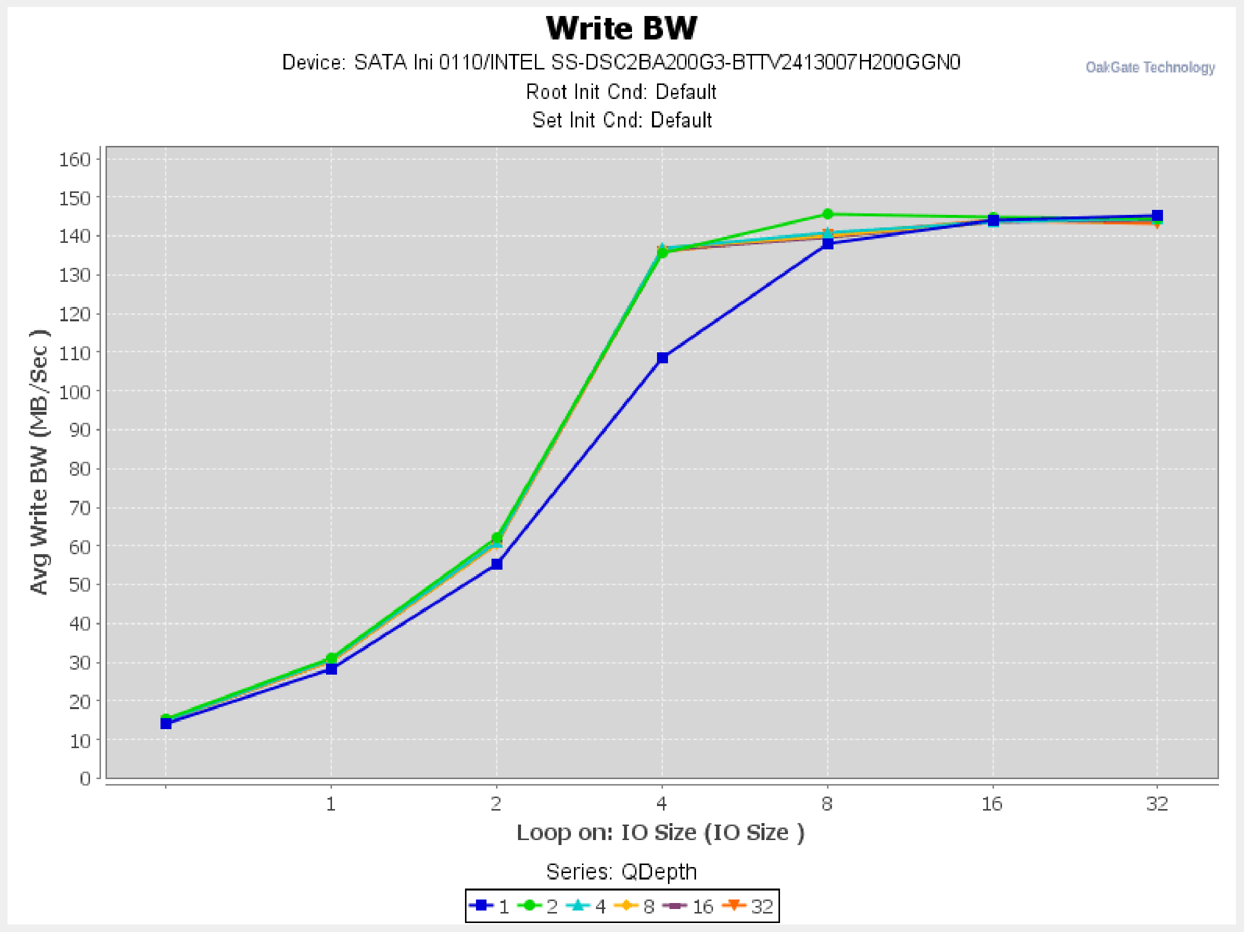
Random Reads



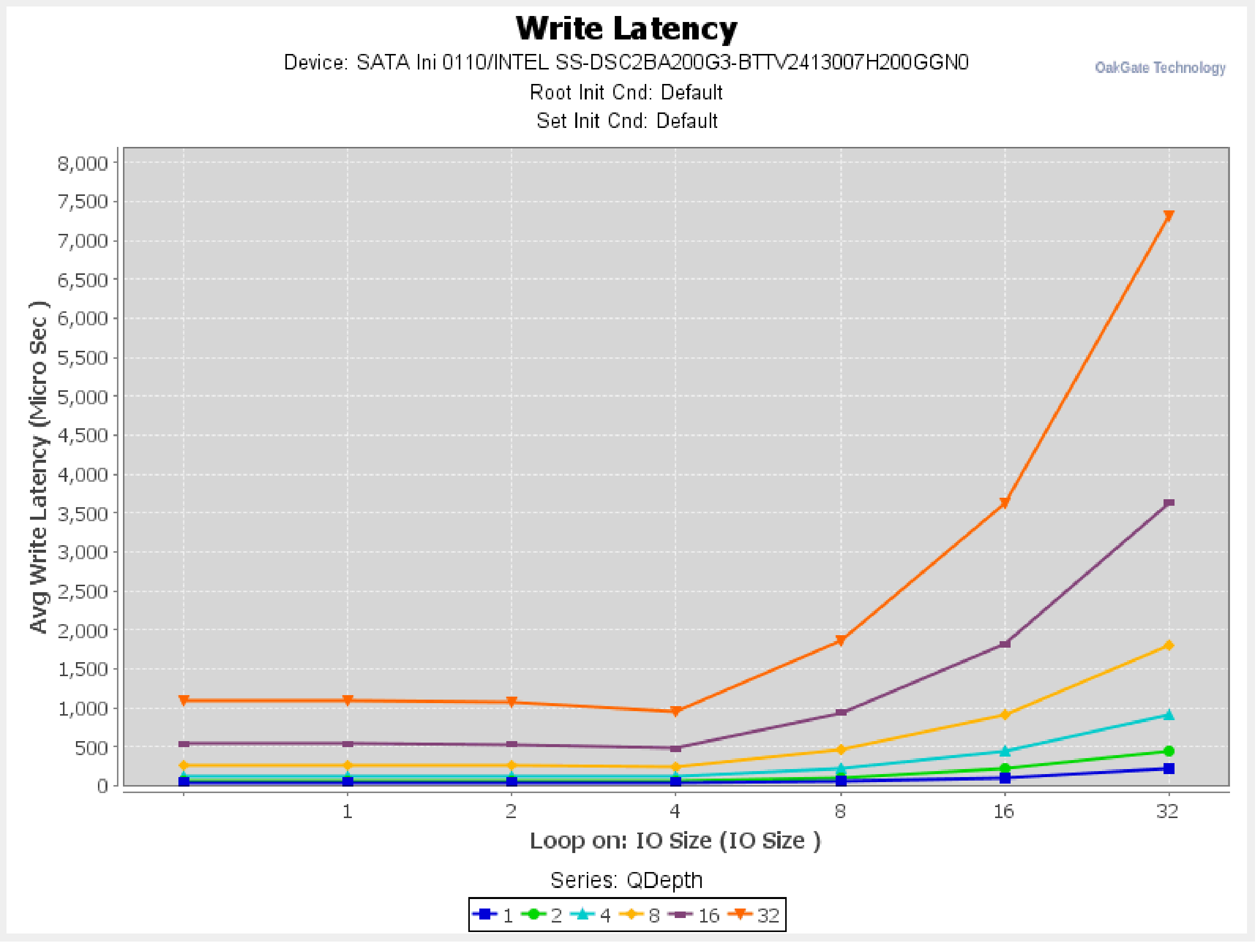
Random Writes



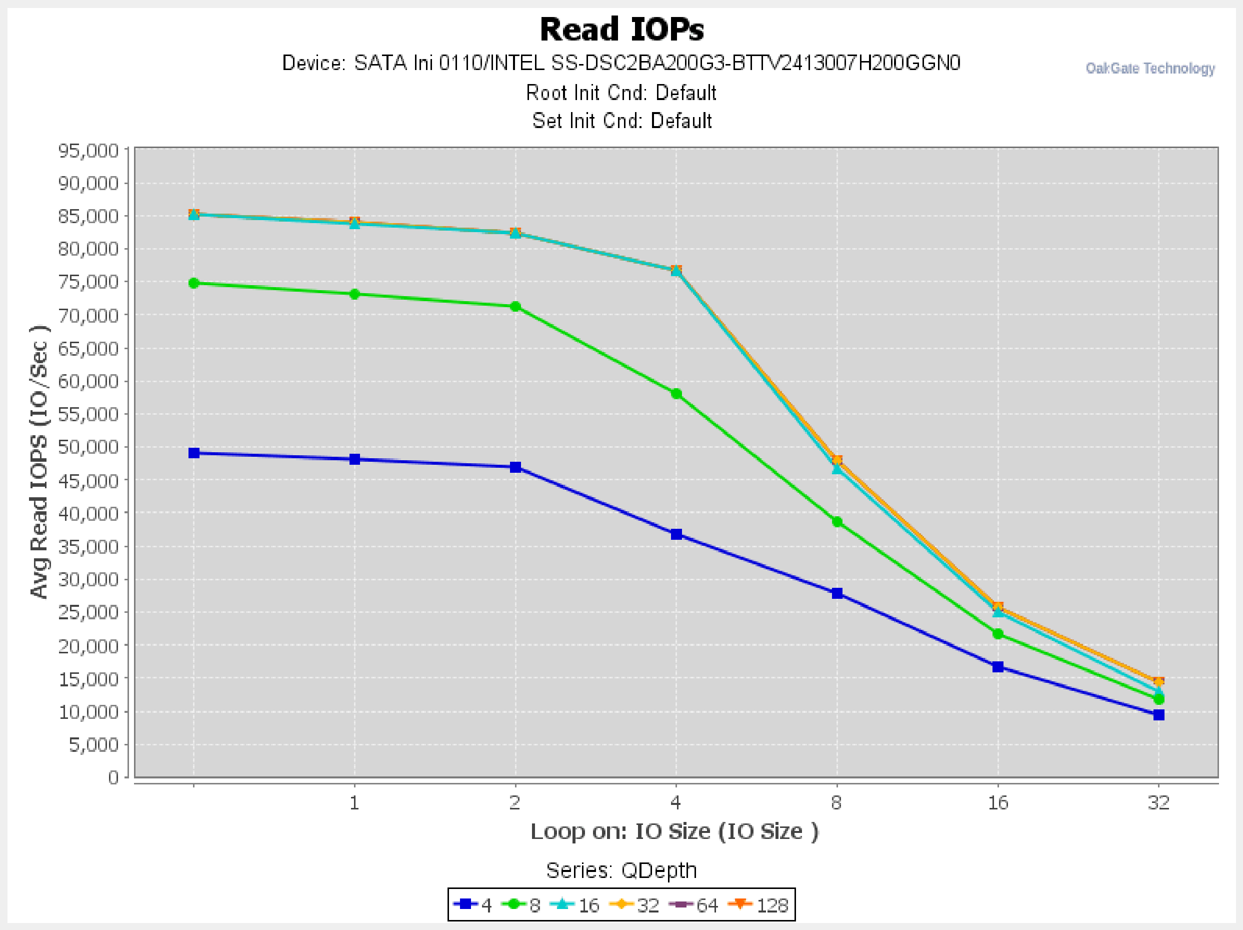
Random Writes



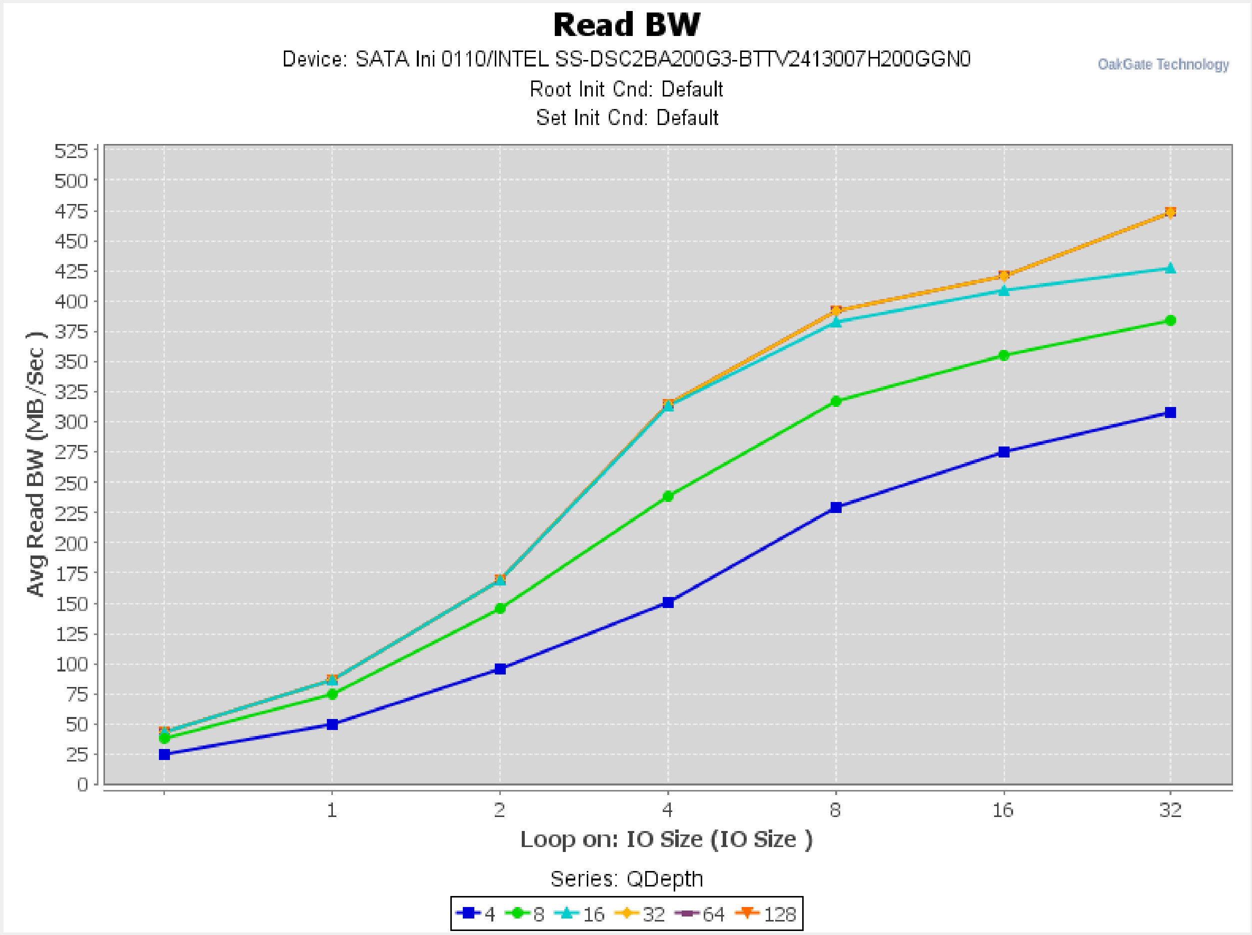
Random Writes



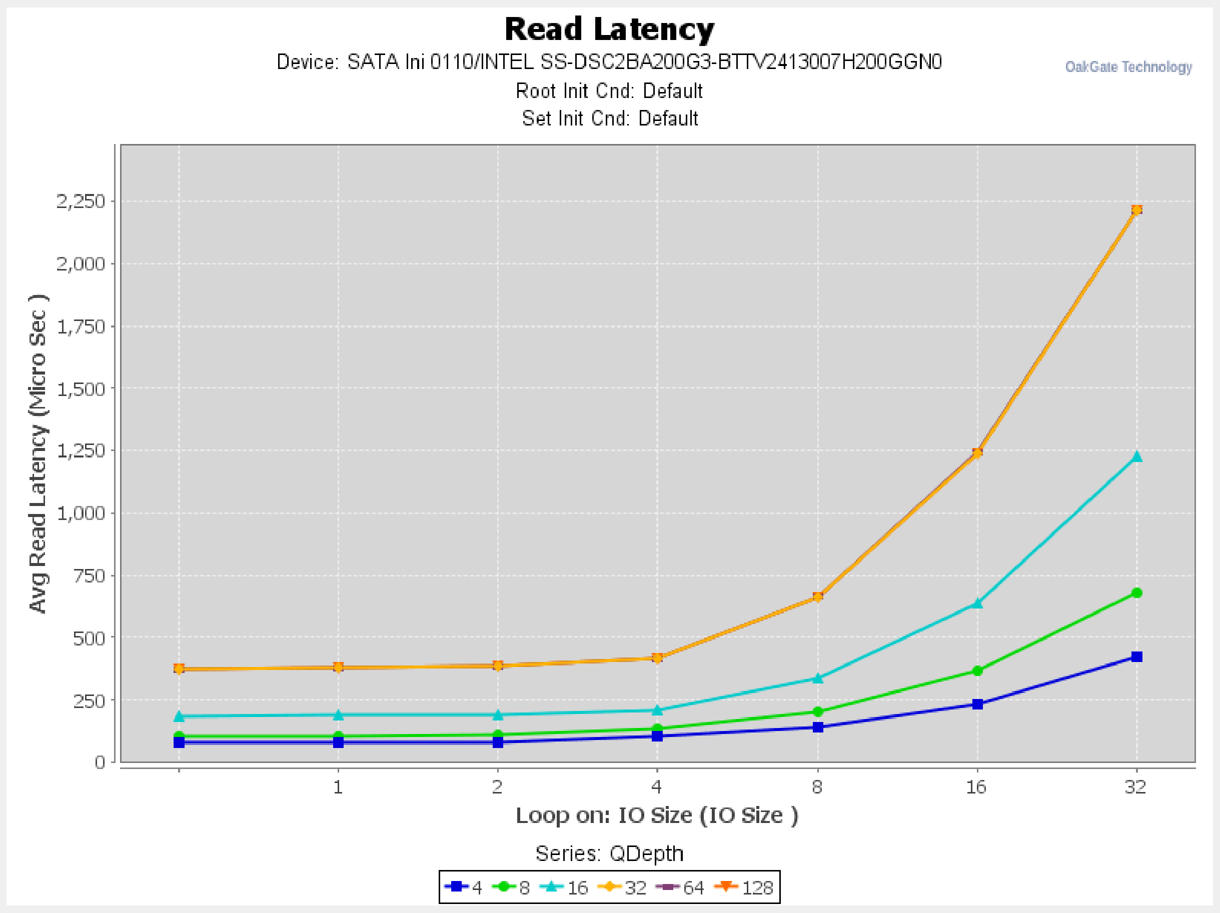
Sequential Reads



Sequential Reads



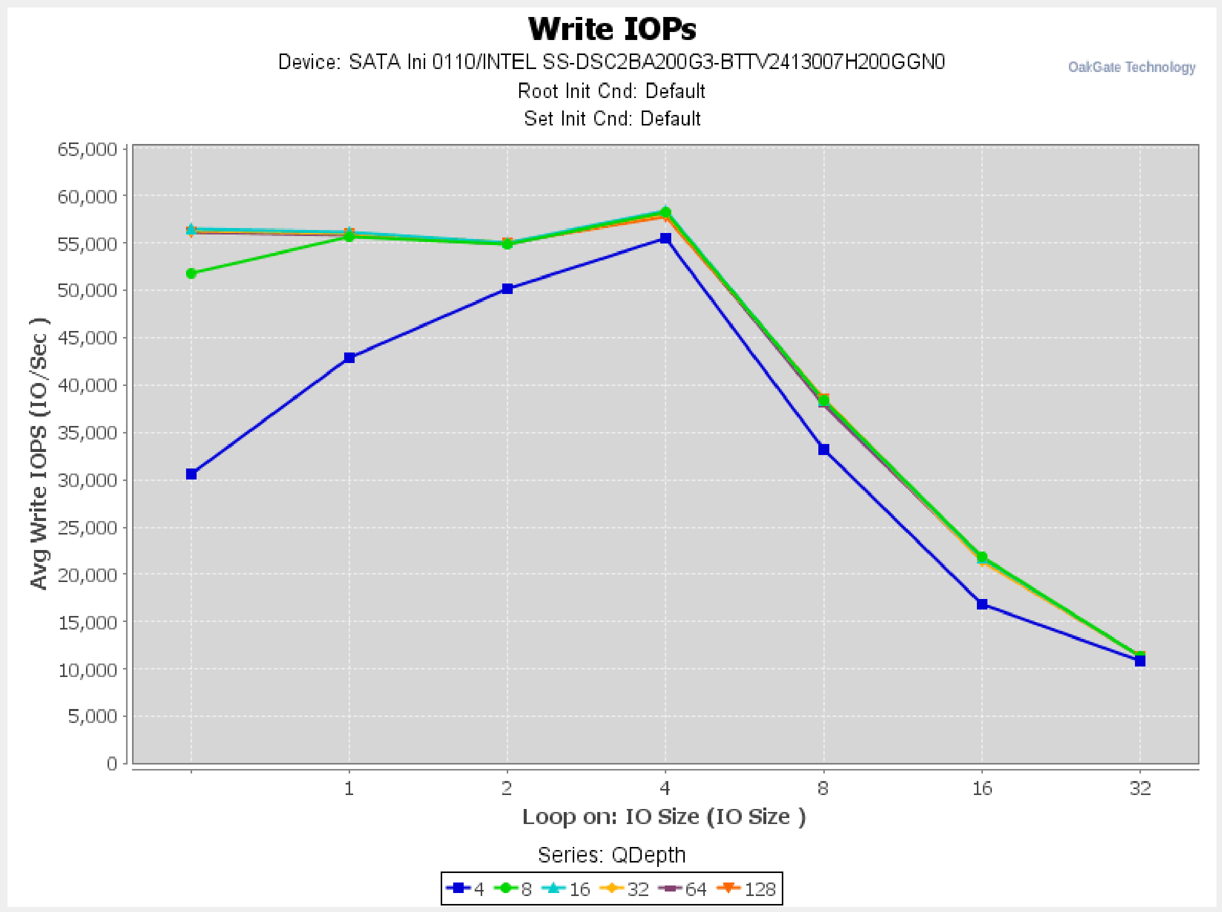
Sequential Reads



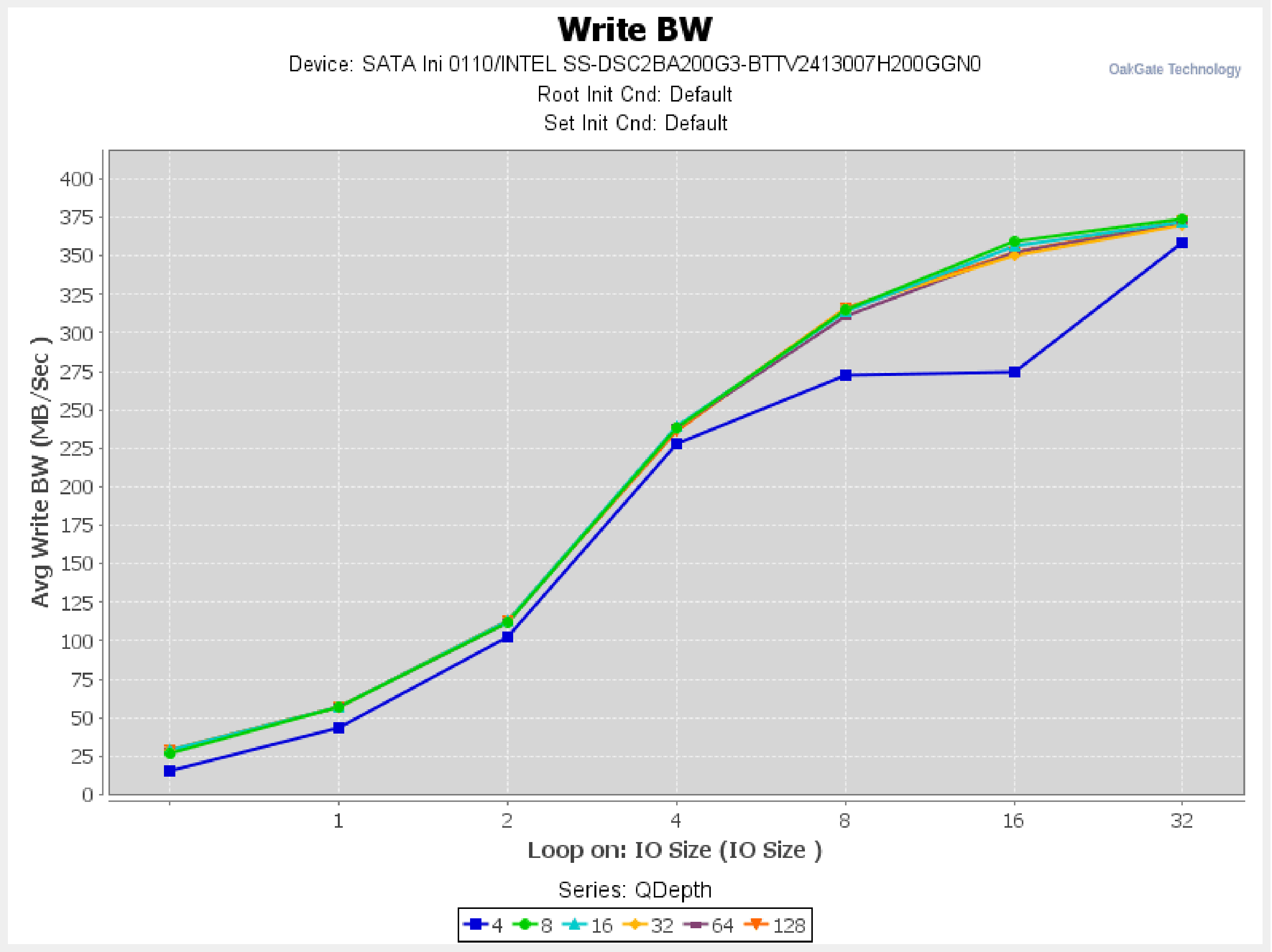
myce

OakGate Technology

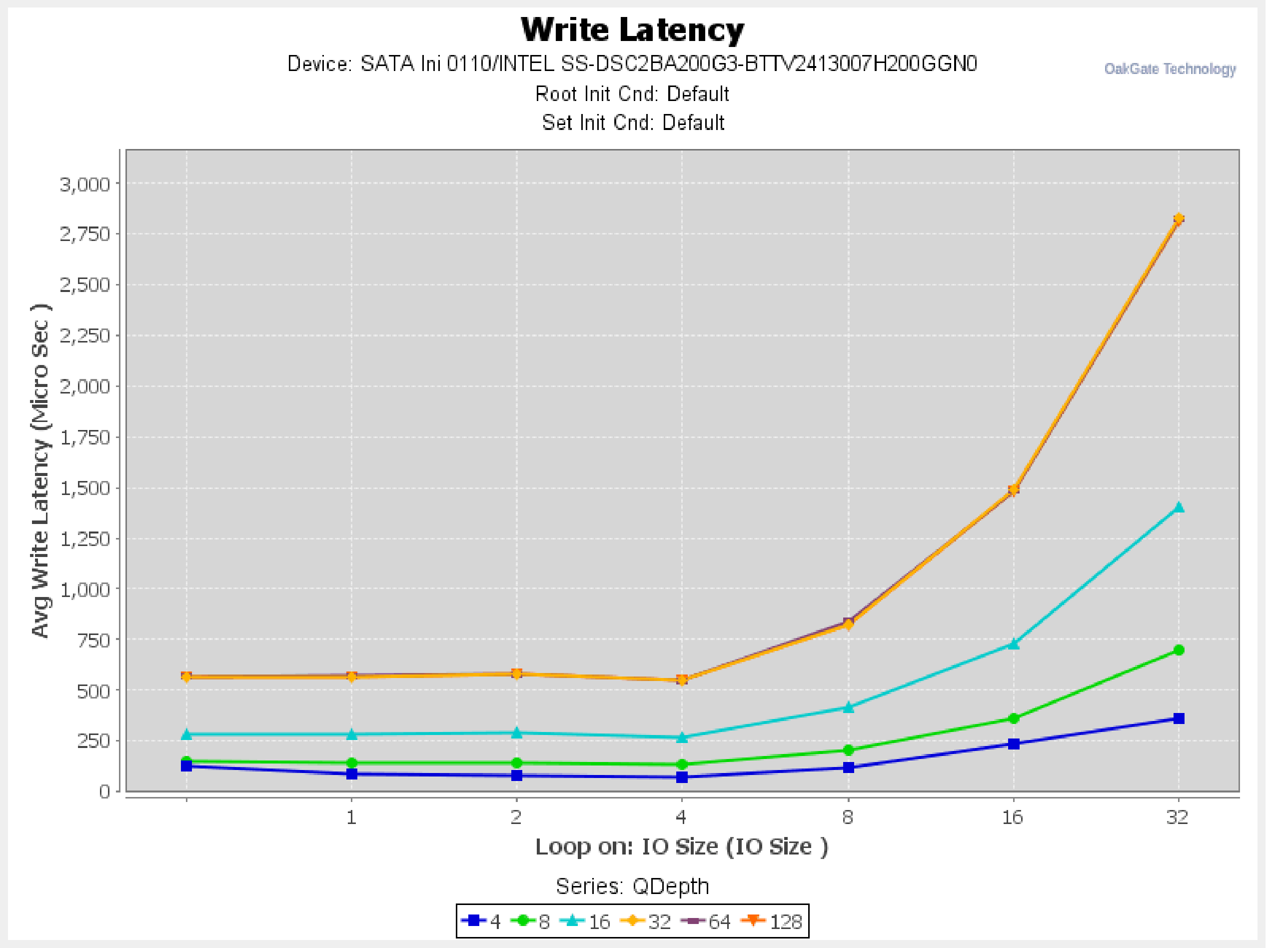
Sequential Writes



Sequential Writes



Sequential Writes



5.3 Myce/OakGate Mixed Reads/Writes Test

