Application Note AN310

Autogen Cutting Gas Supply System

Autogen cutting is the process when the kerf is created by burning of the material with pure oxygen. Material is preheated by oxygen – fuel gas flame until the combustion temperature is reached (carbon steel approx. 1150°C / 2100°F). Then the cutting oxygen is switched-on which is reacting with the steel to create oxides. Fast blowing oxygen jet is then removing the oxides out of the cut.

The process is based on gases. Autogen cutting is also called Oxy-Fuel or Gas or Flame cutting – the name always related to gas. Simplifying the situation a bit (but only a little bit), all the cutting machine with CNC control, software, torches, sensors etc is only used to bring proper amount of the gases with right parameters to the desired place on the table. **Gases are the key** factor of the process what is unfortunately often underestimated.

Cutting performance as cutting speed, hole piercing capability, preheating time, and also cut quality are strongly depending on parameters of both oxygen and fuel gas. There are various types of fuel gases available in the market. The selection of the optimal fuel gas type depends on many factors but this topic is not the point of AN310. Most important gas parameters are:

- Gas purity
- Gas Flow rate
- Gas Pressure
- Stability of the Flow and Pressure

Oxygen purity should be minimally 2.5 (99,5%). As higher oxygen purity as better cut quality and faster cutting speed. **Fuel gas purity** is strongly depending on the gas type but from various potential impurities the most important is low content of the moisture (water). There is unfortunately very often relatively high moisture content especially in the low-cost fuel gases what decreases process efficiency, reliability of process automation and equipment lifetime. The issue is also variable composition of the Natural Gas which is depending on the source of origin of the Natural Gas.

The technology requires relatively high **gas flow rate**. Flow rate guarantees proper amount of the gas needed for the process (flame preheating and steel burning - cutting). Only with the right flow rate of heating oxygen and fuel gas the optimal flame composition and power is achieved. Also the steel combustion, chemical reaction between steel components (mainly Fe) and oxygen, requires particular amount of cutting oxygen as well as the additional amount of cutting oxygen is needed for transporting the slag out of the kerf. Flow rate is given by gas sources, and it is strongly influenced by used pressure regulators, valves, fittings, manifolds, hoses, flashback arrestors etc. which are part of the end-user's gas installation but also part of the cutting machine. Dimensions of gas supply components should be carefully designed. Following approximate calculation of the gas flow rate for High-Speed Cutting nozzles should be applied:

- Oxygen: 10m^3/h / 350scfh per each 100mm / 4" of the plate thickness for one torch
- Fuel gas: 1m^3/h / 35scfh per one torch

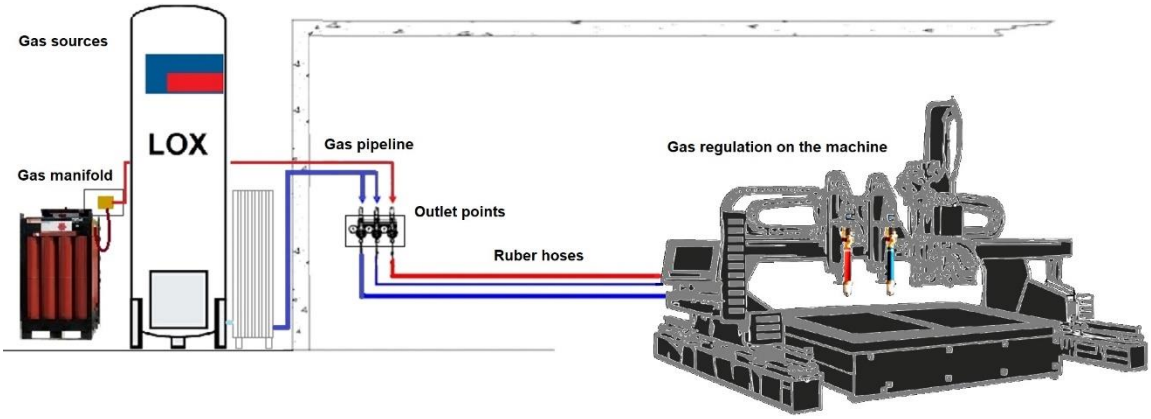
The gas supply system should be able to deliver these flow values at any time regardless on the gas content in the source (e.g. regardless on the pressure level in the gas source).

But even when the perfect sizes of the gas supply system components are used, optimal gas flow cannot be achieved without keeping exact and stabile **gas pressure**. The pressure gives energy to the gas delivery for the process e.g. speed of flow, flame burning intensity, cutting oxygen dynamics etc. There are exact orifices and channels produced in the Cutting and Heating nozzles. With them, only at right pressure at the inlet of the cutting nozzles, the required gas flow is achieved. Laval-type of the cutting oxygen channel is CNC machined to reach very thin and laminar oxygen jet with supersonic blowing

speed. But that only works at very exact final pressure setting. This final setting is adjusted in the cutting machine system but for that following minimal pressures values at machine inlet are required:

- Cutting Oxygen: 12bar / 174psi
- Heating Oxygen: 10bar / 145psi
- Fuel gas: 1bar / 14,5psi

Typical gas installation for cutting machine at end-user site



Gas delivery sources

Oxygen:

- Stationary cryogenic tank (see the picture)
- Multi-cylinder pack (bundle), multi-cylinder rack (battery) or liquid (cryo-) cylinder with proper high-flow gas manifold and pipeline
- Single cylinders with cylinder regulators are not an option for professional use (cylinder valve and cylinder regulator are shrinking the flow capacity of such supply).

