BASIC WELDING

CONTINUING EDUCATION UNIT
PROFESSIONAL DEVELOPMENT COURSE

Technical Learning College

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All downloads are electronically tracked and monitored for security purposes.

Some States and many employers require the final exam to be proctored.

Do not solely depend on TLC's Approval list for it may be outdated.

Most of our students prefer to do the assignment in Word and e-mail or fax the assignment back to us. We also teach this course in a conventional hands-on class. Call us and schedule a class today.

Contributing Editors

James L. Six Received a Bachelor of Science Degree in Civil Engineering from the University of Akron in June of 1976, Registered Professional Engineer in the State of Ohio, Number 45031 (Retired), Class IV Water Supply Operator issued by Ohio EPA, Number WS4-1012914-08, Class II Wastewater Collection System Operator issued by Ohio EPA, Number WC2-1012914-94

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Dr. Pete Greer S.M.E., Retired biology instructor, chemistry and biological review.

Jack White, Environmental, Health, Safety expert, City of Phoenix. Art Credits.

Important Information about this Manual

Disclaimer
This CEU training manual has been prepared to assist employees in the general awareness of the dangerous welding procedures and operations. Dealing with often-complex procedures and requirements for safely handling hazardous energy and fire related subjects. The scope of the material is quite large, requiring a major effort to bring it under control. Employee health and safety, as well as that of the public, depend upon careful application of federal and state regulations and safe working procedures.

This course will cover general laws, regulations, required procedures and work rules relating to welding and fire related procedures and principles. It should be noted, however, that the federal and state regulations are an ongoing process and subject to change over time.

This manual is a guidance document for employees who are learning general electrical and welding principles. It is not designed to meet the full requirements of the United States Environmental Protection Agency (EPA) or the Department of Labor-Occupational Safety and Health Administration (OSHA) rules and regulations. Only qualified licensed welders should be allowed to work on any or all related installations or components. This course will not qualify you to work on any type of electrical system, welder or component.

This course manual will provide welding general guidance and safety procedures and should not be used as a preliminary basis for developing general welding procedures. This document is not detailed electrical procedure or electrical safety textbook or a comprehensive source book on electrical safety or building codes rules and regulations.

Technical Learning College makes no warranty, guarantee or representation as to the absolute correctness or appropriateness of the information in this manual and assumes no responsibility in connection with the implementation of this information.

It cannot be assumed that this manual contains all measures and concepts required for specific conditions or circumstances. This document should be used for guidance and is not considered a legal document. Individuals who are responsible for welding or electrical repairs or installation and the health and safety of workers should obtain and comply with the most recent federal, state, and local regulations relevant to these sites and are urged to consult with OSHA, the EPA and other appropriate federal, state, and local agencies.

Technical Learning College's Scope and Function

Welcome to the Program,

Technical Learning College (TLC) offers affordable continuing education for today's working professionals who need to maintain licenses or certifications. TLC holds several different governmental agency approvals for granting of continuing education credit.

TLC's delivery method of continuing education can include traditional types of classroom lectures and distance-based courses or independent study. TLC's distance based or independent study courses are offered in a print - based distance educational format. We will beat any other training competitor's price for the same CEU material or classroom training.

Our courses are designed to be flexible and for you to finish the material at your convenience. Students can also receive course materials through the mail. The CEU course or e-manual will contain all your lessons, activities and instruction to obtain the assignments. All of TLC's CEU courses allow students to submit assignments using e-mail or fax, or by postal mail. (See the course description for more information.)

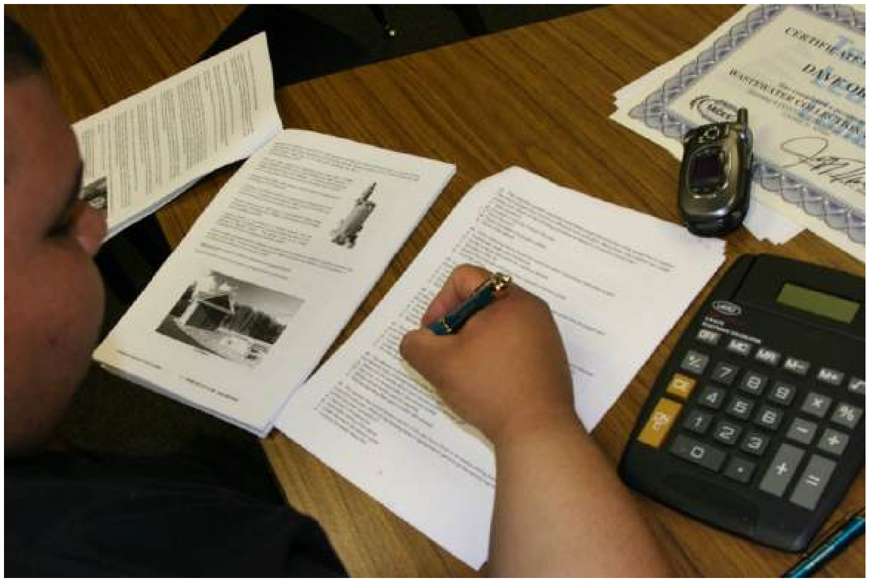
Students have direct contact with their instructor—primarily by e-mail or telephone. TLC's CEU courses may use such technologies as the World Wide Web, e-mail, CD-ROMs, videotapes and hard copies. (See the course description.) Make sure you have access to the necessary equipment before enrolling; i.e., printer, Microsoft Word and/or Adobe Acrobat Reader. Some courses may require proctored closed-book exams, depending upon your state or employer requirements.

Flexible Learning
At TLC, there are no scheduled online sessions or passwords you need contend with, nor are you required to participate in learning teams or groups designed for the "typical" younger campus based student. You will work at your own pace, completing assignments in time frames that work best for you. TLC's method of flexible individualized instruction is designed to provide each student the guidance and support needed for successful course completion.

Course Structure
TLC's online courses combine the best of online delivery and traditional university textbooks. You can easily find the course syllabus, course content, assignments, and the post-exam (Assignment). This student-friendly course design allows you the most flexibility in choosing when and where you will study.

Classroom of One
TLC offers you the best of both worlds. You learn on your own terms, on your own time, but you are never on your own. Once enrolled, you will be assigned a personal Student Service Representative who works with you on an individualized basis throughout your program of study. Course specific faculty members (S.M.E.) are assigned at the beginning of each course providing the academic support you need to successfully complete each course. Please call or email us for assistance.

Satisfaction Guaranteed
We have many years of experience, dealing with thousands of students. We assure you, our customer satisfaction is second to none. This is one reason we have taught more than 20,000 students.



We welcome you to do the electronic version of the assignment and submit the answer key and registration to us either by fax or e-mail. If you need this assignment graded and a certificate of completion within a 48-hour turn around, prepare to pay an additional rush charge of $50.

We welcome you to complete the assignment in Word.

Once we grade it, we will mail a certificate of completion to you. Call us if you need any help.

Contact Numbers

Fax (928) 468-0675
Email Info@tlch2o.com
Telephone (866) 557-1746

CEU Course Description

BASIC WELDING CEU TRAINING COURSE

This continuing education course will cover basic electric, gas welding, cutting and welding safety principles. The student will be provided with the fundamental principles of joining ferrous and non-ferrous metals, welding and cutting processes, equipment operation, and safety procedures. The student will understand the need to safely use oxy-acetylene cutting equipment and Arc Welding processes. This course will also cover *Fire Prevention Program* and "*Emergency action plan*" -1910.38(a)(1) are to make sure employers and employees know about potential fire hazards, how to recognize them and, most importantly, how to protect themselves and correct the hazards. This course is designed to help reduce the possible incidence of fire related illness and injuries.

Course Purpose
The main purpose of this course is to provide continuing education in understanding basic welding procedures, metal joining principles and welding operation safety, fire prevention, general fire principles/reactions, Right-to-Know and OSHA fire regulations.

Audience
The target audience for this course is the person interested in working mantanence facility and/or wishing to maintain CEUs for certification license or to learn how to do the job safely and effectively, and/or to meet education needs for promotion.

Suggested Materials
For a successful training session, have the following items on hand:

- Your Company's Fire Prevention Program/Escape Plan used in your facility

Prerequisite
Basic electrical knowledge on at a high school level is recommended but not required for successful completion of this course.

Course Procedures for Registration and Support
All of Technical Learning College's distance learning courses have complete registration and support services offered. Delivery of services will include e-mail, web site, telephone, fax and mail support. TLC will attempt immediate and prompt service.

When a student registers for a correspondence course, he/she is assigned a start date and an end date. It is the student's responsibility to note dates for assignments and keep up with the course work. If a student falls behind, he/she must contact TLC and request an end date extension in order to complete the course. It is the prerogative of TLC to decide whether to grant the request. All students will be tracked by a unique computer generated number assigned to the student.

Disclaimer and Security Notice
The student shall understand that it their responsibility to ensure that this CEU course is either approved or accepted in my State for CEU credit. The student shall understand and follow State laws and rules concerning distance learning courses and understand these rules change on a frequent basis and will not hold Technical Learning College responsible for any changes. The student shall understand that this type of study program deals with dangerous conditions and will not hold Technical Learning College, Technical Learning

Consultants, Inc. (TLC) liable for any errors or omissions or advice contained in this CEU education training course or for any violation or injury caused by this CEU education training course material. The student shall contact TLC if they need help or assistance and double-check to ensure my registration page and assignment has been received and graded.

Student Verification
The student shall submit a driver's license for signature verification and track their time worked on the assignment. The student shall sign an affidavit verifying they have not cheated and worked alone on the assignment. All student attendance is tracked on the student attendance database.

Feedback Mechanism (examination procedures)
Each student will receive a feedback or survey form as part of his or her study packet. You will be able to find this form in the front of the assignment lesson. The student can e-mail, snail mail or telephone TLC for any concern at any time. Most of these concerns will be answered in 2 hours but not more than 24 hours.

Security and Integrity
All students are required to do their own work. All lesson sheets and final exams are not returned to the student to discourage sharing of answers. Any fraud or deceit and the student will forfeit all fees and the appropriate agency will be notified. A random test generator will be implemented to protect the integrity of the assignment.

Instructions for Written Assignments
The Basic Welding CEU correspondence course will have a multiple choice type of an exam. TLC will require that the document is typed and preferably e-mailed to TLC. You may find an extra copy of the assignment and Student/Course Support on TLC's website under the Assignment Page.

Grading Criteria
TLC will offer the student either pass/fail or a standard letter grading assignment. If TLC is not notified, you will only receive a pass/fail notice. For security purposes, please fax or e-mail a copy of your driver's license and always call us to confirm we've received your assignment and to confirm your identity. TLC offers students the option of either pass/fail or assignment of a standard letter grade. If a standard letter grade is not requested, a pass/fail notice will be issued.

