UNDERSTANDING GAS REQUIREMENTS FOR

Additive Manufacturing

Airgas®

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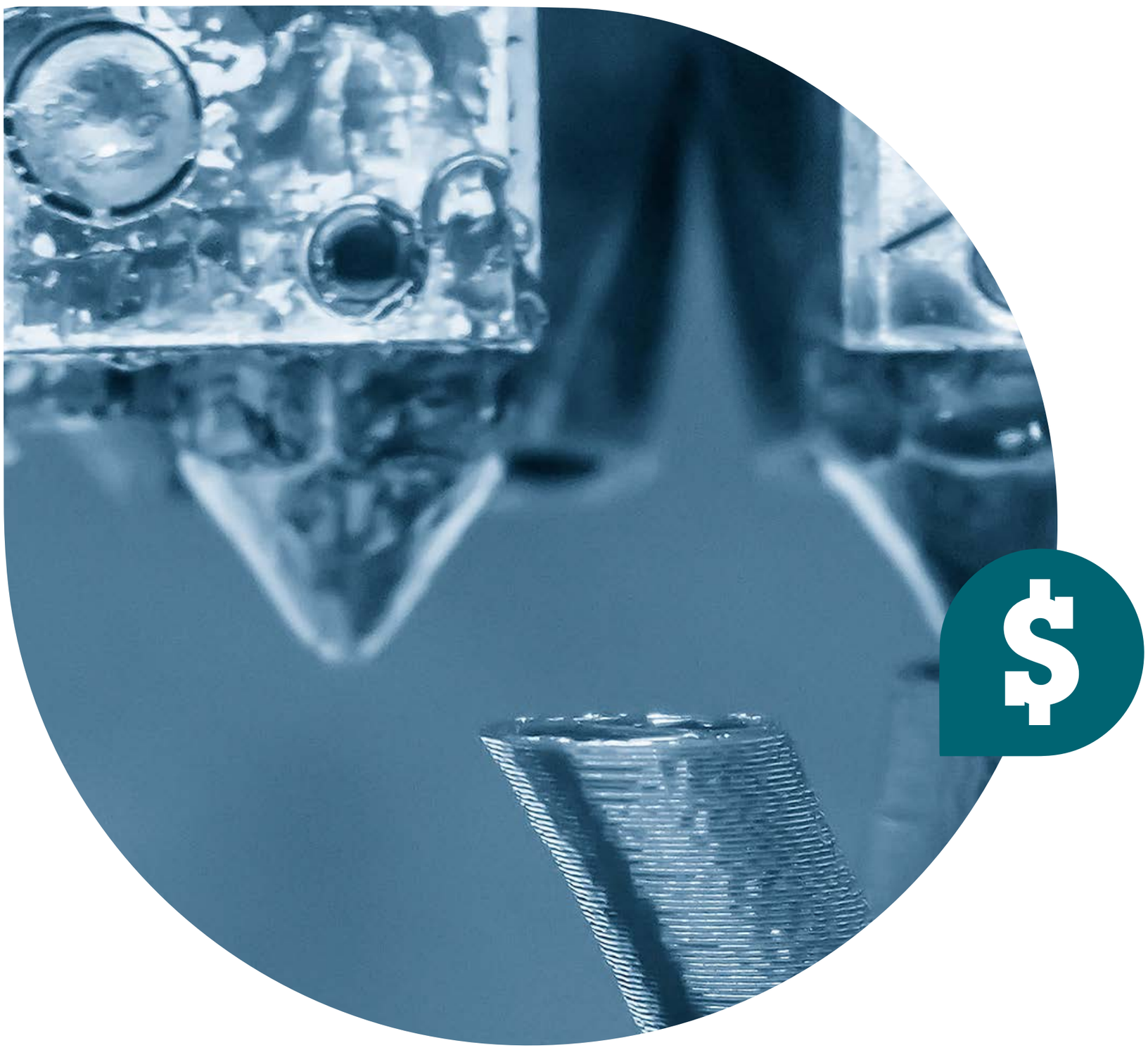
Understanding Gas Requirements for Additive Manufacturing



Additive manufacturing (AM) is a transformative method of industrial production, utilizing 3D printing technology to make functional components from digital models. This innovative approach has undergone extensive development over the past three decades, evolving into a $16 billion industry in 2023.[1]

Unlike “subtractive manufacturing” processes like machining, where parts are created by removing material, AM builds geometries by “adding” feedstock such as filament, wire or powder. This includes gas-critical processes, from powder bed fusion and binder jetting to directed energy deposition and metal material extrusion.

