OXYFUEL GAS WELDING

FUNDAMENTALS OF THE PROCESS

- OXYFUEL GAS WELDING (OFW) includes any welding operation that uses combustion with oxygen as a heating medium. The process involves melting the base metal and usually a filler metal, using a flame produced at the tip of a welding torch. Fuel gas and oxygen are combined in the proper proportions inside a mixing chamber which may be part of the welding tip assembly. Molten metal from the plate edges, and filler metal, if used, intermix in a common molten pool and coalesce upon cooling. OFW is ideally suited for repair welding and for welding thin sheet, tubes, and small diameter pipe. Thick section welds, except for repair work, are not economical when compared to the many available arc welding processes.

- The equipment used in oxyfuel gas welding is low in cost, usually portable, and versatile enough to be used for a variety of related operations, such as bending and straightening, preheating, postheating, surfacing, brazing, and braze welding.
- Cutting attachments, multiflame heating nozzles, and a variety of special application accessories add greatly to the overall versatility of the basic OFW equipment.
- Metals normally welded include carbon and low alloy steels, and most nonferrous metals, but generally not refractory or reactive metals.
- Commercial fuel gases have one common property - they all require oxygen to support combustion. To be suitable for welding operations, a fuel gas, when burned with oxygen, must have the following:
- (1) High flame temperature
- (2) High rate of flame propagation
- (3) Adequate heat content
- (4) Minimum chemical reaction of the flame with base and filler metals

- Among commercially available fuel gases, acetylene most closely meets all these requirements. Other fuel gases, such as methylacetylene-propadiene products, propylene, propane, natural gas, and proprietary gases based on these, offer sufficiently high flame temperatures but exhibit lower flame propagation rates. These latter gas flames are excessively oxidizing at oxygen-to-fuel gas ratios that are high enough to produce usable heat transfer rates.

Characteristics of the Common Fuel Gases

Fuel Gas	Formula	Specific Gravity[a]	Volume to Weight Ratio[a]		Oxygen-to-Fuel Gas Combustion Ratio[b]	Flame Temperature for Oxygen[c]		Heat of Combustion					
								Primary		Secondary		Total	
		Air = 1	ft^3/lb	m^3/kg		°F	°C	Btu/ft^3	MJ/m^3	Btu/ft^3	MJ/m^3	Btu/ft^3	MJ/m^3
Acetylene	C_2H_2	0.906	14.6	0.91	2.5	5589	3087	507	19	963	36	1470	55
Propane	C_2H_3	1.52	8.7	0.54	5.0	4579	2526	255	10	2243	94	2498	104
Methylacetylene-propadiene (MPS) (d)	C_3H_4	1.48	8.9	0.55	4.0	5301	2927	571	21	1889	70	2460	91
Propylene	C_3H_6	1.48	8.9	0.55	4.5	5250	2900	438	16	1962	73	2400	89
Natural gas (methane)	CH_4	0.62	23.6	1.44	2.0	4600	2538	11	0.4	989	37	1000	37
Hydrogen	H_2	0.07	188.7	11.77	0.5	4820	2660					325	12

a. At 60°F (15.6°C)

b. The volume units of oxygen required to completely burn a unit volume of fuel gas

c. The temperature of the neutral flame.

d. May contain significant amounts of saturated hydrocarbons.

Chemical Equations for the Complete Combustion of the Common Fuel Gases

Fuel Gas	Reaction With Oxygen
Acetylene	$C_2H_2 + 2.5O_2 \longrightarrow 2CO_2 + H_2O$
Methylacetylene-propadiene (MPS)	$C_3H_4 + 4O_2 \longrightarrow 3CO_2 + 2H_2O$
Propylene	$C_3H_6 + 4.5O_2 \longrightarrow 3CO_2 + 3H_2O$
Propane	$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$
Natural gas (methane)	$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
Hydrogen	$H_2 + 0.5O_2 \longrightarrow H_2O$