Required Texts
The Basic Welding course does not require any course materials. Course is complete.

Recordkeeping and Reporting Practices
TLC will keep all student records for a minimum of seven years. It is your responsibility to give the completion certificate to the appropriate agencies.

ADA Compliance
TLC will make reasonable accommodations for persons with documented disabilities. Students should notify TLC and their instructors of any special needs. Course content may vary from this outline to meet the needs of this particular group.

Educational Mission

The educational mission of TLC is:

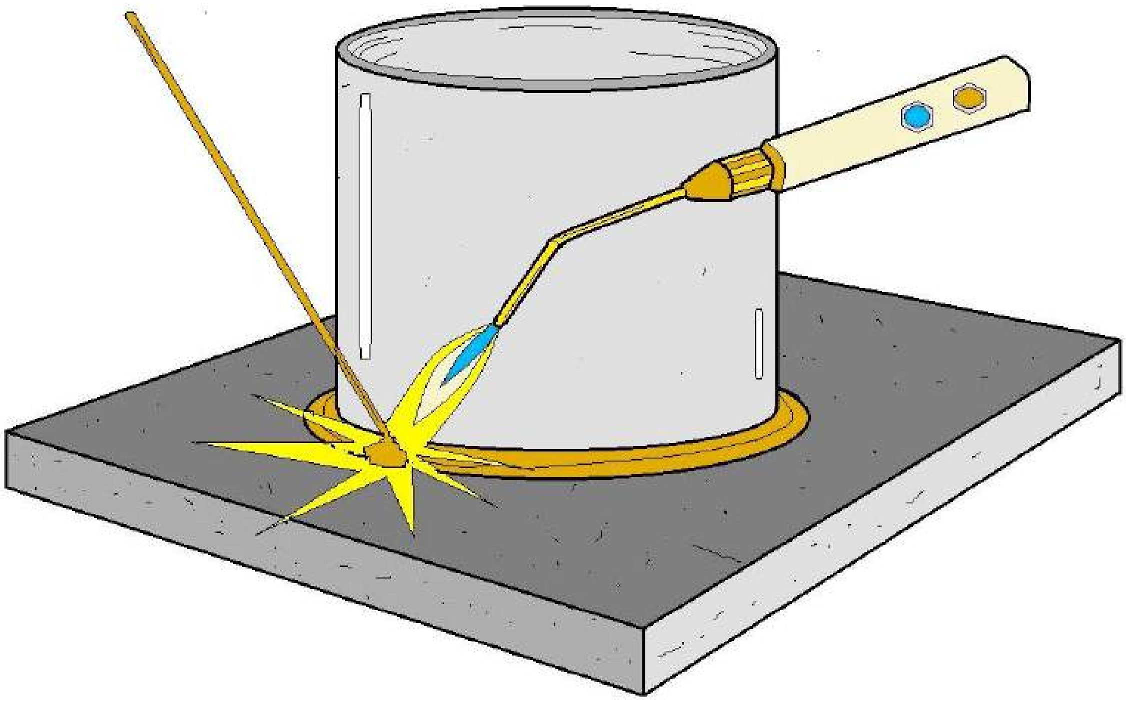
To provide TLC students with comprehensive and ongoing training in the theory and skills needed for the environmental education field,

To provide TLC students opportunities to apply and understand the theory and skills needed for a successful career,

To provide opportunities for TLC students to learn and practice environmental educational skills with members of the community for the purpose of sharing diverse perspectives and experience,

To provide a forum in which students can exchange experiences and ideas related to environmental education,

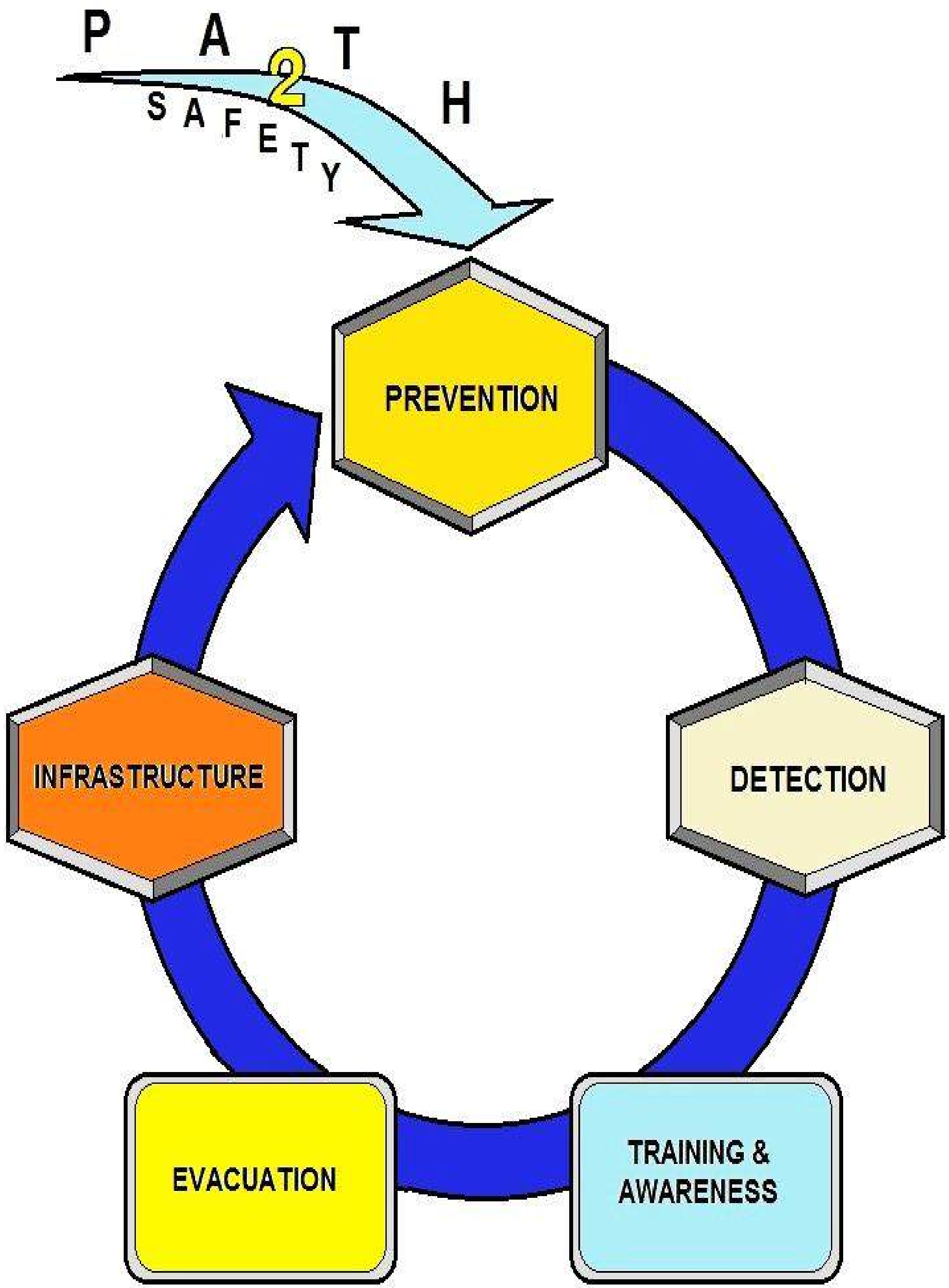
To provide a forum for the collection and dissemination of current information related to environmental education, and to maintain an environment that nurtures academic and personal growth.



BRONZE/BRAZE WELDING EXAMPLE

At the end of the course...

The student shall have a knowledge and understanding of basic welding procedures, metal joining principles and welding operation safety, fire prevention, general fire principles/reactions, Right-to-Know and OSHA fire regulations.



CIRCLE OF SAFETY

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NOTICE

THIS MATERIAL WAS PREPARED BY TECHNICAL LEARNING COLLEGE. THIS PUBLICATION IS DESIGNED TO PROVIDE BASIC INFORMATION IN THE REGARD TO THE SUBJECT OF SAFETY AWARENESS ONLY.

THE INFORMATION PROVIDED IS NOT DESIGNED TO INTERPRET THE FEDERAL RULES OR STATE LAWS, STANDARDS, RULES OR REGULATIONS OR TO REPLACE THE LEGAL ADVICE OF AN ATTORNEY.

TECHNICAL LEARNING COLLEGE WILL NOT TAKE ANY RESPONSIBLY FOR ANY INJURIES, DEATHS, OR TO DAMAGE PROPERTY, REAL OR OTHERWISE CONNECTED TO THIS TRAINING.

WELDING AND RELATED WORK IS VERY DANGEROUS. IF THERE IS ANY MATERIAL WHICH YOU DO NOT CLEARLY UNDERSTAND, IT IS YOUR RESPONSIBILITY TO HAVE THOSE AREAS EXPLAINED TO YOU BY YOUR SUPERVISOR.

TECHNICAL LEARNING COLLEGE AND THE INSTRUCTOR ARE NOT RESPONSIBLE FOR ANY PERSONAL PROPERTY DAMAGE OR FOR YOUR COMPANY'S SAFETY POLICES OR PROCEDURES.

TECHNICAL LEARNING COLLEGE IS NOT LIABLE IN ANY WAY FOR ANY INJURIES, DEATHS, LOSS OF WAGES, OR LOSS OF PROPERTY.

I HAVE READ THE ABOVE AND UNDERSTAND THAT THIS IS ONLY TRAINING AWARENESS OR WELDING SAFETY REVIEW SESSION.

I ALSO UNDERSTAND THAT WELDING WORK IS VERY DANGEROUS AND THAT IT IS MY RESPONSIBILITY TO KNOW AND FOLLOW ALL PERTINENT SAFETY POLICES AND PROCEDURES.

NAME:____DATE:____________

Basic Electrical Terms

AC and DC: Abbreviations for alternating current and direct current respectively.

> ***Current*** - A movement of electricity analogous to the flow of a stream of water.
>
> ***Direct Current*** - An electric current flowing in one direction only (i.e. current produced using a battery).
>
> ***Alternating Current*** - a periodic electric current that reverses its direction at regular intervals.

Accessible: Three common uses of accessible: (Wiring methods) - Capable of being removed or exposed without damaging the building structure of finish, or not permanently enclosed by such. Wires in concealed raceways are not considered accessible. (Equipment) -Admitting close approach; not guarded by locked doors or other effective means.

> ***Readily Accessible*** - Capable of being reached quickly for operation, renewal, or inspections without the requirement of climbing over or removing obstacles or use of portable ladders, chairs, etc.

Amp or Ampere: The unit of intensity of electrical current (the measure of electrical flow), is abbreviated a or A.

