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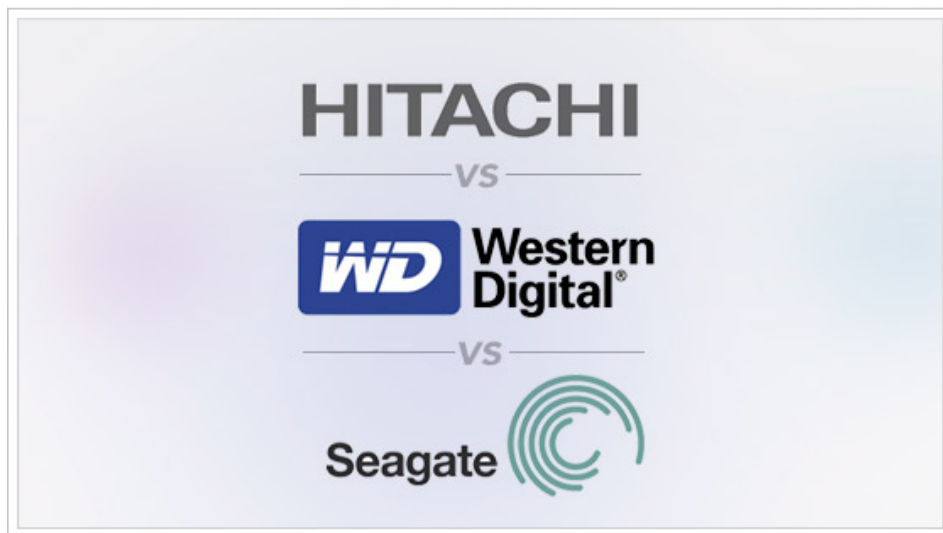
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What Hard Drive Should I Buy?

Brian Beach January 21, 2014

My last two blog posts were about [expected drive lifetimes](#) and [drive reliability](#). These posts were an outgrowth of the careful work that we've done at [Backblaze](#) to find the most cost-effective disk drives. Running a [truly unlimited online backup](#) service for only \$5 per month means our cloud storage needs to be very efficient and we need to quickly figure out which drives work.

Because Backblaze has a history of openness, many readers expected more details in my previous posts. They asked what drive models work best and which last the longest. Given our experience with over 25,000 drives, they asked which ones are good enough that we would buy them again. In this post, I'll answer those questions.

Drive Population

At the end of 2013, we had 27,134 consumer-grade drives spinning in [Backblaze Storage Pods](#). The breakdown by brand looks like this:

Hard Drives by Manufacturer Used by Backblaze

Brand	Number of Drives	Terabytes	Average Age in Years
Seagate	12,765	39,576	1.4
Hitachi	12,956	36,078	2.0
Western Digital	2,838	2,581	2.5
Toshiba	58	174	0.7
Samsung	18	18	3.7

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As you can see, they are mostly Seagate and Hitachi drives, with a good number of Western Digital thrown in. We don't have enough Toshiba or Samsung drives for good statistical results.

Why do we have the drives we have? Basically, we buy the least expensive drives that will work. When a new drive comes on the market that looks like it would work, and the price is good, we [test a pod full](#) and see how they perform. The new drives go through initial setup tests, a stress test, and then a couple weeks in production. (A couple of weeks is enough to fill the pod with data.) If things still look good, that drive goes on the buy list. When the price is right, we buy it.

We are willing to spend a little bit more on drives that are reliable, because it costs money to replace a drive. We are not willing to spend a lot more, though.

Excluded Drives

Some drives just don't work in the Backblaze environment. We have not included them in this study. It wouldn't be fair to call a drive "bad" if it's just not suited for the environment it's put into.