Continuing with the style adopted in the SNIA SSS PTS here is the specification for our Mixed Reads/Writes Test –

Myce / OakGate Mixed Reads Writes Tests

For Active Range (0:100)

1) Purge the device

2) Preconditioning
    a) Queue Depth = 32, Data pattern = 0 Fill
    b) 4K Random Writes for 2 hours

3) Mixed Reads/Writes
    For Queue Depth (4, 8, 16, 32, 64, 128)
        For Read/Write Mix% (100, 99, 95, 90, 70, 50, 0)
            Execute Random Reads for 5 minutes
            Record Ave Read IOPS, Ave Read MBs, Ave Read Latency

4) Random Writes
    For Queue Depth (4, 8, 16, 32, 64, 128)
        For Block Size (0.5K, 1K, 2K, 4K, 8K, 16K, 32K)
            Execute for 5 minutes
            Record Ave Read IOPS, Ave Write IOPS, Ave Total IOPS
            Ave Read MBS, Ave Write MBs, Ave Total MBs,
            Ave Read Latency, Ave Write Latency, Ave Total Latency

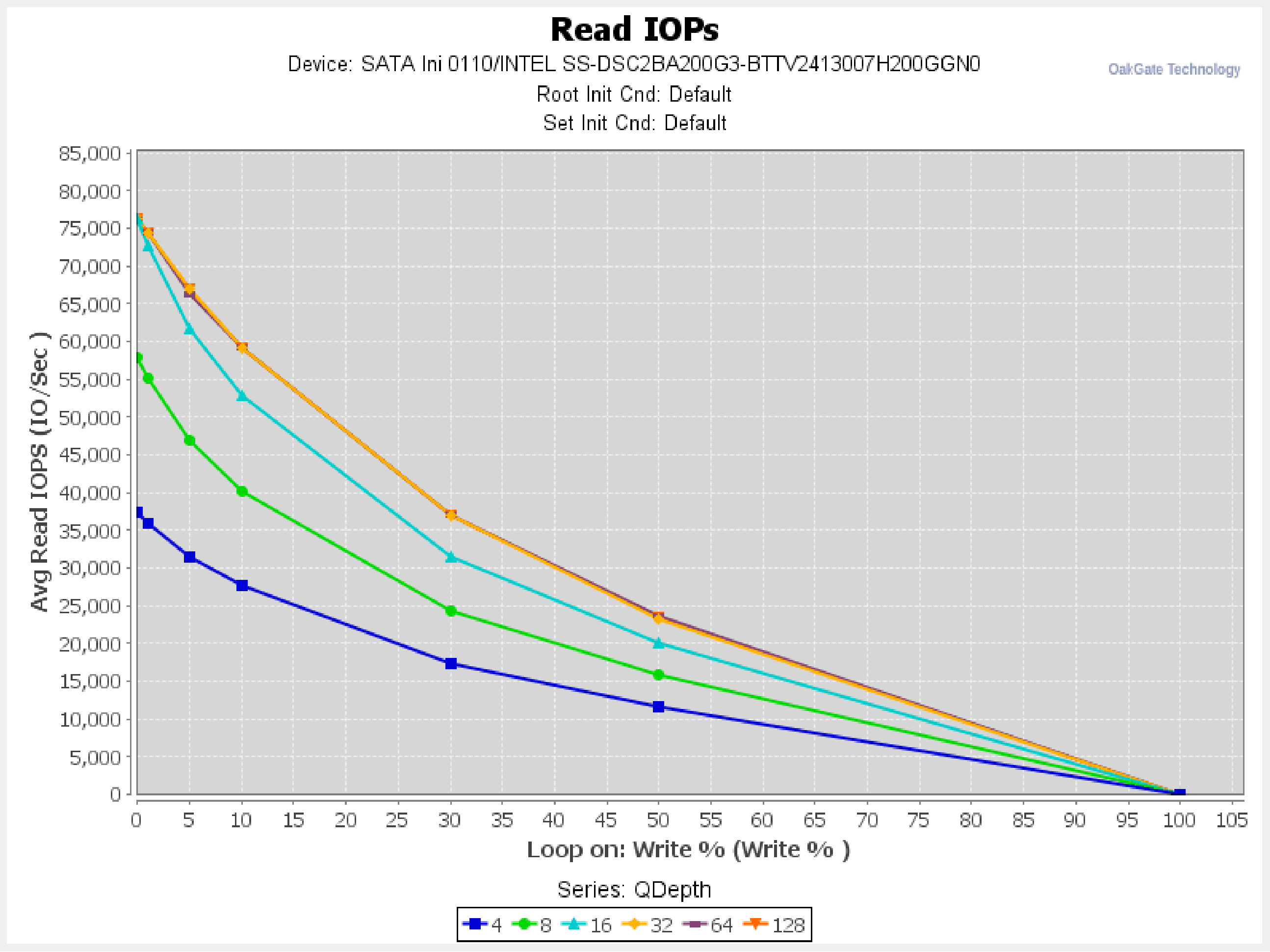
End For Active Range

Note that the test examines performance at 99% reads to see if there is a marked impact upon performance when just a small amount of write activity is introduced.

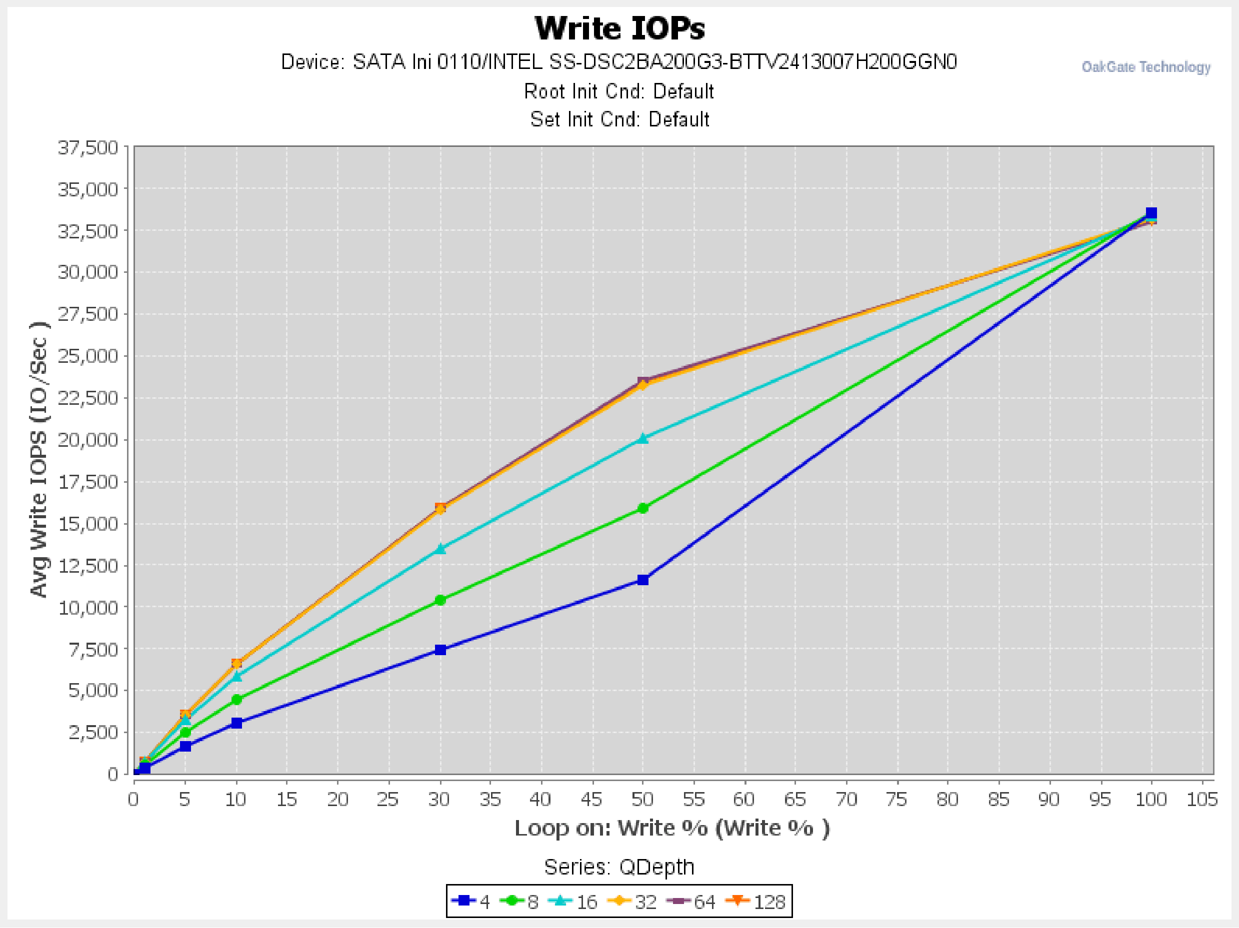
Myce/OakGate Mixed Reads/Writes Tests Reporting Artefacts