Box: An enclosure designed to provide access to the electrical wiring system. Uses include but are not limited to provide device and lighting outlets and wiring system junction points. Specially designed boxes are required for the support of listed ceiling fans weighing less than 35 lb (15. kg). Fans exceeding this weight limit must be supported independently of the outlet box.

Circuit Breaker: A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined over current without damaging itself when operated according to its rating.

Circuit: A complete path from the energy source through conducting bodies and back to the energy source.

Conductor: a substance or body capable of transmitting electricity. Bare - A conductor having no covering or electrical insulation whatsoever.

> ***Covered*** - A conductor encased within material of composition or thickness that is not recognized by the NEC as electrical insulation.
>
> ***Insulated*** - A conductor encased within material of composition or thickness that is recognized by the NEC as electrical insulation.

Device: A unit of an electrical system that is intended to carry but not utilize electricity.

Equipment: A general term including material, fittings, devices, alliances, fixtures, apparatus, and similar items used as a part of, or in connection with, an electrical installation.

Fuse: An over current protective device with a circuit opening part that is heated and broken by the passage of an over current through it.

GFCI (Ground Fault Circuit Interrupter): A device intended for the protection of personnel that de-energizes a circuit or portion of a circuit when the current to ground exceeds a preset value. "*Ground Fault*" is the name applied to this undesired circuit condition. In dwelling units (e.g. houses, apartments), GFCI protection is currently required in bathrooms, garages, outdoors, unfinished basements, kitchens and wet bar sinks. Other specific installations and/or areas may also necessitate the need for protection

Ground: A conducting connection, intentional or accidental, between an electrical circuit or equipment and the earth, or some conducting body that serves in place of the earth. Other associated terms are: Grounded conductor - A system or circuit conductor that is intentionally connected to ground. This conductor has also been referred to as the *neutral* or common conductor. Grounding conductor - a conductor used to connect equipment or the grounded circuit of a wiring system to the grounding electrode (s). Ungrounded conductor - A current carrying conductor not connected to ground.

Kilowatt-hour: Work done at the steady rate equivalent to 1000 watts in one hour. Power utility companies' base their billing upon the number of kilowatt-hours (KWH) consumed.

Labeled: Equipment or materials that a label or other identifying mark of a listing organization has been attached.

Lamp: A general term for various devices for artificially producing light.

Listed: Equipment and/or materials included in a list published by an organization concerned with product evaluation and production of listed items. The listing states whether the item meets designated standards or is suitable for use in a specified manner. Listing organizations acceptable to jurisdiction authorities include Underwriters' Laboratories (UL) and CSA.

NEC (National Electrical Code): a document produced by the National Fire Protection Association for the purpose of the practical safeguarding of persons and property from hazards arising from the use of electricity. Authorities having legal jurisdiction over electrical installations adopt the code for mandatory application (i.e. incorporate the code into law).

Ohm: The unit of electrical resistance and impedance, abbreviated with the symbol omega, W. Resistance is the opposition offered by a substance to the passage of electrical current. Impedance is the apparent resistance in a circuit to the flow of alternating current.

Ohm's Law: A statement of the relationship, discovered by the German scientist G. S. Ohm, between the voltage, amperage and resistance of a circuit. It states the voltage of a circuit in volts is equal to the product of the amperage in amperes and the resistance in ohms. **E=IR**

Over current: Any current in excess of the rated current or ampacity. It may result from overload, short circuit or ground fault.

Overload: Operation in excess of normal full-load rating or rated ampacity which could cause damage or dangerous overheating if continued for a sufficient time. A fault, such as a short circuit or ground fault, is not an overload. See "Over Current".

Phase: the point or stage in the period to which the rotation, oscillation, or variation has advanced relative to a standard position or starting point. *Electrically,* one of the voltage sources of an alternating current electrical system whose voltage state is measured relative to a standard point.

Raceway: An enclosed channel of metallic or nonmetallic materials designed expressly for holding wires, cables, or bussbars. Examples are electrical metallic tubing (EMT), flexible

Receptacle: a device installed for the connection of a single contact device. Receptacles provide a means of connecting apparatus that utilize electricity to the wiring system.

Service: the conductors and equipment for delivering electrical energy from the supply system (e.g. the electric power utility) to the wiring system of the premises served.

Single Phase: a system of alternating current power where the phase relationship between ungrounded conductors is either 0 or 10 degrees.

Three Phase: a system of alternating current power where the phase relationship between ungrounded conductors is either 0 or 120 degrees.

Transformer: An apparatus for converting an alternating electrical current from a high to a low potential (voltage) or vice versa. Uses of transformers include but are not limited to the conversion of utility transmission voltage to the voltage of the premises wiring system and conversion of voltage for use with chimes, alarm systems and *low-voltage* lighting. Transformers can also be used to compensate for minor variations equipment voltage requirements. Transformers only change voltage and amperage.

Volt: the unit of electromotive force, the measure of electrical pressure, is abbreviated v or V, and voltage is represented by I. The voltage (of a circuit) is the effective (greatest root-mean-square) difference of potential between any two conductors of the circuit concerned. *Some systems, such as 3-phase 4-wire and single-phase 3-wire may have multiple circuits of differing voltages.* The **Nominal Voltage** is the value assigned to a circuit to conveniently designate its voltage class (e.g. 120 volts, 240 volts, 480 volts). The *actual* voltage of the circuit can vary.

Watt: the unit of power or rate of work represented by a current of one ampere under a pressure of one volt (abbreviated w or W). The English horsepower is approximately equal to 846 watts. Wattage ratings of lamps actually measure the power consumption not the illuminating capability.

Credits
Many of the definitions used are based on information contained in the National Electrical Code published by the National Fire Protection Association and Webster's New World Dictionary.

Welding Introduction

Welding is a general term for various processes used to join metal parts by producing coalescence, called a weld, at a joint. This is usually done by applying heat and energy whilst bringing the pieces of metal together. This course will refer to the fire dangers and precautions of not only welding, but also cutting metals, which is similar to welding except that the metals are separated instead of joined.

As welding (and cutting) involves very high temperatures (up to 5500 degrees C), there is always the risk of fire, especially when combustible materials are around. These fires cause millions of dollars damage each year and the loss of life. Therefor it is important to recognize and understand the dangers and risks involved when welding, and to implement safe practices to reduce these risks.

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld.

This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space. Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

19th Century

Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used for centuries to join iron and steel by heating and hammering. Arc welding and oxyfuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after. Welding technology advanced quickly during the early 20th century as World War I and World War II drove the demand for reliable and inexpensive joining methods. Following the wars, several modern welding techniques were developed, including manual methods like SMAW, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as GMAW, SAW, FCAW and ESW.

Developments continued with the invention of laser beam welding, electron beam welding, magnetic pulse welding (MPW), and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is commonplace in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality.

To understand why welding/cutting pose such a dangerous fire hazard, this course will firstly discuss the most common welding practices. The extent of the danger will then be discussed. The ways in which welding/cutting operations cause fires is described, which then leads into a comprehensive discussion of precautions and safety practices that should be implemented when welding to reduce the risk of fire, or at least minimize the amount of damage caused. The conclusion will summarize both the fire dangers of welding, and the most important safety practices to reduce these dangers.

Background

Cutting

Gas and arc welding equipment can also be used for cutting metals. In fact, oxyacetylene gas and arc cutting cause more welding environment fires than any other means. Oxyacetylene gas cutting is similar to oxyacetylene welding, except that the blowpipe is fitted with a cutting attachment and work is done at a greater pressure. The effect is quite dramatic as sparks of hot metal shower from the work. These sparks provide a potential ignition source for a fire.

Arc cutting is similar to arc welding, except that special electrodes are used and the molten metal is either oxidized or blown away. The electrodes are coated with an insulating material which does not conduct electricity, and hence they are non-consumable, unlike in arc welding where the electrodes are used up.

Welding Processes
Welding has many applications, both domestically and industrially. Some welded products include ships, aircraft, automobiles, electric and electronic parts, and in building and construction work. Although over 50 welding processes are used today, the most common ones are gas welding and arc welding.

Gas Welding
The most common gas welding process is oxyfuel welding, also known as oxyacetylene welding. It is one of the oldest and most versatile welding processes, but in recent years it has become less popular in industrial applications. It is still widely used for welding pipes and tubes, as well as repair work.

The equipment is relatively inexpensive and simple, generally employing the combustion of acetylene in oxygen to produce a welding flame temperature of about 3100 °C. The flame, since it is less concentrated than an electric arc, causes slower weld cooling, which can lead to greater residual stresses and weld distortion, though it eases the welding of high alloy steels. A similar process, generally called oxyfuel cutting, is used to cut metals.

Oxyacetylene welding (a form of gas welding) is the oldest type of welding and was developed at the beginning of the twentieth century. Oxygen and acetylene are fed into a torch and ignited to produce a burning gas with a temperature of around 3000 degrees C. The welder has good control of the weld, as they hold the oxyacetylene torch in one hand and a rod of filler metal in the other. The heat of the torch causes the filler metal to gradually fuse with the joint.

NECESSARY WELDING SIGNAGE EXAMPLES

The intense heat of welding and sparks can cause burns. Contact with hot slag, metal chips, sparks, and hot electrodes can cause eye injuries.

• Excessive exposure to heat can result in heat stress or heat stroke. Welders should be aware of the symptoms - such as fatigue, dizziness, loss of appetite, nausea, abdominal pain, and irritability. Ventilation, shielding, rest breaks, and drinking plenty of cool water will protect workers against heat-related hazards.

Visible Light, and Ultraviolet and Infrared Radiation

• The intense light associated with arc welding can cause damage to the retina of the eye, while infrared radiation may damage the cornea and result in the formation of cataracts.

• Invisible ultraviolet light (UV) from the arc can cause “arc eye” or “welder’s flash” after even a brief exposure (less than one minute). The symptoms of arc eye usually occur many hours after exposure to UV light, and include a feeling of sand or grit in the eye, blurred vision, intense pain, tearing, burning, and headache.

• The arc can reflect off surrounding materials and burn co-workers working nearby.

About half of welder’s flash injuries occur in co-workers who are not welding. Welders and cutters who continually work around ultraviolet radiation without proper protection can suffer permanent eye damage.

• Exposure to ultraviolet light can also cause skin burns similar to sunburn, and increase the welder’s risk of skin cancer.

Welding Safety Section

Welding, cutting, and brazing are hazardous activities that pose a unique combination of both safety and health risks to more than 500,000 workers in a wide variety of industries. The risk from fatal injuries alone is more than four deaths per thousand workers over a working lifetime.

Welding, cutting, and brazing are addressed in specific standards for the general industry, shipyard employment, marine terminals, and construction industry.

The main types of welding are oxyacetylene gas welding and arc welding (wire welding). Both involve the joining of metals at high temperatures. Cutting metals using these techniques involves the separating of metals at high temperatures. Welding and cutting pose a serious fire hazard as fragments of metal at high temperature are produced and if these hot metal fragments come into contact with a combustible material they may act as an ignition source and start a fire.