Exploring Key Gas-dependent AM Processes

There are seven distinct additive manufacturing (AM) processes used across the industry. Choosing the right one depends on part size, production volume, geometric intricacy, and material. In this eBook, we’ll explore the four primary gas-dependent techniques:

- **Powder bed fusion (PBF)**
- **Binder jetting**
- **Fused filament fabrication (FFF), and**
- **Directed Energy Deposition (DED)**

1 globenewswire.com/news-release/2023/06/21/2692058/0/en/Additive-Manufacturing-Global-Market-Report-2023.html

Powder Bed Fusion

Powder bed fusion is a cornerstone of AM, using a high-powered laser or electron beam to melt and fuse metal powder layer-by-layer into complex geometries.

While electron beam melting (EBM) requires a vacuum, laser-based PBF relies on inert gases like argon or nitrogen to maintain a controlled atmosphere. This inert environment protects part integrity by:

- **Removing process by-products** to prevent contamination and maintain uniform material properties.
- **Displacing oxygen** to prevent oxidation during the build.
- **Eliminating fire hazards** by ensuring the laser heat source cannot ignite the metal powder.

To further ensure consistent properties throughout the build chamber, Airgas offers an exclusive diagnostic tool that measures and maps internal gas velocity to verify uniform distribution.

Sinter-based Technologies: Binder Jetting and Fused Filament Fabrication

Sinter-based technologies separate the part creation stage from the densification stage, combining cold printing methods with a secondary thermal treatment to achieve final part properties.

Binder Jetting

Unlike thermal AM processes, binder jetting requires no heat during printing. Instead, a liquid binding agent “glues” the powder feedstock together. While this process produces parts much faster than laser powder bed methods, these initial “green” parts lack mechanical strength.

To achieve full density and strength, parts undergo a secondary sintering step in a batch or continuous furnace. Heating the parts in a controlled gas atmosphere removes lubricants and fuses the metal particles, which causes part shrinkage as density increases.

While the printing stage rarely requires gas, inerting the build chamber can be used when handling combustible powders like titanium or aluminum.

Fused Filament Fabrication

Fused filament fabrication (FFF) is another sinter-based process where metal filament is extruded layer-by-layer. Like binder jetting, printed components are subsequently transferred to a furnace for debinding and sintering.

Common Sintering Gases:

- Argon
- Nitrogen
- Non-flammable hydrogen-argon blends
- Pure hydrogen

Directed Energy Deposition

Directed energy deposition (DED) uses a focused energy source — such as a laser, electron beam, or plasma arc — to precisely melt powder or wire material as it is deposited. This concentrated heat forms layers or weld beads directly onto a substrate.

Manufacturers frequently rely on DED’s versatility to repair components, add features to existing parts, and build complex custom fabrications.

Gases are critical to the process, primarily serving to stabilize the deposition environment and shield the melt pool from atmospheric contamination. For example, when working with oxygen-sensitive metals like titanium, DED requires an argon-filled enclosure for both inerting and shielding.

What Does Gas Purity Mean to Your Process?