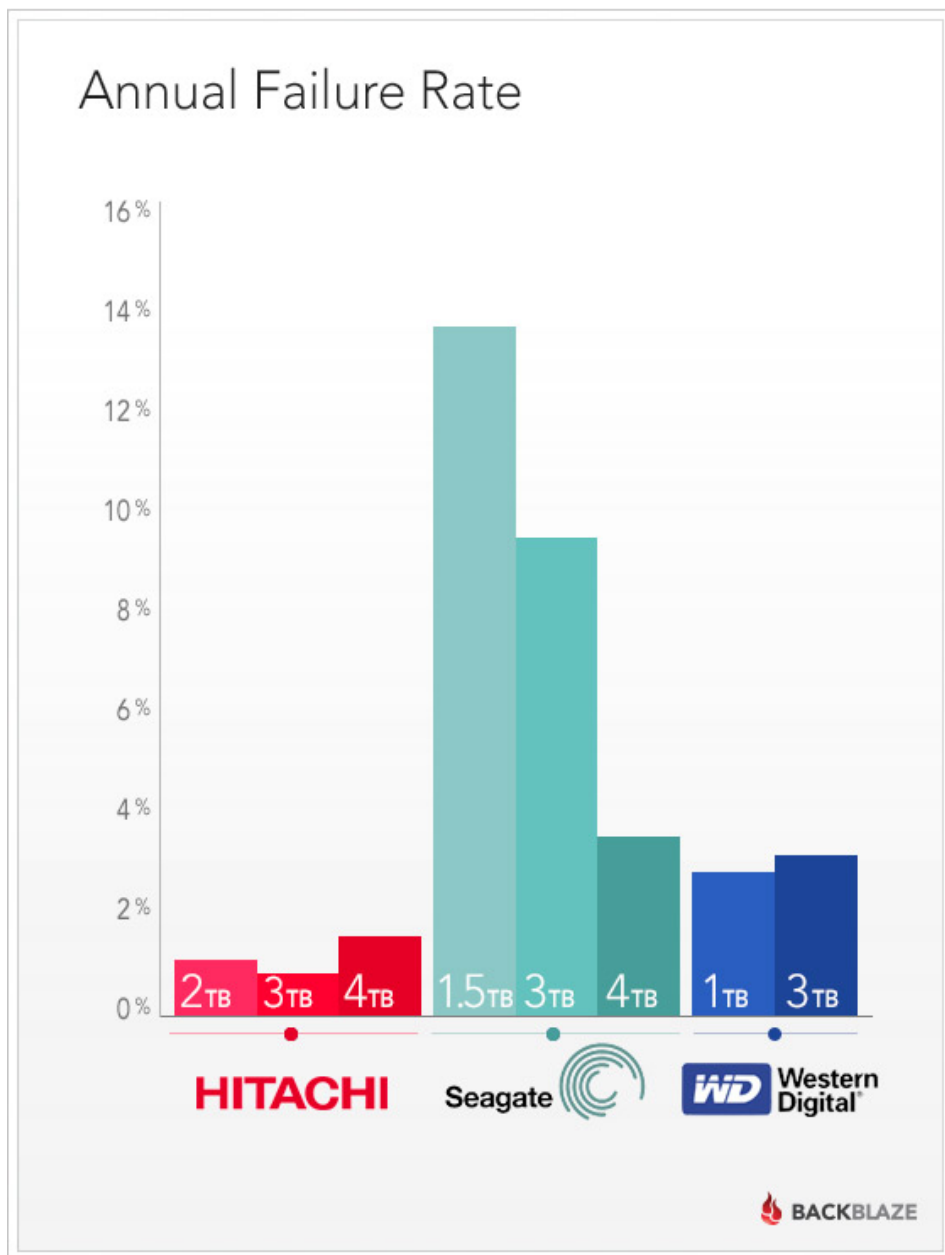
We have some of these drives running in storage pods, but are in the process of replacing them because they aren't reliable enough. When one drive goes bad, it takes a lot of work to get the RAID back on-line if the whole RAID is made up of unreliable drives. It's just not worth the trouble.

The drives that just don't work in our environment are Western Digital Green 3TB drives and Seagate LP (low power) 2TB drives. Both of these drives start accumulating errors as soon as they are put into production. We think this is related to vibration. The drives do somewhat better in the new low-vibration [Backblaze Storage Pod](#), but still not well enough.

These drives are designed to be energy-efficient, and spin down aggressively when not in use. In the Backblaze environment, they spin down frequently, and then spin right back up. We think that this causes a lot of wear on the drive.

Failure Rates

We measure drive reliability by looking at the annual failure rate, which is the average number of failures you can expect running one drive for a year. A failure is when we have to replace a drive in a pod.



