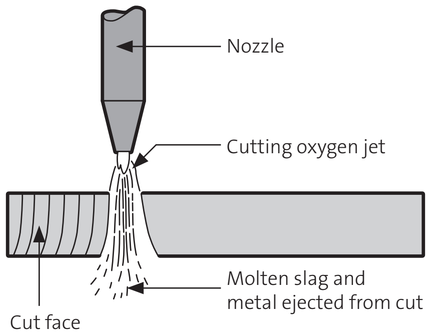
Oxy-fuel cutting
Gas selection guide

Introduction

Oxy-fuel cutting is a traditional process that has been widely used in manufacturing and repair applications since the early 1900's. The process is effective in cutting ferrous metals. It is capable of operating with a wide range of fuel gases with each fuel gas giving slightly different performance charateristics. The equipment is relatively low cost. The process can easily be automated to enhance productivity and cut accuracy. Acetylene is the only commonly used fuel gas that can produce a variety of bevel edge preparations on plate, pipe, and tube. All cut surfaces require grinding prior to welding to remove the oxide layer.

The role of the fuel gas is to heat the material to the ignition temperature. The role of the oxygen is to react exothermically with the iron in the material. The heat from the reaction melts the material which is blown from the cut by the oxygen jet. The purity of oxygen should be at least 99.5%.



Fuel gases are characterised by:

- **flame temperature –** the hottest part of the flame is at the tip of the primary flame (inner cone)
- **heat of combustion –** the total amount of heat available when the inner and outer parts of the oxy-fuel flame are combined
- **fuel gas to oxygen ratio –** the volumetric ratio of fuel gas to oxygen in the flame. This will vary according to whether the flame is neutral, oxidising or reducing. Unless otherwise stated the ratio quoted is the stoichiometric, neutral flame ratio

The choice of fuel gas will depend upon a multitude of factors, such as:

- **Availability**
- **Safety considerations**
  - local regulations and fuel gas restrictions
  - working in confined space
- **Applications**
  - fuel gas required for other processes e.g. welding
  - lay-out requires multiple piercings
- **Cut quality**

Typically, the fuel gas represents only a small percentage of the overall cutting cost.

Common Oxy-fuel gases

Acetylene (C_2H_2)

The maximum flame temperature for Acetylene (in oxygen) is 3,162°C. Acetylene has a high heat release in its focussed primary or inner cone (18,890 kJ/m^3 compared with 10,433 kJ/m^3 for Propane) and hence produces a more intense flame at the surface of the metal which reduces the width of the Heat Affected Zone (HAZ) and minimises distortion. As the heat release from its secondary or outer cone is less than that of Propane it is better suited for cutting up to 10mm.

Acetylene produces the hottest and most concentrated primary flame of all industrial fuel gases. Its calorific value is fairly low (ref table 1) and the portion emitted by the primary flame is very high, approximately 30%, making it better suited for cutting rather than heating.

The hotter and more focussed flame ensues rapid piercing of materials with the pierce time being significantly lower than with Propane. This is particularly advantageous when the pierce time is a significant proportion of the total cutting time. In addition, a faster flame speed (7.4 metres per second (m/s) compared with 3.3m/s for Propane) means it is easier to light.

Propane (C_3H_8)

The maximum flame temperature in oxygen is 2,832°C. Propane has the disadvantage of having a high stoichiometric (oxygen to fuel gas ratio) of approximately 4.3 to 1 by volume, compared to 1.2 to 1 for Acetylene. It has a greater total heat of combustion than Acetylene, but the heat is generated mostly in the outer cone and hence the flame appears to be less focused. Consequently, piercing is much slower but as the burning and slag formation are affected by the oxygen jet, cutting speeds in thicker sections are about the same or even better than for Acetylene. It is well suited for cutting 10mm and over, showing speed advantages compared to Acetylene above 25mm.

Propylene (C_3H_6)

The maximum flame temperature in oxygen is 2,897°C. It gives off a high heat release in the outer cone (72,000kJ/m^3) but, like Propane, it has the disadvantage of having a high stoichiometric fuel gas requirement of approximately 3.7 to 1 by volume. It is well suited for cutting all thicknesses.

Compared to Propane, the total calorific value of Propylene is slightly lower (ref table 1), however; the portion emitted by the primary flame is much higher, approximately 18% compared to 11% for Propane. This more focussed flame ensures quicker piercing compared to Propane. In addition, a faster flame speed, of around 4 m/s compared with 3.3m/s for Propane, means it is easier to light.

MAPP

MAPP gas; as originally developed; is a controlled mixture of several hydrocarbons, principally, Methylacetylene, Propadiene and Propane. The maximum flame temperature for MAPP (in Oxygen) is 2,929°C . It has a high heat release in the primary flame (15,445kJ/m³), which is less than for Acetylene, similar to Propylene and higher than that for Propane (table 1). MAPP gives a very similar performance to Propylene and has a comparable stoichiometric oxygen ratio.

The term MAPP is also used generically to refer to hydrocarbon-based fuel gas mixtures (e.g. Propylene – Propane mixtures) and hence performance characteristics can vary between suppliers and over time.

Hydrogen

The maximum flame temperature in Oxygen is 2,808°C. Hydrogen has the lowest stoichiometric ratio to oxygen, produces a clean flame and is suitable for welding aluminium. As Hydrogen can be used at a higher pressure than Acetylene, it is therefore useful for underwater welding and cutting.

