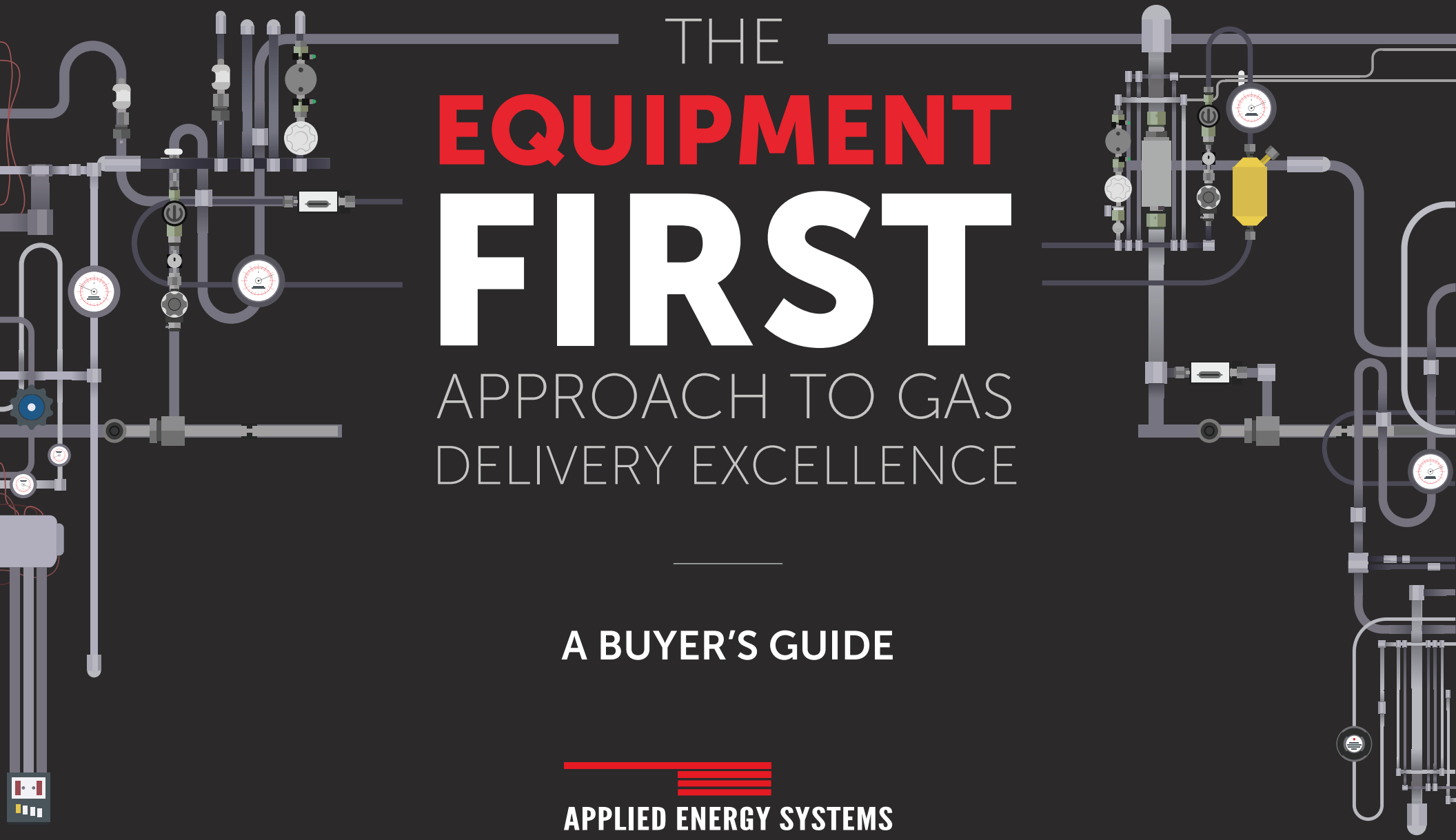


THE EQUIPMENT FIRST APPROACH TO GAS DELIVERY EXCELLENCE

A BUYER'S GUIDE

APPLIED ENERGY SYSTEMS

Are your process gas molecules empowered to perform?

