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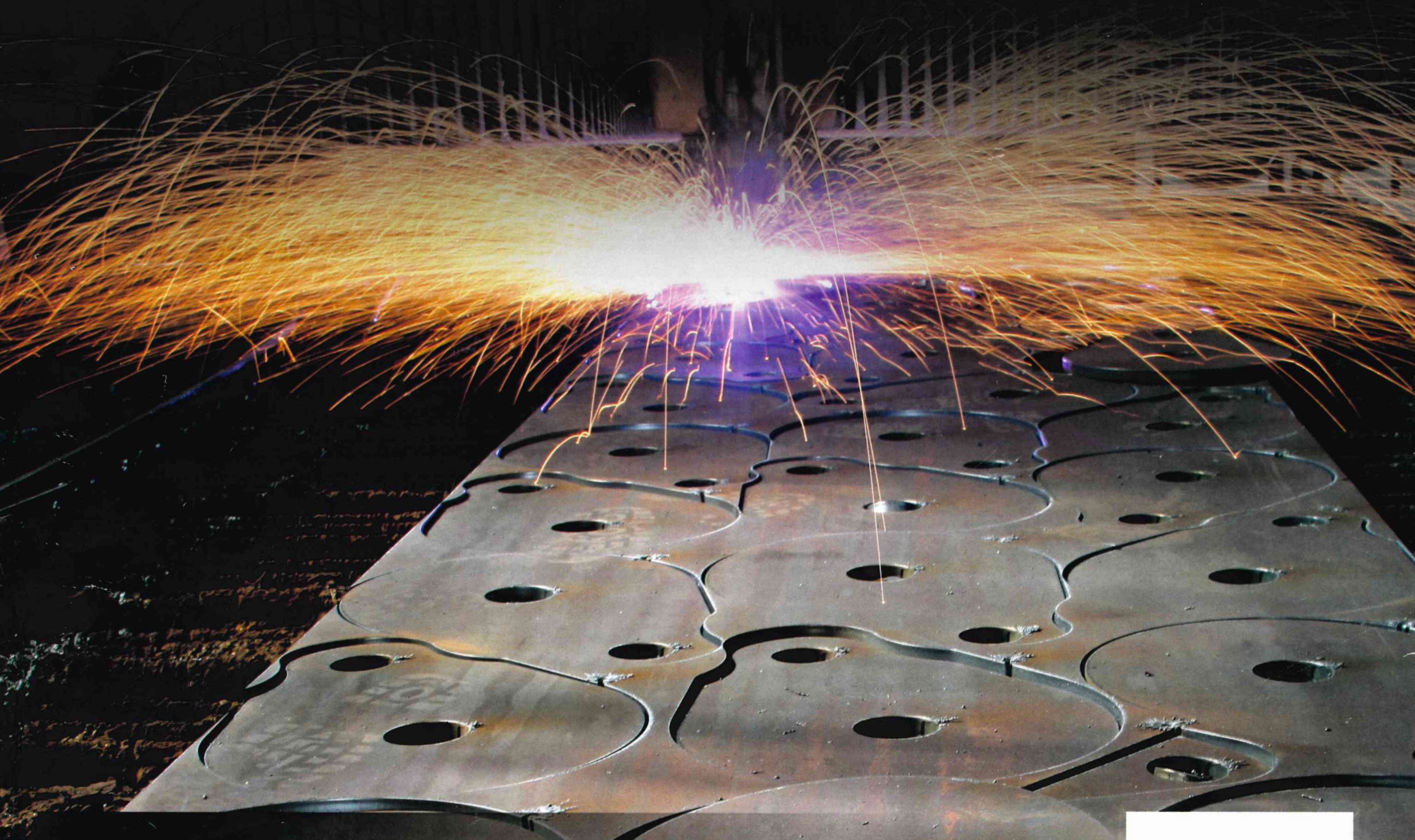

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Laser cutting, no gas delivery trucks required

In-house assist gas generation picks up steam

By Tim Heston

Assist gas generation for laser cutting has come a long way during the past decade. As more shops expand their laser cutting capacity, they often take another look at assist gas consumption. More operations are looking at alternatives for delivered gas, and this includes generating gas on-site—specifically, nitrogen.

Purity in on-site nitrogen generation has reached so-called "five-nines levels"— 99.999+ percent pure. According to Jordan Messick, industrial sales market manager at Wilmington, N.C.-based South-Tek Systems, "The latest nitrogen generation systems can be tuned to the flow rate and purity level an application requires."