Cutting metals is much more of a fire hazard than welding, because during cutting operations many more sparks of hot metal shower from the work, providing a potential ignition source for a fire.

General Welding Safety Rules

1. Arc rays from the welding process produce intense visible and invisible (ultraviolet and infrared) rays that can burn eyes and skin. Sparks fly off from the weld.
2. Wear a welding helmet fitted with a proper shade of filter to protect your face and eyes when welding or watching (see ANSI Z49.1 and Z87.1 listed in Safety Standards).
3. Use protective screens or barriers to protect others from flash, glare, and sparks; warn others not to watch the arc.
4. Wear body protection made from durable, flame−resistant material (leather, heavy cotton, wool). Body protection includes oil-free clothing such as leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap.
5. Before welding, adjust the auto-darkening lens sensitivity setting to meet the application.
6. Stop welding immediately if the auto-darkening lens does not darken when the arc is struck. See the Owner’s Manual for more information.
7. Arc rays from the welding process produce intense visible and invisible (ultraviolet and infrared) rays that can burn eyes and skin. Sparks fly off from the weld.
8. Use impact resistant safety spectacles or goggles and ear protection at all times when using welding helmet.
9. Inspect the auto-lens frequently. Immediately replace any scratched, cracked, or pitted cover lenses or auto-lenses.
10. NOISE can damage hearing. Noise from some processes or equipment can damage hearing. Wear approved ear protection if noise level is high.
11. READ INSTRUCTIONS. Read and follow all labels and the Owner’s Manual carefully before installing, operating, or servicing unit. Read the safety information at the beginning of the manual and in each section. Use only genuine replacement parts from the manufacturer. Perform maintenance and service according to the Owner’s Manuals, industry standards, and national, state, and local codes.
12. FUMES AND GASES can be hazardous. Welding produces fumes and gases. Breathing these fumes and gases can be hazardous to your health.
13. Keep your head out of the fumes. Do not breathe the fumes.
14. If inside, ventilate the area and/or use local forced ventilation at the arc to remove welding fumes and gases. The recommended way to determine adequate ventilation is to sample for the composition and quantity of fumes and gases to which personnel are exposed.
15. If ventilation is poor, wear an approved air-supplied respirator.
16. Read and understand the Safety Data Sheets (SDSs) and the manufacturer’s instructions for adhesives, coatings, cleaners, consumables, coolants, degreasers, fluxes, and metals.
17. Work in a confined space only if it is well ventilated, or while wearing an air-supplied respirator.
18. Always have a trained watchperson nearby. Welding fumes and gases can displace air and lower the oxygen level causing injury or death. Be sure the breathing air is safe.
19. Do not weld in locations near degreasing, cleaning, or spraying operations. The heat and rays of the arc can react with vapors to form highly toxic and irritating gases.
20. Do not weld on coated metals, such as galvanized, lead, or cadmium plated steel, unless the coating is removed from the weld area, the area is well ventilated, and while wearing an air supplied respirator. The coatings and any metals containing these elements can give off toxic fumes if welded.

Welding Safety Issues

Welding can be dangerous and unhealthy if the proper precautions are not taken. However, using new technology and proper protection greatly reduces risks of injury and death associated with welding. Since many common welding procedures involve an open electric arc or flame, the risk of burns and fire is significant; this is why it is classified as a hot work process. To prevent injury, welders wear personal protective equipment in the form of heavy leather gloves and protective long sleeve jackets to avoid exposure to extreme heat and flames.

Additionally, the brightness of the weld area leads to a condition called arc eye or flash burns in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Goggles and welding helmets with dark UV-filtering face plates are worn to prevent this exposure. Since the 2000s, some helmets have included a face plate which instantly darkens upon exposure to the intense UV light. To protect bystanders, the welding area is often surrounded with translucent welding curtains. These curtains, made of a polyvinyl chloride plastic film, shield people outside the welding area from the UV light of the electric arc, but cannot replace the filter glass used in helmets.

Welders are often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. This is because smaller particles have the ability to cross the blood brain barrier. Fumes and gases, such as carbon dioxide, ozone, and fumes containing heavy metals, can be dangerous to welders lacking proper ventilation and training.

Exposure to manganese welding fumes, for example, even at low levels (<0.2 mg/m^3), may lead to neurological problems or to damage to the lungs, liver, kidneys, or central nervous system. Nano particles can become trapped in the alveolar macrophages of the lungs and induce pulmonary fibrosis. The use of compressed gases and flames in many welding processes poses an explosion and fire risk. Some common precautions include limiting the amount of oxygen in the air, and keeping combustible materials away from the workplace.

Controlling Hazardous Fume and Gases during Welding
Welding joins materials together by melting a metal work piece along with a filler metal to form a strong joint. The welding process produces visible smoke that contains harmful metal fume and gas by-products. This fact sheet discusses welding operations, applicable OSHA standards, and suggestions for protecting welders and coworkers from exposures to the many hazardous substances in welding fume.

Welding Disasters
July 1994 Boston Harbor Tunnel fire. Welders were cutting bolts from a bearing housing and these hot bolts and nuts then fell into the shaft. On coming in contact with the conveyor belt, the hot metal bits then started a fire which could have been avoided had a fire resistant tarp been suspended beneath the work area.

April **1991** fire in the US embassy in Moscow. The fire was caused by hot sparks dropping down from welding that was being done in the elevator shaft. Had a fire resistant tarp been suspended beneath the welders, this fire too, could have been avoided.

Fighting the Fire
Even after precautions are taken to reduce the risk of a fire occurring, a fire may still occur. It is important to be prepared in case this does happen. Before commencing the work, it is important to establish that the appropriate firefighting equipment is available and ready for use, and that staff are properly trained in using such equipment.

Fire protection systems
Depending on the nature of the work, various types of firefighting systems should be present. Before any work commences, it should be established that these systems are functioning, and will continue to function during and after hot work operations.

To establish that fire protection systems are not malfunctioning, various checks should be carried out. For example control valves for fixed protection systems should be fully opened. As well as a fire extinguisher, a bucket of dry sand and a pair of water buckets should be at hand. These are used in addition to other firefighting equipment to fight certain types of fires. Sand is effective in smothering fires of flammable liquids such as oil, petrol, paint, etc. (class 6 fires). The only to fight fires in which wood, paper, clothing (class A fires). Buckets of water should be used and similar materials are burning

Hot work permit system
A hot work permit is required before any welding or cutting is carried out in a 'hazardous situation'. It is the responsibility of property and plant management to oversee the permit issuance system. The Responsible Officer issues the hot work permit after they are satisfied that certain precautions have been followed and the hot work may proceed safely.

The hot work permit covers aspects of the work such as the times the work may be carried out, the equipment to be used and the precautions which have been taken. Once work has been approved as safe, the hot work permit is filled out and signed by the Responsible Officer. The permit is then posted at the worksite. It is signed again at the completion of the work, and filed for documentation.

Welding on Containers
Containers of flammable materials should never be welded or cut with a torch, even if the container has been completely empty and sitting empty for a long time, as vapors and flammable materials can still permeate the metal. An example of what can occur when such containers are welded on occurred in the early 1990s when a welder in the USA was cutting 55-gallon oil drums in half. As his cutting torch pierced the metal of one of these drums, the drum exploded and the welder was blown through the shop's roof, 50-feet up in the air.

Vapors from flammable liquids are explosive and should be handled with extreme care. Vapors from non-flammable liquids can also be explosive under certain conditions. If welding b to be carried out on vessels of flammable or combustible materials, the vessel should be drained, cleaned, purged and tested for flammable vapors before the work begins. The transfer piping should also be drained, purged and blanked.

As a rule, only welders who are properly trained to do so should weld or cut a container that has held flammable or hazardous materials.

Whose Responsibility is Fire Safety in Welding?

To reduce the risk and minimize the damage of fire, personnel involved in welding/cutting operations should cooperate in taking adequate precautions and pursuing safe practices.

The general guidelines of responsibilities are as follows:
Management- arrange hot work permit and ensure that adequate firefighting equipment is available (for immediate use). Ensure that supervisors are correctly trained.

Supervisors- verify that safety equipment is present and properly maintained; ensure workers are correctly trained on safety aspects of their work, especially what to do in the case of a fire. Ensure the working environment is fire-safe, especially the removal of flammable materials, arrange firewatchers.

Workers- follow safe practices, report unsafe conditions, mark hot metal and stop work if conditions change and become unsafe.

Workers and supervisors- should be properly trained in the correct use of firefighting equipment such as extinguishers and blankets.

To minimize injuries/loss of life, they should also be shown where the fire exits are, and how to use them in an emergency. A good method of doing this is to have periodic fire drills. To reduce fire hazards, workers and supervisors should also be made aware what equipment should be shut down before leaving the work area.

Oxyacetylene Gas Welding
There are some special precautions which should be taken when welding or cutting with oxyacetylene gas to reduce the risk of fire.

Cylinders of acetylene, oxygen and other high-pressure gases should be stored upright in an approved area (vented to atmosphere with flameproof switches and lights), with their safety caps in place.

Acetylene gas should not come into direct contact with copper or alloys >70% copper, since copper acetylide, an explosive compound is formed. Acetylene piped from the manifold should be conveyed in iron or steel pipes. When the welding work is finished and the flame has been extinguished, the system should be emptied of all gases from the cylinder outlet to torch tip.

The torch should never be pointed at the cylinders, regulators, hose, or anything else that may be damaged and cause a fire or explosion. If the torch is lit, it should be in the welder's hand only. A lit torch should never be hung up or placed down on the bench or workpiece.

Check valves and flashback arrestors should be installed in all oxyacetylene gas welding and cutting outfits.

Be sure that no combustible material is in the area where the torch is to be lighted.

Light the torch with a spark lighter.

Backfire
A backfire is when the flame flashes back up the nozzle and is arrested at the mixer or injector in the blowpipe body. Backfires may be caused by using a dirty tip, an overheated tip, or working at insufficient pressure. If this occurs, the blowpipe valves should be turned off. The cylinder vales should be closed and the equipment checked before welding recommences. Overheated tips or nozzles may be cooled in a bucket of water.

Flashback
A flashback is when the flame burns back into the tip, torch, hose, or regulator. It means that there is something radically wrong with the equipment which should be corrected before being used again. If a flashback occurs, the oxygen torch valve should be turned off quickly and then the fuel gas torch valve. Next the oxygen cylinder and fuel gas cylinder regulators should be closed.

Acetylene gas itself, although bottled at relatively low pressure, is highly explosive. If it leaks into a confined space, nothing will happen until there is a spark or flame to ignite it. Then it may explode similarly to a stick of dynamite.

