



Acetylene.

There is no better one.

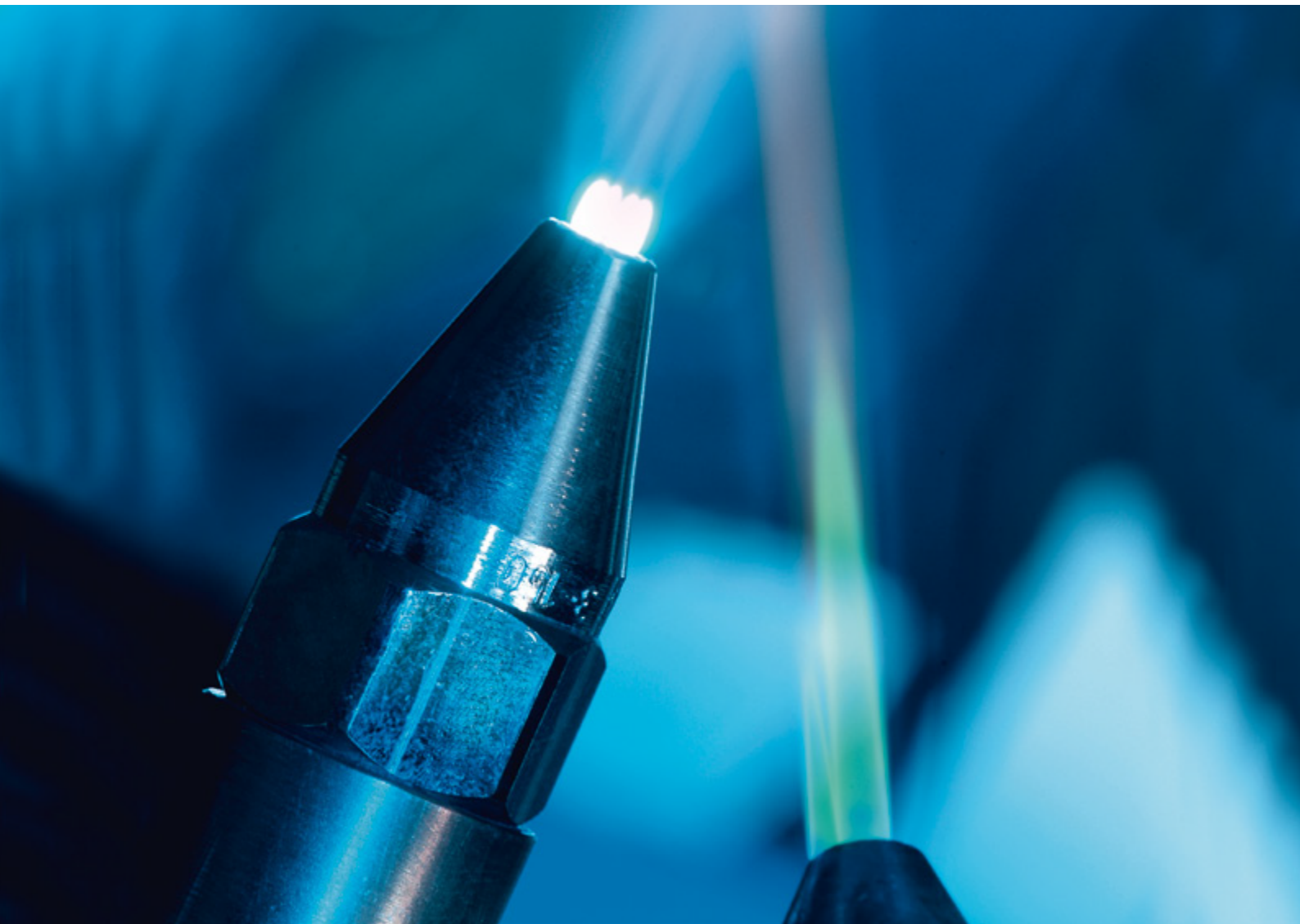


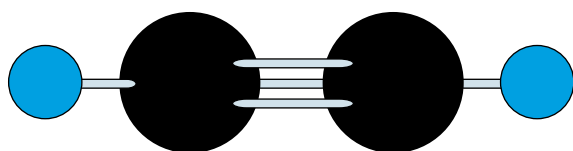
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Introduction.

Acetylene – highly efficient by nature.

The acetylene molecule



Comprises two carbon atoms linked by a triple bond and two symmetrically arranged hydrogen atoms.

The high efficiency of acetylene is easy to explain: the energy released during combustion, the high flame temperature, and the flame propagation rate of the oxy-acetylene flame are due to the favorable molecular structure of the acetylene. Even during decomposition of the acetylene molecule energy is being released, in contrast to other hydrocarbons; this is the so-called energy of formation or formation enthalpy.

In the case of acetylene 8,714 kJ/kg of utilizable energy is released. More heat is added by the partial combustion of the oxygen in the gas stream. And, since in oxy-fuel gas processes the first combustion stage only, i.e. the primary flame, is of practical importance, the favorable combustion properties of acetylene offer a big advantage that is inherent in the product itself.

Details of the acetylene molecule

Conversion data:	m ³ of gas 0.1 MPa (1 bar), 0 °C*	m ³ of gas 0.1 MPa (1 bar), 15 °C*	kg
	1	1.068	1.175
	0.936	1	1.100
	0.851	0.909	1
Properties:	Acetylene is a colorless fuel gas with a slightly ethereal, sweet odor.		
Chemical symbol:	C ₂ H ₂		
Molar mass:	26.04 g/mol		
Triple point:	-80.8 °C/0.128 MPa (1.28 bar)*		
Critical point:	35.18 °C/6.191 MPa (61.91 bar)*		
Density (at 15 °C/1 bar):	1.095 kg/m ³		
Density (at 0 °C/1.013 bar):	1.175 kg/m ³		
Comparison of density:	10% lighter than air		
Ignition temperature:	335 °C in air, 300 °C in oxygen		
Flammability limits:	in air 2.3–82% by vol.		
	in oxygen 2.5–93% by vol.		
	* 0.1 MPa ≙ 1 bar		

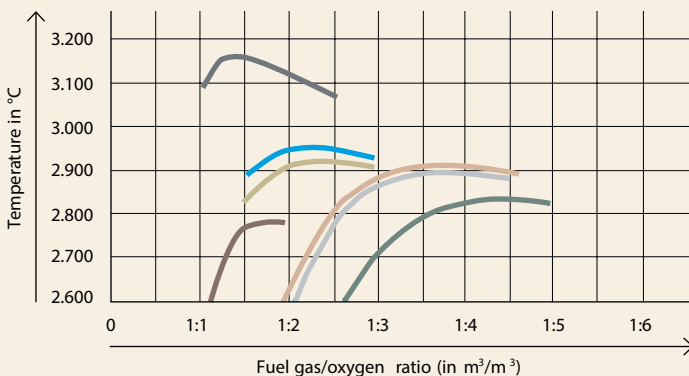
Meeting your needs in the various oxy-fuel gas processes.

Acetylene provides all of the properties that matter most.

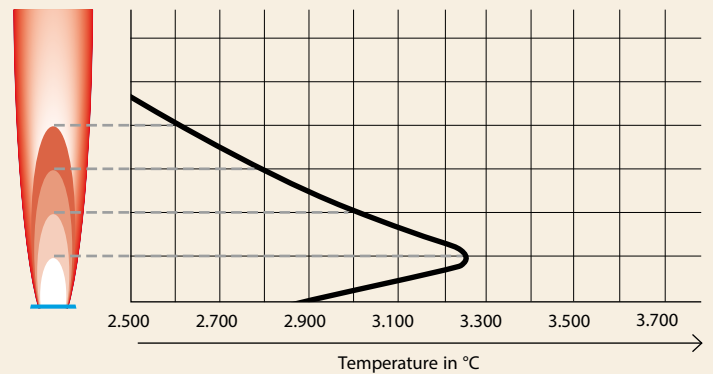
Whenever rapid and concentrated heating and preheating of the work is essential, flame temperature is an important factor. The higher the temperature, the faster transfer of heat from the flame into the workpiece.