ACETYLENE

- ACETYLENE is THE fuel gas of choice for of welding because of its high-combustion intensity. While the other fuel gases are rarely, if ever, used for welding, their characteristics are described here.
- Acetylene is a hydrocarbon compound, C2H2, which contains a larger percentage of carbon by weight than any of the other hydrocarbon fuel gases. Colorless and lighter than air, it has a distinctive odor resembling garlic. Acetylene contained in cylinders is dissolved In acetone and therefore has a slightly different odor from that of pure acetylene.
- At temperatures above 1435°F (780°C) or at pressures above 30 psig (207 kPa), gaseous acetylene is unstable and decomposition may result even in the absence of oxygen. This characteristic has been taken into consideration in the preparation of a code of safe practices for the generation, distribution, and use of acetylene gas. The accepted safe practice is never to use acetylene at pressures exceeding 15 psig (103 kPa), in generators, pipelines, or hoses.

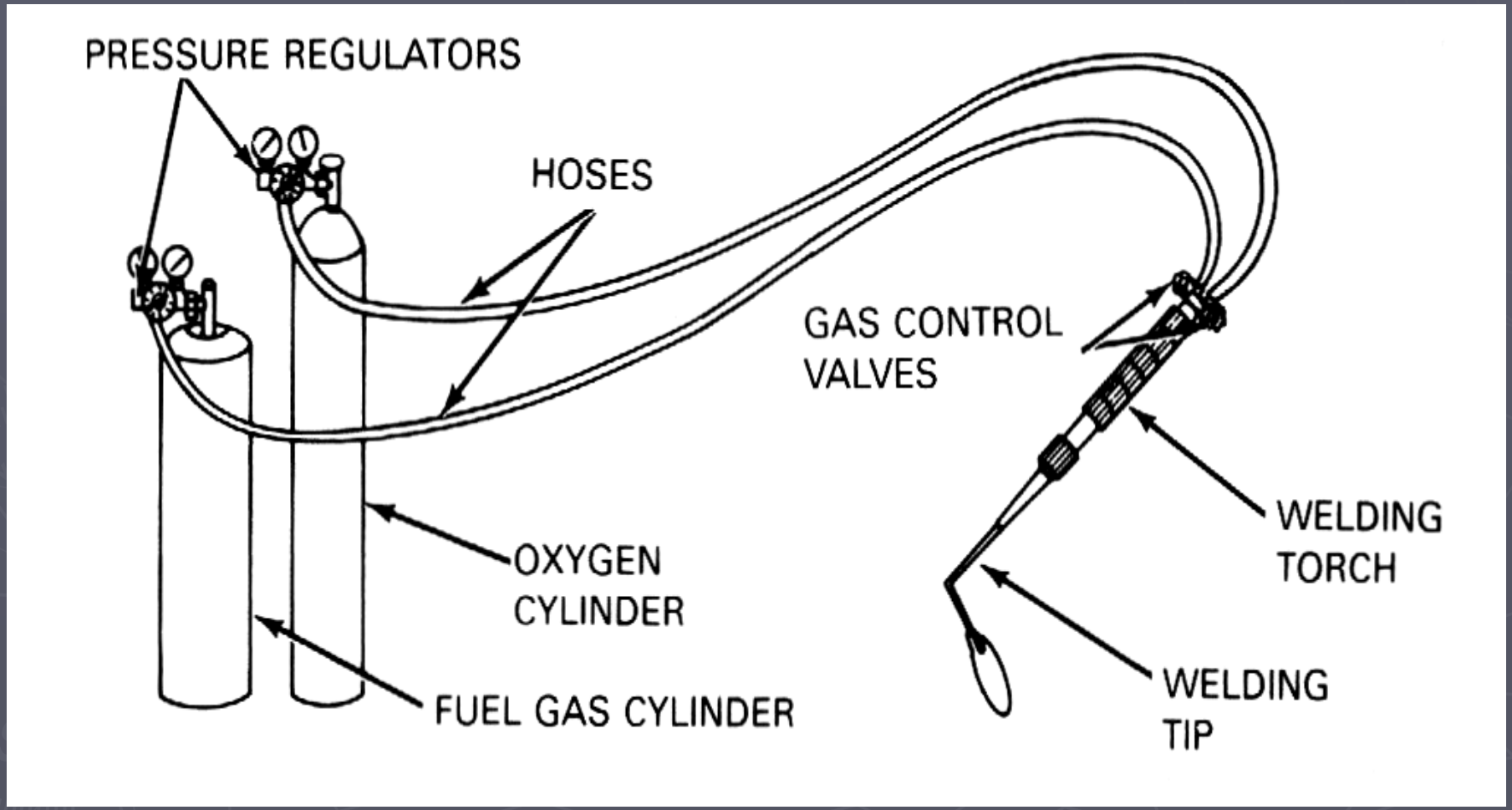
THE OXYACETYLENE FLAME

- Theoretically, the complete combustion of acetylene is represented by the chemical equation
- $C_2H_2 + 2.5\ 0_2 \rightarrow 2C0_2 + H_2O$
- This equation indicates that one volume of acetylene (C_2H_2) and 2.5 volumes of oxygen (0_2) react to produce two volumes of carbon dioxide (CO_2) and one volume of water vapor (H_20). The volumetric ratio of oxygen to acetylene is 2.5 to one.
- As noted earlier, the reaction of equation does not proceed directly to the end products shown. Combustion takes place in two stages. The primary reaction takes place in the inner zone of the flame (called the inner cone) and is represented by the chemical equation:
- $C_2H_2 + 0_2 \rightarrow 2C0 + H_2$

