Engineered Material Solutions for Data Centers:

Creating Competitive Advantage in Enterprise Applications

Overview

This paper addresses current and upcoming trends and material science design challenges for Hyperscale Networks. As processing power and IoT/IoE (Internet of Things/Internet of Everything) continue to evolve, Hyperscale applications will be vital to societal and consumer needs.

Boyd engineered material solutions address these challenges with key manufacturing innovations that increase compute density in the same footprint, lower the total cost of data center ownership, and improve efficiency and reliability across all systems levels.

This article will aid engineers in understanding the role of material applications to improve system development and foster design creativity.

CURRENT HYPERSCALE NETWORK MARKET TRENDS

The hyperscale compute and networking industry is rapidly changing as processing power continues to exponentially grow. Consumers and OEMs continually demand more functionality, faster connectivity, and greater reliability. Enterprise titans' launch into the quantum computer race to develop a viable quantum computer capable of being mass-produced requires improved speed and capacity while miniaturizing current available technology.

These ambitious development roadmaps are inspiring industry leaders to invest in disruptive technologies that can keep up with them. These applications require equally advanced thermal management and engineered material solutions. The higher the processing power the more critical Boyd solutions are to the system.

3D Model of Data Center Chassis.

KEY CHALLENGES IN ENTERPRISE AND HYPERSCALE ELECTRONICS

- User Safety
  - Decibel level must be maintained at a safe volume
  - Equipment must be organized and with appropriate safety labels
  - Systems must be Electrically Insulated, Leak and Waterproof, and with Shock Prevention
  - Fail-safes to protect technicians like fingerguards, grounds and electrical barriers are a must
- Noise, Vibration, and Harshness (NVH)
  - Mitigate NVH and damp mechanical vibration to minimize product wear, extend lifetimes, increase reliability, and reduce susceptibility to read/write errors
- Connectivity
  - Protect advanced electronics susceptible to electromagnetic interference with EMI/RFI Shields and Absorbers
  - Minimize LED cross talk in user and technician interfaces
- Dust, Fluid, Particle Ingress
  - Components must be sealed and protected from contaminant ingress for longer lifetimes and higher reliability
- Branding and Component Tracking
  - Custom, Standard, or Serialized Labels, Graphics and Membrane Switches protect branding, communicate regulatory and safety information, direct organization, and assist in maintenance tracking
- Excess Heat, Airflow Management, Air Blockers
  - Thermal management prevents overheating or degradation in performance with Airflow Management and Air Blockers optimizing thermal system efficiency

BOYD ENGINEERED MATERIALS IN HYPERSCALE NETWORKS

The key challenges in Enterprise Electronics are magnified for Hyperscale networks. They are much more powerful systems in larger facilities, making noise louder, vibration harsher, and with greater safety concerns. These facilities and high-power systems more densely pack additional electronics into a space, requiring more electromagnetic interference management, unique solutions for new multifunctional equipment, minimized maintenance and downtime, and better organization. Boyd material science, engineering, and conversion processes enable novel solutions for high-power systems to be more cost efficient, higher performing, and more scalable for high production volumes. Boyd's Engineered Material solutions include a broad range of functional, custom products like dielectric insulators, air flow management and air blockers, seals, gaskets, NVH reduction, EMI shielding, graphic overlays, and labels. From global rapid prototyping to large scale mass production, Boyd develops custom technologies that enable more functional, highly reliable Hyperscale computing.