Few would argue that the purity of the gases used to power processes across industries – from semiconductor and electronics to research labs, manufacturing, aerospace, and more – is of top priority. But there is a critical component to ensuring purity that is too often overlooked.

Precision-driven sectors like these cannot uphold gas purity, and in turn quality output, without a strong foundation of gas delivery systems. For these innovative and fast-paced organizations, the role of gas delivery equipment is not only functional, but strategic.

Why is it important to put Equipment First?

If gases are compromised by their handling equipment, so is the output – meaning that system selection has a direct impact on productivity, profitability, and even brand reputation. The right gas delivery equipment solutions enable excellence at every level, by ensuring operators can reliably and safely maintain purity, precision, and control of the gases that are used in their essential business processes.

But, not all equipment is created equal.

It is important to first determine how your gas delivery solutions must function within your operating environment, and compare the features and limitations of your equipment options against those requirements. **To be a truly strategic asset, your equipment selection must be able to meet every operational standard you set.**

In this Buyer's Guide, we explain how to take an 'Equipment First' approach to gas delivery excellence, by detailing the key aspects you should assess in a high or ultra high purity gas delivery system. By addressing the following questions, you can help to ensure that your chosen gas delivery system meets both your functional and strategic needs.

1 Materials of Construction

Is the equipment itself optimized to preserve the purity levels of the gases it handles?

2 Proof of Quality

Is the system validated to uphold purity requirements of your industry and application?

3 Control Technology

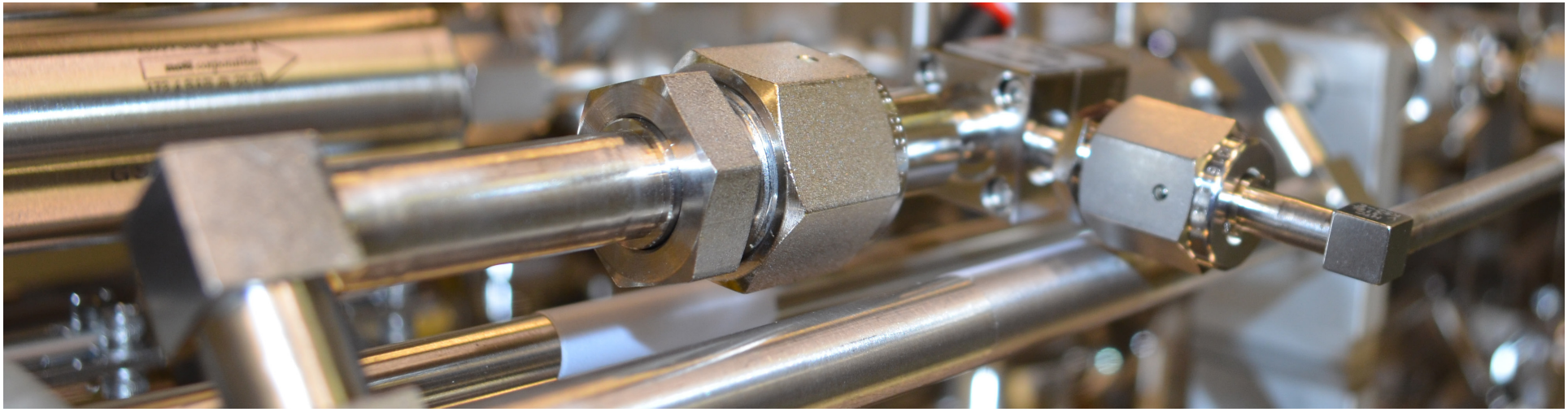
Will your staff be able to intuitively and safely operate the system, based on their skill level?

4 Customization Opportunities

Can the system be custom-engineered to your unique application requirements if needed?

5 Ongoing Support

Who are the experts behind the equipment? What type of ongoing system support can they offer?



CONSIDERATION #1

Material of Construction

The material of your gas delivery equipment is intrinsically linked to its ability to preserve the purity of the gases it handles.

Pure gases are required for pure output, and the wetted components of your gas delivery system can either uphold or hinder that purity level based on their materials of construction. That is why it is important to understand material differences in your equipment choices—ensuring they are built, at the most foundational level, for your purity demands.