Flame temperature

■ Acetylene ■ Mixture with ethene ■ Ethene
■ Methane ■ Propene ■ Propane
■ Mixture with methyl acetylene



Temperature distribution within an acetylene oxygen flame



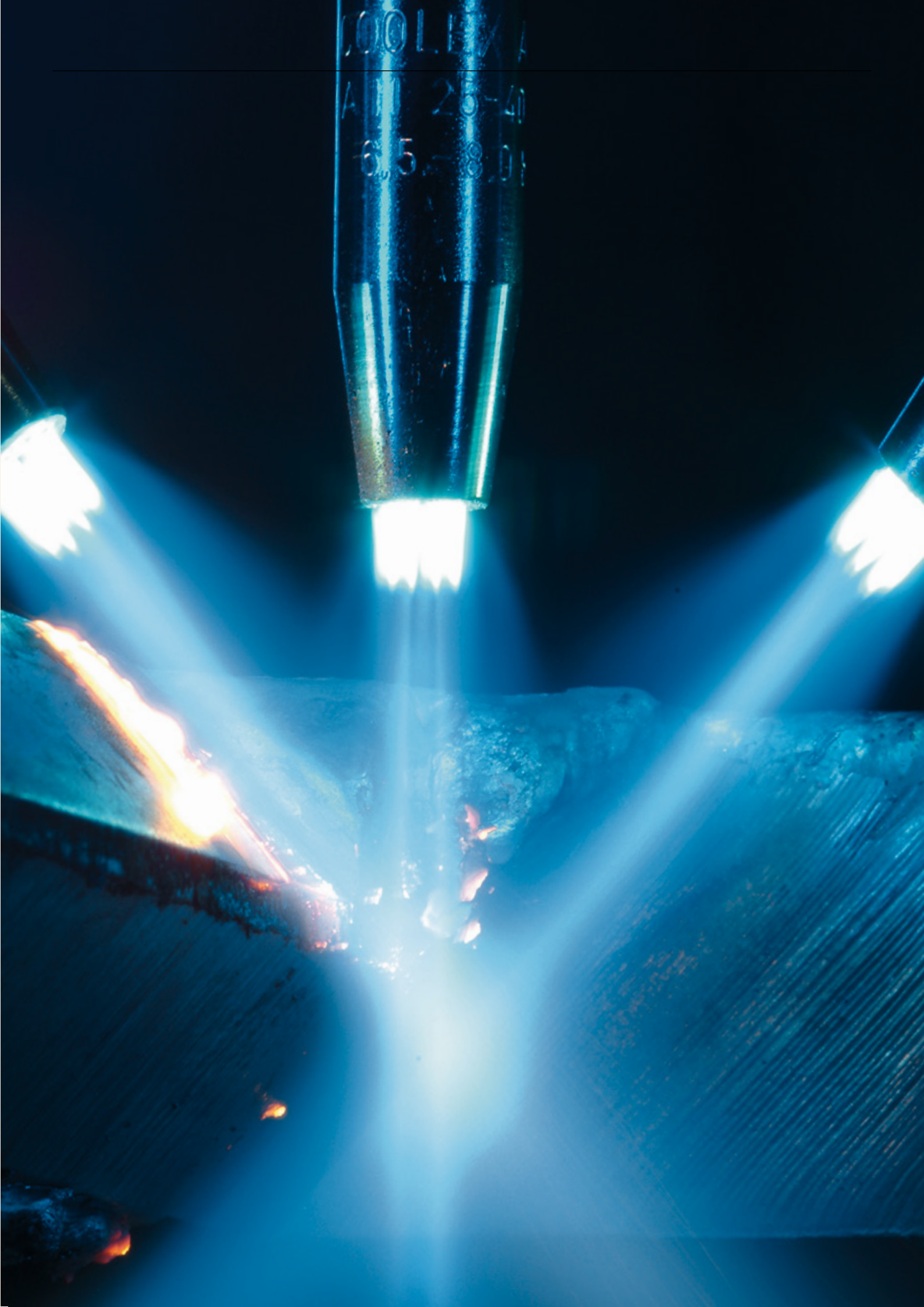
Flame cutting.

Effective and efficient with acetylene.

Flame cutting, whether by hand or by machine, is one of the main fields of application for the highly effective oxy-acetylene flame. Flame cutting is a labor-intensive process. 80 to 90% of total costs are costs for labor and equipment. So in this respect, the high efficiency of the acetylene flame pays off extremely well: rapid preheating for starting or cutting holes; optimal cutting speed even with rusty, scaled, or primed sheet; cutting quality leaves nothing to be

desired. Sharp cut edges, smooth cut surfaces, and easily removable scale are guaranteed. Regardless of the type of cut, and even with extreme bevel cuts.

The latest types of flame cutting machines and technically advanced tips contribute to high cost-effectiveness in flame cutting with acetylene.

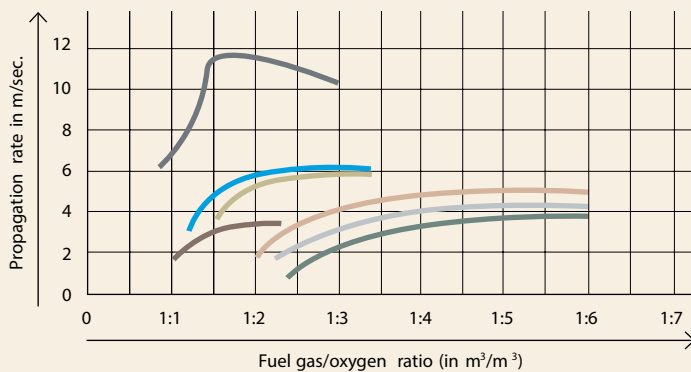
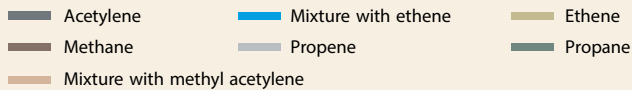


Efficient power with superior heat and distribution.

Acetylene provides the highest flame temperature and propagation rate.

Acetylene is also the fuel gas with the highest flame propagation rate. The faster the hot combustion products meet the work piece, the greater the thermal efficiency. This requirement is particularly important when heating metallic materials with high thermal conductivity like steel, copper, or aluminium.

