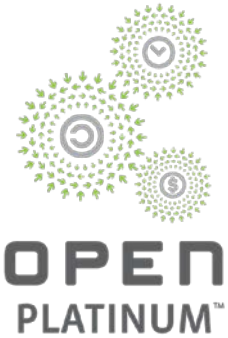
Thermal Methodology Standard for SSD Form Factors

Paul J. Gwin, Intel
Dave Landsman, Western Digital
Brandon Gary, Microsoft
Jason Adrian, Microsoft



SSD Form Factors present a new thermal design challenge

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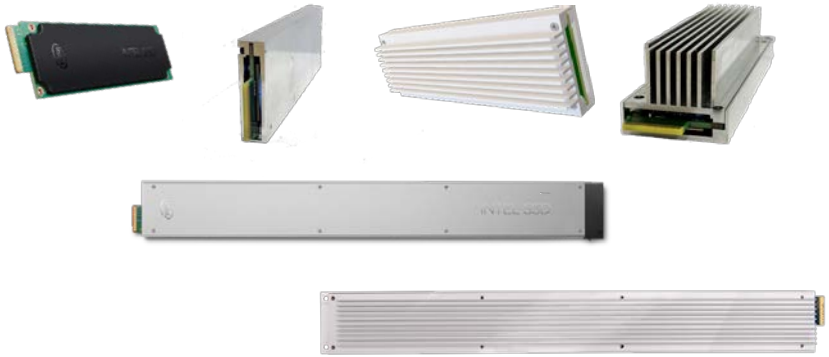
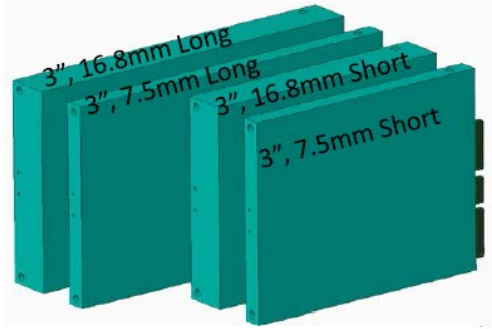
SFF 2.5” and 3.5” HDD

EDSFF SSD





We went from basically 2 HDD form factors to ….

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How do we pick design points for new SSD Form Factors?

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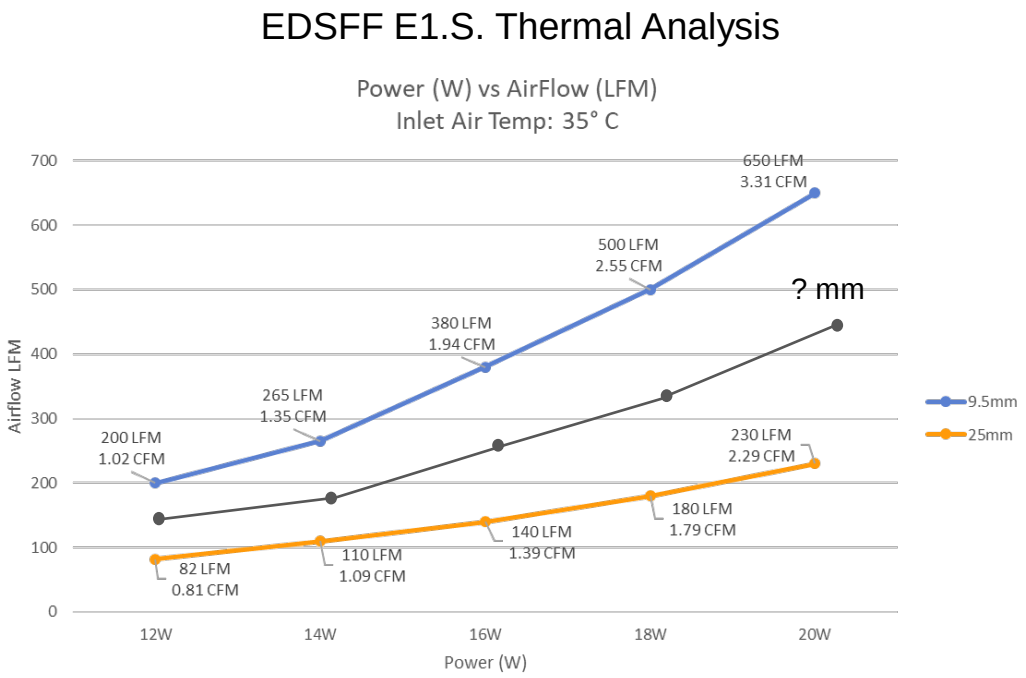
- In 2H 2019, Microsoft was looking for a new thickness for the E1.S
  - But what should it be?
- Microsoft asked OCP for an industry consensus on
  1. New E1.S variant thickness
  2. Standard methodology for analyzing device and system thermals to improve how we define optimal SSD form factors
- OCP reached consensus on E1.S 15mm, but we still need a standard methodology
  - Today's talk reviews a proposed methodology