Arc Welding Electrical Safety
As arc welding involves electricity and high currents, these may create special fire and safety hazards. Prior to the commencement of a welding project, it is important to ground all electrical equipment. This is to reduce the risk of electrical shock or the transformer causing an electrical fire by triggering the electrical supply circuit protection.

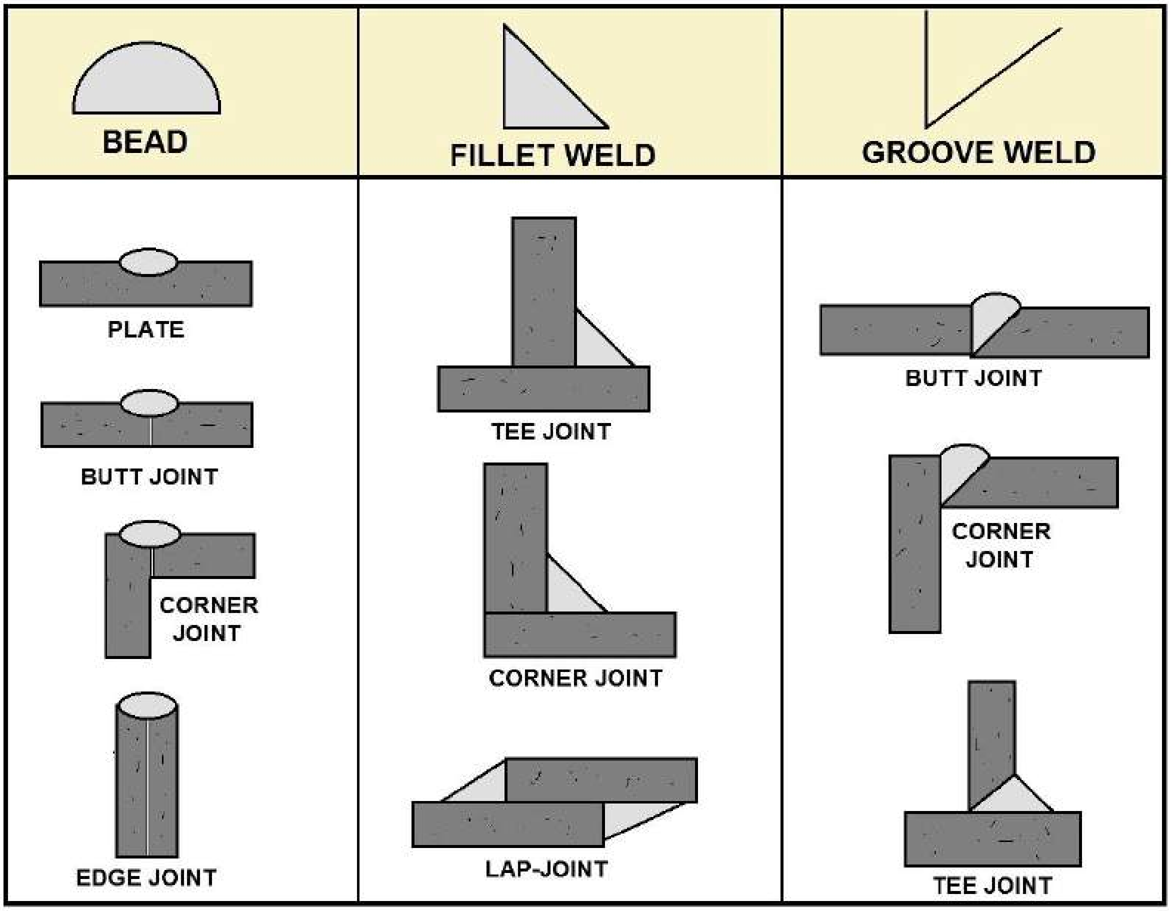
Clothing
When welding, special protective clothing should be worn to protect the welder. Clothing and accessories should be fire resistant. Leather is the best choice, but wool is also suitable. The clothing should not contain cuffs or open pockets, as these might collect sparks or hot metal.

Flammable material (e.g. matches) should not be carried in the pockets of clothing. With regard to fire safety, the two relevant items of clothing are a flame-resistant apron, usually made of leather, and spats, which prevent molten metal going down the welder's boots.

Noise
• Exposure to loud noise can permanently damage welders' hearing. Noise also causes stress and increased blood pressure, and may contribute to heart disease. Working in a noisy environment for long periods of time can make workers tired, nervous, and irritable.
• If you work in a noisy area, the OSHA Noise Standard, Code of Federal Regulations (CFR) 1910.95, requires your employer to test for noise levels to determine your exposure. If your average noise exposure exceeds 85 decibels for over 8 hours, your employer must provide you with a choice of free hearing protection and annual hearing tests.

Conclusion
Welding and cutting metals by various methods especially oxyacetylene gas and arc welding produces very hot fragments of metal, or 'sparks' and thus pose a dangerous fire hazard. Every year much damage is caused by these types of fires, especially fires caused by cutting, and often these fires could have been prevented, or the amount of damage reduced, by taking precautions and undertaking fire-safe welding practices.

Types of Welding



TYPES OF WELDS

Welding is classified into two groups: fusion (heat alone) or pressure (heat and pressure) welding. There are three types of fusion welding: electric arc, gas and thermit.

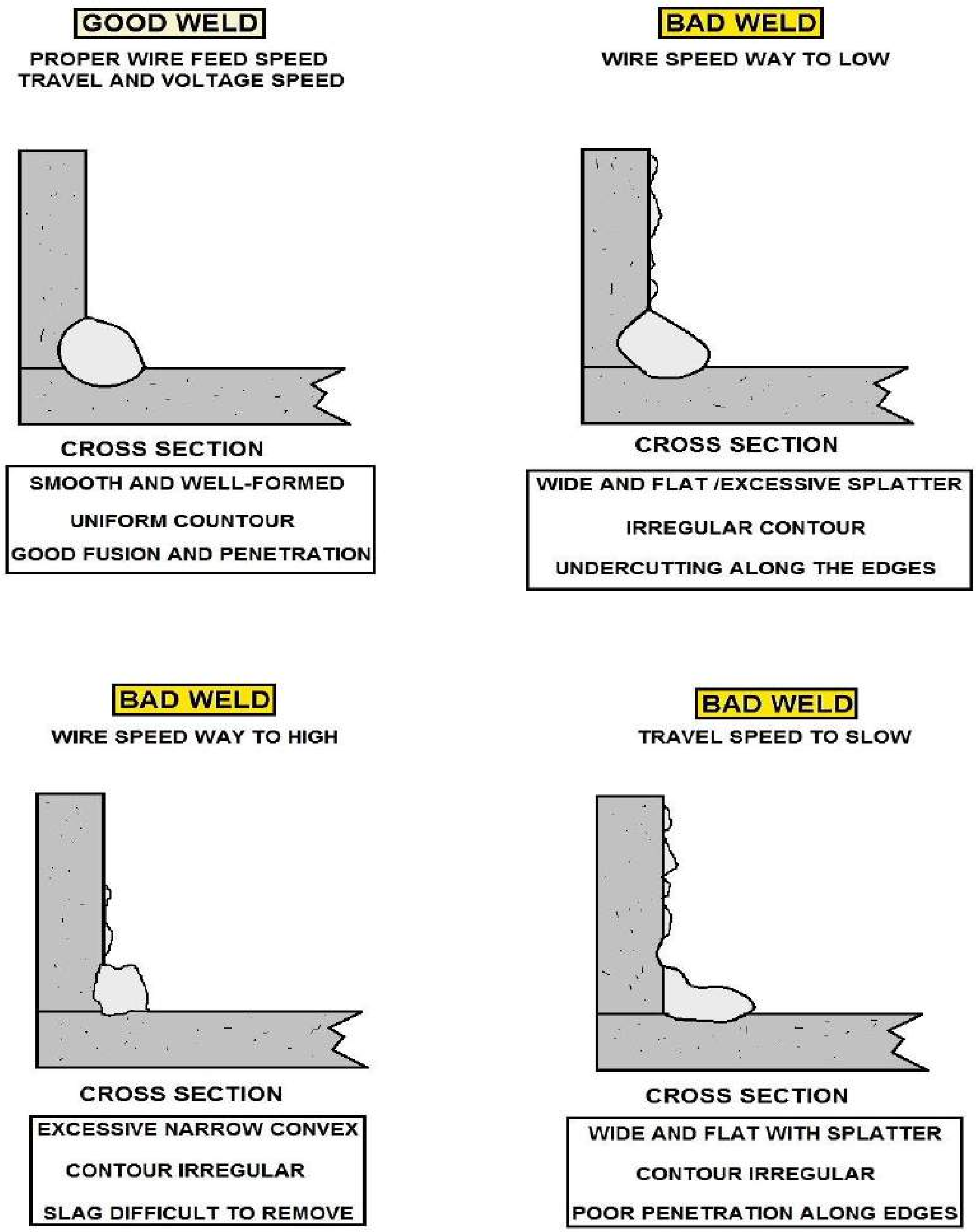
Electric arc welding is the most widely used type of fusion welding. It employs an electric arc to melt the base and filler metals.

Arc welding types in order of decreasing fume production include:

