Best Practices for Performing JEDEC-Based Endurance Testing

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JEDEC Standards For Endurance

- The JEDEC JC-64.8 subcommittee was created to establish standards for SSDs
  - JEDEC already has expert resources dedicated to memory components, packaging, and reliability
  - Both manufacturers and end users are involved in the standards development process
  - Standard methods to predict verify SSD endurance is needed for market development and customer satisfaction
  - JEDEC standards are available free to the public

SSD Endurance Rating

- How good is the endurance rating of your SSD?
  - What method was used to produce the rating?
  - Does the endurance rating tell you what you really want to know about your SSD?
    - What determines pass/fail?
    - What workload was used?
    - How realistic was the testing to determine the endurance?
  - Does the rating allow you to compare your SSD with SSD's from other manufacturers?

Drive Writes Per Day versus TBW

- Sometimes endurance is expressed in the number of drive writes per day for an SSD
  - What does drive writes per day that really mean?
  - It is a great expression in terms of SSD capacity, but make sure the SSD manufacturer can answer these questions:
    - What determines end of life?
    - Does it mean that the SSD had to wear level or was the workload such that it did not require the drive to do any wear leveling?
    - Was the data content random or compressible?

Full Writes Per Day versus TBW

- TBW (TeraBytes Written) is a defined JEDEC endurance term that has specific guidelines for defining how it is verified and what it means

Best Practices To Verify Endurance

- The JEDEC endurance rating (TBW)
  - Significant sample size
  - Proven technical stressing
  - Differentiation of application classes
    - Client and enterprise workloads
    - Client and enterprise activity
    - Client and enterprise temperatures
    - Client and enterprise “end of life” data retention
    - Client and enterprise UBER

JEDEC Endurance Rating - TBW

JESD218A SSD Classes and Requirements table:

Table 1 — SSD Classes and Requirements

Application Class	Workload (see JESD219)	Active Use (power on)	Retention Use (power off)	Functional Failure Requirement (FFR)	UBER Requirement
Client	Client	40 °C 8 hrs/day	30 °C 1 year	≤3%	$\leq 10^{-15}$
Enterprise	Enterprise	55 °C 24hrs/day	40 °C 3 months	≤3%	$\leq 10^{-16}$

These requirements and classes define what the JEDEC TBW endurance rating really means

Endurance Rating Workload

- Enterprise workload:
  - Leveraged from SPC-1 but not totally on 4K boundaries
  - Writes 100% of LBA's, including more writes to some areas than others
- Client workload:
  - Leveraged from a 9 month trace on client application
  - Includes trim commands
- Both workloads use a random data payload

Endurance Rating Workload

- Client workload just published in JESD219A
- Collected on standard laptop PC, 2 GB RAM, 128 GB SATA SSD, operating system supporting trim
  - Main use: office productivity
  - Secondary use: storage of photos, music, and apps
- Trace Characteristics
  - Writes/Trims/Flushes captured in a file with a CSV format: command LBA size
  - 49 GB footprint (total data touched)
  - 64 GB spanned (range of LBA's accessed)
  - Average amount of Trimmed space = 13 GB (average across duration of trace)

Activity, DATA Retention, UBER

- Enterprise is rated at 24 hours per day, client, 8 hours per day
- Enterprise data retention shorter to allow longer usage life and expected scheduled maintenance availability
- UBER rating higher for enterprise critical applications

Endurance Rating Temperature

- Temperature does matter – But maybe not like you think it does!
  - Hot and cold are both important
  - Writing hot “hardens” data
  - Storing hot accelerates data retention loss
  - Write cold/store hot at “end of life” leads to shortest data retention
- JEDEC endurance verification uses both room temperature and hot conditions to verify the SSD endurance rating

Endurance Rating Temperature

Table C.1 — Expected retention (weeks) at different use temperatures

Power Off Temperature	Active Temperature 25	30	35	40	45	50	55
55							8
50						9	15
45					10	17	27
40				14	20	31	52
35			20	26	38	61	101
30		32	39	52	76	120	199
25	58	65	79	105	155	244	404

Client

Power Off Temperature	Active Temperature 25	30	35	40	45	50	55
55							2
50						2	4
45					2	4	7
40				3	4	7	13
35			3	5	8	14	25
30		4	6	10	16	28	50
25	7	9	12	20	33	58	101

Enterprise

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These numbers reflect data retention for NAND after 100% P/E cycles. Less than 100% has much longer data retention.

JEDEC Endurance Rating - TBW

- Verified with a statistically valid sample size
- Workload designed to fit the application and to make the SSD wear level
- Temperature ranges to fit the application
  - Testing single lot ramped temperature or dual lot (one hot, one room temp) with equally valid results
- Standard rating to allow comparison between SSDs and vendors

Use JEDEC JESD218 methods and JESD219 workloads to have a meaningful standard SSD endurance rating