Hardware Composition

The right material type and design of your equipment will depend on whether you are using it for high or ultra high purity gas applications. Here are some key considerations:

Component Material

A system designed with 316L stainless steel can maintain higher purity levels than those built with brass, copper, or forged components. In fact, only stainless steel can support ultra high purity gas applications, because it minimizes trace component absorption.

Seal Types

Diaphragms that are made out of stainless steel and that have a metal-to-metal seal design help to ensure the highest leak integrity.

Tubing and Hose

For ultra high purity or corrosive gases, stainless steel tubing is required. For high purity gases, flex hose or copper tubing is sufficient.

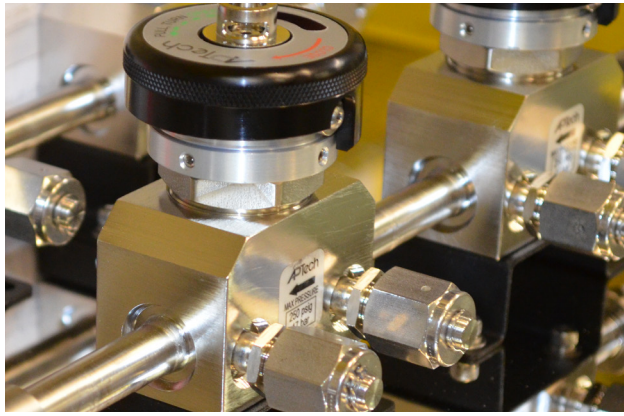
Inlet Connections

Systems that have reverse flow check valves on their vent connections will help to prevent the intrusion of contaminants.

Component Finishes

Equally important to the type of material used to build your system's components is their surface finish. You want to identify the system's surface finish roughness average (Ra) – the lower the Ra, the lesser chance you have of particle impurities from the system's components contaminating the gas stream.

- **For a ppm Gas Spec (High Purity):** Anodically cleaned or mechanically polished tubing is adequate.
- **For ppb or ppt Gas Spec (Ultra High Purity):** Internally electropolished tubing with an internal roughness of 5 – 15 Ra µin surface finish is adequate.



Weld Quality

The more pressing the need to minimize process gas contamination, the more critical weld quality becomes. Make sure to carefully assess the design specifications of your system to confirm that its welds have been quality assured to the appropriate standards, and that the most appropriate welding technique was used:

- **For High Purity Applications:** Conventional welding techniques such as manual metal arc welding can be used for systems that deliver high purity gases, but be aware of any minimum requirements those welds must uphold for your specific application or gas.
- **For Ultra High Purity Applications:** The use of a high speed automated welding technique, such as orbital welding, in a controlled ambient environment is necessary to create clean, crevice-free welds that reduce contamination for UHP equipment.

AES: Well-Composed

Applied Energy Systems (AES) offers two industry-leading equipment brands that are built to address different gas delivery demands, so you can balance features and cost for optimal results.

SEMI GAS®

For Rigorous Ultra High Purity Needs in Specialized Applications

- **Internal Material Component Finish:** 10 Ra µin Maximum
- **Component Microcleanliness:** Double Melt 316L Stainless Steel
- **Enclosure:** Welded 11 Ga Cold Rolled Steel

VERSA GAS™

For Safe, Versatile High Purity Gas Delivery and Handling Needs

- **Internal Material Component Finish:** 15 Ra µin Maximum
- **Component Microcleanliness:** Single Melt 316L Stainless Steel
- **Enclosure:** Welded 11 Ga Cold Rolled Steel

CONSIDERATION #2

Proof of Quality

Validated quality assurance testing ensures that your equipment meets and upholds purity requirements, while conforming to your distinct industry standards.

Once you have determined your system's appropriate material specifications, you must confirm there are no other issues that could compromise gas purity, delivery precision, and most of all, safety. Be sure that any equipment you are assessing has already undergone a QA/QC process during construction, and that the testing was rigorous enough to satisfy the regulatory and process-specific quality requirements you have.

Proof of Purity

There are many components within a gas delivery system that can provide a path for atmospheric contamination from even trace levels of oxygen, moisture, carbon dioxide, and nitrogen. You should verify that your system, at a minimum, has undergone helium leak testing and/or pressure decay testing to detect and correct any points of leakage around joints, valves, and fittings.