Flame propagation rate

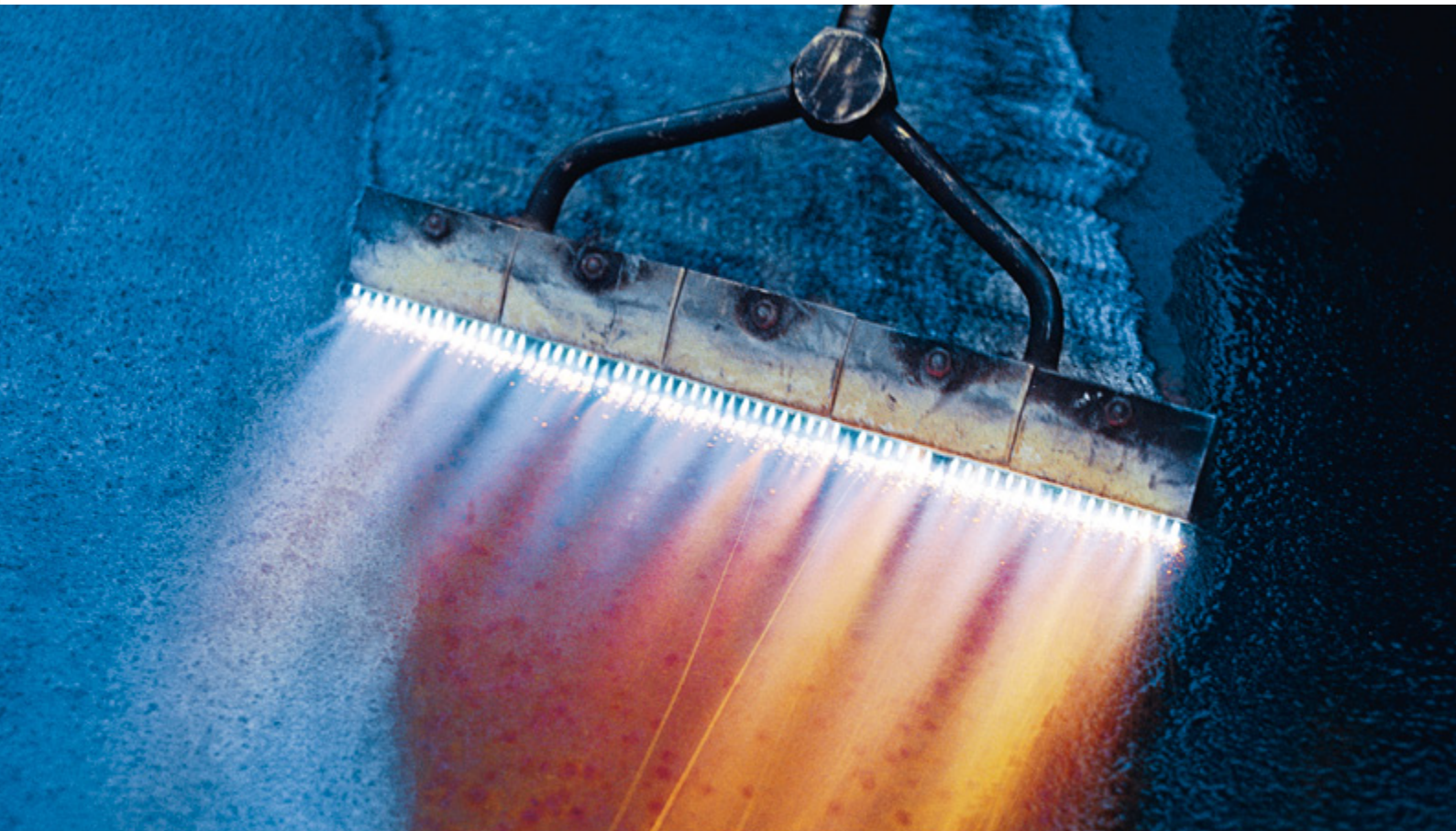


Most suitable flame setting for welding



Flame cleaning and gouging.

Efficient, low-cost flame technology applications.



Flame cleaning of a steel surface.

Flame cleaning: clean surfaces, low costs

Flame cleaning with acetylene is used wherever clean sheet metal surfaces are required for further processing. Rust, mill scale, and other scale are efficiently removed by low-cost flame cleaning. Flame cleaned surfaces ensure excellent adhesion of paint and coatings. Thereby, corrosion resistance is also improved. Flame cleaning procedures are also used for thermal treatment of concrete and natural stone surfaces. In particular for cleaning and preparatory pretreatment of concrete carriage way surfaces. Also old paint and coatings, oil contamination, and abraded rubber can be removed in an environmentally friendly way. The concrete thus exposed gives optimal adhesion for synthetic resin coatings.

Flame gouging: optimal for producing a channel or removing defects in a welding seam

Gouging is used to remove weld defects or to prepare welds for root passes. Proper guidance of the torch tip gives a perfect weld joint.

Gouging of the root for reverse side welding.



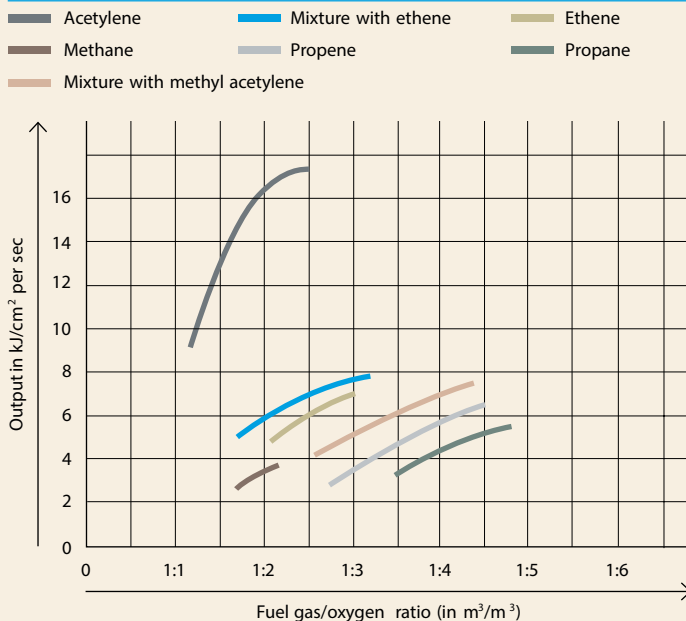
An inherent advantage in combustion.

The primary flame output in oxy-fuel gas processes.

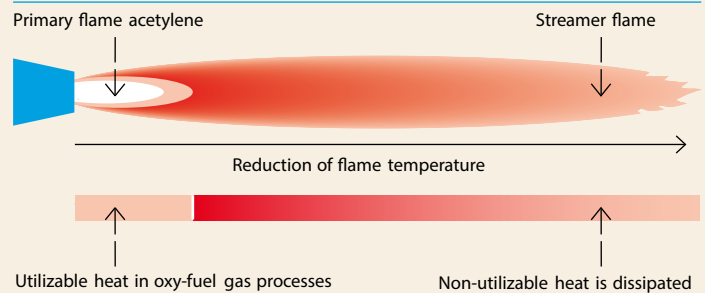
The primary flame output (related to volume unit) is the product of the flame propagation rate and the heat evolved in the primary combustion stage in the flame cone. This alone provides the heating capacity. And, since in oxy-fuel gas processes the primary combustion stage only, i.e. the primary flame, is of practical importance, the favorable combustion properties of the acetylene flame offer a big advantage that is simply inherent in the product itself.

The calorific value of a fuel gas is not the decisive factor. This value also includes the heat output released in the secondary combustion stage in the flame, which cannot be utilized in oxy-fuel gas processes.