The Proposed Thermal Analysis Methodology

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OEM Characterizes Platform Requirements

- Air Inlet Temp (T_{inlet}) Curves
- System Fan Curves
- SSD Impedance Curves

Device Vendor designs SSD w/ platform targets in mind

Device Vendor and OEM discuss and compare based on standard metrics

OEM Specifies: T-inlet Curve, Impedance Curve

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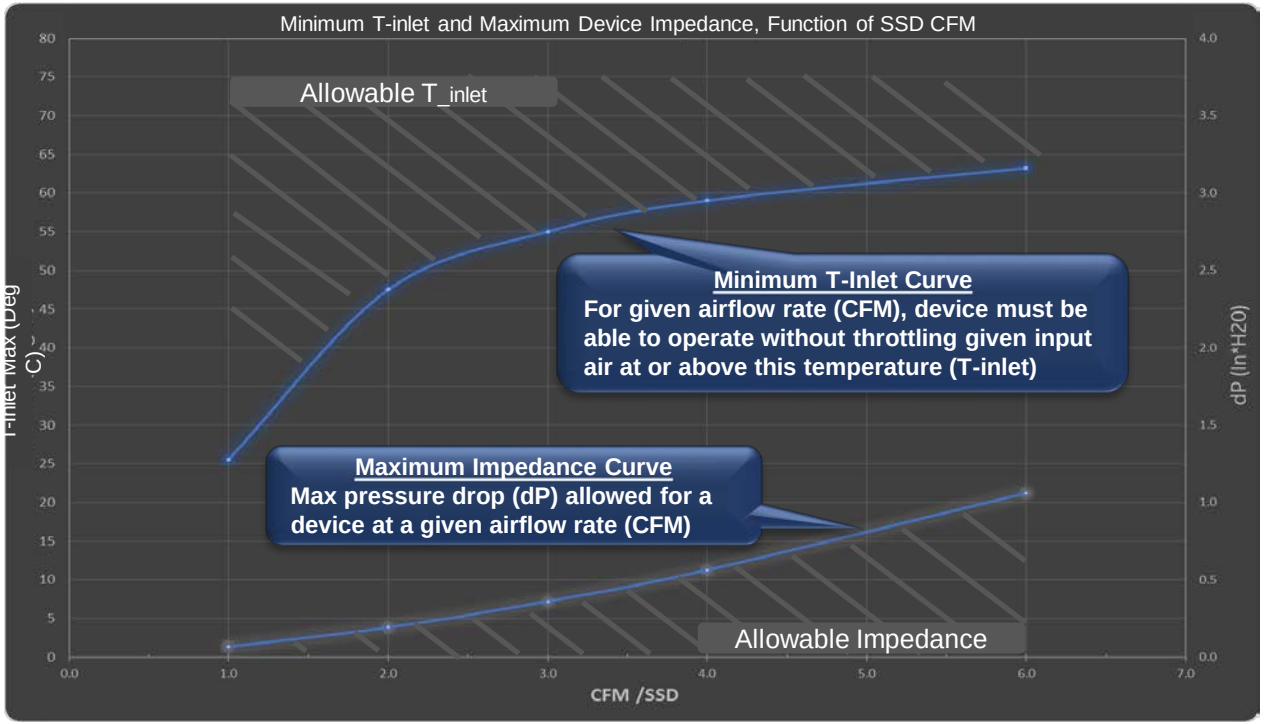
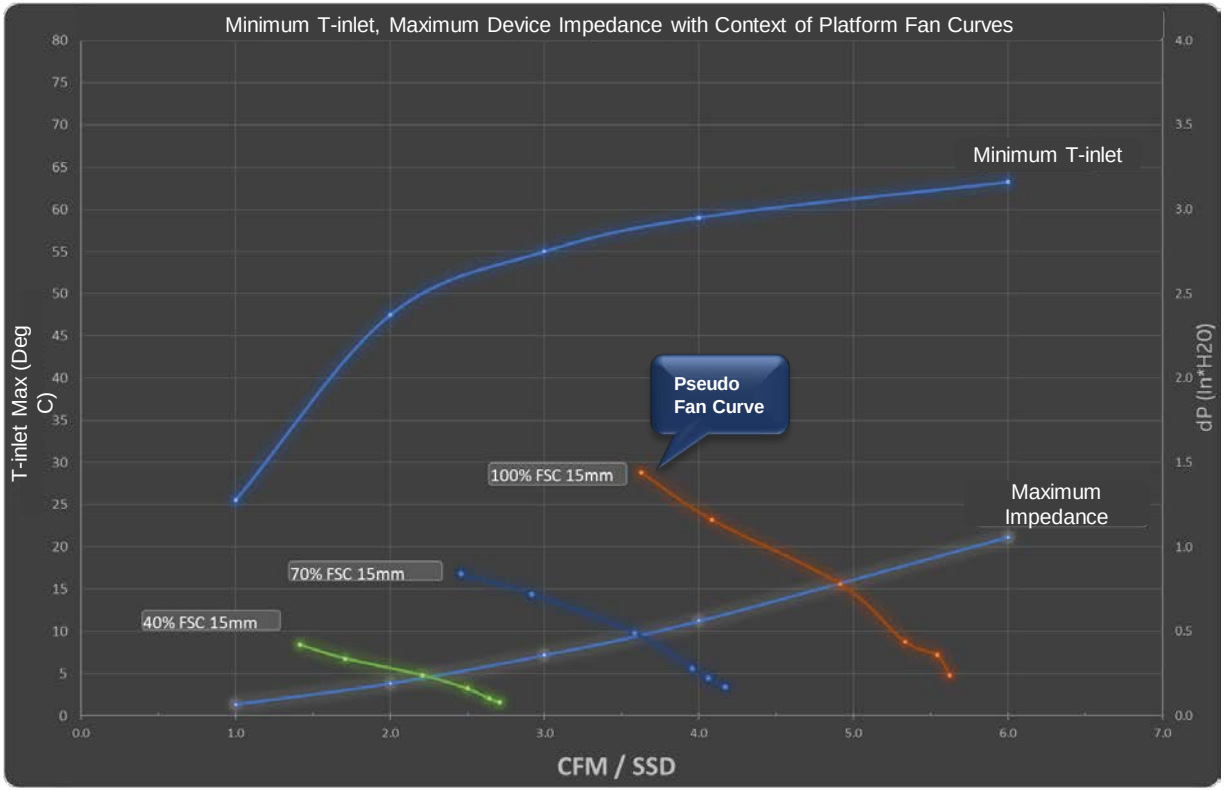
- **Characterize system with a minimum T-inlet Curve**
  - Device must support full performance (i.e., no throttling) at or above this boundary condition
- **Characterize system w/ maximum Impedance Curve**
  - Air resistance caused by the device, as measured by dP at a given airflow rate, must be at or below this boundary condition
- Provides understanding of platform SSD requirements
- Allows designers to optimize the SSD design for a system



OEM Specifies: Pseudo Fan Curves



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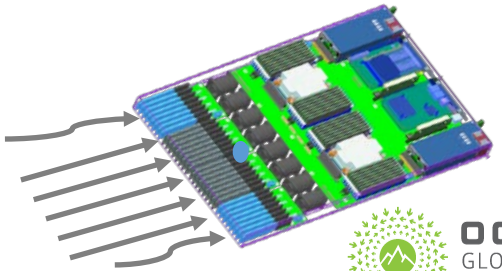
- **Fan curves** represent the flowrate of air as a function of air flow impedance (dP)
- **Pseudo fan curves** represent "de-rated" flowrate (i.e., accounting for impedance of non-SSD elements in enclosure)
- Multiple Fan Curves can represent drive operation targets for multiple boundary conditions:
  - Low room temp
  - Average room temp
  - Maximum room temp or altitude
  - Fan Curve at 100% w/ Fan Failure
- Fan curves provide necessary information to design for platform operation, at multiple fan conditions