If your system is being used for ultra high purity applications, additional analytical testing should be done to verify trace elements fall below required ppb standards, which for ultra high purity gases must be less than 100 ppb, but could be as low as 1 ppb depending on your application.

Proof of Precision

The quality and uniformity of your desired output – from semiconductor chips to research results – is heavily dependent on the precision with which you can control and regulate different gas flow rates, blending processes, and more. Much of this control is achieved through the system's fluid components, as well as the control technology used to set and monitor system conditions. Controllers that are UL 508 labeled meet the Underwriters Laboratories' standards for safety and confirm the controller's quality.

Proof of Safety

You must ensure that your system has been designed in accordance with all applicable building, state, fire, and safety code requirements. Some systems require additional design and installation considerations, such as those installed in seismic areas, or those used in applications that leverage highly hazardous gases like silane. Those used in semiconductor fabs, or similarly stringent production environments, should conform to the SEMI S2 standard: the environmental, health, and safety guideline for semiconductor manufacturing equipment.

Be sure to research the range of safety requirements your equipment must comply with prior to system selection, and ask for manufacturer verification that all appropriate codes have been met.

AES: Quality Driven

All AES equipment undergoes rigorous analytical testing aligned with the end applications for which the system will be used. Levels of purity, precision, and safety are verified to meet or exceed all appropriate standards.

SEMI S2 GAS®

Testing Standards for AES Ultra High Purity Gas Delivery Systems

- **Helium Leak Testing to 1x10^{-9} atm-cm^3/sec**
- **Pressure Testing at 110% Maximum Operating Pressure for 4 Hours**
- **Sample Validation Testing:**
  - 100 ppb for Moisture, Oxygen, and Total Hydrocarbons
  - < 5 particles/ft^3 for 0.1-0.3 um
  - 0 particles/ft^3 for > 0.3 um
- **SEMI S2 Standards**
- **Uniform & International Building and Fire Codes**

VERSA GAS™

Testing Standards for AES High Purity Systems

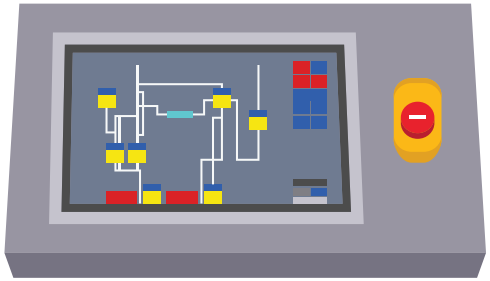
- **Helium Leak Testing to 1x10^{-9} atm-cm^3/sec**
- **Pressure Testing at 110% Maximum Operating Pressure for 4 Hours**
- **Uniform & International Building and Fire Codes**
- **Additional Validation Testing is *Optional***

CONSIDERATION #3

Control Technology

The right equipment controllers will align with your users' skill level and empower them to intuitively, safely, and precisely operate the system you select.

Controllers are used to manage, monitor, and analyze gas delivery system functions and status, as well as shut down equipment in the event of a sensor excursion. Just like equipment itself, not all control technology is created equal. The features and functionality of your system's control technology should scale with the complexity of your processes. Here are some factors that impact controller selection:



Monitoring and Management Capabilities

While safety monitoring is always mission-critical no matter the application, more advanced management capabilities may only be necessary in certain environments. The following are the types of controllers typically used for:

- **High Purity Applications:** Emergency Shutdown Systems (ESS); and Hazardous Process Material Controllers (HPM II & III)
- **Ultra High Purity Applications:** Emergency Shutdown Systems (ESS); Gas Safety Monitors (GSM); Programmable Logic Controllers (PLC); Pressure Status Indicators (PSI); and Compact Data Monitors (CDM)

Consider Your Need For:

- Continuous System Monitoring
- Emergency System Shutdown
- Process Sensor Monitoring
- Programmable Inputs
- Configurable Alarm Setpoints
- Remote System Monitoring
- Remote System Shutdown

Frequency of Use

The amount that your users interact with your gas delivery systems should also impact your control technology selection. For operators handling high purity gases on an occasional basis, a simple, straightforward interface will ensure ease of use and help users to safely manage handling and delivery processes.