Primary flame output

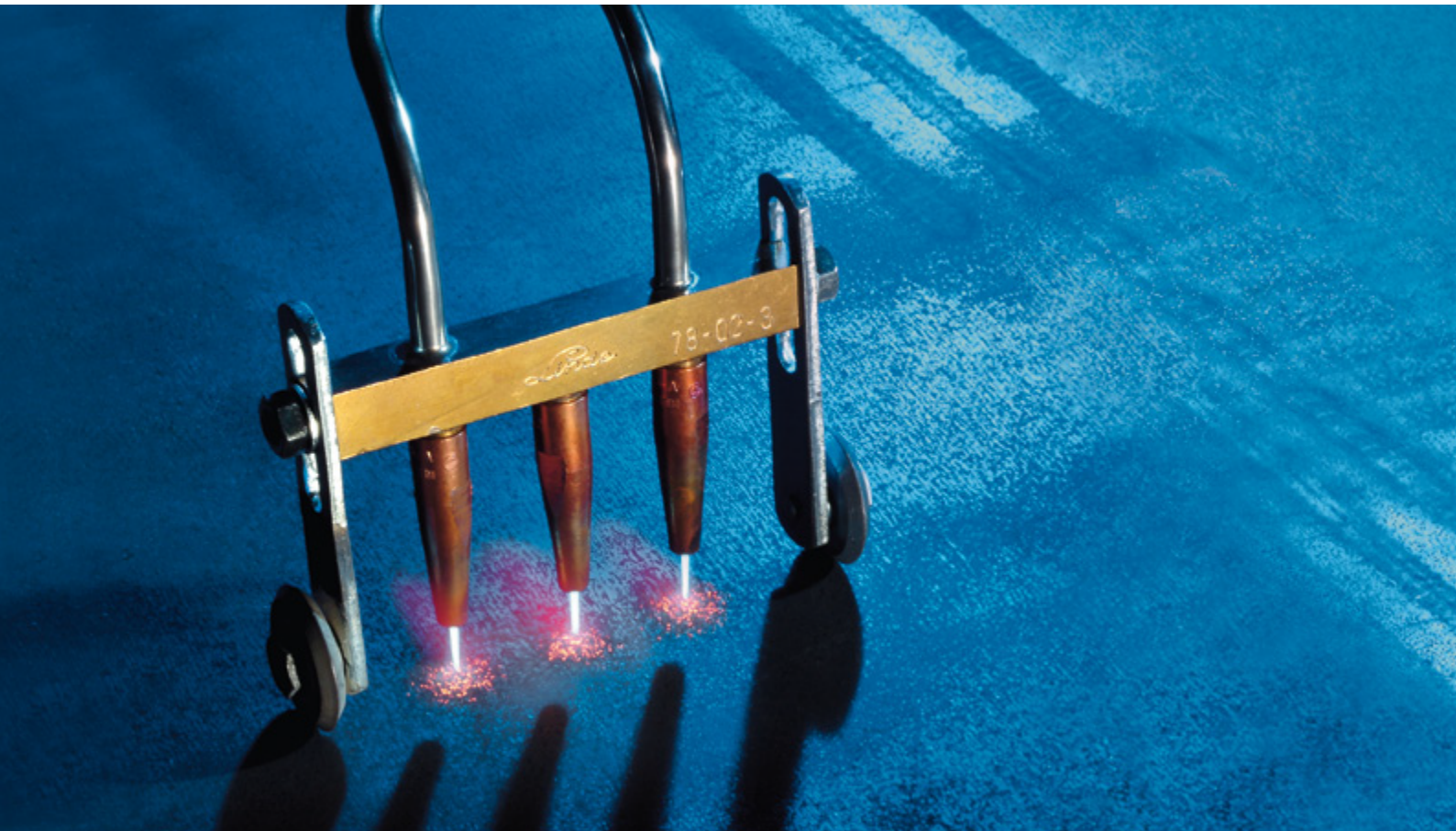


Heat released by complete combustion (calorific value)



Flame straightening.

High temperature and combustion velocity, flexible heat output.

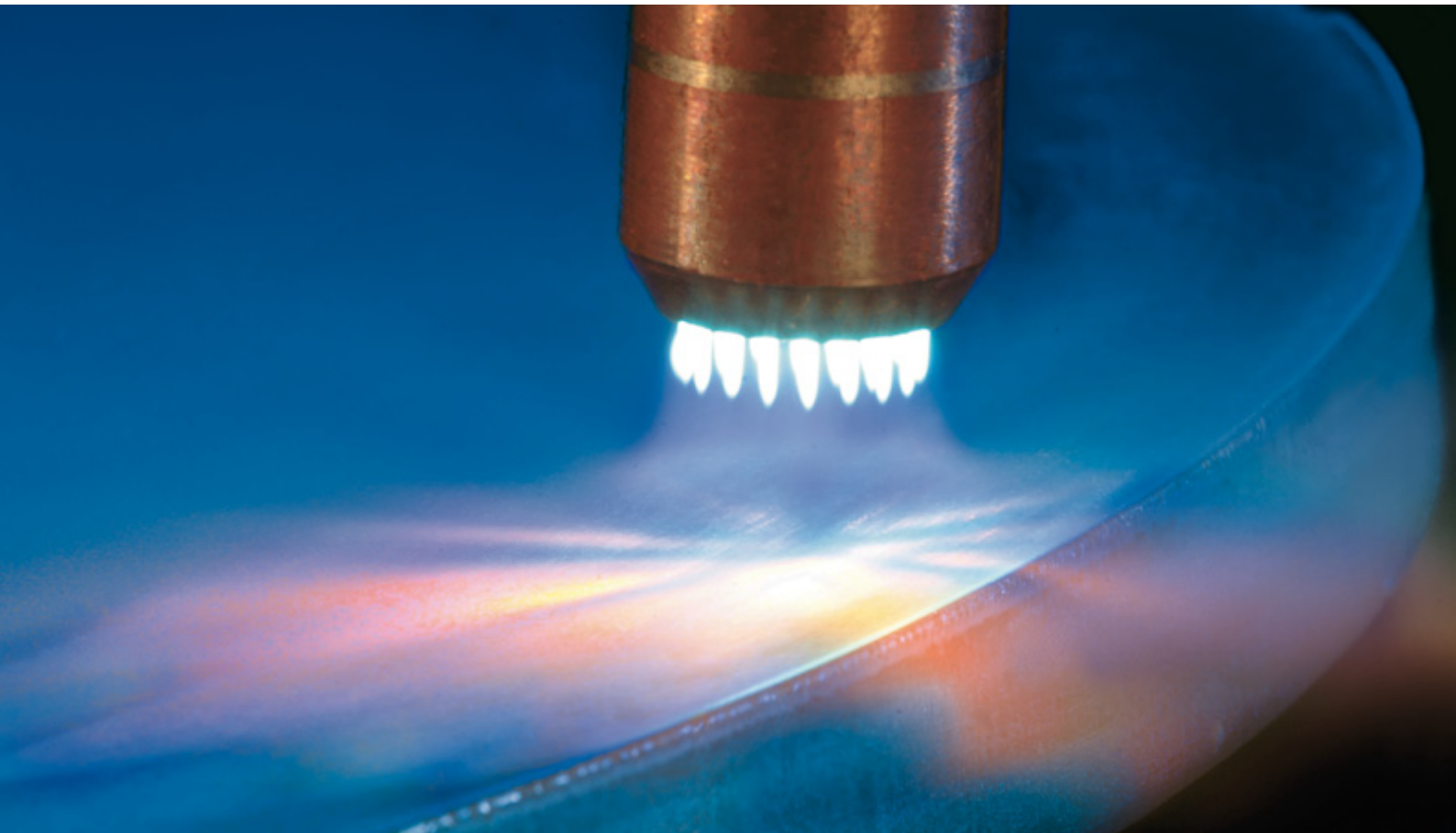


Flame straightening.

In flame straightening the high efficiency of acetylene is of particular value. The high flame temperature combined with the high combustion velocity ensures rapid and precise heating. Due to the variable oxy-acetylene flame and easily interchangeable torch tips, any desired heat output can be set, enabling optimal and economical treatment of the work piece.

Flame heating.

An oxy-acetylene flame intensifies heat output.