Here are examples of the reporting artefacts, automatically produced by the OakGate Test Unit, that Myce publishes –

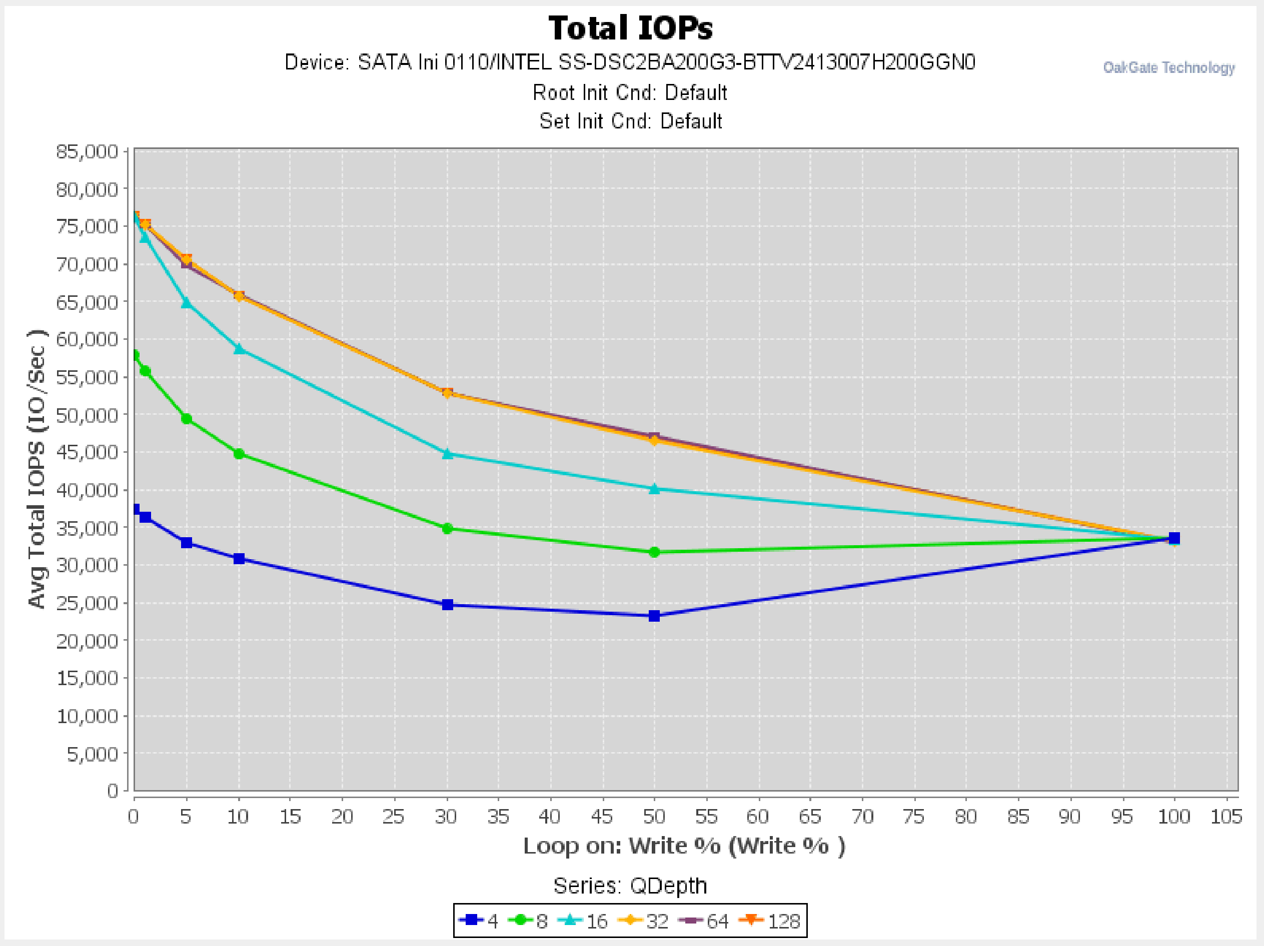
4K Mixed R/W Test



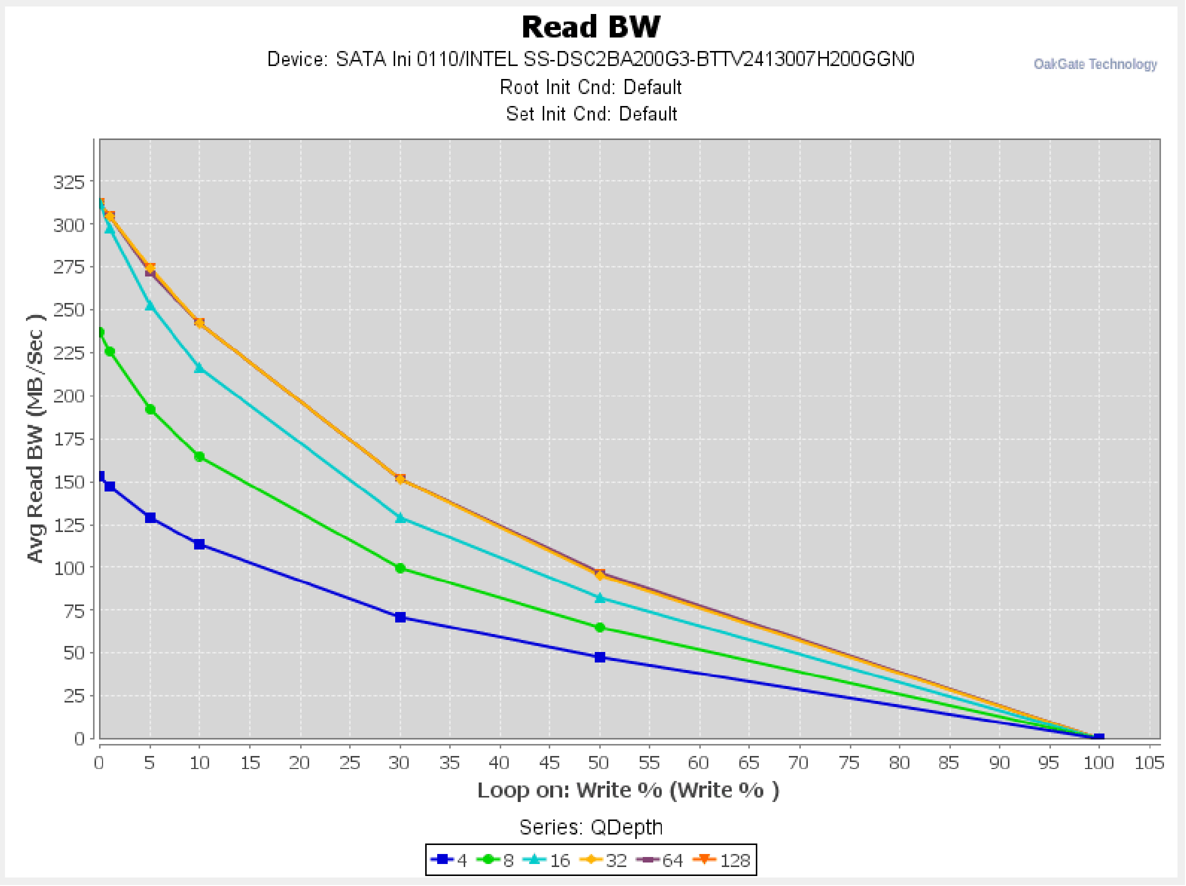
4K Mixed R/W Test



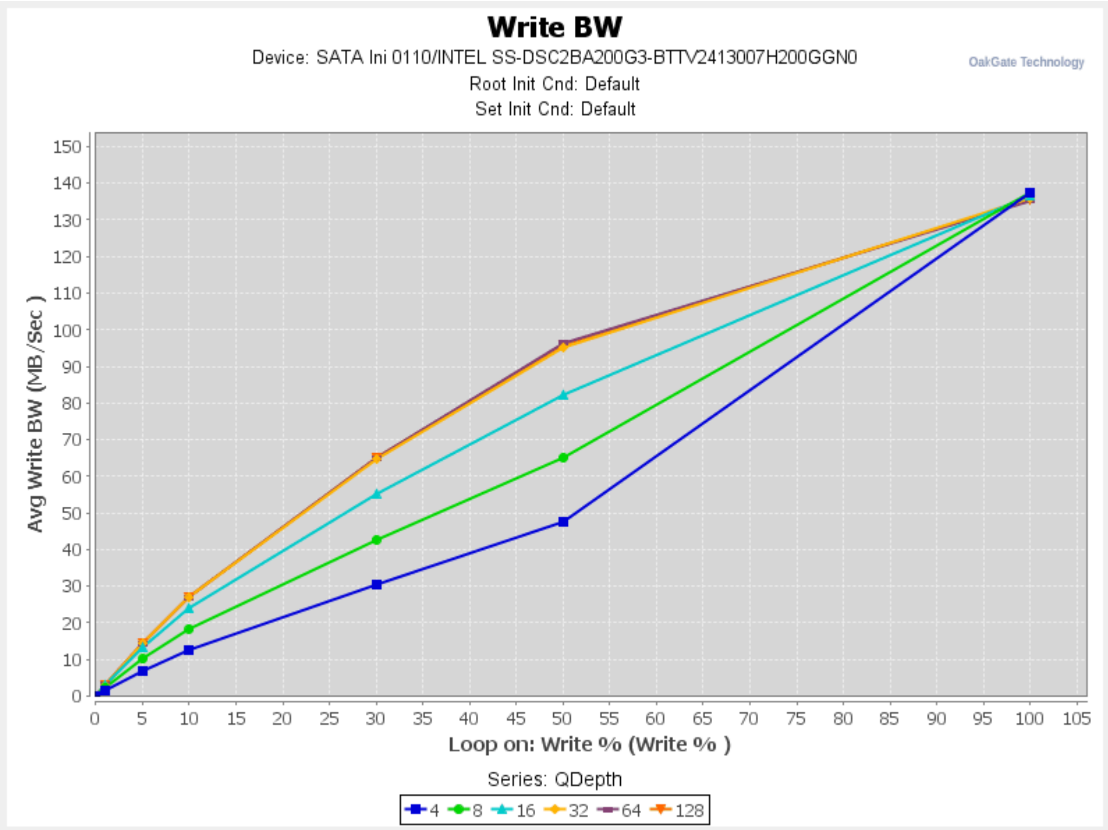
4K Mixed R/W Test



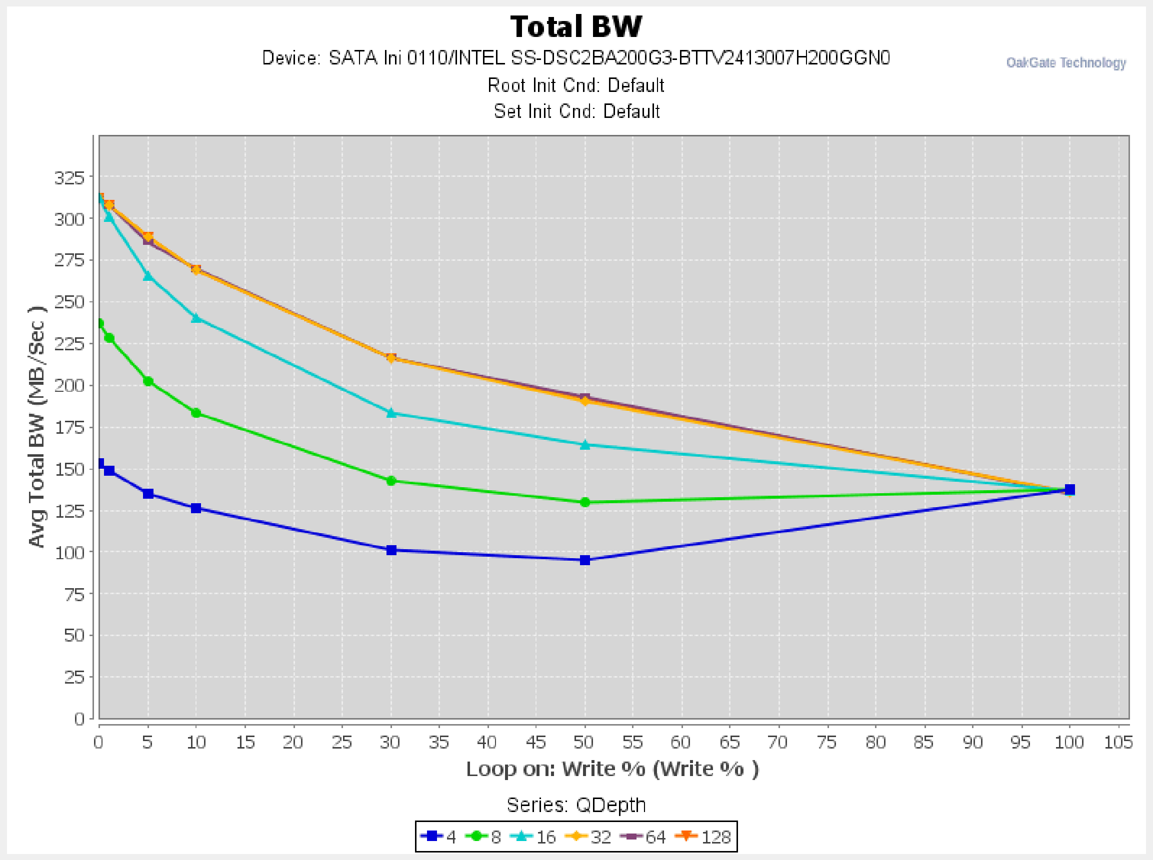
4K Mixed R/W Test



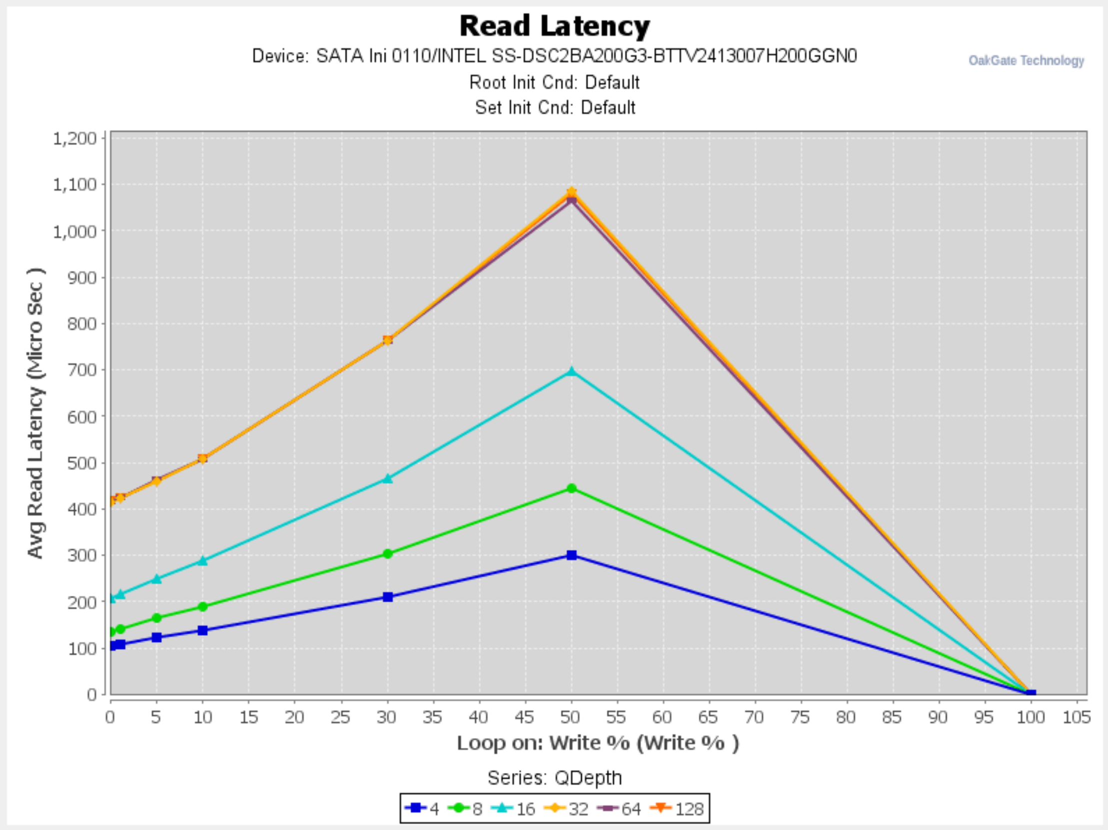
4K Mixed R/W Test



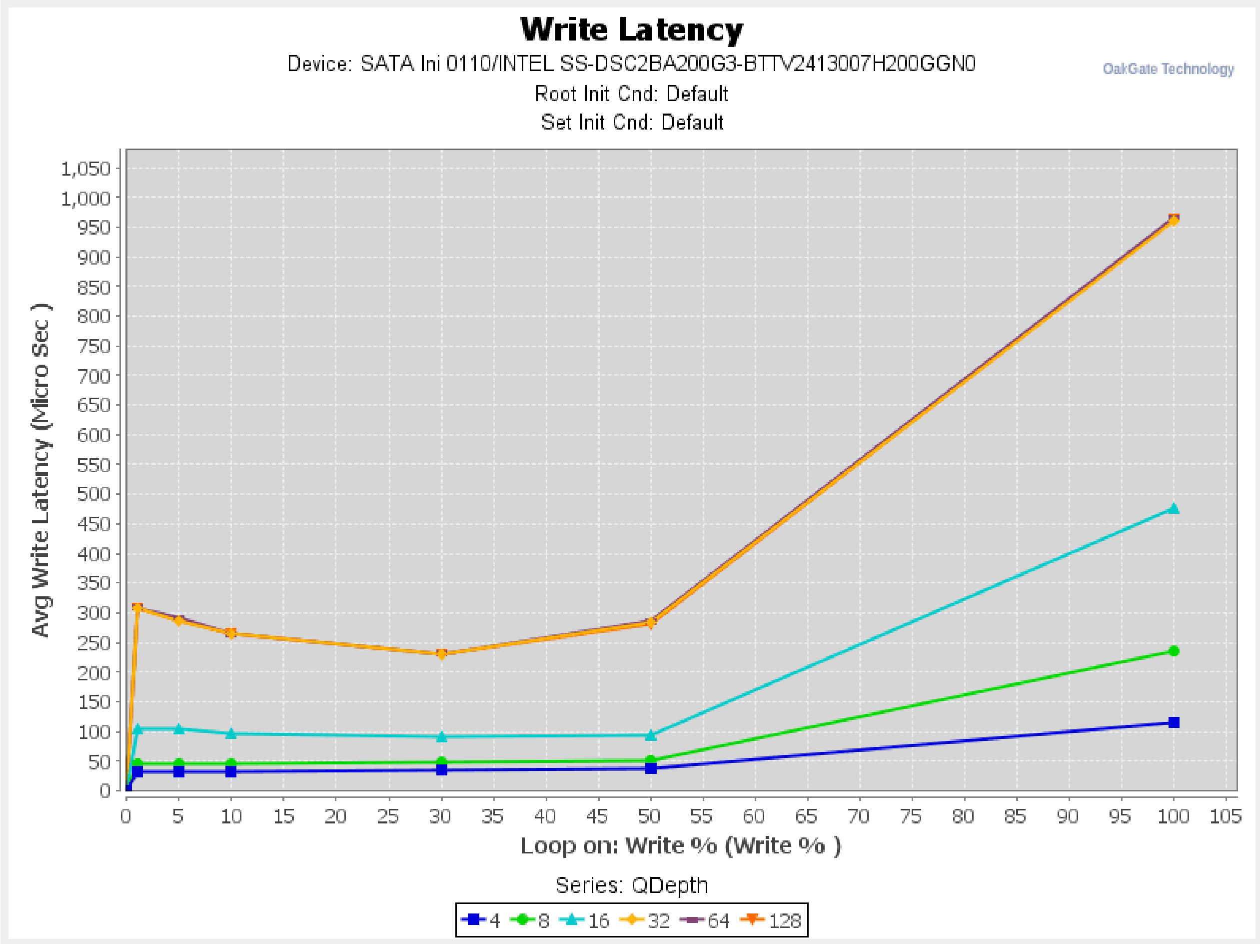
4K Mixed R/W Test