Alternatively, systems being used integrally each day in a production environment will require much more robust control technology. Operators of these systems are typically experienced in gas handling and should have the ability to program their own setpoints and other monitoring parameters, as well as proactively analyze system performance. These interfaces will be inherently more complex, making it even more important for the user interface (UI) to be optimized for intuitive operator control.

Specialized Safety

If you are working in a National Electrical Code (NEC) Class 1 Division 2 hazardous location, or using hazardous gases such as silane, you will need a controller with additional safety features like an NEC Class Z Enclosure Purge. Make sure the controller can be upgraded as needed with options to support your specific safety requirements.

AES: In Control

AES's gas delivery systems come standard-equipped with state-of-the-art monitoring and management controllers featuring intuitive interfaces that ensure ease of use.

SEMI-GAS®

Featuring GigaGuard™
Control Technology

SEMI-GAS® production-ready systems are equipped with UL 508-labeled GigaGuard™ controllers—premium technology that includes color touchscreens and LED displays, allowing operators to effectively manage complex processes via a visual interface.

VERSA-GAS™

Featuring vRun™
Control Technology

VERSA-GAS™ systems leverage vRun™ controllers designed for clear, intuitive ease of use. They conform to all relevant safety standards, and come in semi automatic and fully automatic options.

CONSIDERATION #4

Customization Opportunities

Your requirements are unique, and your gas delivery system should be too. If a standard system does not have all the capabilities you require, can it be customized to fit your needs?

Whether your system specifications are driven by regulation, by innovation, or both, your manufacturing partner should be able to satisfy all your requirements with either a standard offering or one that is custom-adapted with appropriate features and functionality. Consider the following:

Custom Engineering Process

Thoughtful and methodical assessment of application demands is the foundation for effective custom gas delivery system design. Does your chosen manufacturer have a formal process by which they uncover your equipment requirements, and then engineer and validate your custom solution?

The equipment customization process should be a collaborative effort between you and your manufacturing partner's engineering team.

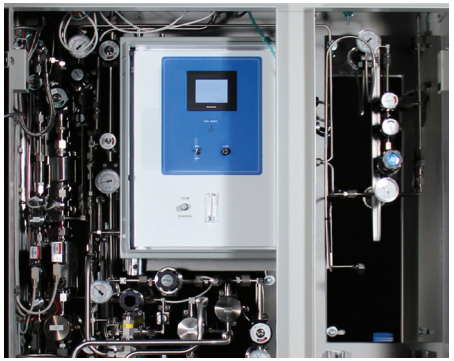
Industry Expertise

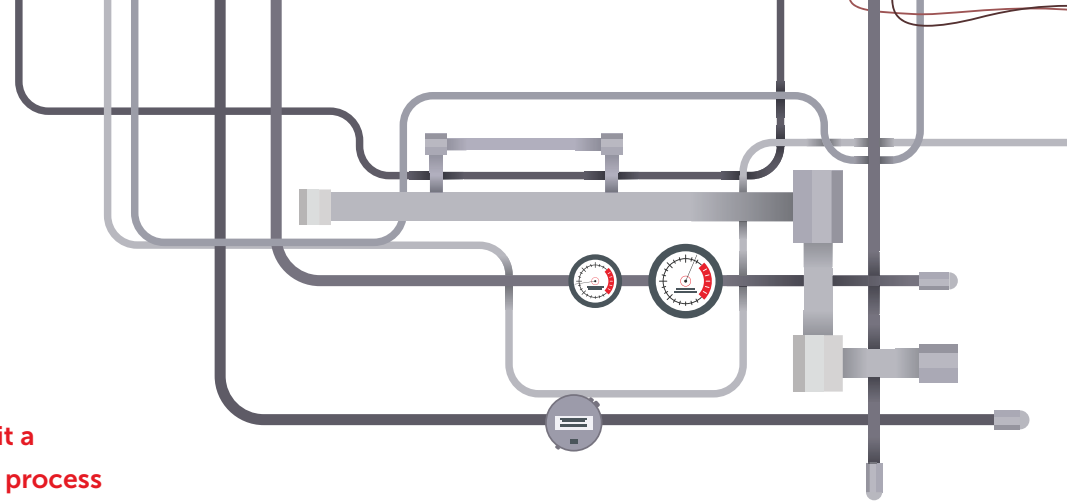
The nuances of gas delivery for semiconductor fabs differ greatly from those in a research lab, or on an industrial manufacturing floor. Does your manufacturer understand the unique regulatory parameters and process environment in which your system will function?