In addition, having a faster flame speed (8.9m/s compared with 3.3m/s for Propane) means it is easier to light.

Natural gas

Natural gas, which is a naturally occurring hydrocarbon-mixture, primarily Methane, has the lowest flame temperature in Oxygen of 2,786°C and the lowest total heat value of the commonly used fuel gases. The heat release in the primary or inner cone is the lowest of all the fuel gases at only 1,490kJ/m³ compared with 18,890kJ/m³ for Acetylene. Consequently, natural gas is the slowest to initiate piercing. The preheat times are also significantly slower than Propylene and Propane.

Chemtane 2® gas mixture[1]

Chemtane 2 concentrate is a mixture of hydrocarbons of 4% Pentane in Propane. Typically, the blending proportions are one-part Chemtane 2 concentrate to 199 parts of Propane. It has a flame temperature in Oxygen of 2,832°C. This product has limited availability.

[1] Chemtane 2 is a registered trademark of Chemtane Energy LLC.

MagneGas 2® gas mixture[2]

MagneGas 2 is manufactured by gasification of liquid waste and is principally a mixture of around 50% Hydrogen with the other 50% consisting Carbon Monoxide, Acetylene, Methane and Ethylene with small amounts of other gases. It has a flame temperature in Oxygen of 2,867°C. As the composition of the liquid waste can vary; the composition and performance of the resulting MagneGas will also vary. This product has limited availability.

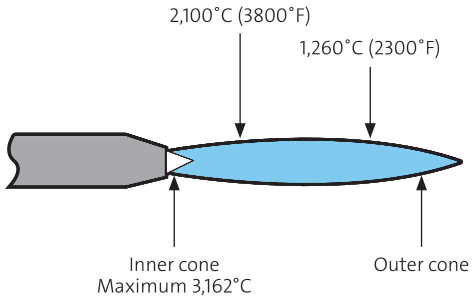
[2] MagneGas 2 is a registered trademark of MAGNEGAS IP, LLC.

Table 1 - Fuel gas characteristics

Fuel gas	Max flame temp (°C)[3]	Oxygen/fuel gas ratios (vol) stoichiometric	Torch	Heat distribution (kJ/m^3) primary cone	Total	Primary cone (%)	Heating value (MJ/kg)
Acetylene	3,162	2.5:1	1.2:1	18,890	54,772	34.5	48.5
Propane	2,832	5:1	4.3:1	10,433	95,758	10.9	46.1
Propylene	2,897	4.5:1	3.7:1	16,000	88,000	18.2	45.8
MAPP	2,929	*	3.3:1	15,445	71,876	21.5	-
Hydrogen	2,808	2:1	0.42:1	-	12,100	n/a	120.1
Natural gas	2,786	0.5:1	1.8:1	1,490	37,260	4	40.7
Chemtane 2 mix	2,832	*	-	-	-	-	-
MagneGas	2,867	*	-	-	-	-	-

[3] Calculated maximum adiabatic flame temperature with Ansys Fluent
* Stoichiometric ratio not given as composition of the fuel is variable

Acetylene
Neutral flame



Hydrogen
Neutral flame

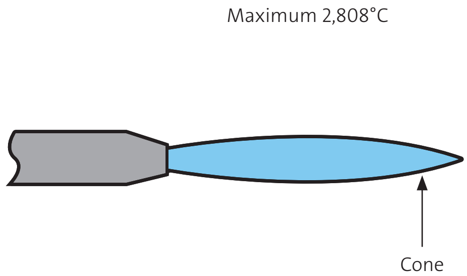


Table 2 - Oxy-fuel cutting comparison

25mm carbon steel, 10m long, semi-automated

	Acetylene	Propane	Propylene	MAPP	Hydrogen	Natural Gas	Chemtane	MagneGas
Piercing	***	*	**	**	*	*	*	*
Cutting speed	***	**	***	***	**	*	**	**
Cost efficiency[4]	***	*	**	**	*	*	*	*

[4] Based on estimated cost of fuel gas, oxygen and labour

Oxygen and acetylene Integra® cylinder

Our safest fuel-gas cylinder

Protective valve guard

Prevents accidental damage and makes the cylinder easy to handle. Independently safety tested. Exceeds the requirements of EN ISO 11117. Protects all critical components and provides full access for valve operation.

Contents gauge

Always shows how much gas is left, even when cylinder is not in use!

Built-in regulator

Calibrated and maintained by Air Products. Regulates outlet pressure and provides a variable pressure control. Suitable for all cutting, welding and brazing applications.

Quick connect gas outlet

Allows safe and rapid gas cylinder change-over. Safety device in valve outlet ensures no gas flow if the quick connector is not fitted to the valve.

Quick connector with built-in safety

Ensures the safest connection every time the cylinder is used. Snap-on connection to cylinder – no spanner needed. Additional safety locking and release device prevents accidental removal.

Built in safety devices:

- Safety locking and release mechanism
- Flame arrestor
- Non-return valve
- Thermal cut-off valve
- Dust filter

Filling point

Acetylene Integra® cylinder shown

For more information please contact us at:

Air Products PLC
T 0800 389 0202
E apukinfo@airproducts.com
airproducts.co.uk

Air Products Ireland Ltd.
T 1800 99 50 29
E ieinfo@airproducts.com
airproducts.ie

tell me more
airproducts.co.uk
airproducts.ie

 213-21-004-EN-May21