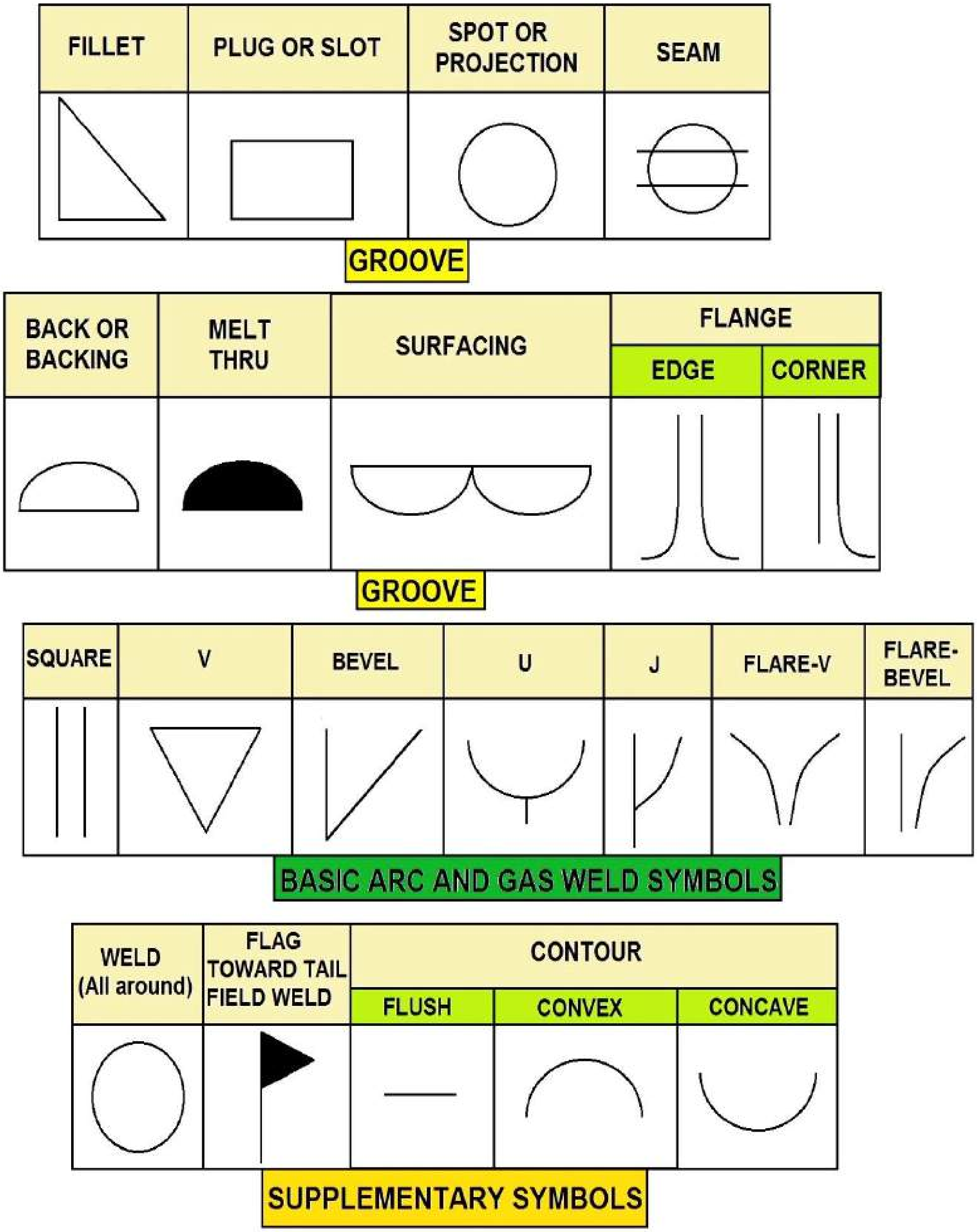
- ✓ **Flux Core Arc Welding (FCAW)** filler metal electrode; flux shield
- ✓ **Shielded Metal Arc (SMAW)** electrode provides both flux and filler material
- ✓ **Gas Metal Arc (GMAW or MIG)** widely used; consumable electrode for filler metal, external gas shield
- ✓ **Tungsten Inert Gas (GTAW or TIG)** superior finish; non-consumable electrode; externally-supplied inert gas shield

Gas or oxy-fuel welding uses a flame from burning a gas (usually acetylene) to melt metal at a joint to be welded, and is a common method for welding iron, steel, cast iron, and copper. Thermit welding uses a chemical reaction to produce intense heat instead of using gas fuel or electric current. Pressure welding uses heat along with impact-type pressure to join the pieces.

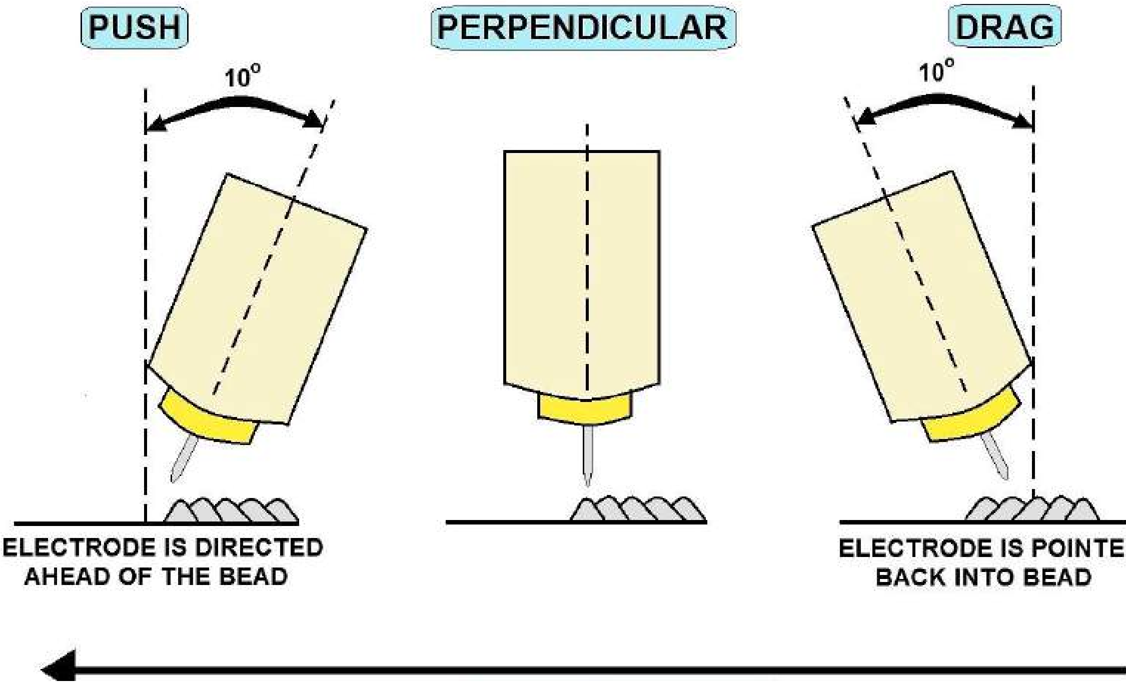
Oxy-fuel and plasma cutting, along with brazing, are related to welding as they all involve the melting of metal and the generation of airborne metal fume. Brazing is a metal-joining process where only the filler metal is melted.



COMMON WELDING PROBLEMS



BASIC AND SUPPLEMENTARY ARC AND GAS WELD SYMBOLS



DIRECTION OF WELDING

Electrical Hazards

• Even though welding generally uses low voltage, there is still a danger of electric shock. The environmental conditions of the welder (such as wet or cramped spaces) may make the likelihood of a shock greater. Falls and other accidents can result from even a small shock; brain damage and death can result from a large shock.

• Dry gloves should always be worn to protect against electric shock. The welder should also wear rubber-soled shoes, and use an insulating layer, such as a dry board or a rubber mat, for protection on surfaces that can conduct electricity.

• The piece being welded and the frame of all electrically powered machines must be grounded. The insulation on electrode holders and electrical cables should be kept dry and in good condition. Electrodes should not be changed with bare hands, wet gloves, or while standing on wet floors or grounded surfaces.

Fires and Explosions

• The intense heat and sparks produced by welding, or the welding flame, can cause fi res or explosions if combustible or flammable materials are in the area.

• Welding or cutting should only be performed in areas that are free of combustible materials, including trash, wood, paper, textiles, plastics, chemicals, and flammable dusts, liquids, and gases (vapors can travel several hundred feet). Those that cannot be removed should be covered with a tight-fitting flame-resistant material. Doorways, windows, cracks, and other openings should be covered.

• Never attempt to weld containers that have held a flammable or combustible material unless the container is thoroughly cleaned or filled with an inert (non-reactive) gas.

What is in Welding Fume?

Metals
Aluminum, Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Molybdenum, Nickel, Silver, Tin, Titanium, Vanadium, Zinc.

Gases
- **Shielding**—Argon, Helium, Nitrogen, Carbon Dioxide.
- **Process**—Nitric Oxide, Nitrogen Dioxide, Carbon Monoxide, Ozone, Phosgene, Hydrogen Fluoride, Carbon Dioxide.

Factors that affect worker exposure to welding fume
- Type of welding process
- Base metal and filler metals used
- Welding rod composition
- Location (outside, enclosed space)
- Welder work practices
- Air movement
- Use of ventilation controls

Health effects of breathing welding fume

- Acute exposure to welding fume and gases can result in eye, nose and throat irritation, dizziness and nausea. Workers in the area who experience these symptoms should leave the area immediately, seek fresh air and obtain medical attention.
- Prolonged exposure to welding fume may cause lung damage and various types of cancer, including lung, larynx and urinary tract.
- Health effects from certain fumes may include metal fume fever, stomach ulcers, kidney damage and nervous system damage. Prolonged exposure to manganese fume can cause Parkinson's–like symptoms.
- Gases such as helium, argon, and carbon dioxide displace oxygen in the air and can lead to suffocation, particularly when welding in confined or enclosed spaces. Carbon monoxide gas can form, posing a serious asphyxiation hazard.

Welding and Hexavalent Chromium ••Chromium is a component in stainless steel, nonferrous alloys, chromate coatings and some welding consumables.

••Chromium is converted to its hexavalent state, Cr(VI), during the welding process.

••Cr(VI) fume is highly toxic and can damage the eyes, skin, nose, throat, and lungs and cause cancer.

••OSHA regulates worker exposure to Cr(VI) under its Chromium (VI) standard, 29 CFR 1910.1026 and 1926.1126.

••OSHA's Permissible Exposure Limit (PEL) for Cr(VI) is 5 $\mu g/m^3$ as an 8-hour time-weighted average.

Reducing exposure to welding fume

- Welders should understand the hazards of the materials they are working with. OSHA's Hazard Communication standard requires employers to provide information and training for workers on hazardous materials in the workplace.
- Welding surfaces should be cleaned of any coating that could potentially create toxic exposure, such as solvent residue and paint.
- Workers should position themselves to avoid breathing welding fume and gases. For example, workers should stay upwind when welding in open or outdoor environments.
- General ventilation, the natural or forced movement of fresh air, can reduce fume and gas levels in the work area. Welding outdoors or in open work spaces does not guarantee adequate ventilation. In work areas without ventilation and exhaust systems, welders should use natural drafts along with proper positioning to keep fume and gases away from themselves and other workers.
- Local exhaust ventilation systems can be used to remove fume and gases from the welder's breathing zone. Keep fume hoods, fume extractor guns and vacuum nozzles close to the plume source to remove the maximum amount of fume and gases. Portable or flexible exhaust systems can be positioned so that fume and gases are drawn away from the welder. Keep exhaust ports away from other workers.
- Consider substituting a lower fume-generating or less toxic welding type or consumable.
- Do not weld in confined spaces without ventilation. Refer to applicable OSHA regulations (see list below).
- Respiratory protection may be required if work practices and ventilation do not reduce exposures to safe levels.