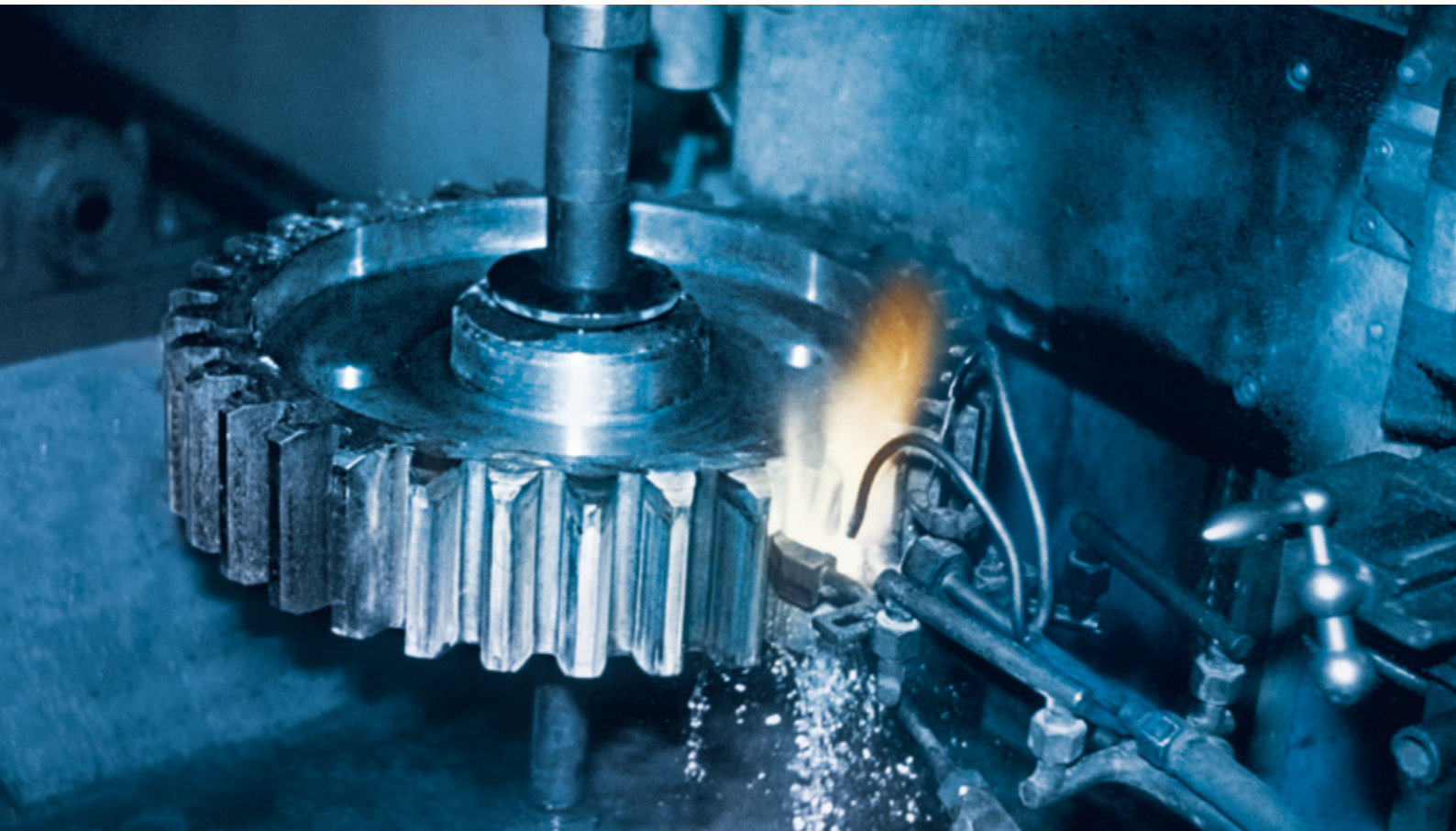
Locally defined flame heating to forging temperature by oxy-acetylene torch.

There is a direct relationship between flow velocity and flame propagation rate. The higher the flame propagation rate, the higher the flow velocity can be set. The higher the flow velocity, the higher the gas volume combusted per unit of time. The more gas is combusted, the higher the concentration of heat released.

Flame heating means local heating preparatory to hot forming, e.g. bending of pipes, necking of distributors, dishing of vessel bottoms, or for preheating and reheating in welding and flame cutting. Both normal welding torches and specially developed high-output oxy-acetylene torches are used for these heating procedures. The use of high-output heating torches is recommended in particular when large quantities of heat are to be applied to the work piece with the highest speed and concentration possible.

Flame hardening.

For improved wear resistance without adverse effects.



Special torch with water cooling for flame hardening.

Flame hardening of ferrous metal workpieces is used to improve wear resistance. Particularly in the case of components for driving assemblies like gear wheels or ball raceways, service life is increased substantially. In the process hardened layers are produced by local heating and quenching of defined surface areas without any adverse effects on the core material. For flame hardening mainly mechanized methods are used in job and batch production.

The workpiece surface layers are heated so rapidly by the high-output oxy-acetylene flame that a sharply defined heat effected zone is formed down to the desired depth, without heat penetrating into the deeper layers. By immediate sub-sequent quenching with water the heat is removed from the workpiece. The inherent compression tension forms the hardened structure. Because the material below the hardened layer is not involved in the structural transformation processes, dimension accuracy and the mechanical properties of the workpiece remain unchanged.

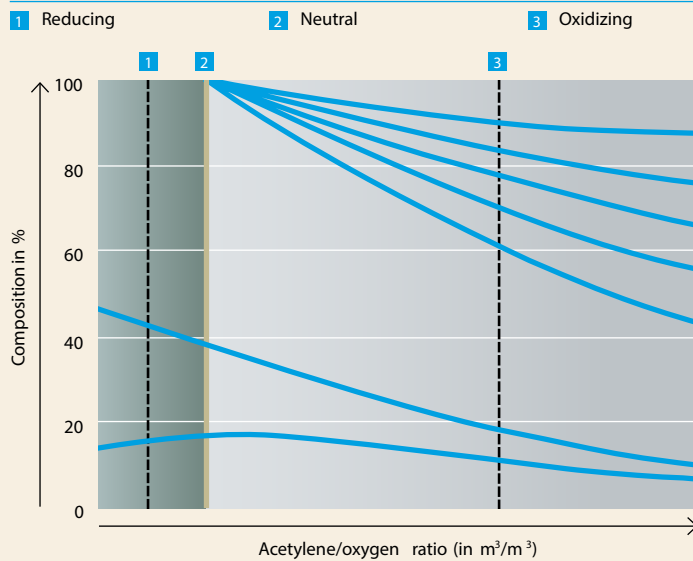
The right stuff for welding and melting.

Acetylene's output and temperature at neutral flame setting.

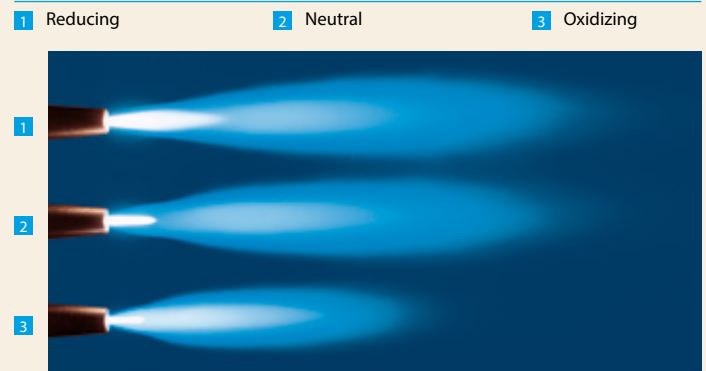
Only acetylene has the necessary flame temperature and flame output at neutral flame setting for melting and welding steel. A neutral flame setting is essential especially when welding steel in order to avoid undesirable reactions in the melt pool. The oxy-acetylene flame is

"neutral" when the acetylene/oxygen ratio is 1:1. The flame is called "reducing" when there is a surplus of acetylene and "oxidizing" when there is an excess of oxygen.

