



# Server Exhaust Temperature: Considerations for Thermal Efficiency

Technical Note by:

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## SUMMARY

Server exhaust temperature is an ongoing concern within the datacenter. In this paper we discuss

- Industry Temperature Trends
- Acceptable server temperatures
- Benefits of warmer temperatures
- Available user controls on Dell EMC PowerEdge Servers

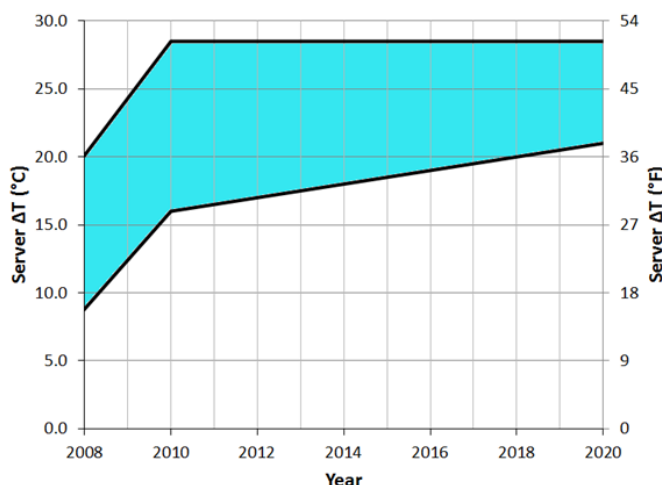
In most server systems, the energy consumed is rejected at the rear in the form of heated exhaust air. Dell PowerEdge servers utilize advanced thermal control algorithms to maintain system temperatures at reliable levels while minimizing fan speed and system airflow. This minimization of system fan speeds and airflow can result in high exhaust temperatures that are of concern to some users. This technical note will explain the reasoning behind these high temperatures and why users should plan for high temperatures within the rear of the rack.

## Exhaust Temperatures Are Rising

As servers consume electrical energy most is converted to thermal energy resulting in temperature increases within the electrical components (e.g. CPU, DIMMs, HDDs, etc.). Fans are utilized to move cool air from the front to the rear of the server. The air picks up heat via convection and exits at a higher temperature. The industry terminology for the temperature rise between system inlet and exhaust is the “Server  $\Delta T$ ”. The magnitude of the Server  $\Delta T$  is a function of system power consumption and airflow.

$$\text{Server } \Delta T = [\text{Exhaust temperature}] - [\text{System Inlet temperature}]$$

The industry’s best authority on data center cooling trends is TC9.9 within the *American Society of Heating Refrigerating and Air conditioning Engineers (ASHRAE)*. In a recent publication ASHRAE indicates that server  $\Delta T$  and subsequent exhaust temperatures have been on the rise and has forecasted an upward trend through 2020.



Source: Fig. “Server  $\Delta T$  projection at 25°C (77°F) server inlet temperature”; *IT Equipment Design Impact on Data Center Solutions*; ASHRAE 2016



The upward trend of system exhaust temperature is the result of industry wide efforts to reduce system power and flow rates. According to ASHRAE, server fan power has reduced from what was ~8-10% of system power consumption to as little as 1-2% industry wide. These reductions in system fan power result from optimizations and advancements in the thermal control logic which enables lower fan speeds. Consequently, when fan speeds reduce, system airflow is reduced, and the system exhaust temperature increases. A general rule of thumb is that server  $\Delta T$  will double when system airflow is cut in half. Or conversely, in order to cut the server  $\Delta T$  in half, the system airflow must be doubled. The thermal control advancements along with continual increases in system power and feature density have resulted in exhaust temperatures in the range of 53-57°C with many dense systems reaching even higher levels. Dell EMC thermal control algorithms aim for maximum system efficiency by targeting exhaust temperatures in the range of 65-70°C.

### What is hot?

The air temperature in many office buildings is around 25°C (77°F) – comfortable for a human. A hot cup of coffee can be around 50°-60°C (122°-140°F) which feels uncomfortably hot to the touch. CPUs and many other components (memory, network controller chips, etc.) in servers are designed to operate reliably at much higher temperatures. For example, typical server CPU temperature limits are in the range of 90°-100°C (194°-212°F) and their reliability models assume operation close to those limits without impacting the long term reliability.