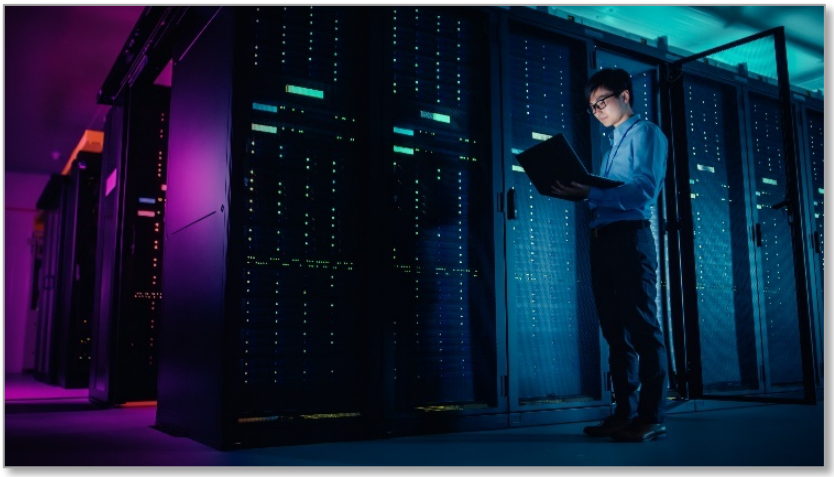
BOYD THERMAL MANAGEMENT IN HYPERSCALE NETWORKS

One of the biggest challenges in Hyperscale is how to handle the additional heat load and thermal density caused by increased processing power and next generation equipment. Thermal Management systems for Hyperscale must manage the higher heat load without increasing volume or weight. To meet the need for higher performance cooling in more compact forms, Boyd develops modular and custom Hyperscale cooling systems to optimize thermal management for any specification. Systems leverage Boyd's decades of design and development expertise in liquid, air, and two-phase cooling to enable higher performing, integrated systems that extend the performance levels of traditional air cooling and help you safely transition to liquid cooling when appropriate.

SOLVING KEY CHALLENGES IN ENTERPRISE

OVERALL ENVIRONMENTAL & USE CONSIDERATIONS

Cloud data center installations are growing fast with accelerated adoption of artificial intelligence and the Internet of Things (IoT) integrating smart functionality and connectivity across most industries. The demand for connectivity between devices and internal electronics has created an increase in the amount of electromagnetic interference and LED cross talk within a server, a data center chassis, and to a larger extent the data center farm. However, EMI "noise" is not the only noise to consider in a hyperscale network environment. As hyperscale compute becomes more robust, technicians and service providers work for longer periods of time surrounded by hundreds of data center chassis that increase noise to harmful levels. Reducing decibel levels to a safe volume for data center technicians is key. In addition to overall technician wellbeing, equipment wellbeing is also dependent on the environment. Precisely controlled data center environments can mitigate humidity, contaminants, and electrical issues for longer life, less maintenance, higher reliability, and more uptime.

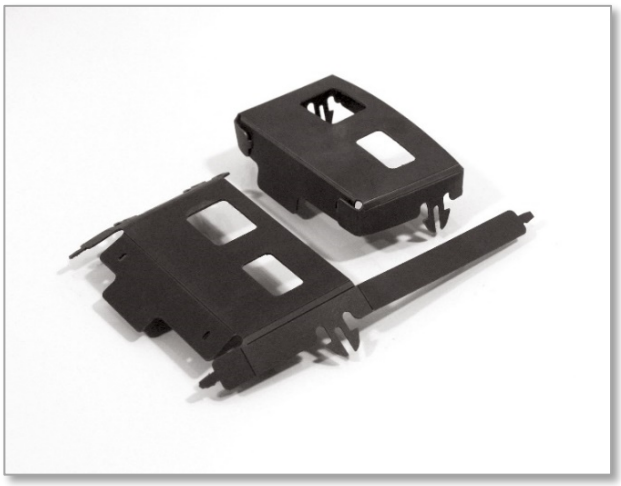


Data center environments must be developed for user safety.

The Engineer's Guide to Hyperscale Network Material Applications

CHALLENGE: ***ELECTRICAL SHORTING, VOLTAGE & INSULATION***

Hyperscale networks use more power and incorporate more smart technology systems than ever before. Additional embedded technologies further increase power density with higher voltage components that are more densely packed together. This creates an immense amount of internal energy that must be isolated with barriers to prevent spark voltage between internal components that can lead to device shorting or fire.