Fuel gases:

- Propane, propylene: Stationary tank, multi-cylinder rack, single cylinder of big size (30kg) for only single-torch machine
- LNG, Ethylene: Stationary cryogenic tank
- CNG, H_2: Multi-cylinder pack
- Natural gas: Pipeline (consider recommended minimal pressure requirements)
- Acetylene: Multi-cylinder pack (see the picture)
- LPG: Not recommended fuel gas (if not any other option then see propane sources)

Gas manifold

High-pressure device where gas cylinders and packs are connected to the pipeline. It makes the first pressure regulation step from high filling pressure to the middle level in the pipeline. Consider size and outlet pressure of the containing valves, regulators and safety devices.

Pipeline

Local rules and regulations should be followed! The chart shows recommended dimensions of the pipeline based on the typical applications: Recommended materials: Cu for oxygen, stainless steel for acetylene and other fuel gases.

Material thickness	300mm /12"	200mm / 8"	300mm /12"	100mm / 4"	200mm / 8"
Nr. of torches	1	1-4	1-4	5-10	5-10
Oxygen flow rate and pipe size	35m³/h / 1300scfh ½“	95m³/h / 3350scfh ¾“	140m³/h / 4950scfh 1“	120m³/h / 4250scfh ¾“	230m³/h / 8150scfh 1“
Fuel Gas flow rate and pipe size	1m³/h / 35scfh ½“	4m³/h / 140scfh ¾“	4m³/h / 140scfh 1“	10m³/h / 350scfh 1“	10m³/h / 350scfh 1“

Outlet points

Stable flow and pressure require two-stage pressure regulation upstream the cutting machine. Outlet point regulators are the second stage to reduce middle-pressure level from the pipeline to the required values to enter the machine (recommended above). Three gas outlets are needed (see the picture): Cutting oxygen, Heating oxygen and Fuel gas. Both oxygens shall be separated with individual pressure regulation at the outlet point to avoid influencing each other negatively. There shall be flashback arrestors of proper size installed at the outlet point.

Gas Hoses

Usually rubber hoses installed between the outlet point and the cutting machine and within the machine before splitting the lines to several Autogen stations. Recommended dimensions of the rubber hoses based on the typical applications:

Material thickness	300mm /12"	200mm / 8"	300mm /12"	100mm / 4"	200mm / 8"
Nr. of torches	1	1-4	1-4	5-10	5-10
Cutting Oxygen flow rate and hose size	35m³/h / 1300scfh 12mm / ½”	95m³/h / 3350scfh 12mm / ½”	140m³/h / 4950scfh 16mm / ¾”	120m³/h / 4250scfh 12mm / ½”	230m³/h / 8150scfh 16mm / ¾”
Heating Oxygen flow rate and hose size	5m³/h / 175scfh 10mm / 3/8”	13m³/h / 460scfh 10mm / 3/8”	20m³/h / 700scfh 10mm / 3/8”	17m³/h / 600scfh 12mm / ½”	33m³/h / 1165scfh 12mm / ½”
Fuel Gas flow rate and hose size	1m³/h / 35scfh 10mm / 3/8”	4m³/h / 140scfh 12mm / ½”	4m³/h / 140scfh 16mm / ¾”	10m³/h / 350scfh 16mm / ¾”	10m³/h / 350scfh 16mm / ¾”

Check all rubber hoses for leakages and exchange them regularly. Maximal recommended lifetime is 3 years (see producer’s instruction). Follow the local standards and rules.

Gas regulation on the machine

When designing the gas system on the machine, please consider that even one single fitting or part designed with too small size can influence the flow capacity of the system very negatively (pressure will be set correctly but the flow rate will not be sufficient).

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The final gas parameters setting should be done in the cutting machine. There are actually two main options:

Automated gas **pressure adjustment** controlled by CNC. This is preferred way for professional use which enables automatic adjustment of different values and enables making required changes within the process operations. Each of the gases should be adjustable, preferably individually for each Autogen station. Pay attention that the value set in CNC operating interface is just the set (desired) value. The real value should be measured by separately installed pressure gauge or sensor.

Manual gas **pressure adjustment** by manual pressure regulators installed within the machine. Simple machines can work with manual adjustment. But such setup requires high level knowledge of the machine operators because the options for process automation are very limited. Especially operator's experience with plate piercing is needed. Following gas/pressure levels needs to be regulated individually, usually for all Autogen stations at the same time with one central system:

- Cutting oxygen high level pressure (for cutting)
- Cutting oxygen low level pressure (for piercing)
- Heating oxygen high level pressure (for preheating and piercing)
- Cutting oxygen low level pressure (for cutting)
- Fuel gas pressure (one level is enough for injector cutting torches)

That means the regulating panel with 5 regulators is needed. Systems with e.g. 3 regulators (one for each gas) are not recommended for professional use.

Gas safety

Gas safety is a specific topic, not the point of AN310.

Consider gas density. Eliminate leakages.

Make regular inspections of the entire gas system and set the maintenance and components preventive testing and exchange program.

Consider oxygen safety. Keep all components and connections clean and free of lubricants. Some parts of the machine should be regularly lubricated. Pay attention that standard lubricant is self-reacting in contact with pure oxygen. Lubricant must never get in contact with oxygen!

Never use Cu-components and fittings for acetylene.

Follow local regulations and standards.