Five-nines nitrogen purity may be overkill for typical laser cutting assist gas applications, but certain machine elements can benefit from such purity. Some cutting heads on the market require a nitrogen purge gas that's 99.999 percent pure, and according to Messick, some smaller, dedicated nitrogen generation systems have been designed to supply that purge gas.

If you're cutting thick stainless, 99.99 percent purity (four nines instead of five) will help prevent discoloration on the cut edge. Some less critical applications—say, thin-gauge mild steel—probably wouldn't need such a high purity level.

"From what we're seeing, 99.99 percent would be a fairly standard purity requirement for most applications," said Mike Montesi, commercial sales manager for On Site Gas Systems, Newington, Conn. But he added that purity requirements do vary, depending on the laser machine and application.

What about oxygen? Oxygen generation systems are on the market, though they usually aren't designed for laser cutting. On Site has systems that generate 95- and 99-percent pure oxygen. According to the company website, the system has been used to generate oxygen in medical applications and even for the International Space Station. In a September blog about its booth at this year's FABTECH® show in Chicago, the company stated, "Our 95 percent and 99 percent oxygen PSA generators are ideal for oxyacetylene cutting and welding purposes."

So is this good enough for laser cutting? "The purity is too low," said Montesi. "You still need 99.95 percent oxygen purity. We sell a lot in the laser cutting market for nitrogen generation. We tested oxygen generation with a laser machine manufacturer about a decade ago, but the oxygen generation technology just isn't there for laser cutting."

Regardless of how technology progresses, one thing is for sure: Fabricators are looking for ways to reduce the cost of laser cutting—and this includes generating assist gas in-house.

Nitrogen Generation Basics

Although nitrogen and oxygen sit next to each other on the periodic table, the two elements behave very differently under pressure, which is basically what makes shop floor nitrogen generation possible for laser cutting. Gas generation technologies take advantage of this difference to separate the nitrogen molecules and send them on to a laser cutting machine.

Industrial applications accomplish this separation in two common ways. One way uses a membrane of permeable hollow fibers. Gas flows through hollow fibers and oxygen permeates outward through pores in the fiber. Nitrogen molecules, which can't fit through the pores, continue flowing to the nitrogen storage tank.

A membrane system controls the flow rate by restricting the outlet flow, building more pressure and forcing more oxygen out. The drawback, however, is that flow can be constricted only so much, so there's a limit to how much oxygen can be drawn out of the compressed-air stream.

The nitrogen generation systems growing more common on the fab shop floor use another technology. It's called *pressure swing adsorption*, or PSA. (Different from absorption, adsorption is a process in which molecules adhere to a surface of the adsorbent.) At the heart of it are two pressure vessels filled with what's called a *carbon molecular sieve*, or CMS. This material performs the gas molecule separation.

"If you look at CMS under a microscope, it looks like a small piece of charcoal that's very porous," Messick said.

Here's how it works. Compressed air is pushed

A pressure swing adsorption nitrogen generator can be tuned to meet the purity and flow rate requirements a fabricator needs. Photo courtesy of South-Tek Systems.

into the first CMS tank, which contains roughly 78 percent nitrogen, 21 percent oxygen, and 1 percent trace gases. As the air enters the tank, the oxygen is trapped in the CMS material. Under pressure, the nitrogen molecules react in such a way that prevents them from adsorbing into the small pores of the CMS. The nitrogen bounces off the CMS and passes through the tank vertically and out to a low-pressure nitrogen storage tank.

As the first CMS tank becomes saturated (meaning that material cannot adsorb any additional oxygen), a pressure swing occurs, hence the name "pressure swing adsorption." The second CMS tank starts to pressurize and begins a separation cycle while the first CMS tank goes into an exhaust mode.

During the exhaust mode, the pressure is released, which also releases the oxygen from within the CMS. It is then purged using pure nitrogen, making it ready for the next pressure swing cycle.

After the nitrogen has been separated from the compressed air and concentrated in a low-pressure nitrogen storage tank, it passes through a high-pressure booster and into a final high-pressure storage tank before being sent to the laser. The high-pressure booster is typically sized to take the desired flow rate up to a storage pressure between 75 and 100 PSI higher than the required pressure at the laser inlet. This provides a healthy buffer between the storage pressure and the point-of-use pressure.