This chart has some more details that don't show up in the pretty chart, including the number of drives of each model that we have, and how old the drives are:

Number of Hard Drives by Model at Backblaze

Model	Size	Number of Drives	Average Age in Years	Annual Failure Rate
Seagate Desktop HDD.15 (ST4000DM000)	4.0TB	5199	0.3	3.8%
Hitachi GST Deskstar 7K2000 (HDS722020ALA330)	2.0TB	4716	2.9	1.1%
Hitachi GST Deskstar 5K3000 (HDS5C3030ALA630)	3.0TB	4592	1.7	0.9%
Seagate Barracuda (ST3000DM001)	3.0TB	4252	1.4	9.8%

Hitachi Deskstar 5K4000 (HDS5C4040ALE630)	4.0TB	2587	0.8	1.5%
Seagate Barracuda LP (ST31500541AS)	1.5TB	1929	3.8	9.9%
Hitachi Deskstar 7K3000 (HDS723030ALA640)	3.0TB	1027	2.1	0.9%
Seagate Barracuda 7200 (ST31500341AS)	1.5TB	539	3.8	25.4%
Western Digital Green (WD10EADS)	1.0TB	474	4.4	3.6%
Western Digital Red (WD30EFRX)	3.0TB	346	0.5	3.2%
Seagate Barracuda XT (ST33000651AS)	3.0TB	293	2.0	7.3%
Seagate Barracuda LP (ST32000542AS)	2.0TB	288	2.0	7.2%
Seagate Barracuda XT (ST4000DX000)	4.0TB	179	0.7	n/a
Western Digital Green (WD10EACS)	1.0TB	84	5.0	n/a
Seagate Barracuda Green (ST1500DL003)	1.5TB	51	0.8	120.0%

The following sections focus on different aspects of these results.

1.5TB Seagate Drives

The Backblaze team has been happy with Seagate Barracuda LP 1.5TB drives. We've been running them for a long time – their average age is pushing 4 years. Their overall failure rate isn't great, but it's not terrible either.

The non-LP 7200 RPM drives have been consistently unreliable. Their failure rate is high, especially as they're getting older.

1.5 TB Seagate Drives Used by Backblaze

Model	Size	Number of Drives	Average Age in Years	Annual Failure Rate
Seagate Barracuda LP (ST31500541AS)	1.5TB	1929	3.8	9.9%
Seagate Barracuda 7200 (ST31500341AS)	1.5TB	539	3.8	25.4%
Seagate Barracuda Green (ST1500DL003)	1.5TB	51	0.8	120.0%

The Seagate Barracuda Green 1.5TB drive, though, has not been doing well. We got them from Seagate as warranty replacements for the older drives, and these new drives are dropping like flies. Their average age shows 0.8 years, but since these are warranty replacements, we believe that they are refurbished drives that were returned by other customers and erased, so they already had some usage when we got them.

Bigger Seagate Drives

The bigger Seagate drives have continued the tradition of the 1.5Tb drives: they're solid

workhorses, but there is a constant attrition as they wear out.

2.0 to 4.0 TB Seagate Drives Used by Backblaze

Model	Size	Number of Drives	Average Age in Years	Annual Failure Rate
Seagate Desktop HDD.15 (ST4000DM000)	4.0TB	5199	0.3	3.8%
Seagate Barracuda (ST3000DM001)	3.0TB	4252	1.4	9.8%
Seagate Barracuda XT (ST33000651AS)	3.0TB	293	2.0	7.3%
Seagate Barracuda LP (ST32000542AS)	2.0TB	288	2.0	7.2%
Seagate Barracuda XT (ST4000DX000)	4.0TB	179	0.7	n/a

The good pricing on Seagate drives along with the consistent, but not great, performance is why we have a lot of them.

Hitachi Drives

If the price were right, we would be buying nothing but Hitachi drives. They have been rock solid, and have had a remarkably low failure rate.

Hitachi Drives Used by Backblaze

Model	Size	Number of Drives	Average Age in Years	Annual Failure Rate
Hitachi GST Deskstar 7K2000 (HDS722020ALA330)	2.0TB	4716	2.9	1.1%
Hitachi GST Deskstar 5K3000 (HDS5C3030ALA630)	3.0TB	4592	1.7	0.9%
Hitachi Deskstar 5K4000 (HDS5C4040ALE630)	4.0TB	2587	0.8	1.5%
Hitachi Deskstar 7K3000 (HDS723030ALA640)	3.0TB	1027	2.1	0.9%

Western Digital Drives

Back at the beginning of Backblaze, we bought Western Digital 1.0TB drives, and that was a really good choice. Even after over 4 years of use, the ones we still have are going strong.