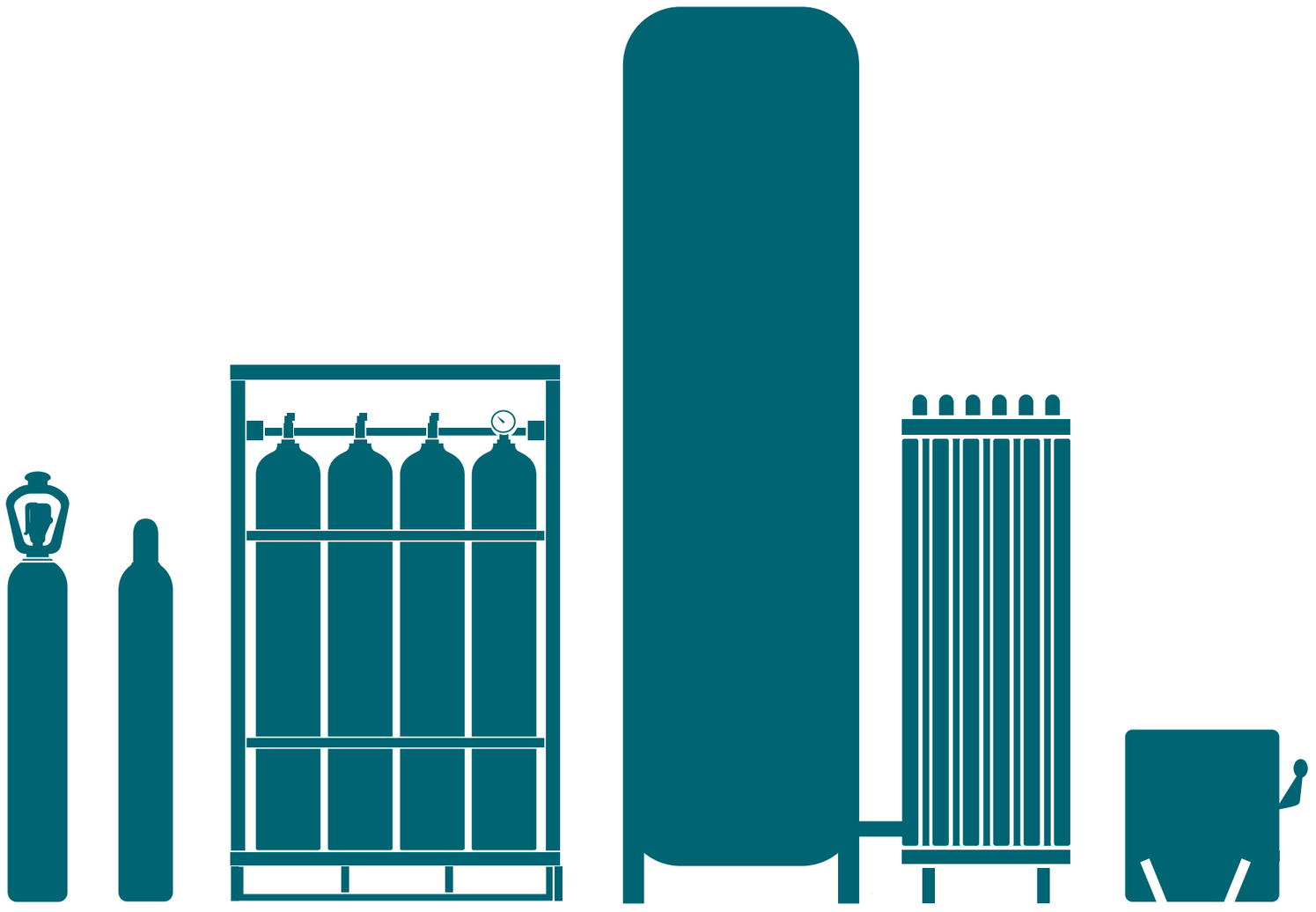
Whether creating an inert atmosphere or storing reactive materials, gas purity is critical in additive manufacturing.

Reactive contaminants like oxygen directly impact part quality and mechanical properties. Insufficient gas purity degrades finished components, leading to increased brittleness, poor material characteristics, and costly scrap.

Industry Standards & Material Sensitivity:

- **Standard Purity Range:** Most AM applications require gas purity between **99.996% and 99.999%** to prevent reactive elements from compromising the product.
- **High-sensitivity Metals:** Highly reactive materials, such as titanium or aluminum, often demand even stricter purity levels.
- **Cost Flexibility:** For standard alloys, outcomes rarely differ between 99.996% and 99.999% purity — giving operators flexibility to lower costs without sacrificing quality.

How Much Gas Do You Need?