- Here, one volume of acetylene and one volume of oxygen react to form two volumes of carbon monoxide and one volume of hydrogen. The heat content and high temperature of this reaction result from the decomposition of the acetylene and the partial oxidation of the carbon resulting from that decomposition.
- When the gases issuing from the torch tip are in the one- to-one ratio indicated in equations, the reaction produces the typical brilliant blue inner cone. This relatively small flame creates the combustion intensity needed for welding steel. The flame is termed neutral because there is no excess carbon or oxygen to carburize or oxidize the metal. The end products are actually in a reducing status, a benefit when welding steel.
- In the outer envelope of the flame, the carbon monoxide and hydrogen produced by the primary reaction burn with oxygen from the surrounding air. This forms carbon dioxide and water vapor respectively, as shown in the following secondary reaction:
- $2C0 + H_2 + 1.50_2 \rightarrow 2C0_2 + H_20$

- Although the heat of combustion of this outer flame is greater than that of the inner, its combustion intensity and temperature are lower because of its large cross-sectional area. The final end products are produced in the outer flame because they cannot exist in the high temperature of the inner cone.
- The oxyacetylene flame is easily controlled by valves on the welding torch. By a slight change in the proportions of oxygen and acetylene flowing through the torch, the chemical characteristics in the inner zone of the flame and the resulting action of the inner cone on the molten metal can be varied over a wide range. Thus, by adjusting the torch valves, it is possible to produce a neutral, oxidizing, or carburizing flame.

