Special Hazards of Acetylene

Acetylene is the most common gas used for fueling cutting torches in both general industry and the mining industry. When mixed with pure oxygen in a cutting torch assembly, an acetylene flame can theoretically reach over 5700°F. Users of this type of equipment are generally familiar with the fire hazards associated hot flames and the production of hot slag. However, many users may not be aware of the unique characteristics of acetylene itself that create special hazards compared to other fuel gases.

Chemical Composition: An acetylene molecule is composed of two carbon atoms and two hydrogen atoms. The two carbon atoms are held together by what is known as a triple carbon bond. This bond is useful in that it stores substantial energy that can be released as heat during combustion. However, the triple carbon bond is unstable, making acetylene gas very sensitive to conditions such as excess pressure, excess temperature, static electricity, or mechanical shock.

Storage: Because of acetylene's unstable nature, it must be stored under special conditions. This is accomplished by dissolving the acetylene in liquid acetone. The liquid acetone is then stored in the acetylene cylinder, which in turn, is filled with a porous (sponge-like) cementitious material.

- NEVER ATTEMPT TO STORE OR INJECT ACETYLENE GAS INTO ANY TYPE OF VESSEL, TANK, OR ENCLOSURE. IMPROPERLY STORED ACETYLENE GAS IS UNSTABLE.

- ACETYLENE GAS REGULATORS SHOULD NOT EXCEED A SETTING OF 15 P.S.I.G.

- FLAME ARRESTORS AND CHECK VALVES SHOULD BE INSTALLED AT BOTH THE TORCH BASE HOSE CONNECTIONS AND AT THE REGULATOR HOSE CONNECTIONS.

- ACETYLENE CYLINDERS SHOULD BE PROPERLY SECURED AT ALL TIMES. MOVEMENT OF CYLINDERS SHOULD BE DONE WITH CARE. CYLINDERS SHOULD BE PROTECTED FROM FLAME OR HEAT.

> When exposed to excess temperature, pressure, or mechanical shock, pure or less than pure acetylene gas can undergo a violent, explosive decomposition reaction. Additionally, if this reaction, or an ignition of acetylene occurs within the torch base or supply hose, it can propagate back into the storage cylinder causing it to explode violently.

Flammable range: Acetylene has a very wide range of flammability. The lower flammable limit (LFL) is typically listed as 2.5% and the upper flammable limit (UFL) is listed as 81%. Although acetylene will not undergo combustion at concentrations above the UFL, it can undergo an explosive decomposition reaction, even at concentrations of 100%.

- NEVER USE ACETYLENE OR ITS EQUIPMENT IN ANY WAY NOT CONSISTANT WITH RECOGNIZED GOOD PRACTICE.

- ALWAYS MAINTAIN ACETYLENE CUTTING EQUIPMENT IN PROPER WORKING CONDITION TO PREVENT INADVERTANT LEAKAGE OF ACETYLENE OR OXYGEN INTO THE SURROUNDING WORK ENVIRONMENT.

- PROTECT ALL CYLINDERS FROM FALLING OBJECTS. AVOID ROUGH HANDLING, DROPPING, OR KNOCKING OF CYLINDERS TO PREVENT DAMAGING THE CYLINDER, FUSIBLE PLUGS, RELIEF DEVICES, CYLINDER VALVES OR GAUGES. STORING ACETYLENE CYLINDERS ON THEIR SIDE MAKES THE ACETYLENE LESS STABLE AND LESS SAFE, AND INCREASES THE LIKELIHOOD OF SOLVENT LOSS AND RESULTANT DECOMPOSITION. ACETYLENE CYLINDERS SHOULD BE STORED AND USED IN THE UPRIGHT POSITION AND FIRMLY SECURED TO PREVENT FALLING OR BEING KNOCKED OVER.

> Acetylene gas is ignitable over a wide range of concentrations.

Ease of ignition: Acetylene is a very easy gas to ignite. In fact, the energy from a static spark capable of igniting acetylene is lower than for any other fuel gas except hydrogen. The ignition energy of acetylene in air is approximately seventeen times lower than that of methane. The static charge developed by walking across a carpet floor on a dry day can be 1700 times greater than that needed to ignite acetylene. When mixed with pure oxygen, the ignition energy of acetylene is almost 100 times lower than it is in air.

- NEVER DISCHARGE UNBURNED ACETYLENE GAS FROM A TORCH EXCEPT FOR THE NORMAL PROCESS OF LIGHTING THE TORCH.

- NEVER DISCHARGE UNBURNED ACETYLENE GAS FROM A TORCH INTO ANY TYPE OF CONTAINER OR VESSEL.