We wish we had more of the Western Digital Red 3TB drives (WD30EFRX). They've also been really good, but they came after we already had a bunch of the Seagate 3TB drives, and when they came out their price was higher.

Western Digital Drives Used by Backblaze

Model	Size	Number of Drives	Average Age in Years	Annual Failure Rate
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			Years	Rate
Western Digital Green (WD10EADS)	1.0TB	474	4.4	3.6%
Western Digital Red (WD30EFRX)	3.0TB	346	0.5	3.2%
Western Digital Green (WD10EACS)	1.0TB	84	5.0	n/a

What About Drives That Don't Fail Completely?

Another issue when running a big data center is how much personal attention each drive needs. When a drive has a problem, but doesn't fail completely, it still creates work. Sometimes automated recovery can fix this, but sometimes a RAID array needs that personal touch to get it running again.

Each storage pod runs a number of RAID arrays. Each array stores data reliably by spreading data across many drives. If one drive fails, the data can still be obtained from the others. Sometimes, a drive may "pop out" of a RAID array but still seem good, so after checking that its data is intact and it's working, it gets put back in the RAID to continue operation. Other times a drive may stop responding completely and look like it's gone, but it can be reset and continue running.

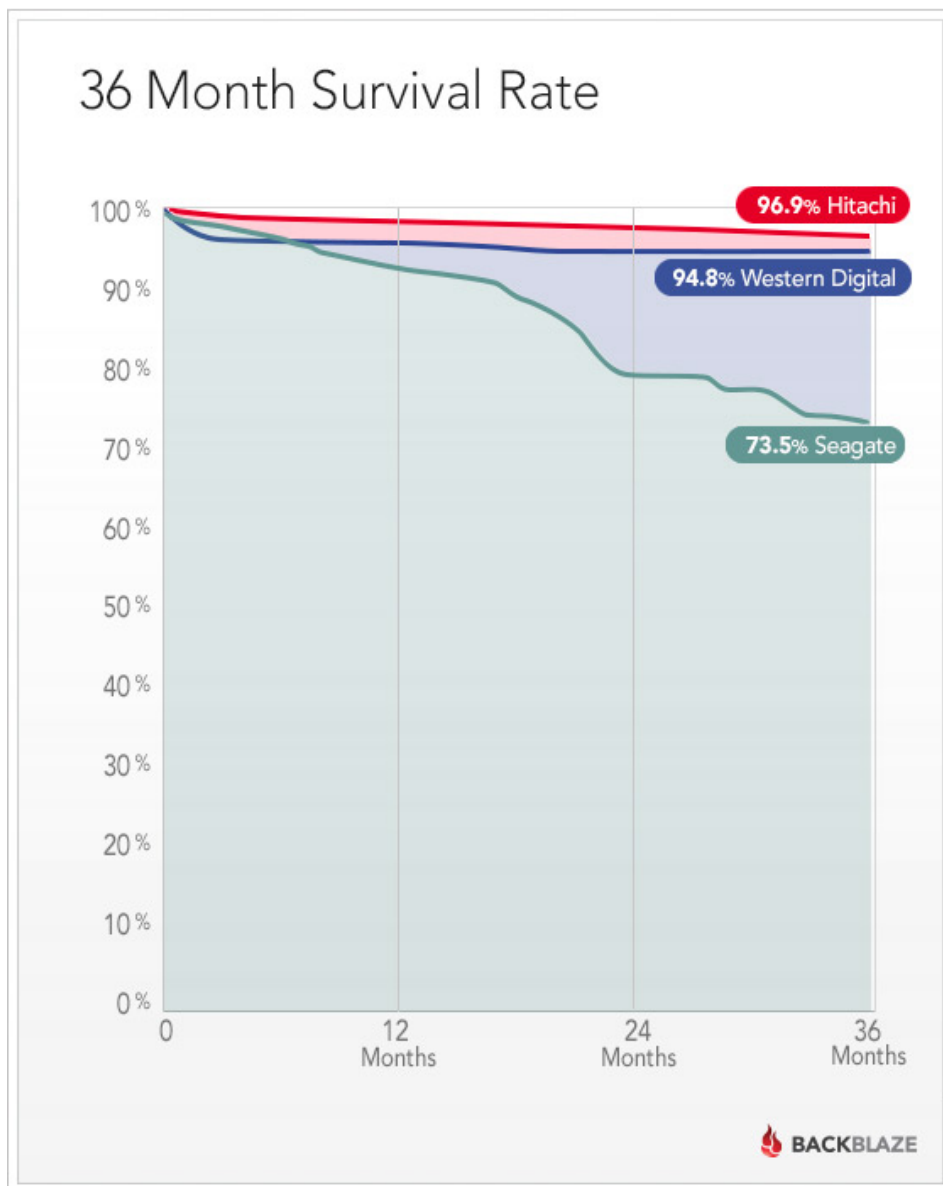
Measuring the time spent in a "trouble" state like this is a measure of how much work a drive creates. Once again, Hitachi wins. Hitachi drives get "four nines" of untroubled operation time, while the other brands just get "two nines".