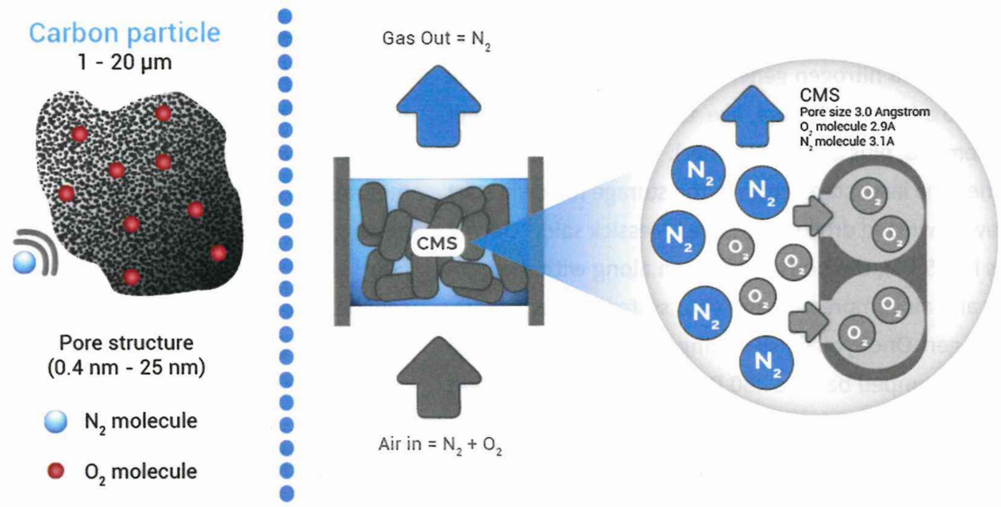
"High-pressure gas-assisted laser cutting typically requires 300 to 400 PSI at the inlet to the laser," Messick said. He added that laser cutting applications often use what are known as *oil-free boosters*—and for good reason. "Any oil carryover could damage the optics on the laser, resulting in a huge expense of replacement as well as production downtime," he said.

The sizing of a nitrogen generator is based on the required purity, hourly flow rate, and pressure. As you go up in purity, you lose flow rate out of the nitrogen generation system. Conversely, if you go up in flow rate, you lose purity. To achieve a higher flow rate *and* purity, you need a larger nitrogen generator, which has more CMS material with more surface area, allowing for more nitrogen separation to occur.

"When you talk about efficiencies of a nitrogen generator," Messick explained, "you're considering how much compressed air it takes to make one cubic foot of nitrogen at a specific purity."

Higher-purity nitrogen requires a greater volume of compressed air, lower purity requires less. The higher purity also requires more CMS material. According to Messick, "To achieve the greatest cost savings and efficiency, it's very important to size the nitrogen generator to the correct purity for your materials and the thicknesses you will actually be cutting."

One issue is that the highest purity a custom fabricator is likely to need may call for an expensive nitrogen generation system. One simple solution has been for fabricators to size a nitrogen generation system for the vast majority of their nitrogen needs, then supplement that with liquid nitrogen dewars for jobs that require it. As OnSite's Montesi said, "If



A carbon molecular sieve, or CMS, adsorbs oxygen and other molecules and allows nitrogen to pass through. Image courtesy of South-Tek Systems.

you have the occasional thick stainless job, you can bring in liquid nitrogen dewars just for that point in time."

Today some systems allow fabricators to adjust purity levels for what they need, using what Messick called a "purity exchange" valve. For instance, say a shop cuts thick stainless only occasionally. This would call for nitrogen assist gas that's 99.99 percent pure. But for the majority of its thin-gauge mild steel work, a consistent flow of 99.90-percent-pure nitrogen would suit.

Considering a shop's beam-on time during a typical shift, the operation needs a system capable of producing a volume of nitrogen at 1,000 cubic feet per hour. This is the instantaneous flow rate the generator can produce, not the amount of nitrogen actually consumed throughout the course of an hour. This amount would provide enough of a buffer to ensure the generation system's storage tank always has the nitrogen the laser cutting machines need.

For most of that time, the lasers need 99.90-percent-pure nitrogen assist gas, but that occasional run of thick stainless steel ups the nitrogen purity requirement to 99.99 percent. To maintain 1,000 CFH at that higher purity level would require larger, more expensive components in the nitrogen generation system.

But there is another way, and here is where the purity exchange valve comes into play. As Messick described, a system now can be designed to produce 99.90-percent-pure nitrogen at a flow rate of 1,000 CFH through the CMS, which is suited for most of the fab shop's mild steel cutting work.