The more experienced they are in your particular industry's challenges, the more likely they will be able to make value-add recommendations for tailoring their equipment to those needs.

Custom Equipment Portfolio

Does the manufacturer have an existing portfolio of custom equipment solutions that prove their ability to effectively deliver adapted systems to customer requirements?

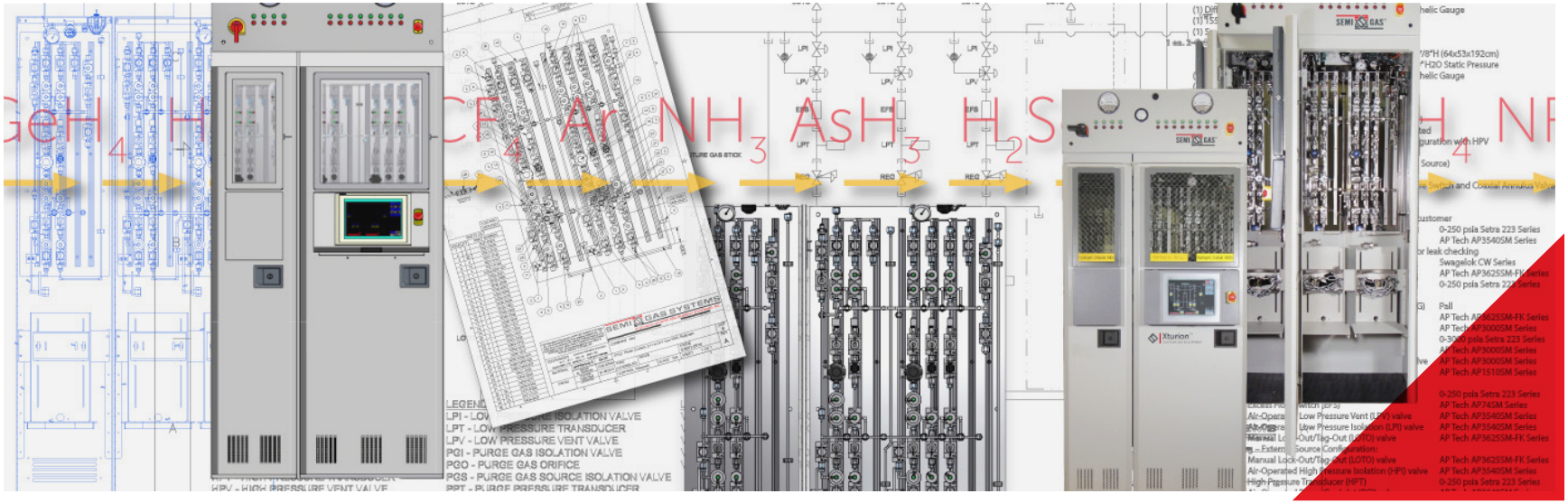




AES: Highly Adaptive

When a standard product from the SEMI-GAS® or VERSA-GAS™ line will not fit a customer's unique requirements, AES employs its methodical customization process to create an 'Applied Solution'.

Applied Solutions bring together AES' robust product offerings, industry-leading services, and vertical expertise to tailor a core system solution into an adapted custom design.



CONSIDERATION #5

Ongoing Support

At the end of the day, the gas delivery equipment you select *must* operate effectively in your environment. Can your manufacturer support ongoing optimization?

Those operating systems in production environments have different support needs than those that are using their gas delivery equipment on a less frequent basis. Still, it is likely that your organization requires some level of ongoing support available for your equipment, and that those services are performed by personnel well-versed the intricacies of your system—and who better than the manufacturer that engineered that system?

It is important to take into account any field service options your manufacturing partner offers, including:

System Installation

Installation requirements vary depending on whether the equipment operates in a cleanroom, outdoor area, gas bunker, etc. If you do not have installation expertise in-house, it can help to leverage your manufacturing partner's resources.