Untroubled Operation of Drives by Manufacturer used at Backblaze

Brand	Active	Trouble	Number of Drives
Seagate	99.72	0.28%	12459
Western Digital	99.83	0.17%	933
Hitachi	99.99	0.01%	12956

Drive Lifetime by Brand

The chart below shows the cumulative survival rate for each brand. Month by month, how many of the drives are still alive?



Hitachi does really well. There is an initial die-off of Western Digital drives, and then they are nice and stable. The Seagate drives start strong, but die off at a consistently higher rate, with a burst of deaths near the 20-month mark.

Having said that, you'll notice that even after 3 years, by far most of the drives are still operating.

What Drives Is Backblaze Buying Now?

We are focusing on 4TB drives for new pods. For these, our current favorite is the Seagate Desktop HDD.15 (ST4000DM000). We'll have to keep an eye on them, though. Historically, Seagate drives have performed well at first, and then had higher failure rates later.

Our other favorite is the Western Digital 3TB Red (WD30EFRX).

We still have to buy smaller drives as replacements for older pods where drives fail. The drives we absolutely won't buy are Western Digital 3TB Green drives and Seagate 2TB LP drives.

A year and a half ago, Western Digital acquired the Hitachi disk drive business. Will Hitachi drives continue their excellent performance? Will Western Digital bring some of the Hitachi reliability into their consumer-grade drives?

Correction: Hitachi's 2.5" hard drive business went to Western Digital, while the 3.5" hard drive business went to Toshiba.

At Backblaze, we will continue to monitor and share the performance of a wide variety of disk drive models. What has your experience been?

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Gordan Bobic · Camberley

"Will Western Digital bring some of the Hitachi reliability into their consumer-grade drives?"

Or will the HGST product line degrade to WD's quality levels?

[Reply](#) · [11 · Like](#) · [Follow Post](#) · January 21 at 10:43am

Yevgeniy Pusin · [Follow](#) · Top Commenter · Social Marketing at Backblaze Online Backup

Since we buy consumer-grade drives, we're hoping for the former :)

[Reply](#) · [Like](#) · January 21 at 2:11pm

Gordan Bobic · Camberley

History teaches us that bad apples spoil the good apples, not the other way around. I'm just in the process of switching my disk estate from 3.5" to 2.5" (4TB+ disks are becoming way too much of a liability given resilvering times), so once this is all upgraded to Hitachi 2.5" drives I suspect that'll be it for my consumption of mechanical drives. I fully expect the price gap between solid state and spinning rust by the time the warranty runs out to close to the point where mechanical drives just aren't worth bothering with.

[Reply](#) · [Like](#) · January 21 at 5:13pm

Adam Zey

toyuniverses For BackBlaze, it's not the case, but for many people, SSDs don't have to be cheaper, just cheap enough. For example, given the choice between a 1TB HDD for \$30 and a 1TB SSD for \$90, which would you buy? Would you even bother with HDDs at that point?