But when the occasional thick-stainless job comes up, the fabricator adjusts the purity exchange valve to the high-purity setting. This raises the purity to 99.99 percent, which in turn reduces the flow rate out of the nitrogen generator. Sure, the lower CFH wouldn't be sufficient to support all the cutting the laser does, but as long as the CFH is lowered on an as-needed basis (again, for the occasional thick-stainless job), it's sufficient.

How Much Nitrogen?

Messick added that this shows how nitrogen generation systems have evolved to suit the complex demands of the custom fabricator, which leads to another factor: sizing a nitrogen generation system.

If a laser cutting operation cuts consistently day after day, hour after hour, it's probably a good idea to size a generation system based on the peak flow rate—that is, the highest nitrogen flow needed plus

A 16-pack bank of high-pressure cylinders (on right) serve as a buffer, allowing the nitrogen generation system to adapt to varying levels of demand.

a little more for good measure—to ensure an opertion never runs short of nitrogen. If a laser's assist gas inlet draws 350 PSI, then a nitrogen generation system's storage tank is sized to a higher pressure, like 450 PSI (350 PSI to meet peak demand, plus a 100-PSI buffer).

"When the laser starts cutting, the storage tank will start to draw down and drop in pressure," Messick said. "Once it drops by 25 PSI, the booster kicks on along with the generator and air compressor, and your system starts producing nitrogen. Once you finish cutting, your nitrogen storage tank gets pumped back to 450 PSI, and the whole system goes into standby."

This assumes a very high percentage of beam-on time during a shift, perfect for lasers with highly automated material handling and jobs with large parts requiring long cuts.

"But we've found that, in reality, no one is cutting 60 minutes out of the hour," Messick said. "You may have gas flowing at a rate of 3,000 SCFH [standard cubic feet per hour] when your beam is on, but if you only have a 60 percent beam-on time, you're consuming only 1,800 cubic feet throughout the course of that hour."

In this case, a shop can size a generation system based on an average hourly consumption of, say, 1,800 SCFH. But instead of a single storage tank at 450 PSI, the shop uses the generator in conjunction with a 16-pack of high-pressure cylinders (filled by the nitrogen generation system to 2,400 PSI or greater) that serves as a buffer to cover the operation for above-average cutting days. Compared to the low-pressure storage tanks, these high-pressure cylinders can store a lot of gas in a small space.

Setting up a system starts with determining the maximum flow rate,

Although nitrogen and oxygen sit next to each other on the periodic table, the two elements behave very differently under pressure, which is basically what makes shop floor nitrogen generation possible for laser cutting.

based on the largest laser cutting nozzle diameter used, then multiplying that figure by the average beam-on time during an hour—say it's, again, 1,800 SCFH (3,000 SCFH flow rate at 60 percent beam-on time). The generator, using a smaller air compressor and other components, is sized down to produce to that 1,800-SCFH usage average. When nitrogen exits the generator, it goes through a high-pressure booster into that 16-pack of cylinders, which collectively hold 4,000 standard cubic feet (SCF) of nitrogen at 2,400 PSI.

This 16-pack of cylinders acts as a buffer between the laser and generator package. The storage volume of 4,000 SCF built up in the 16-pack will supplement the nitrogen generator's performance during any spikes in demand.

"This allows you to have a system that produces nitrogen at a rate of 1,800 SCFH but keep up with a laser that requires 3,000 SCFH with a 60 percent beam-on time," Messick explained.

He added that it also allows fabricators to do shorter runs at higher flow rates. Say a shop has a rare job calling for a larger nozzle setup or higher cutting pressure that requires a flow rate of 4,000 SCFH with the same 60 percent beam-on time. This means it would consume 2,400 SCFH. With the same 1,800-SCFH generator, the fabricator could cut for more than 6 hours.

"You are consuming nitrogen at a rate of 2,400 SCFH and producing it at a rate of 1,800 SCFH. That's a shortage of 600 SCFH," Messick explained. "However, you have a 16-pack containing 4,000 SCF that will serve as a buffer for the shortage."

To run at a higher flow rate for even longer, a fabricator could add a second or third 16-pack of storage cylinders. "Many shops only cutting one shift per day may elect to go with this configuration or even a smaller system and allow it to refill after hours," Messick said.

This buffer also helps when maintaining the system. Nitrogen generators require clean, dry compressed air, so fabricators need to follow a preventive maintenance (PM) schedule on the booster and air compressor. But when they do so, the system can't produce nitrogen. During these times, lasers can rely on that 16-pack cylinder buffer to keep the lasers cutting during those nitrogen system PMs.