Some OSHA Standards Applicable to Welding:

- Welding, Cutting & Brazing—29 CFR 1910 Subpart Q
- Welding & Cutting—29 CFR 1926 Subpart J
- Welding, Cutting & Heating—29 CFR 1915 Subpart D
- Permit-required confined spaces—29 CFR 1910.146
- Confined & Enclosed Spaces & Other Dangerous Atmospheres in Shipyard Employment—29 CFR 1915 Subpart B
- Hazard Communication—29 CFR 1910.1200
- Respiratory Protection—29 CFR 1910.134
- Air Contaminants—29 CFR 1910.1000 (general industry), 29 CFR 1915.1000 (shipyards), 29 CFR 1926.55 (construction)

Hazards of Welding in Confined Spaces

A confined space is a small or crowded area with limited access and little or no airflow or ventilation. Adequate ventilation is essential for working in confined spaces. Dangerous concentrations of toxic fumes and gases can build up very quickly in a small space. Unconsciousness or death from suffocation can occur rapidly because welding processes can use up or displace oxygen in the air. High concentrations of some fumes and gases can also be very explosive.

The following rules apply:

• All workers who may enter dangerous areas either on a regular basis or in an emergency situation should be trained on rescue procedures, self-contained breathing apparatus, use of safety equipment, and proper procedures for entering and exiting a confined space.

• The worker inside the confined space should be equipped with a safety harness, a lifeline, and appropriate personal protective clothing, including a self-contained breathing apparatus. (Never use an air-purifying respirator.)

• Gas cylinders and welding power sources should be located in a secure position outside of the confined space.

• A trained worker must be stationed outside of the confined space, and equipped with appropriate gear (including a fi re extinguisher and personal protective equipment), to assist or rescue the worker inside the confined space if necessary. If the worker notices any indications of intoxication or decreased alertness from the “inside” worker, the inside worker should be removed from the area immediately.

• All confined spaces should be tested before entering for toxic, flammable, or explosive gases or vapors, and oxygen level. Continuous air monitoring may be necessary during welding. No worker should enter a confined space where the percentage of oxygen is below 19.5% unless he or she is equipped with a supplied-air respirator.

• Never use oxygen for ventilation.

• Use continuous mechanical ventilation and a respirator whenever welding or performing thermal cutting in a confined space.

• All pipes, ducts, and power lines connected to the space, but not necessary to the operation should be disconnected or shut off. All shutoff valves and switches should be tagged and locked out so they cannot accidentally be restarted.

• All unnecessary torches and other gas or oxygen supplied equipment should be removed from the confined space.

Hazards of Compressed Gases

Gas welding and flame cutting use a fuel gas and oxygen to produce heat for welding. For high-pressure gas welding, both the oxygen and the fuel gas (acetylene, hydrogen, propane, etc.) supplied to the torch are stored in cylinders at high pressure. The use of compressed-gas cylinders poses some unique hazards to the welder. Acetylene is very explosive. It should be used only with adequate ventilation and a leak detection program. Oxygen alone will not burn or explode. At high oxygen concentrations, however, many materials (even those that are difficult to burn in air, such as normal dust, grease, or oil) will burn or explode easily.

These are some rules to follow when using compressed gases.

• All cylinders should have caps or regulators.

• Only pressure regulators designed for the gas in use should be fitted to cylinders.

• Compressed gas cylinders, all pressure relief valves, and all lines should be checked before and during welding operations.

• Blowpipes must be kept in good condition and cleaned at regular intervals.

Welding Safety Summary

There are many precautions that should be taken when welding or cutting to reduce the risk of fire and/or minimize the amount of damage caused by the fire. Listed below are the ten most important precautions to take when welding/cutting in order to reduce the fire hazard:

1. Have firewatchers present. These are trained people who watch out for fires and know what to do when a fire occurs.
2. Minimize availability of combustible materials. This may involve removing combustible materials from the area, or shielding them from sparks with metal shields and/or fire-resistant tarps.
3. Suspend a fire-resistant tarp beneath the work if necessary, to catch any hot/molten metal that may fall through.
4. Have firefighting equipment (including appropriate extinguishers) available for immediate use.
5. If welding or cutting is to occur in a 'hazardous situation', obtain a hot work permit to ensure adequate precautions have been taken.
6. Workers and supervisors should be trained in safe welding practices, and the use of firefighting equipment.
7. Wear fire resistant clothing. A flame resistant apron (usually leather) and spats to prevent molten metal going down in to the welder's boots. No cuffs or open pockets, and no flammable material (e.g. matches) in pockets.
8. When oxyacetylene gas welding or cutting, never leave a lit torch around when it is not in the welder's hand.
9. When oxyacetylene gas welding or cutting, never point the torch at cylinders, regulators, hose, or anything else that may be damaged and cause a fire or explosion.
10. Before arc welding or cutting, ground the electrical equipment to reduce the risk of the transformer causing a fire by triggering the electrical supply circuit protection.

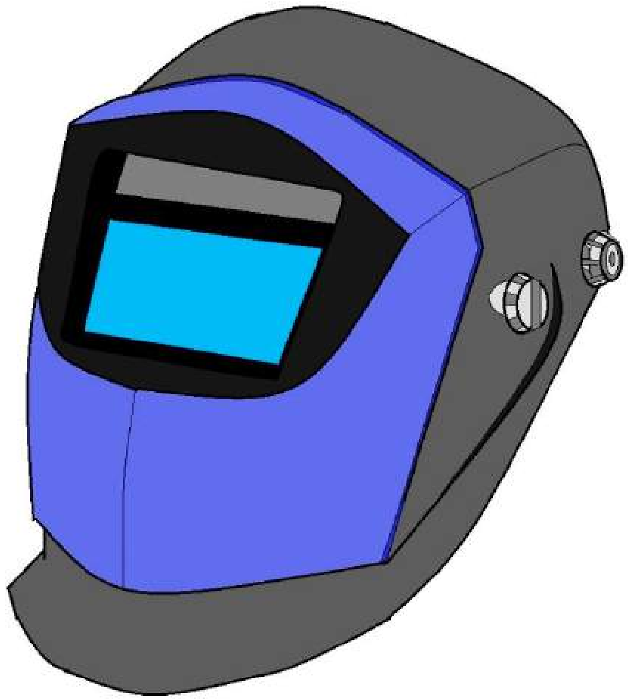
Taking the above precautions, and others, may help to reduce the risk of a fire caused by welding/cutting, and may reduce the amount of damage such fires cause every year.

How the Fire may Occur

Generally, as welding (and cutting) involves such high temperatures, fires occur when hot metal (sparks) comes into contact with some combustible material. To avoid confusion, it should be noted that in welding terminology, a 'spark' refers to the luminous particle that can be formed when an arc melts metal. Quite unlike the usual meaning of the word 'spark', which is a high voltage discharge.

Cutting of metals (arc and gas) poses more of a fire hazard than does welding. This is hardly surprising considering the relatively large amount of sparks produced as the metal is cut as opposed to when it is welded. As the metal is cut, (using welding techniques), sparks and hot, molten metal fly off in all directions. The sparks from cutting may travel some distance, and as they are small, may drop down through small holes causing a fire to start.

In arc welding or cutting, the temperature in an arc path may also be a competent ignition source. In fact, the power in a welding arc is enough to ignite nearly any combustible material. This very rarely happens however, as the arcing is so brief and localized that solid fuels such as wood or plastic cannot be ignited. The arc may cause the fire however, if it comes in contact with fuels with a high surface area to mass ratio, such as cotton batting and tissue paper, or combustible gases and vapors.



WELDING HELMET

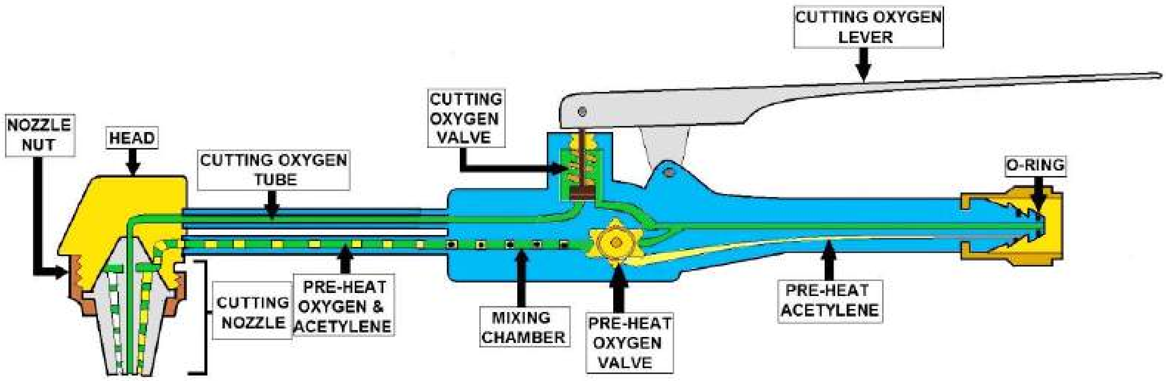
Precautions and Safety Procedures
There are many precautions which should be taken and safety procedures to be followed to reduce the risk of fire or to minimize the amount of damage in the event that a fire does occur. Some of these are general to all cutting/welding operations, whilst others are specific to a certain type of welding, or to specific circumstances of the project.

Firewatchers are people who watch for fires in exposed areas. If a fire does occur, the firewatcher will extinguish the fire or, if this is not possible, sound the alarm. It is important therefore that the firewatcher is well aware of the location of all fire extinguishing equipment, and is properly trained to use it.

Firewatchers should keep watch for fires not only whilst the welding is taking place, but at least half-hour after the completion of the welding operations. This is so they can detect and extinguish smoldering fires.

For larger jobs, several firewatchers may be required to keep watch properly. The work area should also be checked at least 4 hours after completion of the work, in case of smoldering fires. However the same firewatcher needn't do this.