Finding System Operating Point: - Pseudo Fan Curve Enables This

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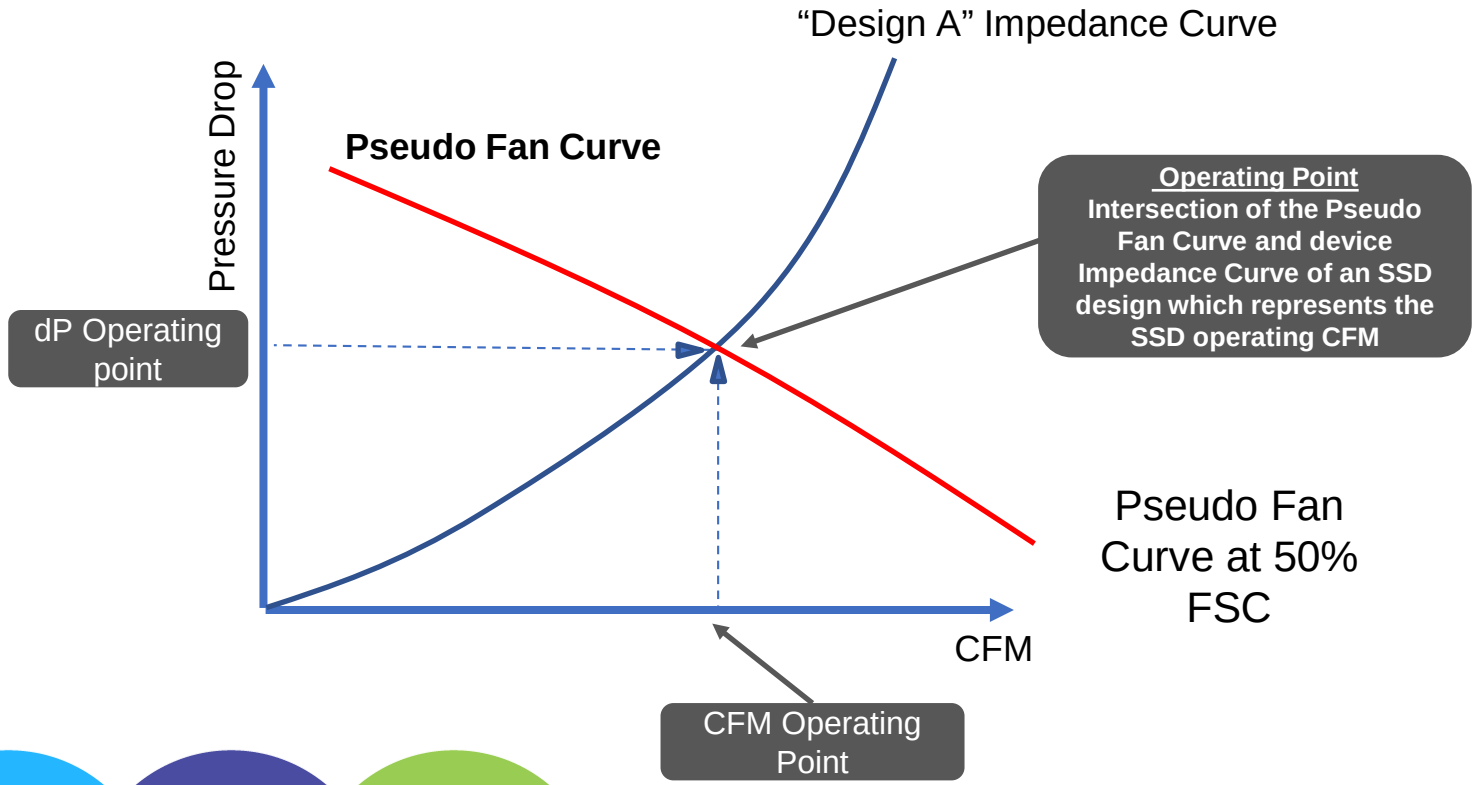