[Reply](#) · [5 · Like](#) · January 21 at 8:01pm

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Joe Evans

I had 2 of the 1.5TB Seagate drives fail in a year. Luckily they were on a RAID 1 config. Seagate's customer service was non-existent and I basically threw the drives away. I haven't bought a Seagate product since and have no plans to. If this article hurts their business - good! Shame on them for not standing behind their products!

[Reply](#) · [6 · Like](#) · [Follow Post](#) · January 21 at 12:58pm

Paul Mansfield · Top Commenter

I've never had a problem sending in a Seagate drive for replacement, I post it off and a replacement comes back.

[Reply](#) · [Like](#) · January 22 at 6:07am



Charles Burns · Pocatello, Idaho

I've returned many drives from every major vendor except Hitachi (but including IBM). I've never had a problem returning an in-warranty drive to Seagate or any other. Some vendors, including Seagate, will even cross-ship the replacement so you get your replacement more quickly. The replacement drive also extends your warranty by up to 90 days.

I'm not trying to say Seagate is perfect, but I do know my hard drives extremely well, and I don't like to see a good vendor get a bad reputation from anecdotal situations.

Admittedly, I have no Seagate drives in my home right now, but not because I avoid them.

Good idea using RAID1, by the way.

[Reply](#) · [Like](#) · Edited · January 22 at 4:53pm



Charles Burns · Pocatello, Idaho

Charts should be saved as PNG, not JPG.

[Reply](#) · [6](#) · [Like](#) · [Follow Post](#) · January 21 at 8:42pm



Charles Burns · Pocatello, Idaho

It looks like exactly one model/size of Seagate had a high failure rate, and the rest did not. That's actually believable, because every hard drive company has bad models from time to time. Western Digital had the Expert and several models of Raptor. IBM/Hitachi had the 75GXP. Perhaps Seagate's is the ST31500341AS (doesn't that just roll off the tongue). This does not mean that you should avoid Seagate anymore than you should avoid any other manufacturer for their bad runs.

[Reply](#) · [4](#) · [Like](#) · [Follow Post](#) · January 21 at 8:46pm



Paul Mansfield · Top Commenter

At a previous job 6 years ago I bought a lot of Seagate Barracuda drives (over 300 in use across 80 servers), and in general they were pretty good, but we did have a whole load of 320GB drives fail in rapid succession, all from the same batch.

We sent them back and the replacements were fine.

A friend had a pair in his desktop computer, bought quite a few months later and they worked reliably for years, they still do I expect.

So an interesting statistic would be to show failure rate graphs of specific models and I expect it'd show how there are bad batches of drives.

[Reply](#) · [2](#) · [Like](#) · January 22 at 6:11am



Bryan Schuman · Top Commenter · Works at IATSE Local 15

Paul Mansfield The WD RED drives had a bad batch go out here a while back. These things happen. Tracking by drive manufacture date would be nice to see consistency, including anomalies like a bad batch.

[Reply](#) · [2](#) · [Like](#) · January 22 at 4:48pm



Brian Beach · Distinguished Engineer at Backblaze Online Backup

You have it right, Charles. Overall the Seagate drives get the job done for us. Overall, their failure rate is low enough that they get the job done for us.

[Reply](#) · [2](#) · [Like](#) · January 24 at 10:36am



Mark Andrew Pemberton · Winston-Salem, North Carolina

I'm sure it's impossible to do, but the manufacturing location of the drives has a factor. Specifically speaking of the Seagate drives. In recent years, they opened up a Mfg plant in China. The drives coming out of China were sub-par compared to the drives coming out of the Thailand facility. Searches on NewEgg will confirm this.

[Reply](#) · [3](#) · [Like](#) · [Follow Post](#) · January 22 at 1:38pm



Kevin Prichard · [Follow](#) · Top Commenter · San Francisco, California

I copied the main Backblaze table into a spreadsheet and added prices to run some calculations (accuracy not guaranteed; based on today's prices)-

26,293 drives (77 PB)

1,215 failed (3 PB)

\$4.38 million acquisition - today's prices

\$173k failed drive replacement

\$2.9 million to acquire 77 PB with the best price/fail rate performer - Seagate Desktop HDD.15. Their conclusion also. (Going with the most reliable drive would cost another \$2 million.).

Those are 5900 RPM drives, though, and the weighted avg RPM across that collection of drives is 6340, so they'd potentially see a drop in throughput up to 7%.

