

**7 STEPS TO
SUCCESS WITH METAL AM**
*PREPARING YOUR PROCESS AND FACILITY FOR
METAL ADDITIVE MANUFACTURING*

WHITEPAPER

*This white paper explores the safety and building considerations when bringing
metal additive manufacturing into your production facility*

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Executive Summary

Metal additive manufacturing (AM) continues to gain widespread acceptance and momentum across diverse industries. This cutting-edge technology facilitates the production of intricate metal components boasting exceptional mechanical properties, all while bypassing the expenses associated with traditional tooling. Moreover, it liberates designers from the constraints of conventional subtractive manufacturing methods, fostering unparalleled design freedom. This empowerment often results in the consolidation of multiple parts into singular entities, simultaneously reducing overall size and weight. The rapid turnaround time, with parts being produced in a matter of days rather than weeks or months, enables engineers to swiftly iterate toward optimized designs, expediting the path to market with superior products.

However, as more companies embrace the transformative potential of metal AM, it becomes imperative to address concerns surrounding facility setup to ensure both user safety and sustained productivity. In this document, we delve into critical considerations such as safety protocols, environmental impacts, facility prerequisites, requisite equipment for support and post-processing, and strategies for mitigating cross-contamination risks—particularly pertinent to the selective laser melting (SLM) process, one of the foremost metal additive technologies.

The optimal preparation of your facility hinges on a multitude of factors, including its unique attributes, intended applications, workload, available resources, adherence to local regulations, and potential for outsourcing certain services. As a stalwart in the field of metal AM, Nikon SLM Solutions stands ready to offer comprehensive guidance. Our team of seasoned applications and systems engineers is adept at tailoring solutions to meet the specific requirements of individual facilities, ensuring a seamless integration of metal AM technology while maximizing operational efficacy and safety standards.

1. Safety Considerations

In the realm of selective laser melting (SLM) technology, the powders utilized are exceptionally fine, with particles as minuscule as 10microns, posing potential hazards to health. Operators engaging with these powders must adhere to stringent safety protocols and wear appropriate personal protective equipment (PPE) whenever the machine doors are open or powder handling is underway. This typically includes the utilization of a National Institute for Occupational Safety and Health (NIOSH) full-face respirator or powered air-purifying respirator (PAPR), along with powder-impermeable protective gloves, electrostatic discharge (ESD) steel-toed shoes, and comprehensive arm protection, incorporating disposable arm protectors and a lab coat.

Precautionary measures must be implemented to curtail the dispersion of metal powder within the facility. Access to production areas should be strictly regulated, employing either locking mechanisms or prominent signage, particularly during powder handling activities. Employing tack mats at exits serves to inhibit residual powder from being inadvertently transported to other areas via footwear.

The alloys employed in additive manufacturing encompass a spectrum of environmental impacts, necessitating a nuanced consideration of the specific materials employed within the facility. When handling reactive materials such as aluminum or titanium, heightened caution is warranted due to the increased risk of fire or explosion. Ensuring the absence of ignition sources, such as open flames or hot surfaces, in powder-handling zones is paramount. Of primary concern is the mitigation of static electricity risks, which can be addressed through the adoption of specialized flooring, mats, and footwear designed to prevent electrostatic discharge.

The laser melting of metal powder mandates the maintenance of an inert gas atmosphere, commonly utilizing Argon. However, this introduces the potential hazard of asphyxiation in the event of significant gas leakage within enclosed spaces. To mitigate this risk, rooms housing additive manufacturing machinery should be equipped with low-oxygen alarms and possess adequate air conditioning and ventilation systems capable of swiftly dissipating any sizable Argon leaks, ensuring a safe working environment for operators.



Secure entry with signage and tack mats inside the lab door prevent powder contamination outside of the machine area

2. Environmental Considerations

The adoption of metal additive manufacturing necessitates diligent attention to environmental stewardship, particularly in the management of generated powder and liquid wastes. Upon completion of a build, the residual powder within the machine must be meticulously addressed. Initial steps typically involve brushing or vacuuming excess powder from the build chamber into designated overflow bins for potential reuse. Subsequently, any lingering powder is wiped clean using lint-free cloths, followed by the utilization of wet separator vacuums to extract residual metal powder from the machinery. These vacuums feature a water column that passivates the metal powder, mitigating flammability risks and streamlining disposal procedures. Similar cleaning methods should be applied to personal protective equipment (PPE), post-processing equipment, and other susceptible areas to prevent the inadvertent dispersion of stray powder.