How Different Device Form Factors are Compared

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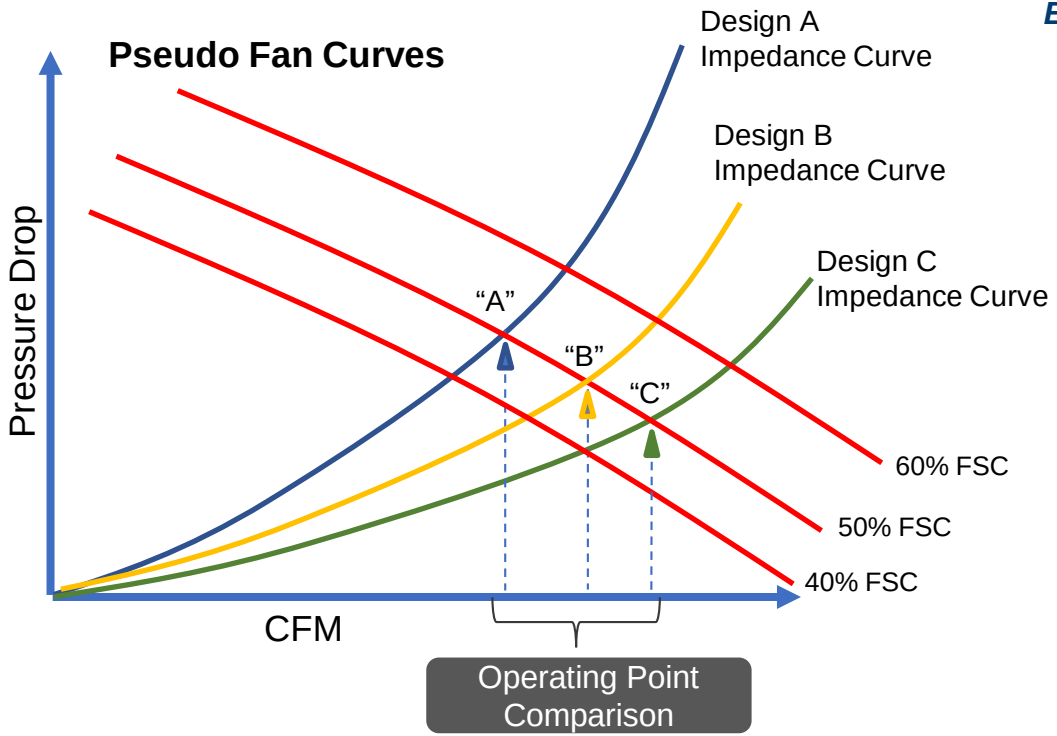

Example:

- 3 devices, same X-Y, increasing thickness
- Pseudo Fan Curves at 40/50/60% fan speed (FSC)
- Points A, B, C show the respective system operating point of each design at 50% FSC
- We now have ability to understand how 3 designs will operate in the platform