Why Not Oxygen?

The physics behind oxygen cutting with a laser requires that oxygen to be very pure. Although the standard purity of oxygen is 99.5 percent, laser cutting benefits from higher oxygen purity levels. According to a publication from Linde, "Our minimum specification for oxygen purity for laser cutting is 99.95 percent." Various laser machine manufacturers recommend the same.

The high purity level requirement is a little counterintuitive, considering many shops use shop air to laser-cut thin stock. But the nature of laser cutting changes when oxygen is the assist gas. While nitrogen (and shop air, which is mostly nitrogen) evacuates material from the kerf, oxygen assist gas also stimulates the cut with an exothermic reaction, making for efficient cutting of thick carbon steel. And again, the cost-benefit analysis of gas generation looks much different, depending on how much oxygen a laser cutting operation really uses.

PSA oxygen generators are available, only in this case they use a different molecular sieve (made of a material called zeolite) designed to separate oxygen instead of nitrogen. The issue lies with the purity level attained, usually between 92 and 95 percent.

Why does conventional PSA work so well for nitrogen but not oxygen, at least for the recommended purity levels for laser cutting? Marc Kornbluh, president of High Volume Oxygen, which produces industrial oxygen generation for glass-blowing and other fields, said it has to do with oxygen and argon molecules being difficult to separate. "The molecular sieve separates the nitrogen, but some of the argon ends up going with the oxygen," he said.

Although High Volume Oxygen has looked into the laser cutting market, and even commissioned a study on ultra-high-purity oxygen generation last year, it has since refocused toward its existing oxygen generation business. Besides its current presence in glass-blowing and the veterinary industry, the company is looking to expand its presence in other metalworking fields, including welding and flame cutting.

"We've been involved with oxyfuel cutting applications using a gas torch," said Bob Schleher, vice president of sales and marketing at North Tonawanda, N.Y.-based Oxygen Generating Systems Intl. (OGSI). "The purity is still an issue with those applications, but it depends a lot on the fuel you're using. In some cases, 93 percent [pure oxygen] can certainly work. Plenty of people who use propane [as a fuel gas] swear by [the oxygen generation] technology." Generating oxygen when using gasoline as a fuel gas has shown particular promise. He added that OGSI has sold oxygen generation systems for brazing applications as well.

Certain oxygen generation systems that achieve 99 percent purity utilize multiple stages—but again, they aren't designed for laser cutting. According to On Site Gas Systems' website, "The 99 percent PSA oxygen generator is a multistage system that starts with a 95 percent oxygen generator. The 95 percent oxygen is then processed through a second stage to produce 99 percent oxygen, and again through an oxygen booster in the final stage. The gas is then available in a tank at the desired pressure."

Could one PSA system generate both nitrogen and oxygen? According to sources, this isn't likely. "A PSA system is optimized for one gas," Schlehr said. "In oxygen generation, could you use the nitrogen that's separated out? Well, as soon as you do that, you alter the production of oxygen." If a fabricator does wish to generate both nitrogen and oxygen for various applications—flame cutting, welding, laser cutting, and more—it probably will be doing it with two different systems.

Oxygen generation for laser cutting may not have taken off (at least not yet), but nitrogen generation certainly has, and that trend doesn't look like it will be changing anytime soon. ***FAB***

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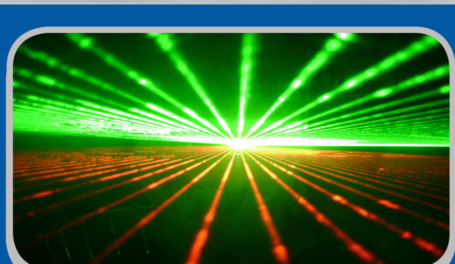

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-See Page 2 for help with sizing your system-