Composition of flame gases at flame cone depending on mix ratio



Flame setting



Status of the mix ratio:	1	1:0.67	Reducing
	2	1:1	Neutral
	3	1:2	Oxidizing

Gas welding.

Advantages that convince.



Rightward welding.

In metal working, gas welding is certainly one of the major processes. The big advantage of acetylene lies in the reducing effect of the welding flame, which is easy to adjust as well as to control. Gas welding with acetylene is characterized by good gap-bridging capabilities. There is no, or very little, joint preparation required. The problem-free application is particularly useful in out-of-position welding.

In pipeline construction, for instance, where other welding methods are usually out of the question or not economical, the oxy-acetylene flame is the welder's reliable and true friend. Combustion of acetylene with oxygen is characterized by a sharply defined flame cone.

Gas welding work on heat exchanger.



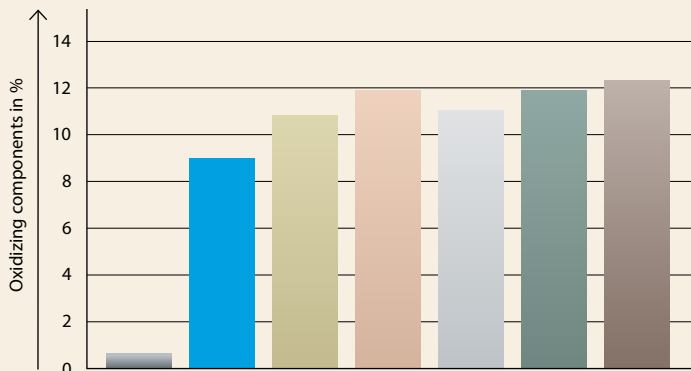
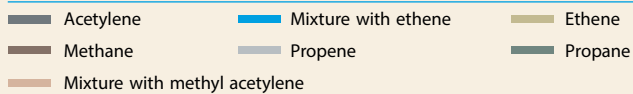
Visual judgment for mixing correctly.

Correct flame adjustment – made easy with acetylene.

Another advantage is the flame adjustability as such. Thanks to the sharply defined primary cone it is easy to adjust the oxy-acetylene flame by observing its appearance. The optimum mixing ratio can be set easily and exactly by eye judgment. Complex and expensive measuring

instruments can be dispensed with. The operator will appreciate this advantage since the quality of his work depends largely on the use of correct flame settings. A constantly correct setting will also save gas.

Oxidizing components in oxy-fuel gas flame at "neutral" setting



Most suitable flame setting for welding



Flame spraying and brazing.

Wear-resistant surfaces, stronger joints.



Automatic fusing of CrNiBoSi alloy sprayed on rope pulley by means of the powder flame-spraying process.



Joining of copper fittings.

Flame spraying: for outstanding surface coating

Flame spraying is used for surface coating of metallic and non-metallic materials. The substrate, wire or powder, is melted by the oxy-acetylene flame and sprayed onto the pre-treated workpiece by compressed air or another gas. The high flame temperature of the oxy-acetylene flame also permits spraying high melting materials like molybdenum. Flame-sprayed coatings have demonstrated their excellent properties in all fields of engineering. For instance, as a wear resistant surface coating, for upgrading machinery components, or for applying anticorrosive coatings of zinc, aluminum, copper, or CrNi steel.

Flame brazing: for joining materials

Flame brazing, like gas welding, belongs to the group of thermal joining processes. By brazing, however, it is possible to join similar, but also dissimilar materials – something which could cause problems during welding. Also in the case of thin and heat-sensitive workpieces, brazing has proved to be an excellent method for producing high-strength, reliable, and leak-proof joints. In general, both the oxy-acetylene flame as well as the air-acetylene flame are used for brazing.

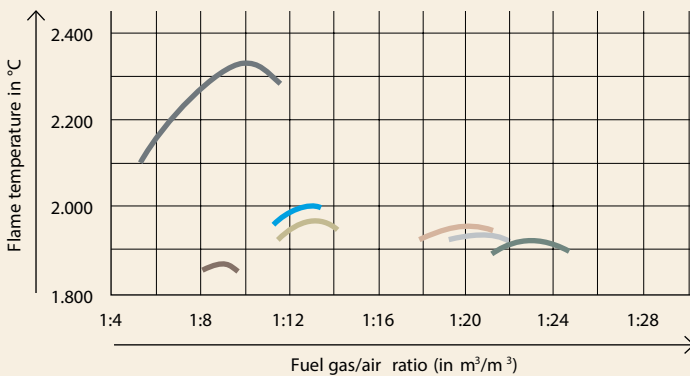
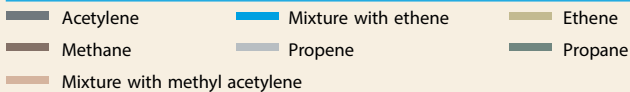
The soft air-acetylene flame for gentler action.

Superior intensity and propagation rate at a favorable mixing ratio.

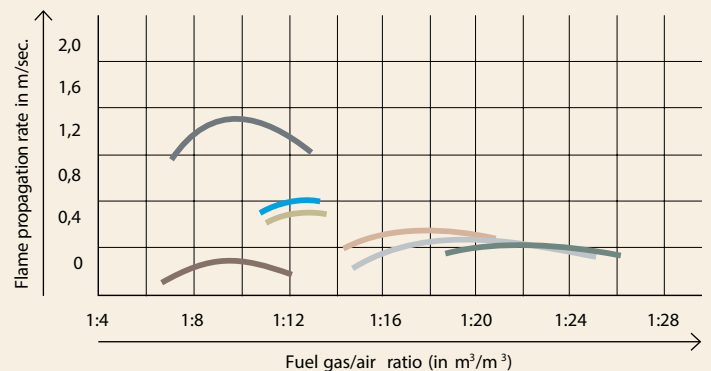
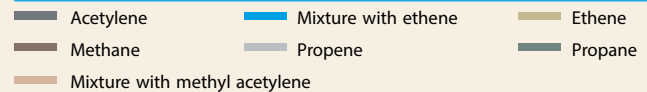
The soft air-acetylene flame features a more gentle action compared with the oxy-acetylene flame. This is important when a flame using pure oxygen is too hot for the workpiece or for the solder. Here again, acetylene is superior to other oxy-fuel gas mixtures as the flame temperature intensity is still 2,325 °C, and the flame propagation rate 150 cm/sec. With the air-acetylene mixture a favorable ratio of 1:9.6 is obtained.

Two different torch systems are mainly used for the application: the air-suction torch (similar to the bunsen burner) and the compressed-air-acetylene torch in which the acetylene is aspirated by the compressed air.