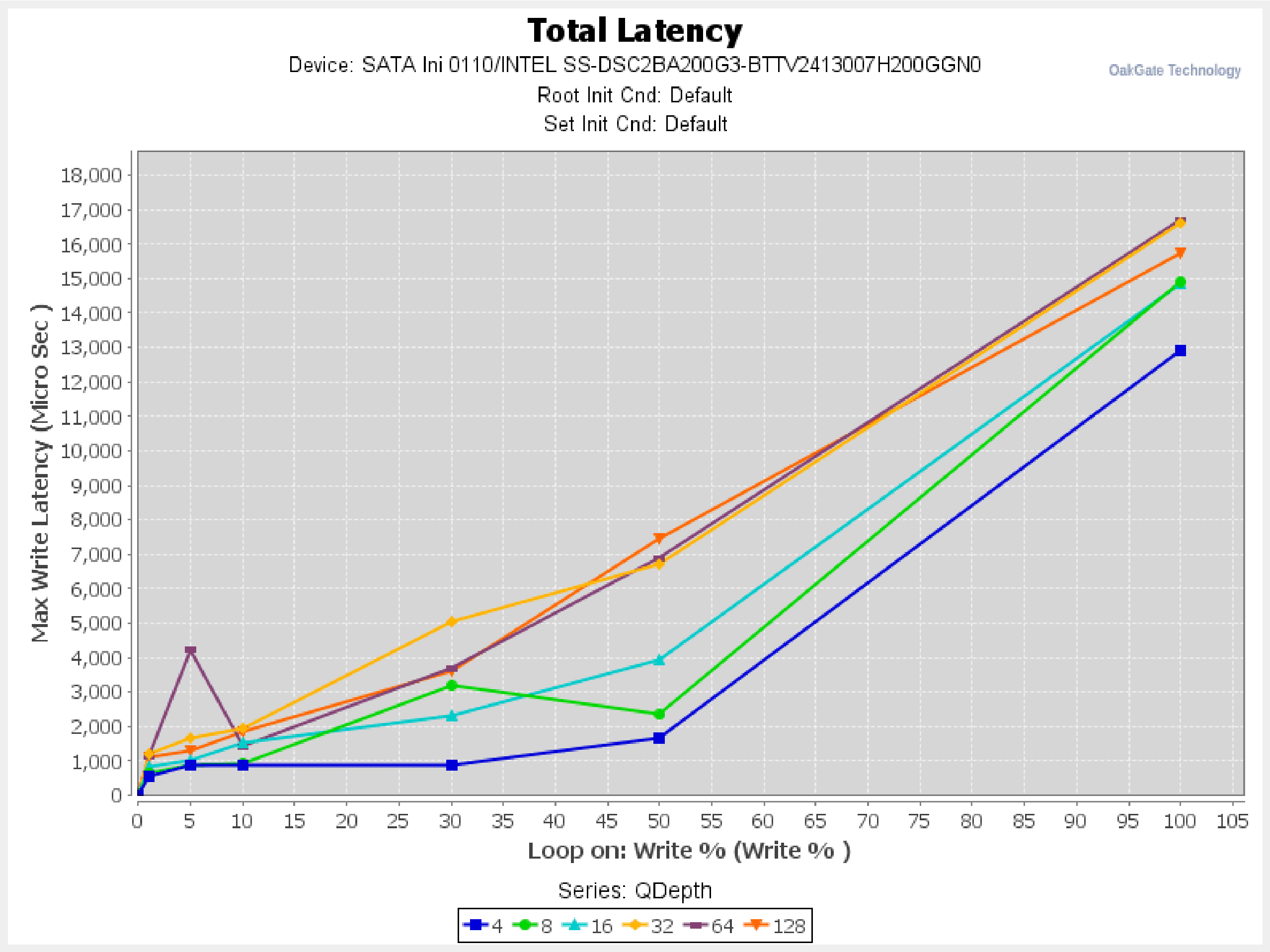
4K Mixed R/W Test



4K Mixed R/W Test



4K Mixed R/W Test



5.4 Myce/OakGate Entropy Tests

Continuing with the style adopted in the SNIA SSS PTS here is the specification for our Entropy Tests –

(Entropy in data compression denotes the randomness of the data that you are inputting to the compression algorithm. The more the entropy, the lesser the compression ratio. That means the more random the data is, the lesser you can compress it.)