Dry waste, including wipes and disposable materials exposed to powder, constitutes additional waste streams. To minimize the spread of loose powder, walk-off tack mats should be strategically positioned near room exits to capture powder adhering to footwear, thus preventing its migration into other facility areas.

Upon extraction, passivating filters from additive manufacturing systems often harbor potentially flammable soot. These filters must undergo flooding in designated stations to render them nonreactive. Both the filter flooding station and wet separators yield soot-laden wastewater, necessitating the provision of proper containment for subsequent disposal.

Many companies opt to engage industrial waste management services for the collection and disposal of both liquid and solid waste, thereby ensuring compliance with regulatory standards. Emphasizing waste reduction strategies can effectively curtail disposal costs; for instance, directing surplus powder into overflow bins post-build significantly diminishes the waste stream. By prioritizing waste minimization and implementing efficient disposal protocols, companies can effectively manage the environmental footprint associated with metal additive manufacturing.

3. Facilities Requirements

Critical to the seamless operation of additive manufacturing are facilities that provide controlled temperature and humidity, reliable electrical power, access to compressed air, inert gas supply, and a clean working environment with controlled access. Most SLM metal additive manufacturing machines require 400-volt 3-phase power, often facilitated by transformers to accommodate the typical power standards in US shops. Ensuring a stable power supply is paramount, as any interruption during a build can lead to downtime or even the loss of an entire build. Investing in uninterruptible power supplies (UPS) and backup power sources can offer added security in such instances. Additionally, a consistent supply of clean, dry compressed air is essential, with Argon or Nitrogen gas readily available through reusable tanks from local suppliers.

While SLM systems do not mandate clean room environments, they necessitate relatively pristine working conditions to safeguard laser optics from contamination. An office setting is unsuitable due to the presence of powder, requiring individuals in proximity to don PPE when machine doors are open. Consequently, the room housing the system should feature locking mechanisms to control access during operation. Temperature regulation within the range of 20°C to 25°C is recommended, alongside a relative humidity level of 40% to 60%. Excessive humidity impedes powder flow, while excessively low humidity elevates the risk of spark generation.

Ideally, a separate room should be designated for post-processing equipment, such as bandsaws or machining centers, assuming these operations are conducted in-house rather than outsourced. Additionally, an area dedicated to handling the more labor-intensive aspects of the process—such as filter changes, wet separator cleaning, and filter flooding—is essential for efficient workflow management and equipment maintenance. By adhering to these facility requirements, companies can ensure the smooth and safe operation of their metal additive manufacturing processes.

4. Supporting Equipment

Metal additive manufacturing necessitates additional equipment to bolster the printing process, notably an external chiller and powder sieve. The chiller, essential for cooling the laser and optics, is typically situated in a separate room from the additive manufacturing system due to its noise, heat, and humidity output. Chilled water is then piped to the selective laser melting machine, with specific requirements dictating the minimum pipe size and maximum rise. Conversely, the powder sieve serves to process unmelted powder post-build, segregating small particles suitable for reuse from larger particles and contaminants destined for disposal.

5. Post-Processing Equipment

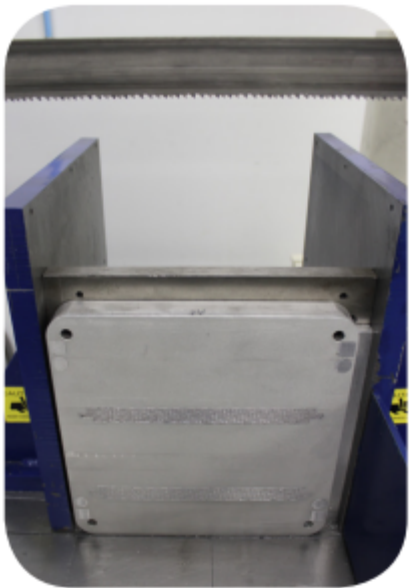
Post-processing equipment plays a pivotal role in extracting parts from build plates, refurbishing those plates for subsequent use, executing heat treatment, and conducting part inspections. Tools such as bandsaws or electrical discharge machines (EDM) are employed for part removal, while build plate refinement can be accomplished via machining centers, milling machines, or grinders.