OXYFUEL GAS WELDING EQUIPMENT

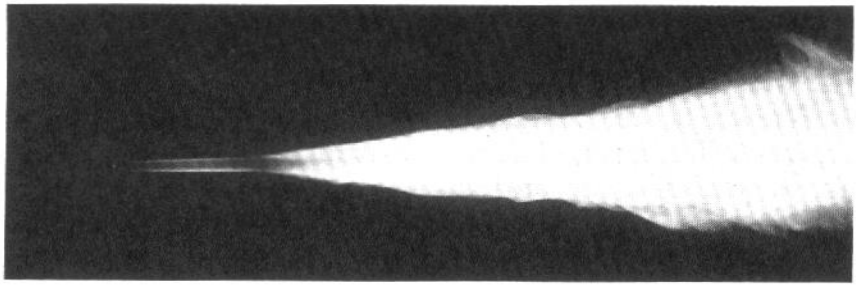


APPLICATIONS OF OXYFUEL GAS WELDING

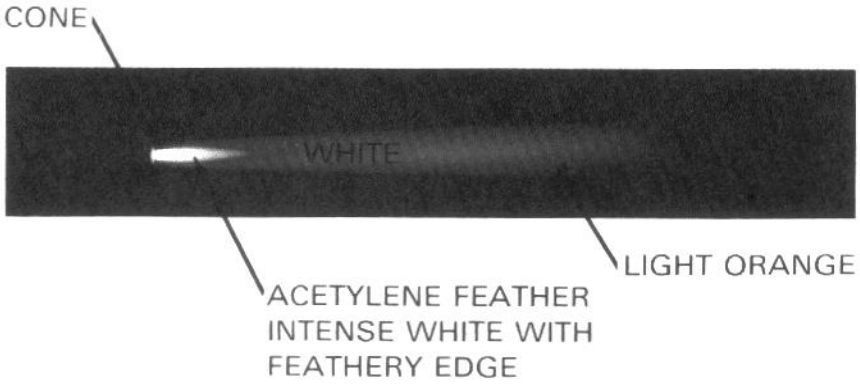
General Conditions for Oxyacetylene Welding of Various Ferrous Metals

Metal	Flame Adjustment	Flux	Welding Rod
Steel, cast	Neutral	No	Steel
Steel pipe	Neutral	No	Steel
Steel plate	Neutral	No	Steel
Steel sheet	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
High carbon steel	Slightly carburizing	No	Steel
Wrought iron	Neutral	No	Steel
Galvanized iron	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
Cast iron, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron, malleable	Slightly oxidizing	Yes	Bronze
Cast iron pipe, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron pipe	Neutral	Yes	Cast iron or base metal composition
Chromium-nickel steel castings	Neutral	Yes	Base metal composition or 25-12 chromium-nickel steel
Chromium-nickel steel (18-8 and 25-12)	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium steel	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium iron	Neutral	Yes	Columbium stainless steel or base metal composition

Oxyacetylene Flame

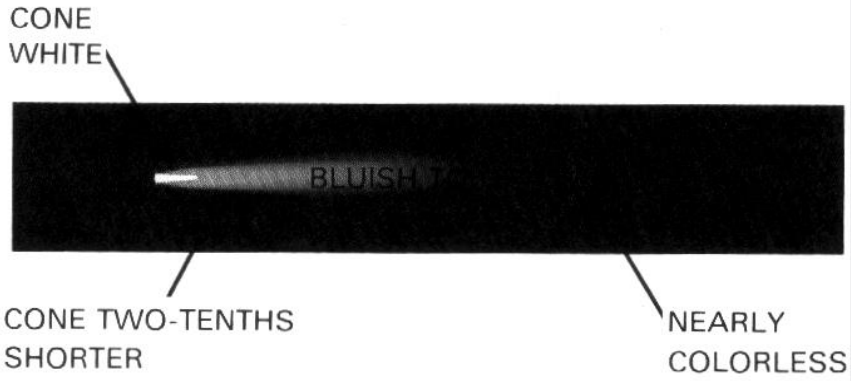


(A) PURE ACETYLENE FLAME



(B) CARBURIZING FLAME

(C) NEUTRAL FLAME



(D) OXIDIZING FLAME

APPLICATIONS

- AIR-FUEL GAS IS used for welding lead up to approximately 1/4 in. (6.4 mm) in thickness. Perhaps its greatest field of application, however, is in the plumbing and electrical industry. There it is used extensively for soldering copper tubing.

END....