Many users may think that an exhaust temperature of 55°C it is too hot because it feels hot compared to normal temperatures he or she may be used to. 55°C (131°F) is actually quite cool for the back of the rack. In fact, components within the server such as power supplies and PCIe cards are designed to operate with local air temperatures up to 55°C. Users may also have concerns about hot-spots on the chassis at the rear of the box or on the top cover. Top cover hot-spots are typically related to the cover being in close proximity to the CPU heatsink or other high power device. Under high utilization portions of the CPU heatsink may reach 50-60°C while the CPU operates at much higher temperatures. The temperature difference between the heatsink surface and the cooling air is what allows convection cooling to work. Hot-spots on the server chassis top cover are a normal byproduct of the higher heatsink temperatures and are not indicative of a cooling problem.

Exhaust temperatures and system hot-spots can be reduced by increasing system airflow. These increases result from higher fan speeds and come at the cost of increased fan power consumption and acoustic levels. Consider, for example a 2U 750W server operating in a 25°C (77°F) data center exhausting 60°C air. Assume this server moves 42CFM while consuming 10.6W of fan power. If a user desired to reduce the exhaust temperature from at 60°C to 50°C they would need to increase system airflow 17CFM (40% increase) with a resulting fan power of 16.7W (57% increase per system). At a single rack level that adds up to 1062 kWh more per year. The power impacts compound with higher data center temperatures. Data centers operating at 30 and 35C can expect to see rack level increases in the ballpark of 2000 and 6000 kWh per year to reduce the exhaust temperature from 60C to 50C on the same 2U server.

### User Exhaust Temperature Control Options

Instances do occur that require exhaust temperatures to be reduced, typically to accommodate legacy PDU's, power cords, or top of rack switches. For this reason Dell EMC provides controls that allow IT professionals to reduce the system exhaust temperature (image below) and to increase fan speeds above those mandated by the system thermal algorithms.



The system will increase fan speeds automatically to achieve the targeted exhaust temperature setting but cannot guarantee the setting will be attained once the fan speeds achieve their maximum RPM. The fan speed and exhaust temperature settings are available via HII, iDRAC web GUI, and RACADM. Further advancements in our 14<sup>th</sup> Generation of servers include Multi-Vector Cooling Thermal Control Algorithms featuring the industry first Linear Feet per Minute (LFM) airflow tuning for PCIe adapter cards.

### ▼ Fans Configuration



**Automatic Fan Speed Calculation**

Thermal Profile Optimization: Default Thermal Profile Settings

**Fan Speed Offset**

Fan Speed Offset: Off

**Thresholds**

Maximum Exhaust Temperature Limit: Default, 70 °C (158.0 °F)

Minimum Fan Speed in PWM (% of Max): (Range 32 - 100)

Temperature options in the dropdown menu:

- 40 °C (104.0 °F)
- 45 °C (113.0 °F)
- 50 °C (122.0 °F)
- 55 °C (131.0 °F)
- 60 °C (140.0 °F)
- 65 °C (149.0 °F)
- Default, 70 °C (158.0 °F)

Some users that have utilized the exhaust temperature control options or other increased fan speed options have expressed concerns about the impact to fan reliability. A common misconception about fan reliability is that operating fans at higher speeds will result in increased fan failures. PowerEdge server fan reliability qualification assumes constant operation at maximum speed. This means that the fans can operate at full speed for the life of the product while meeting MTBF and Dell-EMC warranty requirements. Thus, operating the fans at higher speeds to reduce exhaust temperatures will not result in fan reliability reductions below those required for the full product lifecycle.

Dell EMC servers are designed to run close to temperature specification limits for extended time periods without compromising reliability. It is also more efficient to operate servers at higher temperatures because of the savings associated with reduced server fan power, lower system airflow, and higher CRAC/CRAH return temperatures.

## Conclusion

Dell EMC PowerEdge servers have been engineered to maximize energy efficiency without trade-offs in system reliability. As a result the exhaust temperatures on PowerEdge servers may be higher than expected. If required, exhaust temperatures and hot spots can be mitigated through user exhaust temperature settings resulting in increases to fan speeds, airflow, and fan power. However, to reduce operational costs it is best practice to plan ahead for higher exhaust temperatures. Careful selection of PDUs, top of rack switches, and other in-rack hardware designed for the increased temperature trends will enable increased thermal efficiency and reduced data center OPEX.