Alternatively,outsourcing to local machine shops is a viable option, albeit necessitating a larger plate inventory. Heat treatment ovens may be requisite for stress relief and mechanical property enhancement, necessitating electrical service and inert gas supply. Additional equipment such as shot peeners, tumblers, and grit blasters contribute to surface finishing, while downdraft tables ensure effective debris capture.

Inspection equipment varies based on part requirements, ranging from microscopes to coordinate measuring machines (CMM)or laser scanners. Companies catering to stringent industry standards may opt for full metallurgical labs, incorporating technologies like x-ray or computed tomography (CT) scanning. Outsourcing sophisticated inspection tasks is also feasible, depending on operational needs.

The workshop area dedicated to part removal and post-processing demands substantial space,commensurate with operational scale and complexity. For instance, Nikon SLM Solutions' facility in Wixom, Michigan, boasts a workshop approximately half the size of the additive manufacturing room, housing essential equipment including bandsaws, machining centers, heat treatment ovens, and shot peeners.

Companies engaging in high-volume production and extensive post-processing activities may necessitate expanded workshop capacities relative to the number of additive manufacturing machines deployed.



A bandsaw removes parts from build plates



Workshop area including furnace, downdraft table and peener

6. Information Technology Needs

Information technology (IT) requirements hinge on machine count, resource planning sophistication, and security imperatives. A robust personal computer or professional workstation is recommended for file preparation, ideally connected to a network for seamless file transfer by engineers. Network connectivity extends to the machine itself, enabling users to transmit build files from workstations to the SLM machine. Controlled network access may also be granted to Nikon SLM Solutions for troubleshooting purposes.

7. Avoiding Cross-Contamination

In industries reliant on precision components, such as aerospace or medical sectors, preventing cross-contamination is paramount. Even minimal admixture of foreign powders can compromise part integrity during inspection. Optimal practice involves storing and handling different powders in segregated rooms—for instance, nickel-based alloys in one chamber and titanium-based alloys in another. In low-production settings, meticulous workflow practices, including clear labeling of machines, powders, and sieves, help mitigate cross-contamination risks. However, frequent material switching or concurrent operation of multiple machines necessitates additional safeguards beyond labeling alone.

Conclusion

The burgeoning acceptance of metal additive manufacturing underscores its pivotal role in expediting innovation across diverse industries, revolutionizing design processes, and minimizing reliance on costly tooling. By condensing the time frame for building and testing new designs, metal AM empowers engineers with unparalleled design freedom, thereby catalyzing the development of high-quality metal parts.

Throughout this discourse, we've highlighted key considerations pivotal to the establishment of a safe and efficient facility for metal additive manufacturing. While we've endeavored to cover major aspects within the confines of this article, the complexity of implementation necessitates tailored solutions to address the unique nuances of individual facilities.

For a more comprehensive understanding and tailored guidance on navigating the intricacies of implementing metal additive manufacturing within your facility, we encourage you to reach out to Nikon SLM Solutions. Our team stands ready to provide personalized assistance, addressing specific concerns and facilitating a seamless integration of metal AM technology into your operational framework. Together, let's embark on a journey towards unlocking the transformative potential of metal additive manufacturing in your organization.

About Nikon SLM Solutions

Nikon SLM Solutions is a leading provider of metal-based 3D additive technology and machinery for prototypes and manufacturing production. SLM Machines support an optimal approach for safe, flexible and cost efficient metal part production across the aerospace, automotive, academia, energy and medical industries. Systems include the SLM®125, SLM®280, SLM®500 and the 12-Laser future driver NXG XII 600. With multi-laser options, bi-directional recoating, open software controls and closed-loop powder handling, Selective Laser Melting systems achieve best-in-class safety and increased build speeds for complex and completely dense metal parts. Headquartered in Lübeck, Germany, with offices in Canada, China, France, India, Italy, Singapore and the United States.

Contact

Headquarters

Nikon SLM Solutions AG Estlandring 4

23560 Lübeck

Germany

Phone: +49 451 4060-3000