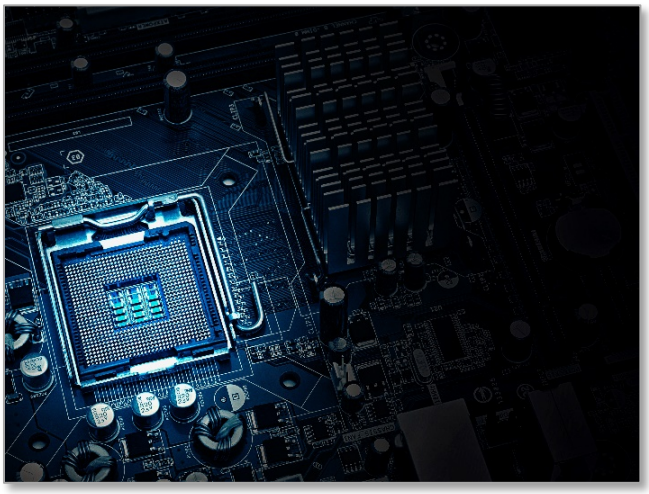


Example of an electrical insulator.

Boyd's Flame Rated (FR) V-0 electrical insulation solutions are enhanced with attachment technologies from 3M. These tapes are optimized for data center environments with specialty low surface energy adhesives that aid in bonding and assembling dielectric insulators and isolators into data center racks and servers.

Boyd integrates electrical insulators with graphics and branding solutions for dual purpose application. Safety, maintenance, regulatory and service information printed on V-0 flame rated dielectric insulated labels act as flame barriers, voltage blockers, and system information labels that enable extended equipment lifetime, reduced premature electrical failure, and safer technician environments. Electrical insulators are also fabricated into three-dimensional airflow management assemblies for dielectrically insulated air flow baffles that efficiently direct cooled air within a server and act as an electrical barrier.

CHALLENGE: ***DUST, FLUID & CONTAMINANT INGRESS***



Processing units and chips need to be protected from dust and fluid ingress.

Dust, fluid, and contaminants are often top causes of electronic malfunction and data centers are no exception. Ingress protection gaskets and seals featured in and around ports, openings, seams, and doors in server blades, racks and chassis extend application lifetime and reduce maintenance expenses by preventing foreign particle contamination and sealing out moisture. Boyd's protective gaskets are often accompanied by high performance 3M pressure sensitive adhesives to aid in assembly efficiency and assure gaskets remain securely in place.

Air filters also play a significant role in protecting sensitive internal server rack equipment as part of the cooling solution. Dust accumulation decreases air cooling system efficiency and total device performance. The incoming air in an air cooled system must be cleansed before use in sensitive internal systems. Air filters are often made of woven mesh or reticulated foam

to remove contaminants from intake air and prevent fouling in the application. This decreases the chance of fire hazards, shortages, or performance degradation.