> When unburned acetylene gas is discharged from a torch, static electricity can be generated at the torch tip. If the tip comes in contact with a ground path, a static spark capable of igniting the acetylene can occur.

Rate of combustion reaction: Because of its simple chemical make up and sensitive triple bond, acetylene burns at a very fast rate. This very fast burning rate can accelerate the rate at which pressure is generated in an explosion beyond what would occur for other fuels. This, in turn, can make acetylene explosions more violent than for other fuels.

- NEVER DISCHARGE UNBURNED ACETYLENE GAS INTO ANY TYPE OF CONTAINER, VESSEL, ENCLOSURE, OR PIPE (SUCH AS A "POTATO GUN") WITH THE INTENT OF IGNITING THE GAS TO "DEMONSTRATE" THE HAZARDS OF ACETYLENE, OR TO PROPEL AN OBJECT FROM AN ENCLOSURE OR TUBE.

Because of the very fast reaction rate of burning acetylene, it is not generally possible to design an enclosure to safely vent the explosive pressures. Furthermore, because of the ease of ignition of acetylene, premature ignition is very possible.

ACETYLENE DATA

General Information [1]
CAS No. 74-86-2
DOT/UN No. 1001
Normal state: colorless gas with garlic-like odor.
Chemical formula C2H2 or H C C H
Molecular weight: 26.04
Vapor density: 0.9

Classification Data [2]
NFPA Hazard Label (health-fire-reactivity): 0-4-3
Note: reactivity rating can be reduced to 2 when acetylene is properly stored dissolved in acetone in approved cylinders.
NOTE: It is prohibited by federal law (USDOT) to transport acetylene except when dissolved in acetone in approved cylinders.
NFPA classification: Class 1A flammable liquid
Boiling point: -119°F

Flammable limits in air [1]
Lower limit (LFL) 2.5%
Upper limit (UEL) 82%
WARNING Even at concentrations above 82%, all the way up to 100%, acetylene is still a significant hazard because it can explosively decompose even at these high concentrations. [3]

Ignition Data [3]
Minimum ignition energy in air: 17 microjoules
Minimum ignition energy in O2: 0.2 microjoules
Autoignition temperature in air: 581°F
Autoignition temperature in O2: 565°F

Chemistry [4]
Stoichiometric concentration in air: 7.73%
Peak explosion pressure ratio (deflagration) in stoichiometric air concentration: 9.7
Constant pressure, adiabatic flame temperature (Stoichiometric in air): 4108°F
Stoichiometric concentration in O2: 28.6%
Peak explosion pressure ratio (deflagration) in stoichiometric O2 concentration: 17
Constant pressure, adiabatic flame temperature (Stoichiometric in O2): 5556°F

Explosion Data [5]
Measured peak explosion pressure: 10.6 atmospheres.
Measured peak rate of pressure rise: 1415 bar-meters per second

Fundamental burning velocity in air [6]
157 centimeters per second
Heats of Combustion and Formation [3]
Gross heat of combustion: 1299.6 kilojoules per gram-mole
Net Heat of combustion: 1255.5 kilojoules per gram-mole
Heat of formation: 226.7 kilojoules per gram-mole

DATA SOURCES

[1] Lewis, Richard J., Sr., *Sax's Dangerous Properties of Industrial Materials, Eighth Edition*, Van Nostrand Reinhold, New York, NY

[2] NFPA 325M - 1994, *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*. The National Fire Protection Association, Quincy MA

[3] Babrauskas, Vytenis, *Ignition Handbook*, Fire Science Publishers/Society of Fire Protection Engineers, Issaquah WA

[4] Mine Safety and Health Administration, Technical Support, Triadelphia WV, internal calculation.

[5] NFPA 68- 2002, *Guide for Venting of Deflagrations*, The National Fire Protection Association, Quincy MA

[6] Kuchta, Joseph M., *Investigation of Fire and Explosion Accidents in the Chemical, Mining, and Fuel-Related Industries A Manual*, U.S. Bureau of Mines, Bulletin 680.

ADDITIONAL READINGS

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NFPA 51-2002, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, National Fire Protection Association, Quincy MA

NFPA 51B - 1999, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, National Fire Protection Association, Quincy MA

NFPA 326 - 1999, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, National Fire Protection Association, Quincy MA

U.S. Department of Labor, Mine Safety and Health Administration, Code of Federal Regulations, Title 30, *Mineral Resources*. U.S. Government Printing Office, Washington DC

U.S. Department of Transportation, Code of Federal Regulations, Title 49, *Transportation*, U.S. Government Printing Office, Washington DC