Flame temperature acetylene/air

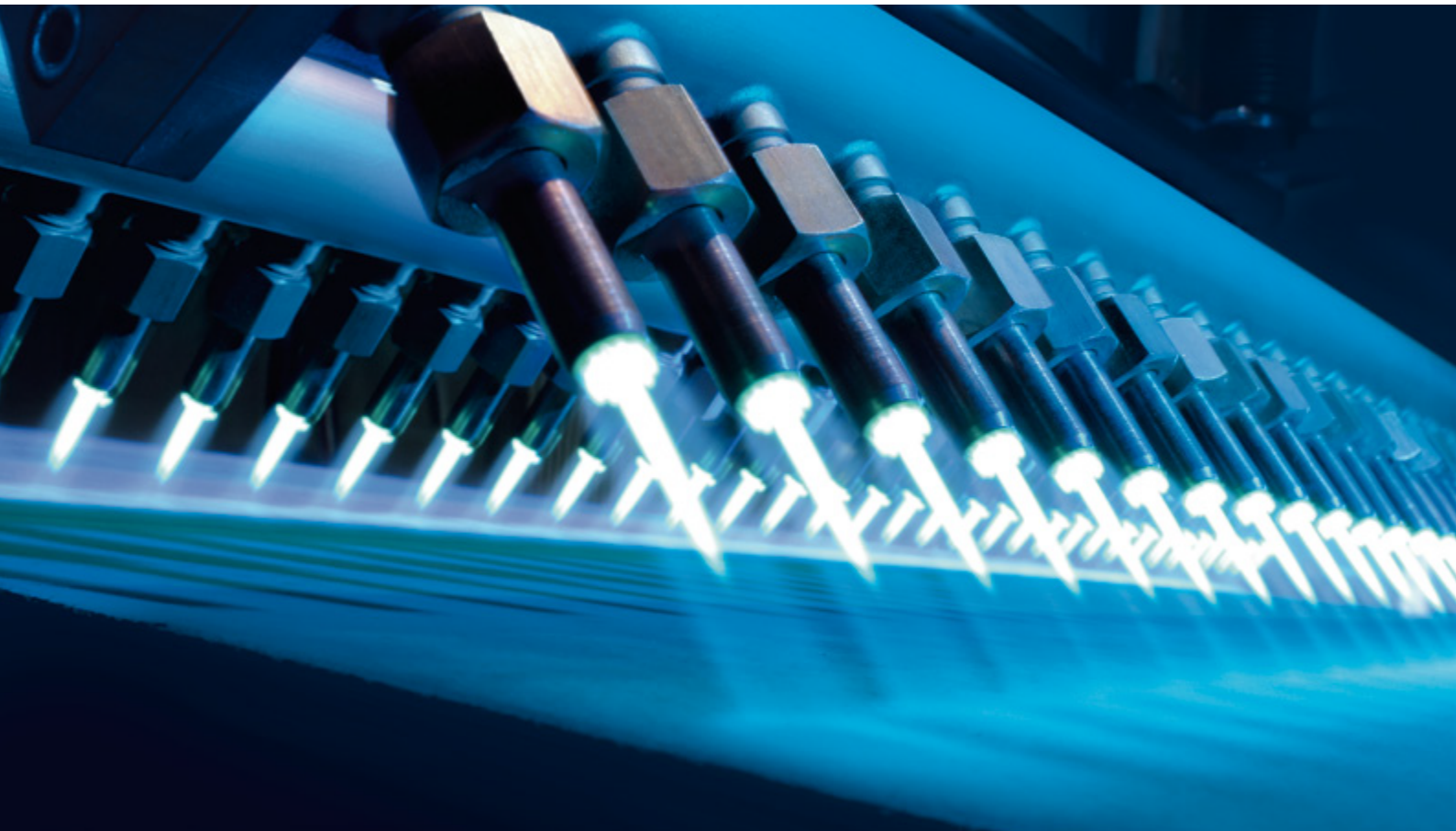


Flame propagation acetylene/air



LINDOFLAMM[™] special torches.

Ideal heat input, low consumption, and mechanization.

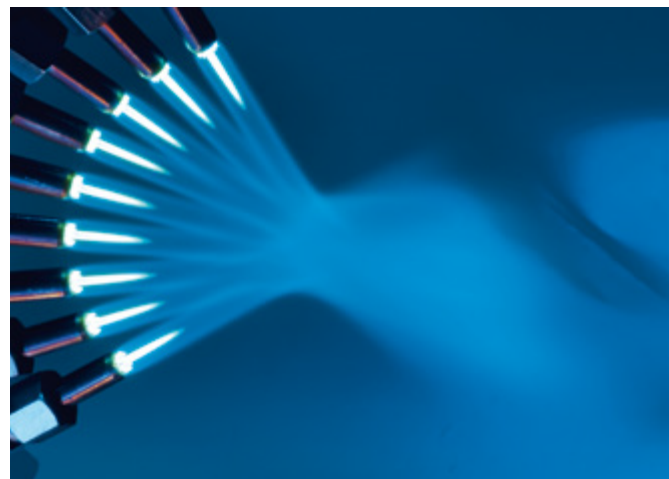


Compressed-air-acetylene torch adjustable on both sides.

The use of designated acetylene torches offers many advantages:

- optimum heat input into the workpiece because the torch is adapted to the application.
- economical gas consumption by adjusting the torch to the job.
- possibility of mechanization.

Flame brazing on rotating brazing device.

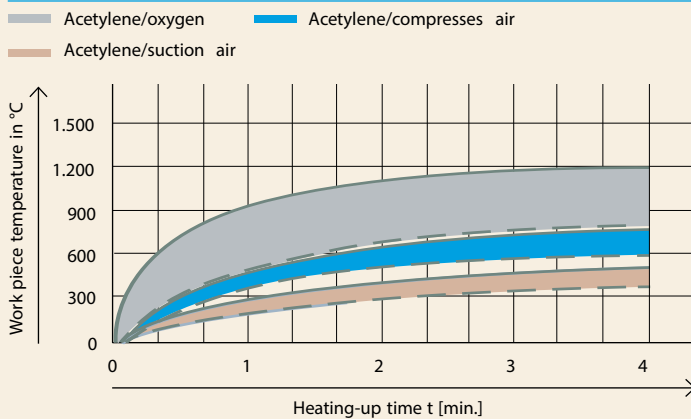


Gentle, yet powerful and efficient.

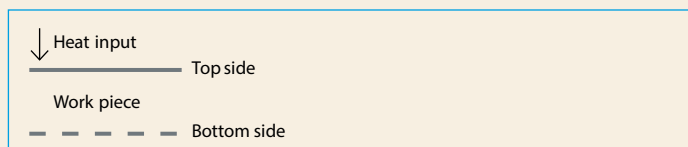
A helpful tool – the air-acetylene flame.

The air-acetylene flame works gently, but nevertheless is intensive and economical. Of course, it is no substitute to the oxy-acetylene flame, but a very useful addition to the great variety of processes available in production plants and workshops.

Temperature depending on heating-up time and type of flame



Air-acetylene flame



CARBOFLAM® surface coating system.

Improved glass quality and higher output.



Use of CARBOFLAM to apply a reproducible carbon coating to a glassmould for manufacturing glass containers.

The container glass industry requires optimized processes in surface coating. The use of carbon offers a number of advantages over traditional surface-coating methods (manual lubrication spraying and insulating with graphite suspensions, waxes, emulsions, etc.). The application includes improved glass quality and reduction in the concentration of vapor and mist in the workplace. To meet increasing demands Linde has developed the CARBOFLAM surface coating system.

The CARBOFLAM surface coating system is based on an understoichiometric acetylene/oxygen flame. The burners for this process include a central pressure panel and could be adapted to individual machines. It is the most effective technique for surface coating and offers excellent process stability.

The key to quality and efficiency.

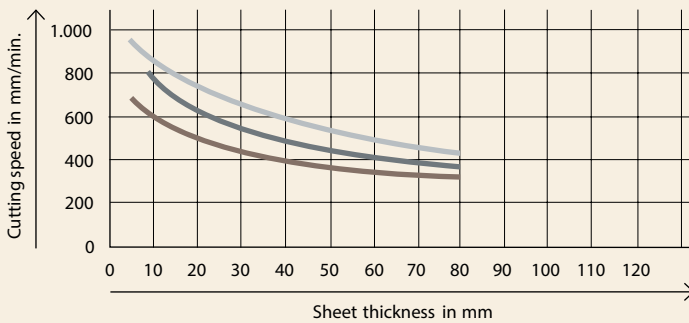
Cost-effectiveness of oxy-fuel gas cutting.