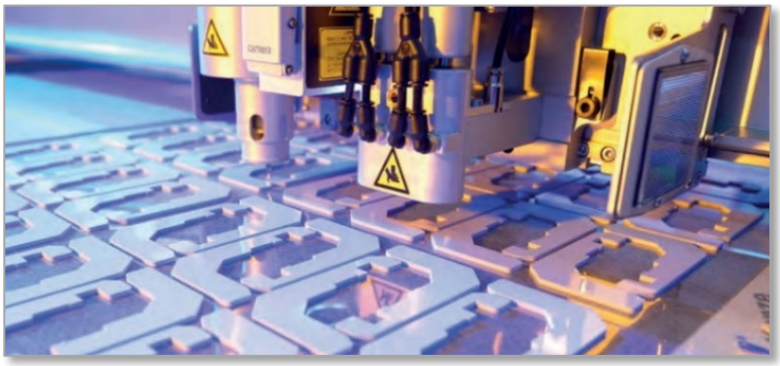
CHALLENGE: ***NOISE & VIBRATION***

Hyperscale applications create and are subject to environments where Noise, Vibration, and Harshness (NVH) are prevalent, with exceptional impact coming from air cooled data centers that create excessive, high level noise and mechanical movement resulting from high-speed fan systems. The sheer size of Hyperscale Network facilities, designed for maximum storage and processing, leads to excessive noise and vibration that quickly reaches unsafe decibel levels and accelerates wear and tear, decreasing reliability and durability, and impeding performance. Extensive NVH exposure is harmful to sensitive equipment, vital electronics, and data center technicians.

A large variety of NVH solutions for any specification.

Vibration damping, acoustic absorbing foams, foils and thin stamped metal are applied strategically throughout the application to reduce excessive resonant behavior, protect applications from mechanical wear and tear, and address other significant NVH challenges. Integrating components that effectively absorb mechanical shock and sound extends product lifetime, reduces read/write errors for improved system reliability, reduces facility noise pollution, and maintains a safer technician environment.

CHALLENGE: ***THERMAL MANAGEMENT, EXCESS HEAT & OPTIMIZING AIR COOLED SYSTEMS***



Converting thermal interface materials.

Heat is an unavoidable byproduct of electronic device operation. More high-power electronics in compact applications placed in close proximity increases heat load. Hyperscale applications and data centers are prime examples of increasing thermal, power, and compute density. In addition to increasing processing power and number of servers and racks in a data center, equipment and component manufacturers continue to find innovative ways to pack *more* high-power components in increasingly

compact geometries to deliver greater functionality and better latency performance for expanding data consumption requirements.

Excessive heat damages internal components, causes applications to perform poorly or fail, shortens lifespan, decreases reliability, puts technicians at risk for heat-related injuries, and acts as a bottleneck to compute innovation. For more information on high thermal performance, integrated cooling systems for Hyperscale, Cloud Compute, and Enterprise such as liquid, air, immersion, or two phase cooling, visit boydcorp.com.

Thermal systems must directly interface with data center heat sources to extract and exhaust heat. Thermal Interface Materials (TIMs) act in this capacity, quickly absorbing and transferring heat from a heat source to the cooling system or ambient environment. Air gaps and pockets are thermal blockers or insulators. TIMs reduce the air gaps and pockets between a heat source, like a processor, and its cooling solution, like a heat sink, vapor chamber, or cold plate, to maximize cooling efficiency and capacity. Proper thermal interface materials lessen the thermal resistance between the heat source and cooling solution, enabling more efficient and effective cooling.

TIMs can be converted and delivered in rolls.

3M offers light weight, high efficiency TIM solutions for faster assembly, improved device reliability, and extended electronic component lifespan. TIMs like 3M™ Thermally Conductive Acrylic Interface Pads and tapes are ideal for designs with smaller spacing requirements or larger format challenges. These materials can increase server rack component lifetimes up to double by reducing the temperature by -10^{o}C.

For data center applications that are air cooled, optimizing the use and distribution of cooled air and management of hot exhaust air improves data center energy efficiency and thermal system performance. Air blockers made of SOLIMIDE® polyimide foam block high temperature exhaust from sensitive environments. Air leak sealing and air gap fillers prevent the loss of cool air, remove design pockets that trap cool or hot air, and connect internal airflow pathways. Air baffle assemblies commonly feature flame rated FR V-0 electrically insulating materials that are thermoformed or folded into airflow management channels that alter the flow of air inside the server to most efficiently direct cold air to heat source dissipators like heat sinks. Engineered Material solutions maximize air cooling system efficiency and thermal performance by optimizing the management of hot and cold air within a server.