An ideal partner will be well-versed in the process, building, state, fire, and safety code requirements of your environment and provide field service experts to handle piping connections, component installs, process reviews, and system confirmations to those standards.

Equipment Training

Training services can be particularly helpful for operators who do not use gas delivery systems on a regular basis. Ask your manufacturer what types of programs they offer to educate your staff on how to safely start-up and operate their equipment.

Ongoing Maintenance and Optimization

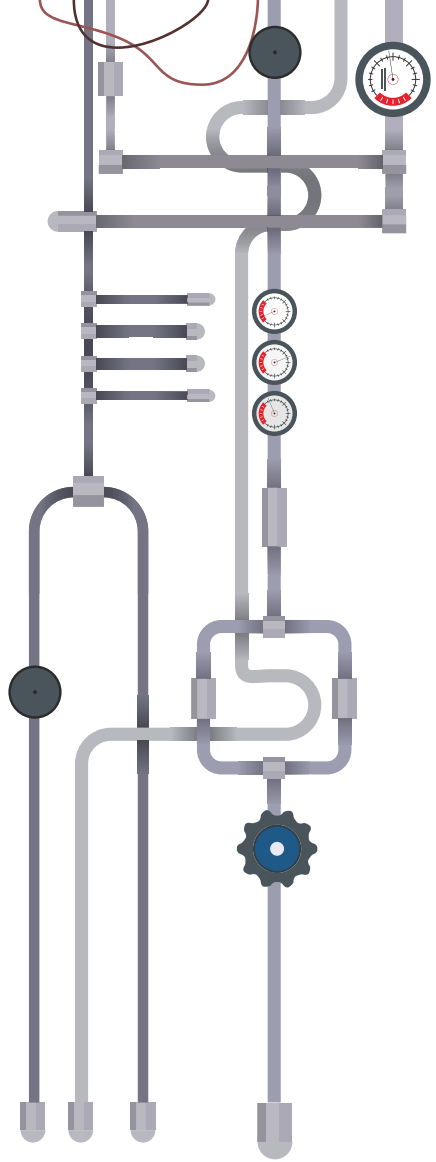
Proactive maintenance will help to keep your system running optimally for the long-term. These services are typically best performed by the partner that built the equipment and who knows the ins and outs of each component. What level of ongoing support will your selected manufacturing partner be able to offer?

From system troubleshooting to diagnosis, preventative and corrective maintenance, and even project consultations for eventual system expansions, make sure your chosen equipment provider can fulfill any long-term system support needs you may have.

AES: At Your Service

AES offers expert field services as an extension of its core gas delivery equipment business, to ensure that the systems they create are optimized for safety, performance and purity in the environments for which they were designed. These services include:

- **High and Ultra High Purity Process Piping:** turnkey installations with unmatched expertise
- **Analytical Testing:** comprehensive quality assurance services
- **Equipment Installation, Commissioning and Training:** on-site optimization
- **Equipment Maintenance and Repairs:** On-demand repairs, proactive maintenance, and system consultations



Pure gases are required for pure output.

That's exactly why your gas delivery system should **never** be an afterthought.

By considering all the aspects covered in this Buyer's Guide, you can take an 'Equipment First' approach to gas delivery system selection—making your choice a strategic decision, so that your equipment becomes a strategic asset.

Rely on the Equipment Experts for System Success

Applied Energy Systems (AES) is singularly specialized in gas delivery systems, and since 1968 our customers have entrusted us with their most complex gas delivery challenges.

With two industry-leading equipment divisions, SEMI-GAS® and VERSA-GAS™, an expert field service division, and comprehensive welding services offered through our Apex Precision brand, AES addresses end-to-end high and ultra high purity gas delivery needs for a diverse range of customers, including those in semiconductors and electronics, pharmaceuticals and biotechnology, photovoltaics, manufacturing, research laboratories, universities and more.

AES: The First Choice for Equipment

System reliability starts with your manufacturing partner. Trust AES' track record of excellence and the leaders across industries that depend on our equipment to deliver for them each day. Learn more about our offerings at **www.appliedenergysystems.com.**

APPLIED ENERGY SYSTEMS

Find the Right-Fit System with AES

Tell us more about your equipment requirements, and we will collaborate to deliver the system that supports your strategic objectives.

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