Gas consumption in additive manufacturing varies widely based on machine size, process type, and the material being printed.

For laser powder bed fusion (PBF-L), the build cycle begins by purging air from the chamber and backfilling it with argon or nitrogen. Once purged, the build process begins.

Builds can take up up to 100 hours to complete. Running out of gas mid-print ruins the component entirely, forcing operators to scrap the part and restart the process from scratch.

Therefore, a continuous gas supply is critical.

For PBF-L, volume requirements can vary dramatically based on machine size:

- **Purge Volumes:** from 3,000 to 22,000 liters per build setup.
- **Active Flow Rates:** from 10 to 150 liters per minute during production.

Don’t Forget Ancillary Processes:

Gas calculations must account for more than just the printer itself. Be sure to include ancillary steps in your total supply needs, such as:

- **De-powdering**
- **Powder sieving**
- **Heat treatment/stress relief**

Because of these wide operational ranges, manufacturers need a gas partner who understands 3D printing requirements and can reliably deliver both the necessary purity and an uninterrupted supply.

With decades of AM experience, Airgas helps operators accurately navigate these demands to secure a continuous supply tailored to their specific footprint.

How to Protect Your Team and Process When Using Gas

While inert gases like argon or helium seem benign, all compressed gases are classified as hazardous materials due to high storage pressures, potential reactivity, and oxygen displacement risks. Safe storage and handling procedures are essential for every AM facility.

Key Safety Protocols:

- **Cylinder Storage Monitoring:** Install fixed room oxygen monitors in storage areas where cylinders are kept to detect overnight leaks that can create dangerous, low-oxygen environments.
- **Build Room Safety:** Because AM machines are not completely gas-tight and often run for extended periods, equipment manufacturers advise installing fixed oxygen monitoring systems with alarms to prevent asphyxiation risks. Airgas specialists can advise on the proper mounting height for these sensors.

With over 30 QSSP- and OSHA-30 certified specialists, Airgas offers a complete line of safety products, personal protective equipment (PPE), oxygen sensors, and respirators to keep your team protected.

Addressing Common Challenges in Gas Management

Gas management directly impacts both production efficiency and final part quality. Running out of gas mid-build or during sintering is one of the most critical risks in additive manufacturing, as it ruins parts beyond repair.