Myce / OakGate Entropy Tests

For Active Range (0:100)

1) Purge the device

2) Preconditioning
a) Queue Depth = 32, Data pattern = 0 Fill
b) 4K Random Writes for 2 hours

3) 4K Entropy Write Test
For Queue Depth (4, 8, 16, 32, 64, 128)
For Entropy % (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60,65, 70, 75, 80, 85, 90, 95,100)
Execute Random Random 4K Writes for 5 minutes
Record Ave Write IOPS, Ave Write Latency

4) Purge the device

5) Preconditioning
a) Queue Depth = 32, data pattern = 0 Fill
b) 4K random writes for 2 hours

4) 4K Entropy 70% Reads 30% Writes Test
For Queue Depth (4, 8, 16, 32, 64, 128)
For Entropy % (5, 10, 15, 20, 25, 39, 35, 40, 45, 50, 55. 60, 65, 70, 75, 80, 85, 90, 95, 100)
Execute Random 4K 70% Reads and 30% Writes for 5 minutes
Record Ave Read IOPS, Ave Write IOPS, Ave Total IOPS, Ave Read MBs, Ave Write MBs, Ave Total MBs, Ave Read Latency, Ave Write Latency, Ave Total Latency

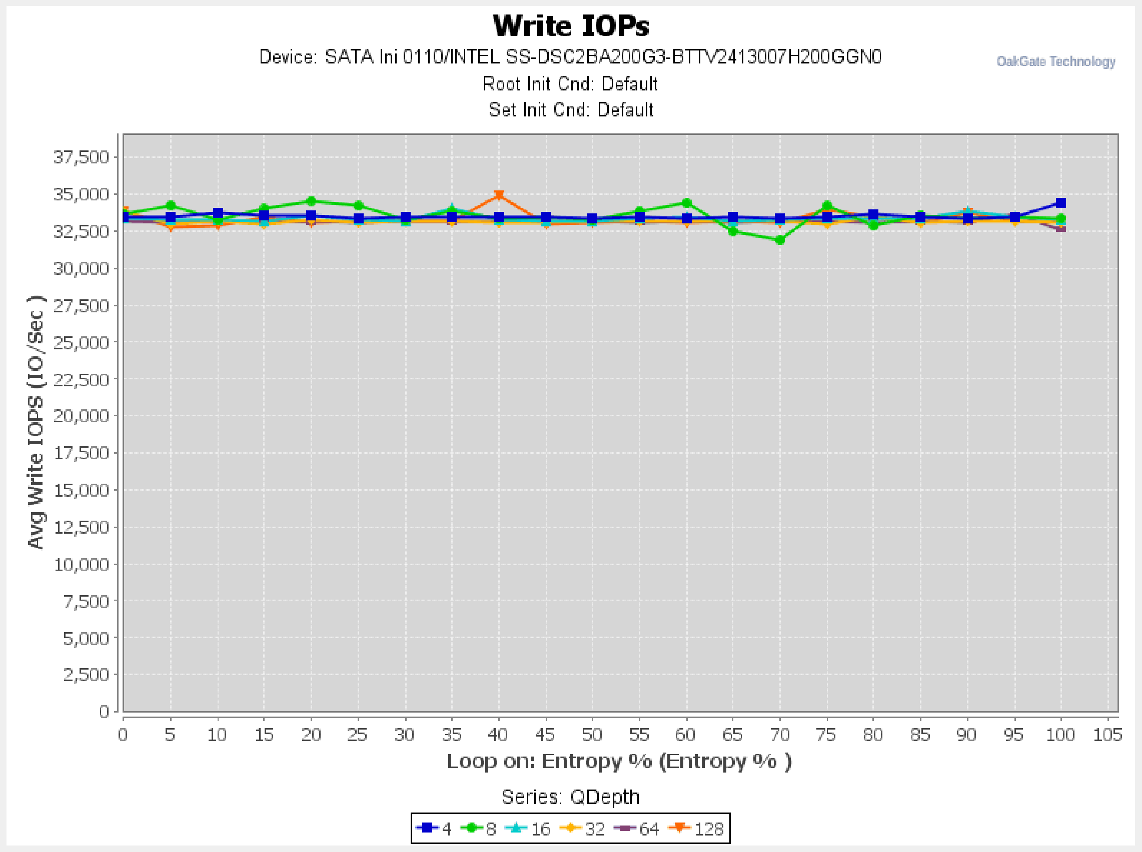
End For Active Range

This test looks closely at the impact of changing the entropy% (degree of randomness of data); this is particularly important if a drive's controller supports the compression of data as the higher the level of entropy% then the less the data is compressible.

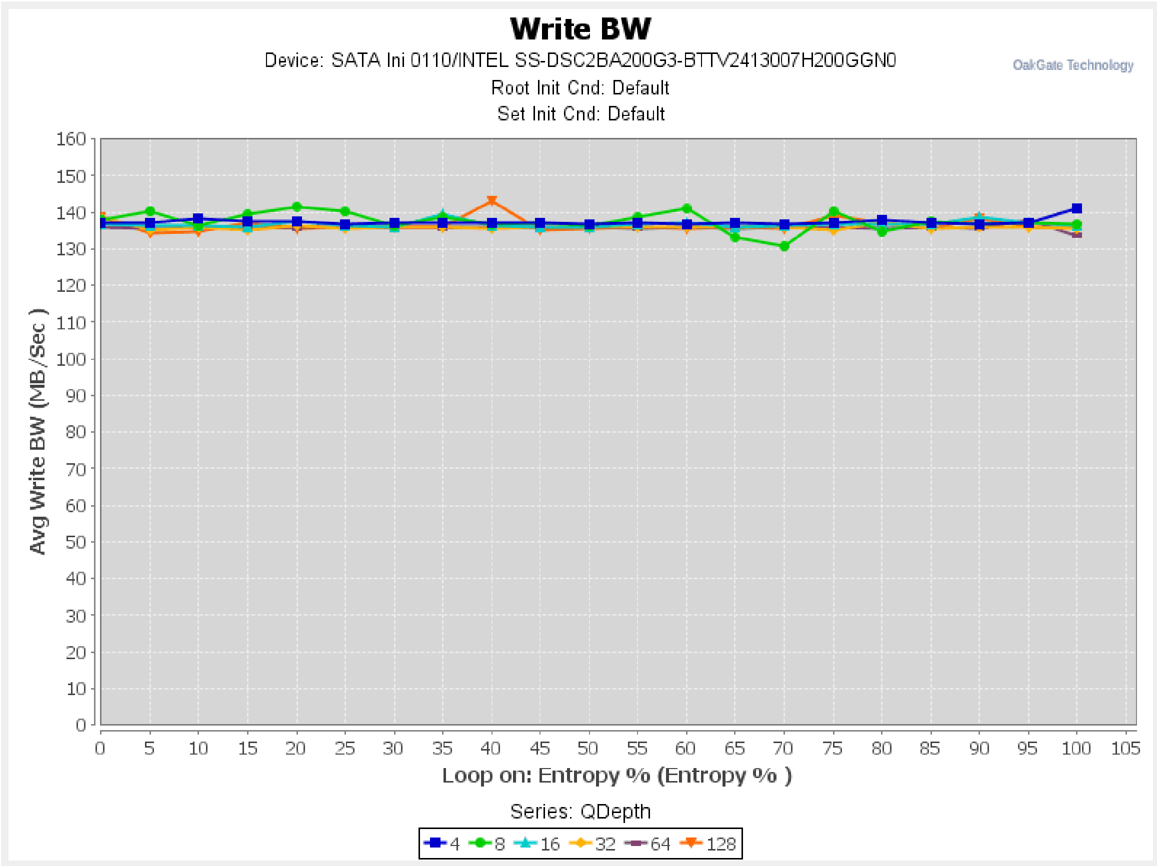
Myce/OakGate Entropy Tests Reporting Artefacts

Here are examples of the reporting artefacts, automatically produced by the OakGate Test Unit, that Myce publishes –