Device Vendor: Design and Analysis compared to System Spec

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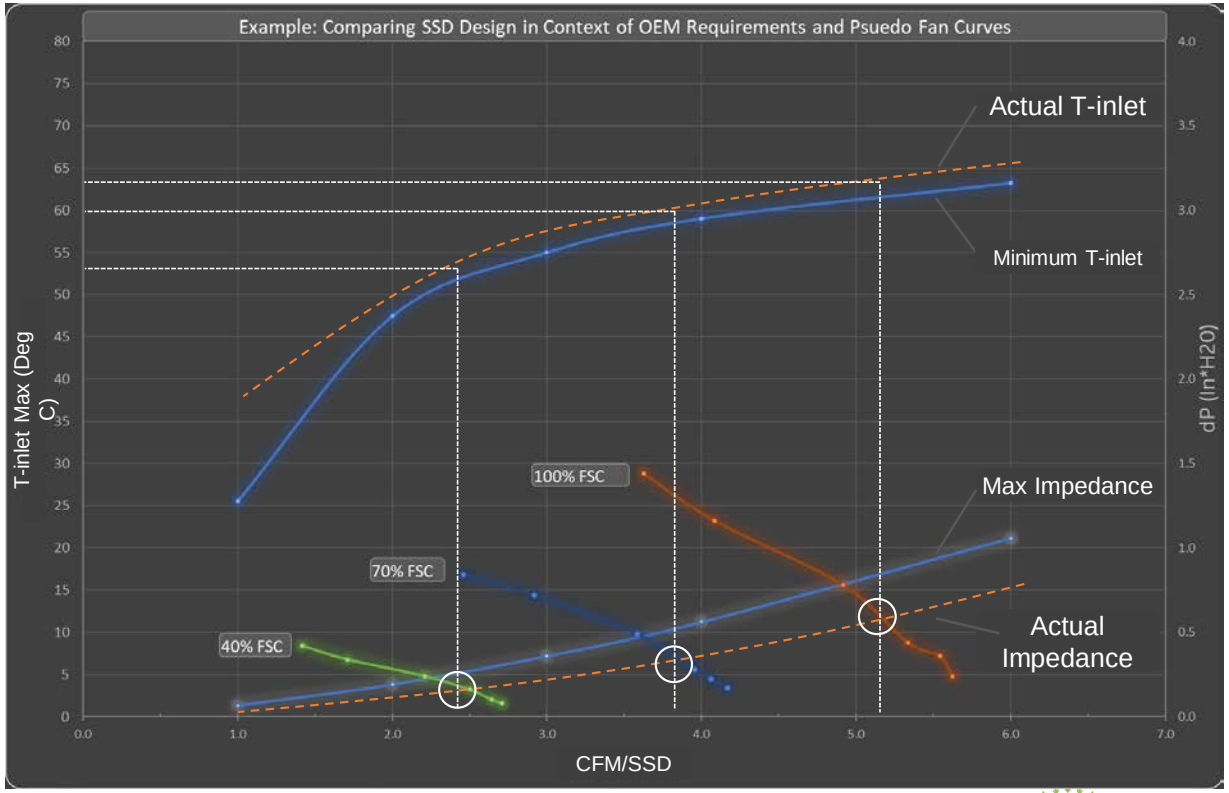
- Vendor response curves allow us to understand how SSD meets OEM's requirements in platform
  - Graph shows the SSD design provides a T-inlet above the minimum while maintaining impedance below the maximum, from low to high fan operation.
- OEM can understand SSD and platform airflow as fan speed increases
  - Ex: A 40% fan speed pulls 2.4CFM through the drive, while a 70% fan speed will pull 3.8CFM
- This chart allows us to compare key metrics of the SSD form factor and platform such as:
  - CFM/SSD
  - CFM/Platform
  - T-inlet supported at each FSC%
  - Power savings insight



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E1.S 9.5, 15, and 25mm Width Platform Response - @70% Fan Speed; 20W

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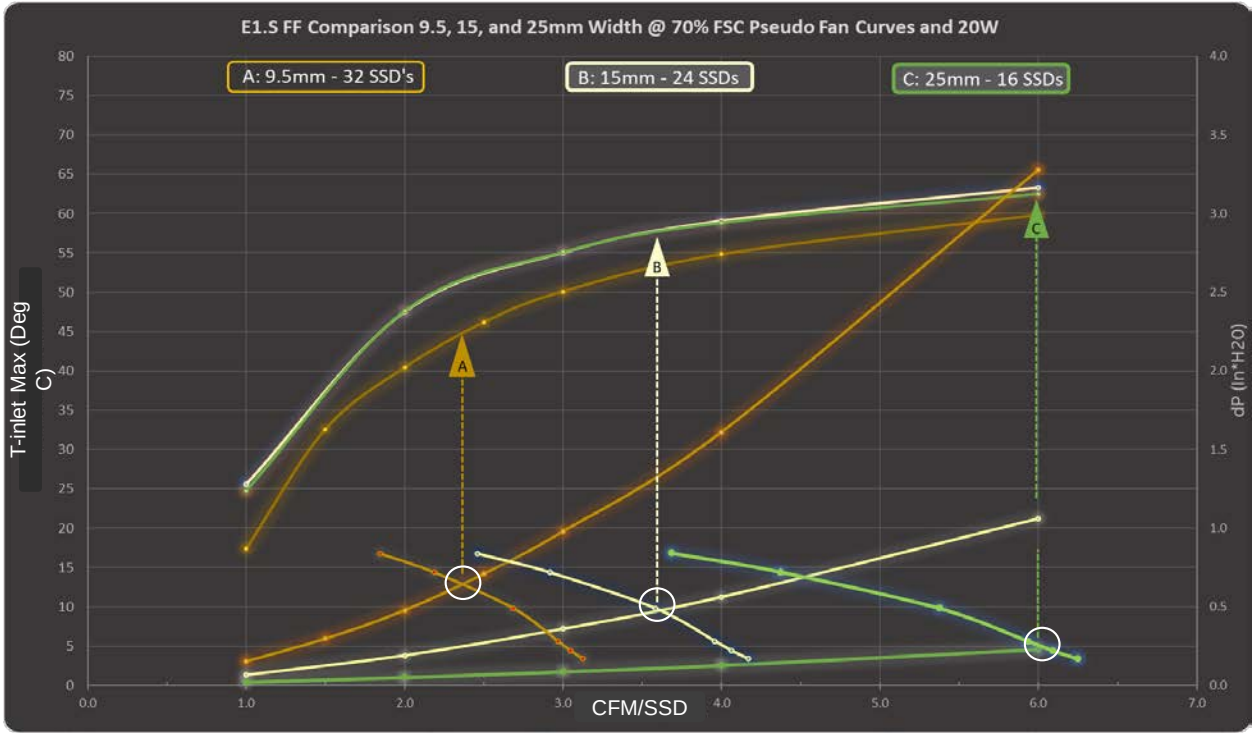
- **This graph shows where 3 different SSDs operate (CFM) in same platform**
  - A: 9.5mm @ 2.3 CFM
  - B: 15mm @ 3.6 CFM
  - C: 25mm @ 6.0 CFM
- **Shows T-inlet allowable of the 3 SSD widths in context of the fan curves**
  - A: 9.5mm = 45C T-inlet
  - B: 15mm = 57C T-inlet
  - C: 25mm = 62C T-inlet
- **Allows key metrics such as total platform CFM for respective designs**