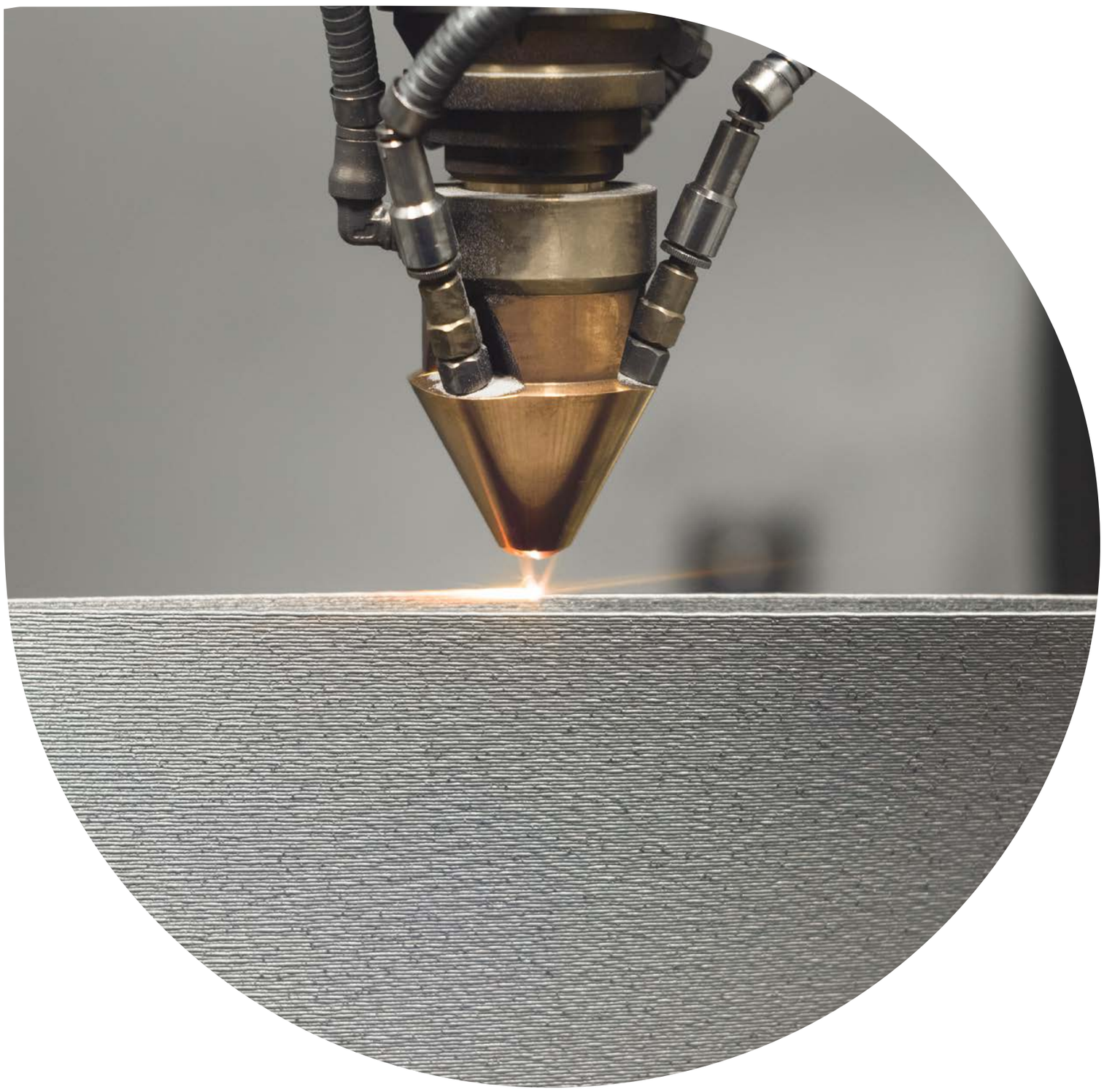
Key Solutions for Operational Control:

- **Gas Flowmeters:** If your machine lacks built-in tracking, installing external flowmeters allows you to log gas consumption for quality documentation, estimate exact manufacturing costs, and optimize flow rates for specific DED materials.
- **EZ-GAZ™ Cylinder Monitoring:** This digital pressure monitoring service provides real-time visibility and control over gas levels, eliminating sudden run-outs and emergency delivery rushes.

Predictive Supply Chain Management:

Airgas mitigates delivery risks through predictive algorithms that analyze usage patterns and production schedules. By accurately predicting reorder points, operations avoid costly downtime while keeping inventory cost-effective.

How Can Airgas Help You Optimize Your Gas Use?



Airgas is committed to helping additive manufacturers succeed with solutions designed for continuous gas supply, optimal purity, and high operational efficiency.

To eliminate supply interruptions and simplify gas management, Airgas provides a powerful suite of digital management tools. Predictive algorithms evaluate your production schedules and real-time usage patterns to automatically notify you when it is time to reorder bulk gas. Paired with an expansive local footprint, this ensures rapid, reliable delivery.

Sustainable Gas Solutions:

Airgas also helps facilities reduce their environmental footprint through optimized, energy-efficient delivery routes. For bulk gas operations, **ECO ORIGIN™** provides certified, low-carbon liquid argon and nitrogen options.

Through tailored digital and physical solutions, Airgas resolves immediate supply challenges while building a more cost-effective, efficient manufacturing setup.

Everything You Need for Additive Manufacturing

As additive manufacturing rapidly evolves, Airgas serves as a trusted partner for companies navigating complex gas management. Our goal is simple: deliver highest-purity molecules with maximum reliability and efficiency.

Leveraging deep expertise across all primary AM processes, Airgas provides tailored gas supply strategies built specifically around your facility's unique operational needs.

Ready to Elevate Your AM Operations?

Get in touch with the Airgas Additive Manufacturing Team to discover how the right gas strategy can optimize your process, protect component quality, and maximize uptime.

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