4K Entropy Write Test



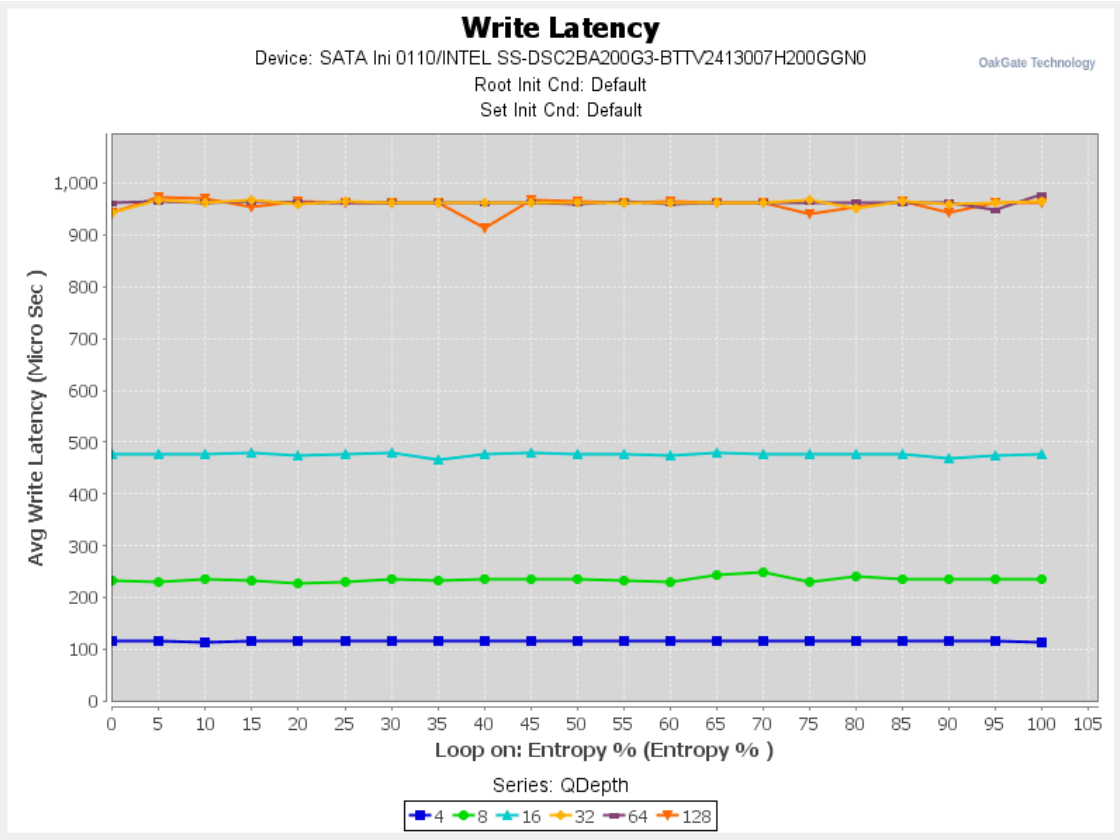
4K Entropy Write Test



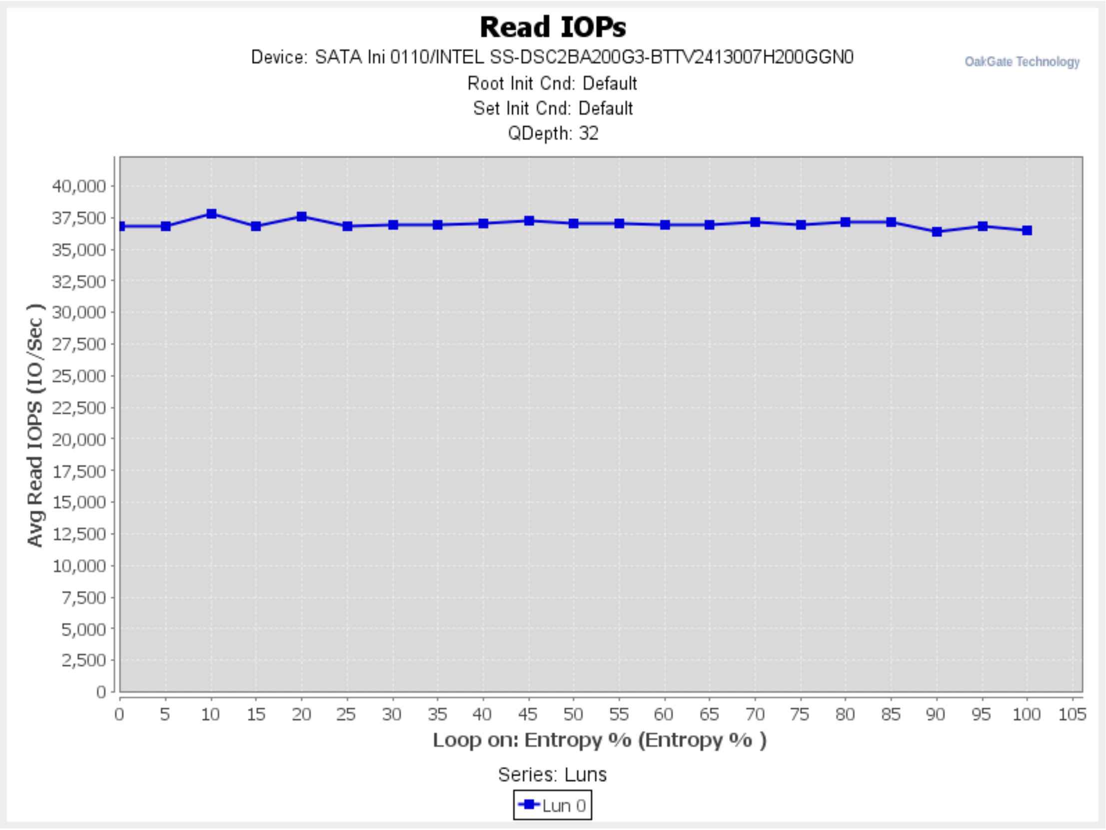
myce

OakGate Technology

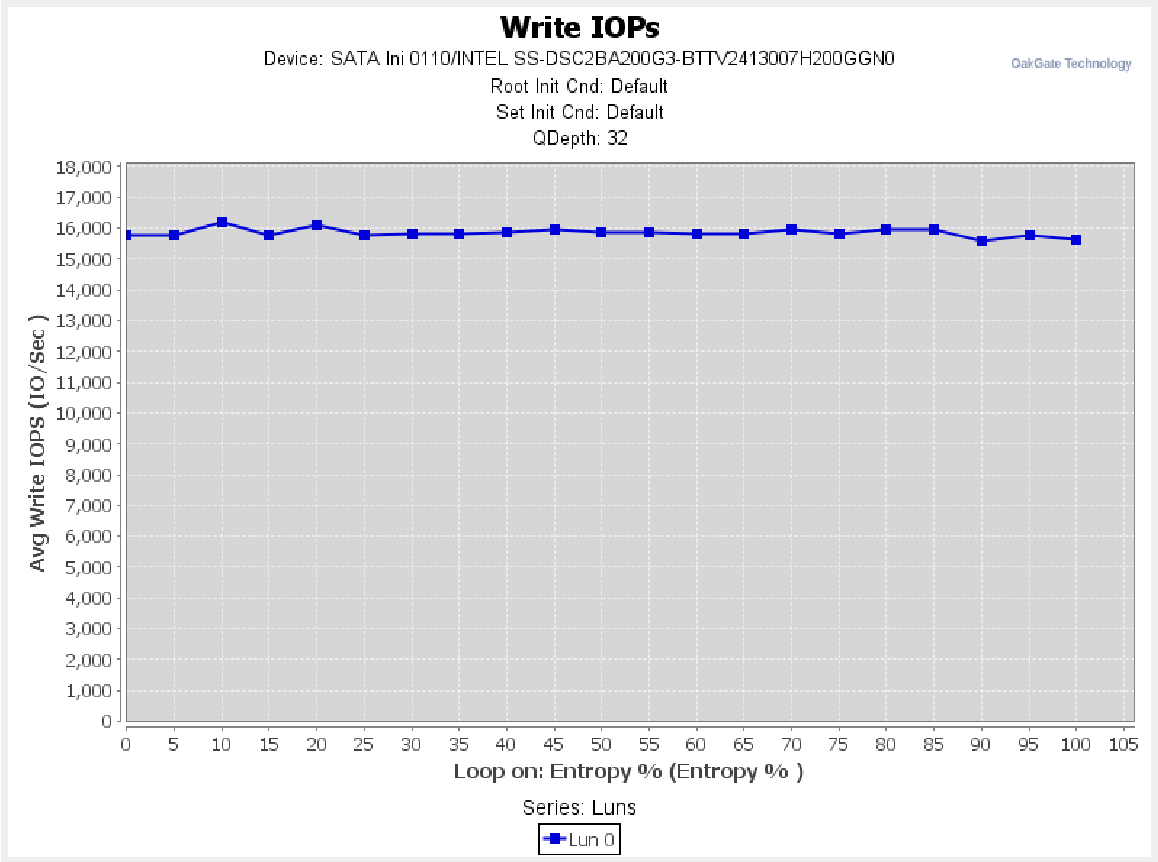
4K Entropy Write Test



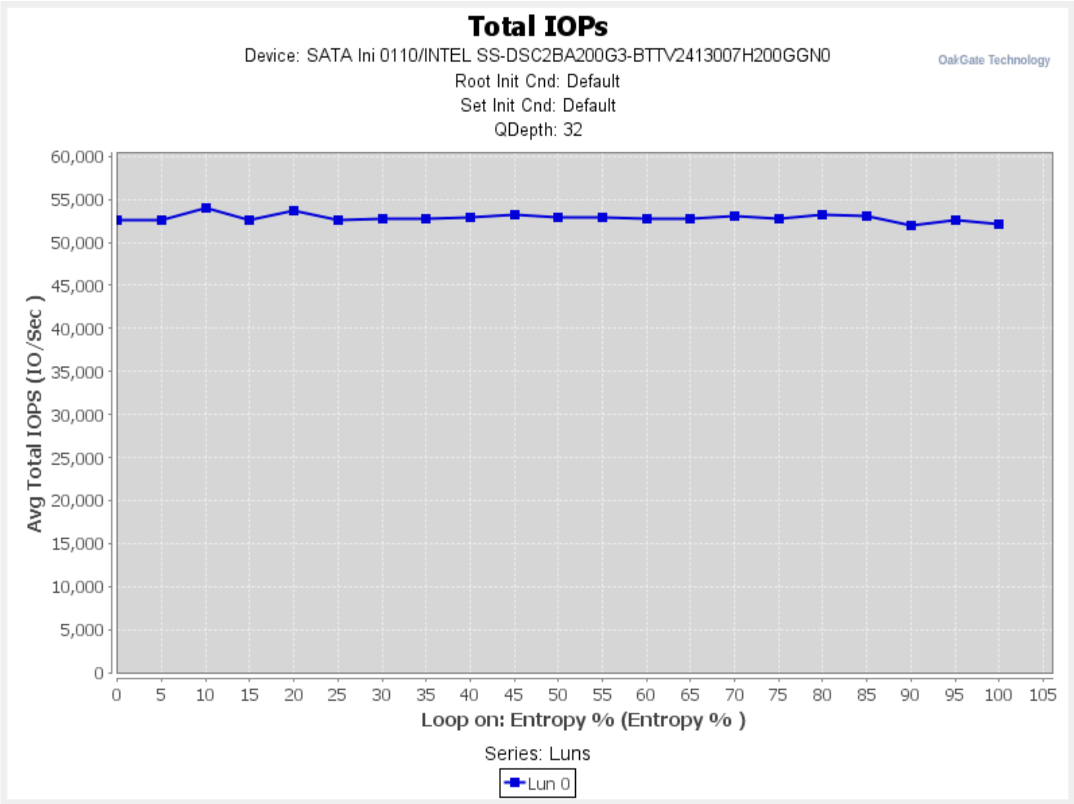
4K Entropy 70%_Reads_30%_Writes Test



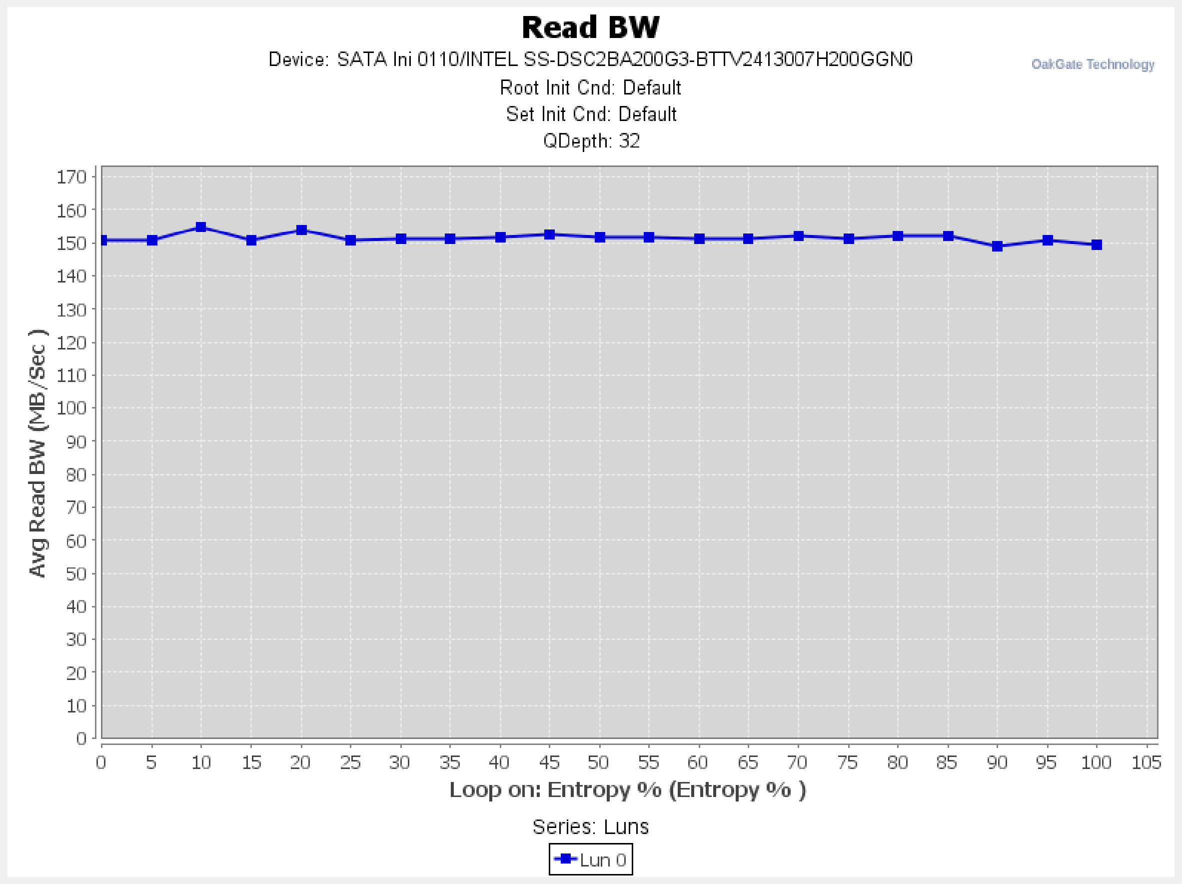
4K Entropy 70%_Reads_30%_Writes Test



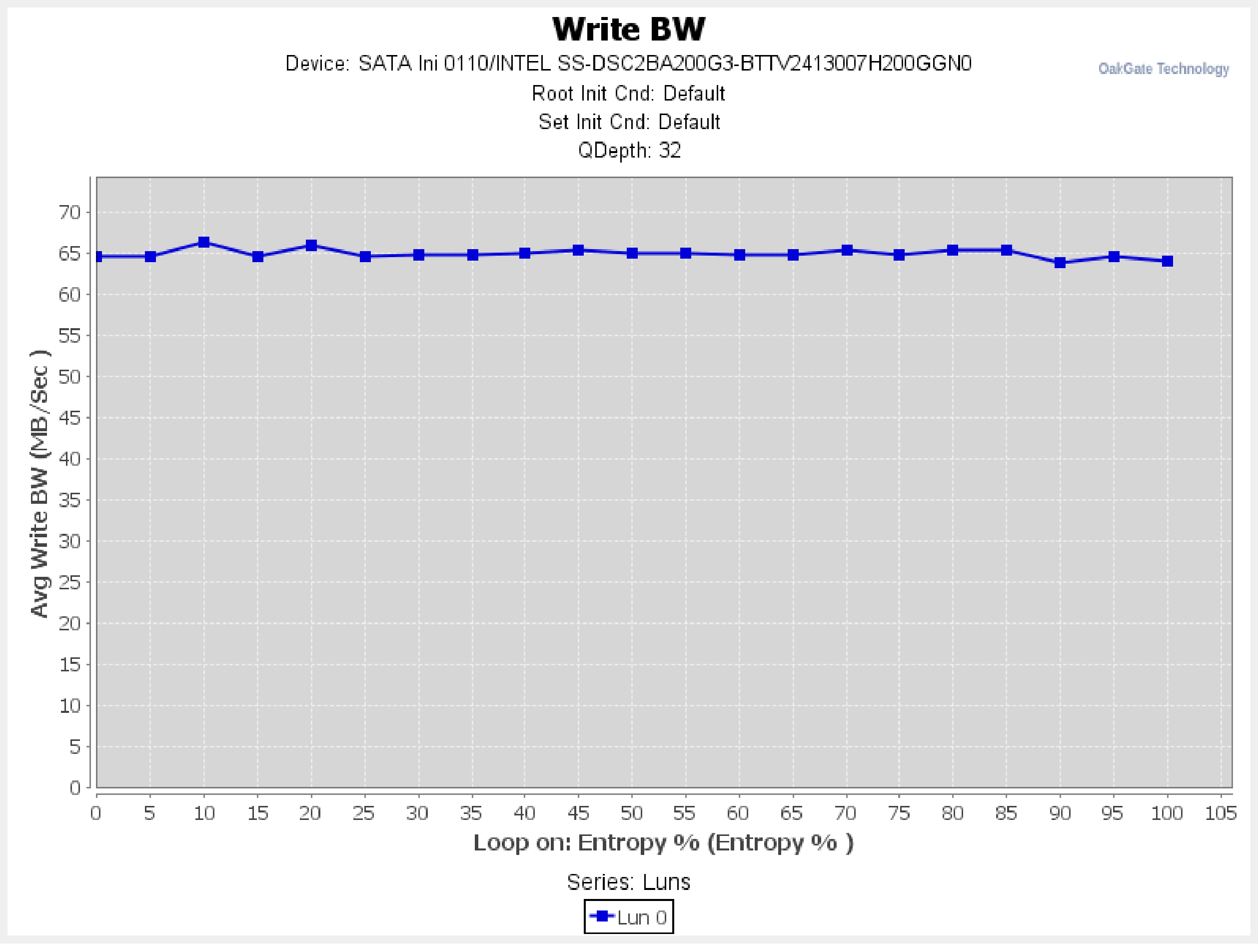