	SSD	Platform
A: 9.5mm	32 @ 2.3 CFM	= 77 CFM
B: 15mm	24 @ 3.6 CFM	= 86 CFM
C: 25mm	16 @ 6.0 CFM	= 96 CFM



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Comparison Metrics: T-inlet and Flowrate
- How do Designs Compare @ fixed 20W SSD PWR

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	Width	SSDs / Platform	CFM/SSD	T-inlet "max air temp allowed"	dP SSD (in-H2O)	Platform CFM	PWR/SSD*	Total SSD PWR	Air T-rise
A	9.5	32	2.4	45	.62	76.8	20	640	16.3
B	15	24	3.6	57	.5	86.4	20	480	10.8
C	25	16	6.0	62	.24	96	20	320	6.5

- Metrics provide understanding of an SSD form factor's ability to scale capacity, performance and cooling when integrated to a platform.
- It also provides insight to which form factor may benefit a platform thermally and or achieve fan power efficiency targets.

Example:

- "Design A" allows a 45C T-inlet @ 640W total SSD power (or equivalent IOPs). A result of high total power and lower platform airflow is a 16C increase in air temp to downstream thermal subsystems.
- Alternatively, "Design B" allows a modest 480 SSD Watts (IOPs), it can support a T-inlet of 57C, and only 10.8C increase in platform air temperature – minimizing the challenge to downstream thermal systems.
- "Design B" may be strategic to achieve platform cooling efficiency targets.

Summary – What does the methodology do for us?

- Proposed Methodology allows us to look at different SSD form factors in context of how they actually operate in the platform.

- OEM requirements (T-inlet and Impedance Curves) allow SSD thermal design for full platform operating CFM.
- Providing Pseudo fan curves allow design optimization and innovation to achieve better thermal designs (wrt platform).
- We can compare effect on platform energy savings or SSD power scaling – what power can be supported for an SSD.
- Standardization of FF comparison metrics allow platform and SSD integration comparisons …….. We can make sense out of different form factors now!

Call to Action

- Join us at OCP to refine this methodology and turn it into a standard
- Workgroup formed within Storage Project and beginning to meet
- To get involved contact:
  - Paul.J.Gwin@Intel.com
  - Dave.landsman@wdc.com
  - Brandon.Gary@Microsoft.com
  - Jason.Adrian@Microsoft.com
- Other Links
  - Storage Project Home: https://www.opencompute.org/projects/storage
  - Storage Project Wiki: https://www.opencompute.org/wiki/Storage
  - Mailing list: OCP-Storage@OCP-All.groups.io

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Backup Slides

SDD Thermal Analysis – In Consideration of Platform Integration

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Goal: Analyze a form factor width or device design with boundary conditions that are realistic to platform integration.