<https://docs.google.com/spreadsheets/cc?key=0AVMPjyAtvUdGRLSVWdjFNdm0yQUo1YkFNyVh2NVE&usp=sharing>

Reply · 2 · Like · Follow Post · January 22 at 11:02am



Charles Burns · Pocatello, Idaho

A good analysis, but you cannot derive throughput through RPM alone. It's one of many factors, and is usually less important than the firmware and areal density (depending on the definition of throughput).

Reply · 1 · Like · January 22 at 4:59pm



Sandon Van Ness · Lab Manager at Inktank Storage

You guys are really lucky you did not get 1 TB seagate drives as those are significantly worse than the 1.5 TB models. I have seen nearly a 50%+ failure rate on those after a couple years of deployment (this is of a pool of more than 10,000 drives).

The thing would be even a better comparison would be look at re-allocated sector count/general smart 'health' rating of drives after a couple years of use. Even if the seagates are still alive I find that they are often getting much worse performance and often have a few hundred re-allocated sectors. I do smart monitoring on all drives and replace them once they got over 50 re-allocations or more than 3 or 4 pending or uncorrect/unreadable sectors as the drives seem to just go downhill at that point.

I have looked at state of 10+ old sun xfire 4500 servers with 500GB drives t... [See More](#)

Reply · 1 · Like · Follow Post · January 23 at 12:50am



Brian Beach · Distinguished Engineer at Backblaze Online Backup

Good point about the reallocated sector count. We do track that, and when it gets too high we'll replace the drive. So counting the replaced drives includes the drives whose reallocated sector count says they are dying.

Reply · 1 · Like · January 24 at 10:39am



Sandon Van Ness · Lab Manager at Inktank Storage

Brian Beach Of course I don't know how bad it has to be until you guys consider replacing but still I find hitachi drives to be impressive to stay near 'new' condition with their general health when even though the drives are still working (at lower performance) the seagate ones almost always have re-allocations and other health issues.

Example:

<http://pastebin.com/RdUvQqbH>

Columns are re-allocated sectors, pending sectors, powercycles, number of days powered on.

First two zpool's show hitachi deskstar drives with ~2000 days powered on and ~1600 days powered on, as you can see from the powered on days almost all of them are the original drive and most have 0 re-allocations and 0 pending (or just a few). Compare that to the seagate zpools. Very few have 0 re-allocations and 0 pending and have atleast some defects. Also lots of failures you can see from the powered on days statistic.

Would be very interested in the averages of the drives still considered not failed between the brands...

Reply · Like · January 28 at 3:03am



Jesse Huizenga

I have always been a WD fan. I have an 85MB WD drive from 1992, still seems to work perfectly. I have another from 98ish that still works fine. Seagate, Maxtors I have had have a pretty high failure rate. I have a few other drive too like fujitsu, quantum, but only a few. a server I had had 2 fujitsu, One just suddenly started going Waco on starting system, and locked up SCSI bus, so have 1 now. had 3 quantums a big foot, and 2 SCA scsi drives, i used ocasinally for a while, and seemed to work fine.

For externals my favorite so far is my 2TB Samsung story station. nice case setup, drive is fairly quiet, and I've never had make an odd sound. I got a 3TB Toshiba canvio on sale at staples to backup Samsung, and use for some other stuff that is about the most annoying drive I've ever dealt with. power save takes effect like 10-15 ... [See More](#)

Reply · 1 · Like · Follow Post · January 21 at 6:00pm



Andre Somma

I've had nothing but bad luck with WD. I'll never buy WD again and never recommend them.



[Reply](#) · [1](#) · [Like](#) · [Follow Post](#) · January 26 at 8:53pm



Johnny Foley · Saint Augustine, Florida

I have had Seagates (currently two) and a Hitachi drive. The Hitachi was some water and shock resistant model which sounded great until the usb connect stopped responding unless it's at the right angle. I haven't tested any others from their line up but don't get that one haha. My Seagates have been awesome, I'm surprised they performed the lowest in the article here.

[Reply](#) · [Like](#) · January 26 at 11:07pm



Mark Donaldson · Computer Geek at Staples

Great article, thanks. A friend sent me this.

<http://lildude.co.uk/effect-of-noise-on-disk-performance>

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