4K Entropy 70%_Reads_30%_Writes Test



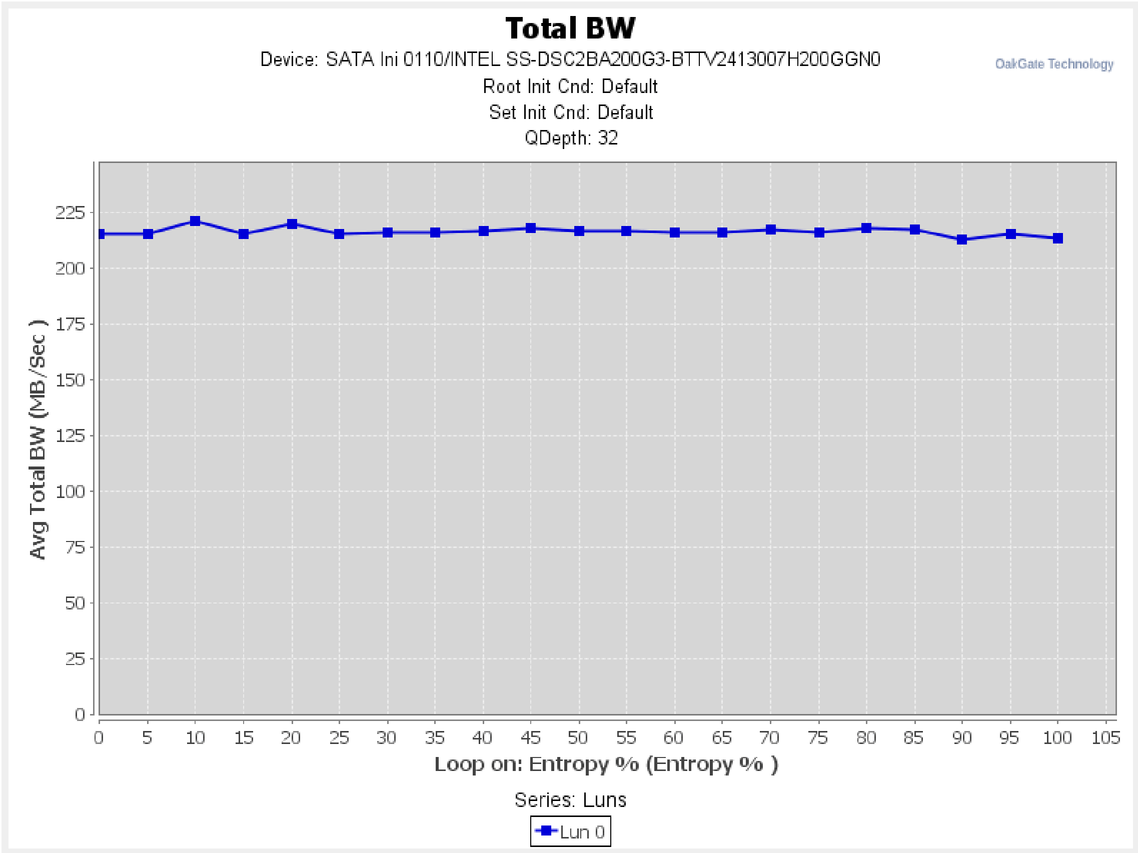
4K Entropy 70%_Reads_30%_Writes Test



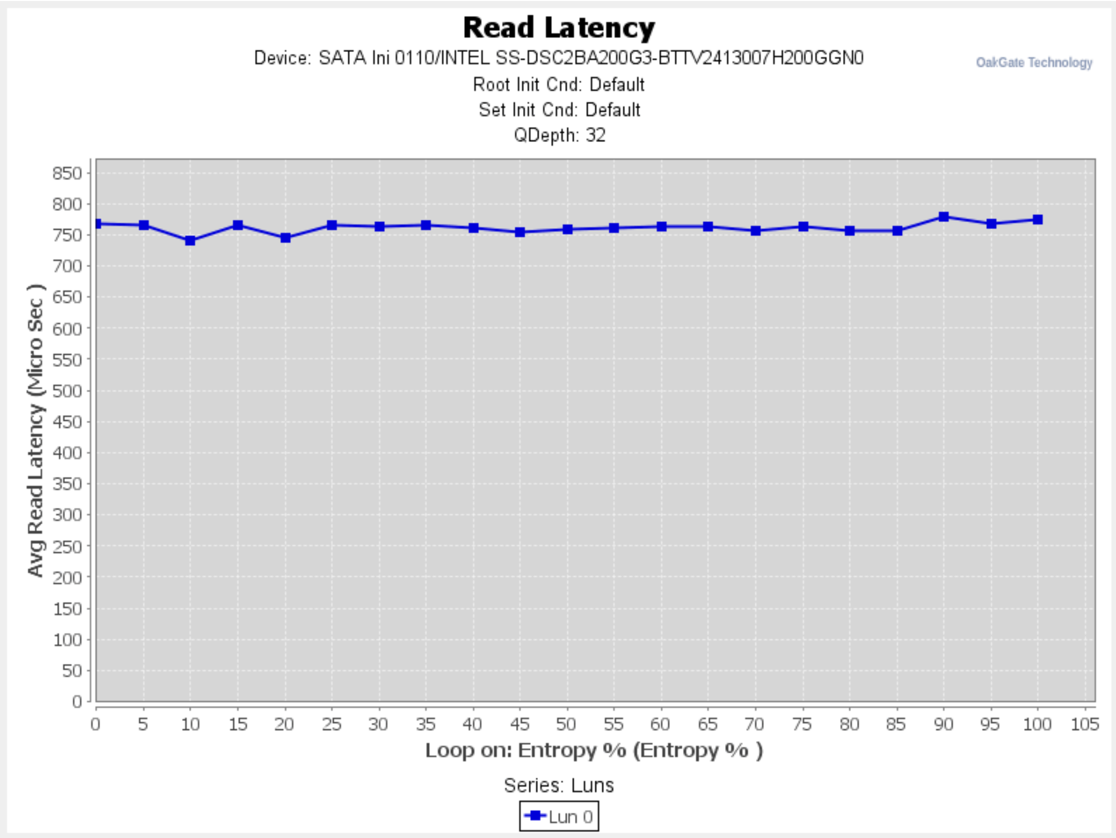
4K Entropy 70%_Reads_30%_Writes Test



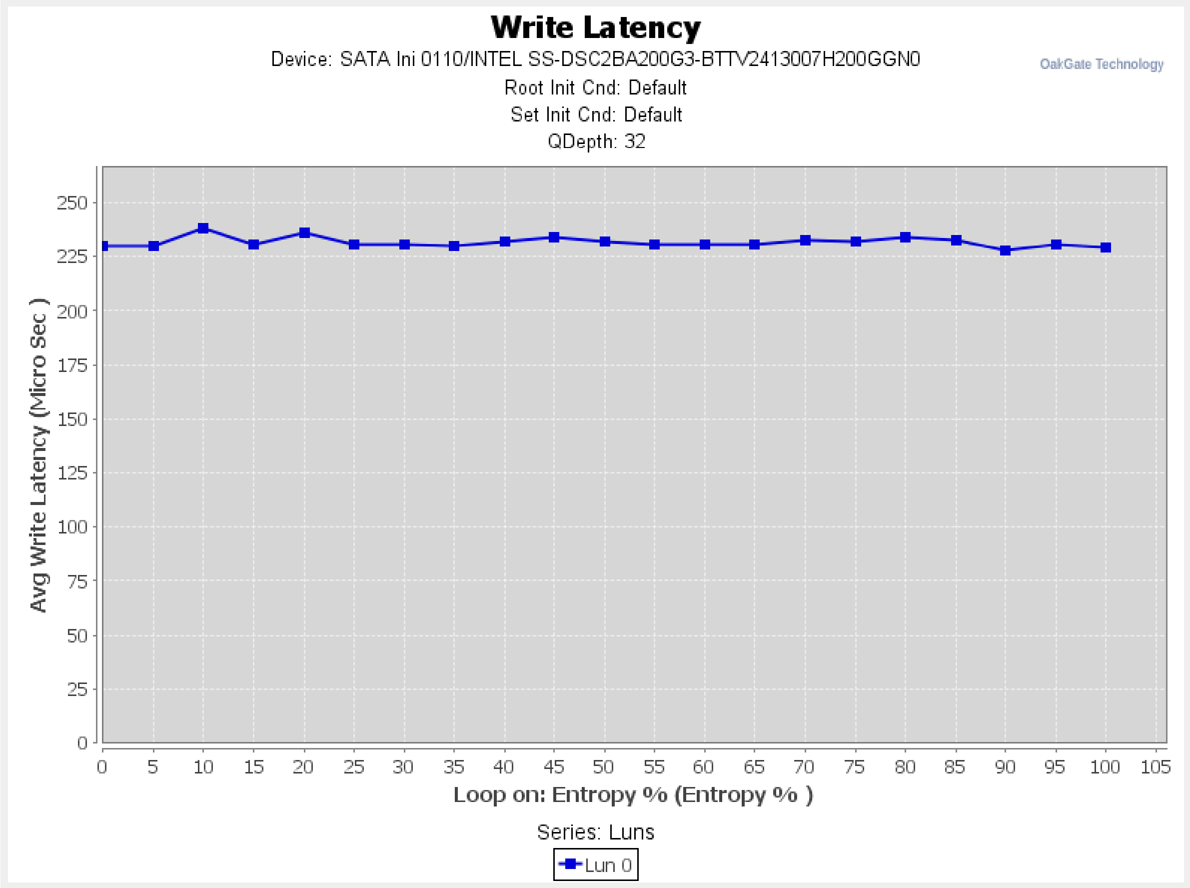
4K Entropy 70%_Reads_30%_Writes Test



4K Entropy 70%_Reads_30%_Writes Test



4K Entropy 70%_Reads_30%_Writes Test



4K Entropy 70%_Reads_30%_Writes Test