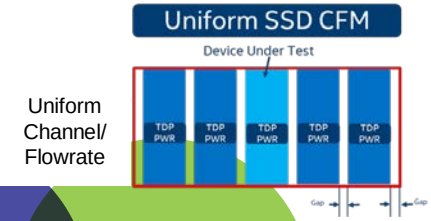
Boundary Conditions

- Width of Carrier or platform - definition
- Drive Pitch options
- # of Drives in platform

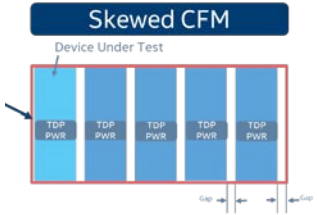
SSD Analysis

Thermal design context of platform boundary

- Analysis at uniform flow channel
- Analysis including Skewed flow Channel



Uniform Channel/ Flowrate



Non-Uniform Channel/ Flowrate

Platform Analysis

- Comparison of Analysis results against platform fan curves
- Feeds into platform metrics (comparison of drive FF)

Evaluating the Form Factor – Thermal Potential!

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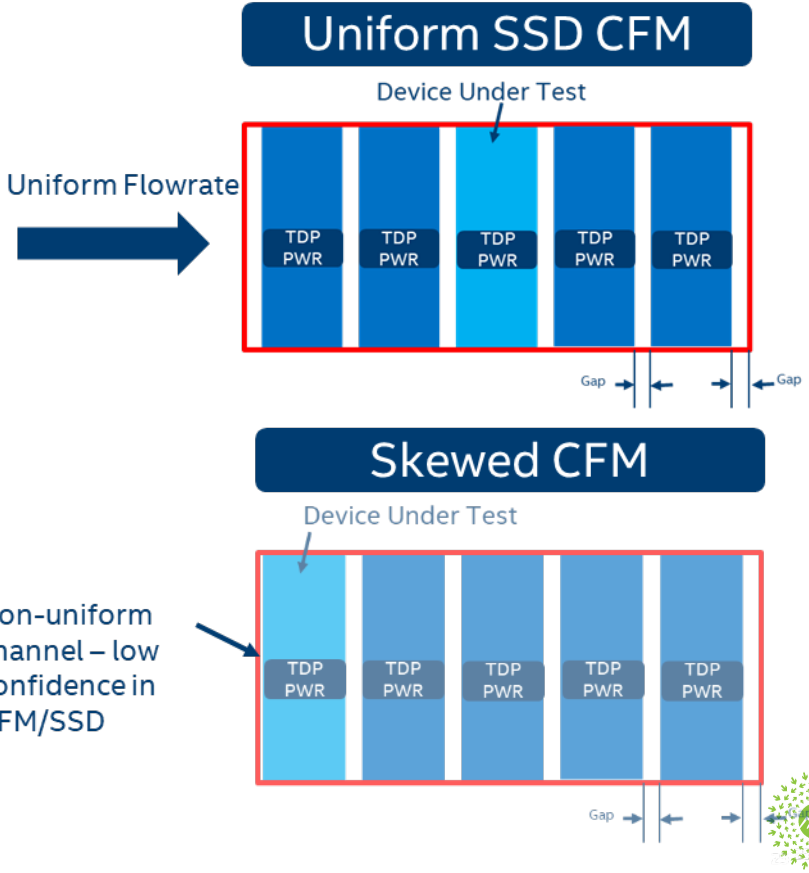
- **Goal: Consistent method across industry** to compare thermal performance of SSD thermal design(s)
- **Approach** – achieve **uniform flowrate through channels** – "simple comparison"
  - Some platform configurations can skew flowrate if not uniform channel thickness.
- **Minimum 3 drives** ISO powered, focus on middle drive thermal response.
  - T-rise contribution included – real power dissipated.



Goals of Standard to Develop

- We need How do characterize and report findings? (Methodology/Metrology physical characterization)
- How do we compare SSD's thermally in a platform? (Table or Chart)
- How do OEM's communicate SSD Thermal requirements?
  - Reference framework for the system (environmental conditions as function of platform)
- How do we report SSD thermal metrics? (Vendor response – curves)