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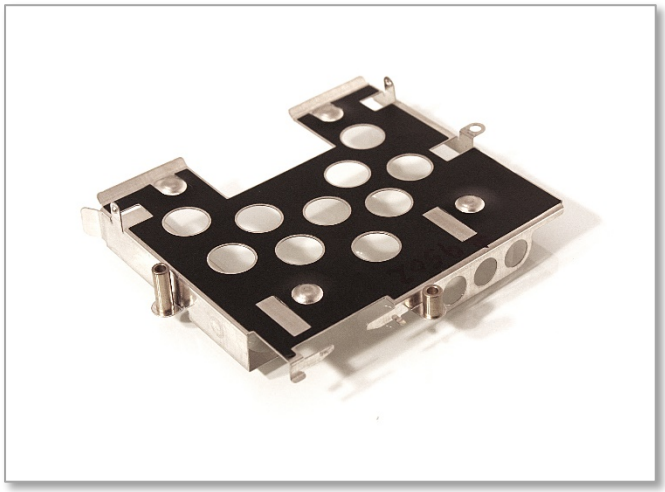
CHALLENGE: ***ELECTROMAGNETIC INTERFERENCE***



EMI absorber.

Data centers experience excessive Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) due to densely packed environments with advanced electronics. This issue is multiplied in Hyperscale applications due to increased volume and density of server racks. Unmanaged EMI/ RFI degrades signal clarity and leads to electronic malfunction. EMI/RFI Shielding reduces electronic malfunction susceptibility by blocking, absorbing, or shielding unwanted external electromagnetic waves or preventing internal electromagnetic waves from emitting and interfering other circuits or devices.

EMI shielding and absorption components from 3M range widely from electrically conductive tapes to EMI Absorber product lines, converted by Boyd to complex geometries in and around ports, openings, gaps, and seams within an enclosure. Boyd Corporation fabricates these components as multifunctional solutions. EMI shielding fabric over foam die cut input/output gaskets combine vibration damping, ingress sealing and EMI/RFI shielding in one easy-to-assemble solution, reducing assembly time and bill of material complexity for manufacturers.

CHALLENGE: ***USER EXPERIENCE***

The importance of an easy user experience is often underestimated in networking applications where trained individuals interact with equipment and automation. However, optimized Human Machine Interfaces and improved easy-to-understand safety and instruction labels create a better user experience for greater efficiency with reduced user error.

Backlighting switches and displays are a cost-effective way to enhance usability, decrease user error, and improve aesthetics. Backlit switches and overlays quickly guide technicians and users to correct device operation, especially in dimly lit or dark environments.

Server cabinet with backlit touchscreens.

Bezel branding, nameplates, logos, labels, switches, graphic overlays, and trim provide an important visual and tactile user experience that differentiates Hyperscale equipment while increasing maintenance efficiency. Data centers and hyperscale facilities may house servers and chassis from multiple manufacturers. Optimized front and back panel graphic overlays, input/output port labels, system information labels, and user interfaces

save time by clearly identifying unique maintenance steps and custom requirements to your design. On-specification branding reduces errant warranty claims from facility managers.

Boyd can convert any decorative or informational label into a multifunctional solution by printing onto one of many 3M materials with special properties such as EMI shielding, electrical insulation, and thermal shielding. User interface solutions can feature FR V-0 rated substrates, high temperature resistant UL 969 compliant materials, deadfront windows visible only when backlit, and highly complex die cut geometries with tight tolerance and registration control.

MULTI-FUNCTIONAL SOLUTIONS

Boyd Corporation works with product designers to create streamlined, multi-functional solutions using a holistic approach to integrated sealing, protection, and thermal design that considers the needs of the most demanding data centers in the world. From low-profile liquid cooling systems that increase compute density to data storage dampers and server seals that create safer data center operations, our solutions help customers increase performance efficiency, optimize resource utilization, maximize energy recovery, and increase reliability across all system levels. Our integrated solutions minimize or remove waste, maintenance costs and downtime for an overall lower total cost of data center ownership.

To receive more information or schedule time with a Boyd Engineer regarding Hyperscale Network Material Applications in Enterprise, visit our website.