In respect of actual work performance the use of acetylene means high cutting speed, fast start-up and preheating, concentrated heat input and, therefore, significant time saving. And, regarding quality: smooth clean cut edges and surfaces, no need for joint preparation, and therefore, an excellent overall quality standard. When considering the economics of a process it is not sufficient to merely look at the cost of fuel gas and oxygen.

The decisive factor rather, is the cost of labor and equipment, which may add up to 90% of total cost. Therefore, the use of acetylene as a fuel gas provides the key to profit by optimum utilization of its high inherent energy.

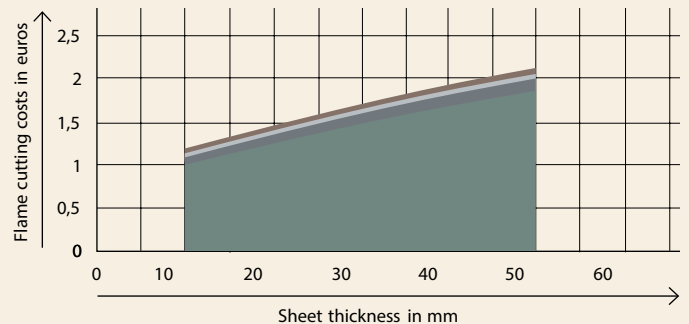
Cutting speed with acetylene

- Maximum cutting speed with special tips
- Cutting speed with high-output cutting tips
- Cutting speed with standard tips



Flame cutting costs with acetylene

- Acetylene
- Heating oxygen
- Cutting oxygen
- Cost of labor and equipment



Safety by lightness with acetylene.

Safety features come built in.

Acetylene features a particular physical property of high value: its density of 1.095 kg/m^3 (at $15^\circ\text{C}/1 \text{ bar}$). This means that acetylene is about 10% lighter than air. If it should escape inadvertently, it will go up and disappear in the atmosphere. Gases heavier than air sink down and there is always the risk that they will form explosive mixtures. The only commercial fuel gas which is lighter than acetylene is methane. Therefore, these are the only fuel gases which may be used for work below ground level or in confined spaces with little ventilation, for instance in shipbuilding or mining.

Everything required with respect to special safety for acetylene applications is already "built into" the steel cylinder: the porous mass which stops any possible decomposition of the acetylene. The acetone or dimethyl formamide (DMF) contained in the porous mass acts as a solvent. It multiplies the storage capacity many times. On the other hand, what is prescribed for safe withdrawal applies to acetylene just as to other fuel gases: the tapping points in the gas distribution system as well as cylinder regulators must be equipped with flashback arrestors.



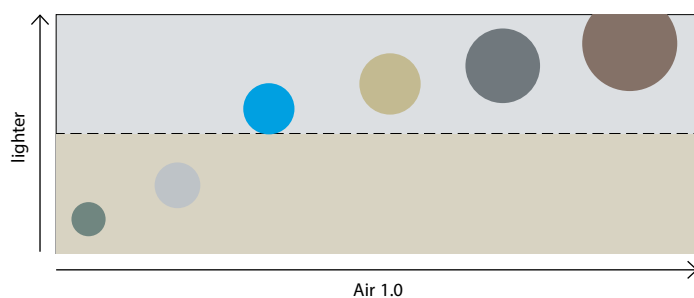
Color marking

To comply with the standard, EN 1089 Part 3, the color markings must be on the cylinder shoulder. The color to mark acetylene cylinders is oxide red (RAL 3009).

10,000x magnification of the high-porosity of the mass (photographed by scanning electron microscope).

Acetylene is lighter than air

Acetylene C_2H_2	Mixture with ethene	Ethene C_2H_4
Methane CH_4	Propene C_3H_6	Propane C_3H_8



Supply options for oxy-fuel gas processes.

Flexibility to meet all types of demands.

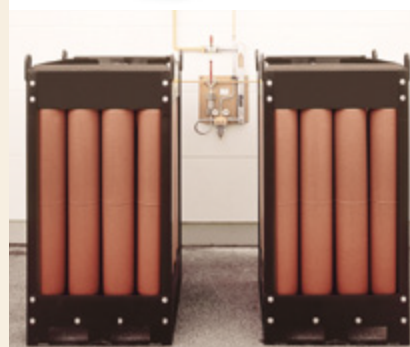
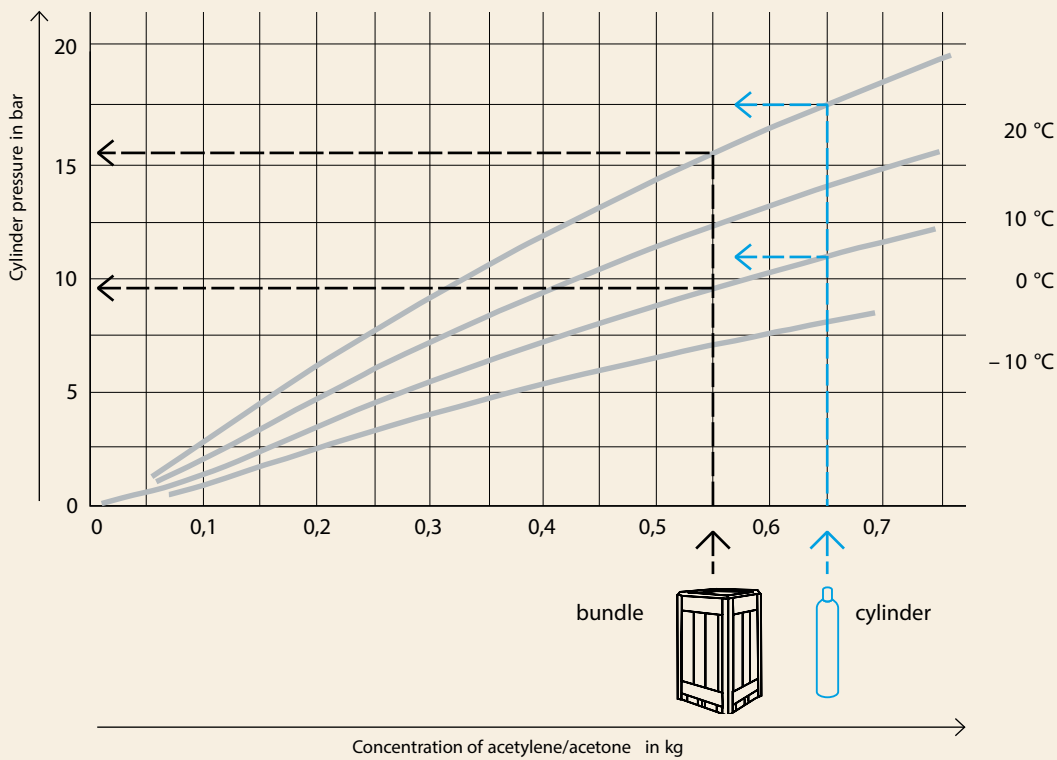


A single-cylinder set combined with an oxygen cylinder permits use of oxy-fuel gas process at nearly any time and in any location. If a single cylinder is not sufficient to supply larger types of torches, several cylinders can be combined to a battery.

Several bundles combined to a battery will cover demands of the large steel processing enterprises.

For even the largest possible users of acetylene we supply cylinder systems holding these quantities ready for consumption plus a well-sized reserve – our acetylene trailer.

Influence of temperature on acetylene cylinder pressure



Delivery as	Type	Contents, kg	Maximum withdrawal l/h
Single cylinder	A-41	7,8	1,000
Cylinder bundle (10 cylinders)	10xA-40	62	10,000

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, our task is to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardized as well as customised solutions. This applies to all industries and all companies regardless of their size.

Linde – ideas become solutions