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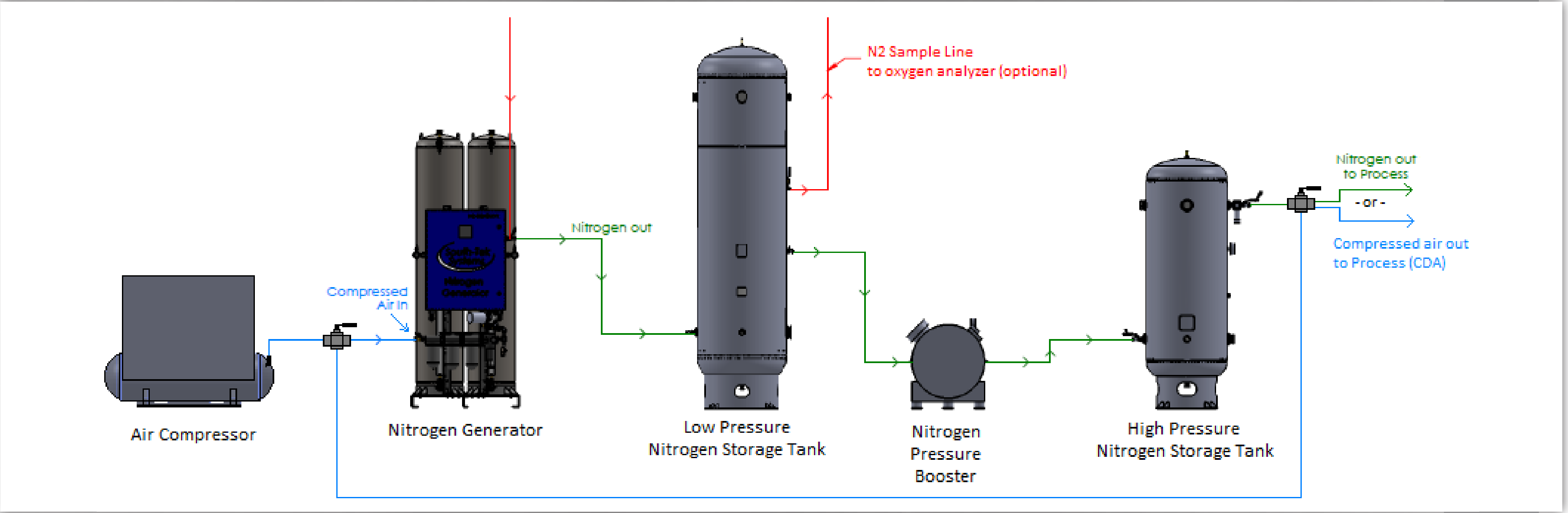


QUESTIONNAIRE

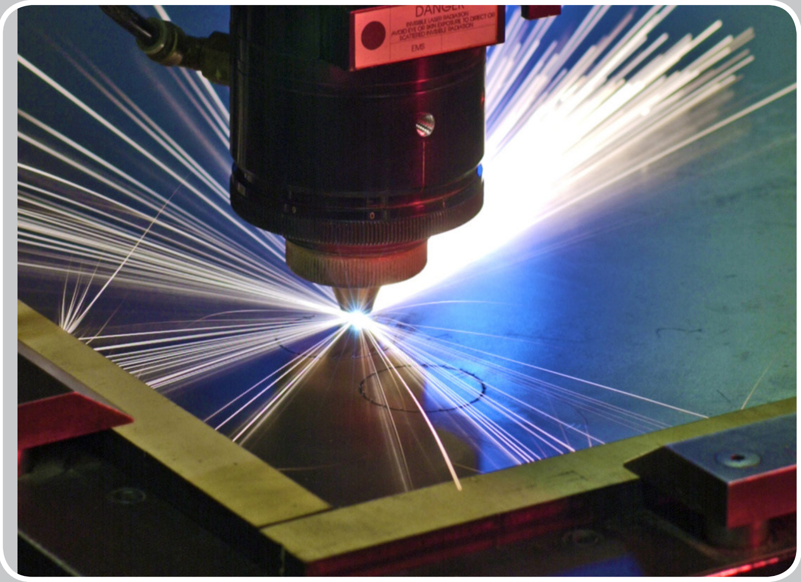
South-Tek Systems prides ourselves on engineering our technology specifically to your requirements. To determine the best system for your shop, please fill out the chart below.

Laser Manufacturer: __________ Laser Model: __________ Fiber -or- CO2 (Circle One)

Nitrogen Pressure Required at Laser Inlet: __________ (different then cutting pressure at laser head)

For each material you are cutting, please let us know the setup info below:

Material Type 1: __________	Material Type 2: __________	Material Type 3: __________
Max thickness: __________	Max thickness: __________	Max thickness: __________
Cutting Pressure @ Head: _____	Cutting Pressure @ Head: _____	Cutting Pressure @ Head: _____
Nozzle Diameter: __________	Nozzle Diameter: __________	Nozzle Diameter: __________



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