Oxy-Acetylene Welding Section



OXY-ACETYLENE CUTTING TORCH

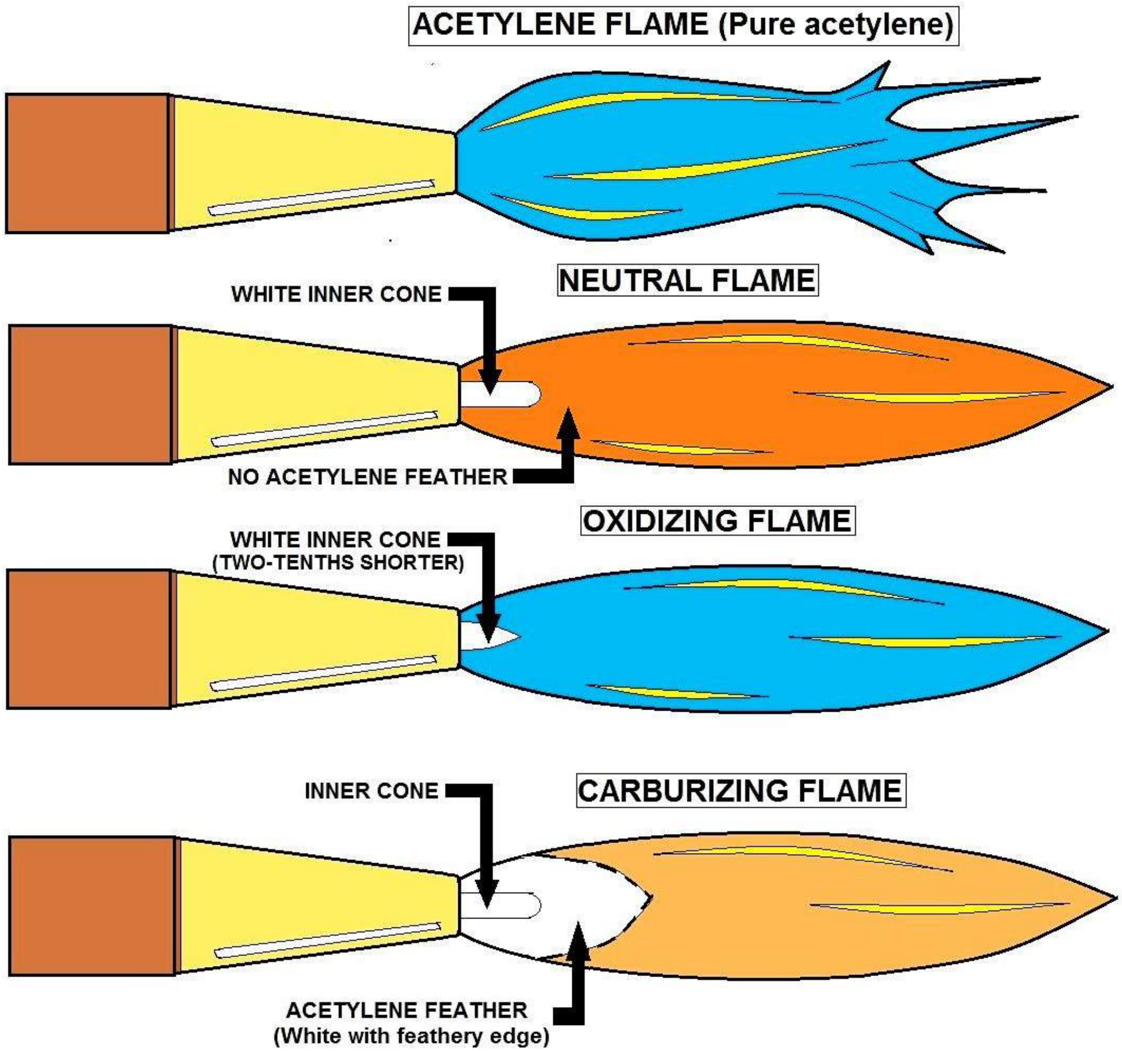
Oxy-Acetylene welding equipment consists of two large tanks (one containing the oxygen and the other containing the acetylene), a regulator assembly at the top of each tank, a pair of hoses leading from the regulators to the torch handle and the torch handle itself. The first thing to do is adjust the line pressure, which is controlled by the large wing nut on the front of each regulator. Close both valves on the torch handle (one controls the oxygen and the other controls the acetylene). Then slowly open the large valves at the top of the tanks. It's a good practice to stand to one side when doing this because the sudden pressure could blow out the face of a defective gauge and send parts flying.

Next, open one valve on the torch handle about a half turn, then screw the regulator wing nut in or out until the line pressure reads about 5psi. Close the valve, and then adjust the other line to the same pressure.

Use a No. 2 or No. 3 welding tip, and begin by experimenting with a piece of scrap metal. The basic idea is to use the torch to create a small puddle of molten metal on the work, then put the end of the welding rod into the puddle. This melts the rod, causing it to mix with the molten metal, which bonds the two pieces together. If you do that correctly, you will have made a good weld. If you don't apply enough heat to get the work to puddle, but instead quickly melt the rod onto the work, the weld will not hold.

If you apply too much heat to a single spot you'll melt away the work entirely, leaving a large hole. Good technique involves adjusting the torch to the correct intensity for the thickness of the work, creating a good puddle, and moving the puddle along at the correct rate as you feed the correct amount of rod. Although we're describing gas welding, the same type of puddling must also occur with arc or MIG welding. A feel for that comes only with practice.

No matter how you try, you cannot make a good weld unless you correctly adjust the torch. The difference between them is caused by the relationship between the amount of oxygen and acetylene, which is controlled by the two valves on the torch handle. The flame you're after is the neutral flame which comes just as the acetylene feather of the carburizing flame disappears into the inner cone.



OXY-ACETYLENE WELDING FLAME ADJUSTMENT DIAGRAM

The correct intensity is determined by the thickness of the work and by how rapidly you move the puddle along. Beginners tend to do better with a lower flame because it allows them to work more slowly.

Angle the flame toward the work with the rod coming in from the opposite direction. Once the puddle forms move the torch in circular or semicircular patterns across the weld as you slowly advance the puddle.

Continue to feed the rod, but don’t force it into the work or it’ll stick. When things start flowing correctly, you’ll know it’s right.

OSHA’s Welding Standard

Specific requirements for assuring the safety of welding, cutting, and brazing operations are covered under OSHA Standard 29 CFR 1910.252. Below are some selected requirements of the standard:

• Compressed gas cylinders must be kept away from radiators and other heat sources and stored upright in a well ventilated, dry location at least 20 feet from highly combustible materials such as oil. Cylinders should be kept away from elevators, stairs, or other spaces where they can be knocked over or damaged.

• Piping systems must be tested and proved gastight at 1 1/2 times the maximum operating pressure, and shall be thoroughly purged with air, before being placed in service. Service piping systems must be protected by pressure relief devices.

• Hoses showing leaks, burns, worn places, or other defects must be repaired or replaced.

• Cutters and welders must be suitably trained in the safe operation of their equipment and the safe use of the process.

• The welder should be enclosed in an individual booth, or by non-combustible screens, that are painted with a finish of low reflectivity such as zinc oxide or lamp black (to absorb ultraviolet radiation).

Other people next to the welding area must be protected by noncombustible or flameproof screens or be required to wear appropriate goggles. The booths or screens should permit circulation of air at the floor level.

• All movable fi re hazards in the vicinity of welding operations must be taken to a safe place. If all the fire hazards cannot be moved, guards must be used to contain the heat, sparks, and slag.

• Suitable fi re extinguishing equipment must be maintained ready for instant use.

• Firewatchers are required whenever welding or cutting is performed in a location where other than a minor fire might develop. A fire watch must be maintained for at least 1/2 hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires.

• No welding, cutting, or other hot work shall be performed on used drums, barrels, tanks, or other containers until they have been thoroughly cleaned (a purge with an inert gas is also recommended).

• Eye protection must be used during all arc welding or arc cutting operations, gas welding, oxygen cutting, resistance welding, or brazing operations (the proper shade number should be selected).

• When a welder must enter a confined space through a manhole or other small opening, an attendant with a pre-planned rescue procedure must be stationed outside to observe the welder at all times and to put the rescue operation into effect, if necessary.

• Special ventilation and/or respirators are required in confined spaces, for cleaning compounds, when fluorine compounds, zinc, lead, beryllium, cadmium, and mercury are encountered, and when cutting stainless steel.

• Warning labels are required for all filler metals and fluxes containing fluorine compounds (fluorides).

Hot Work Section

All hot work shall be performed in a Designated Hot Work Area, if possible.
A **Designated Hot Work Area** must meet the following requirements:

- ✓ The Designated Hot Work Area shall be a discrete area, sectioned off by noncombustible walls, or curtains.

- ✓ Adequate ventilation, such as a suction hood system providing 20 air changes per hour, should be provided for the work area.

- ✓ Where welding, cutting and brazing are done near walls, partitions, ceilings, or a roof of combustible construction, fire-resistant shields or guards shall be provided to prevent ignition.

- ✓ Protective dividers such as welding curtains or non-combustible walls will be provided to contain sparks and slag to the combustible free area.

- ✓ Flammable and combustible liquids and material will be kept 35 feet from work area.

- ✓ Floors shall be swept and clean of combustibles within 35 feet of work area.

- ✓ At least one 10 lb. dry chemical fire extinguisher should be within access of the 35 feet of work area.

Hot Work in areas not designated as Hot Work Areas.
When welding, cutting, or brazing work is to be done outside of a Designated Hot Work Area, it is necessary to meet the following requirements:

- ✓ A Hot Work Permit is required for all Hot Work.
- ✓ Flammable materials that cannot be removed from the area must be adequately covered or guarded before hot work is started.
- ✓ All floor openings and cracks shall be closed, sealed and/or covered to ensure that sparks cannot drop into the openings and come into contact with combustible materials.
- ✓ Guards, shields, and or fire-blankets shall be used to confine the heat, sparks and/or slag from coming into contact with any combustible material with 35 feet of the hot work
- ✓ Portable welding curtains or shields must be used to protect other workers in the welding area.
- ✓ Airflow away from the welder and others present must be established and maintained.
- ✓ Plastic materials must be covered with welding tarps during welding procedures.
- ✓ Suitable fire extinguishing equipment shall be maintained in a state of readiness at all times for instant use. This may include fire extinguishers, water hoses or buckets of sand, depending on the nature of the combustible material exposed.

Brazing Section

Brazing is a popular form of welding. It is an excellent way to join two metals. Fillers are brought to high temperatures – usually above 800 degrees Fahrenheit – and join work pieces together by flowing into the spaces between them and cooling. A flux is often used to protect atmosphere around the work area. There are many techniques for brazing that a welder can choose from.

Torch Brazing
Brazing, often discussed with welding, actually is a fundamentally different process. It's more like heavy-duty soldering using bronze rods instead of solder. The underlying metals are not melted, so it requires substantially less heat than welding processes, which do melt and fuse underlying metals. Mild (low carbon) steel and cast iron include a large percentage of iron, and their composition makes them ideal candidates for brazing.

If you're brand new to metalwork, then brazing is a good way to gain experience without spending a lot of money. It's useful for repairing lightweight machinery parts, thin metal railings and gates, or sheet-metal items such as wheelbarrow pans or steel lawn mower decks.

The technique is simple: Hold a torch in one hand and a bronze rod in the other. Heat the metal parts you're joining to red-hot. Touch the bronze rod to the heated metal so it melts and flows between the parts, forming a strong bond as it cools. Brazing is ideal for metals up to about a quarter-inch thick.

Standard propane torches don't generate enough heat for brazing, but an inexpensive oxygen/propane or oxygen/MAPP gas torch will do the job nicely. These torches cost less than $150 and work quite well for ferrous metals less than an eighth of an inch thick. Either is great starter equipment and easily portable. You'll find them rather expensive to operate for larger jobs, especially for the oxygen. It's the more expensive of the two gases, and the torch uses it much more quickly than the combustible gas. You'll get approximately 20 minutes of brazing time from a disposable cylinder of oxygen that costs about $20-25.

Soldering, Brazing, and Welding Tips

Soldering with a propane torch is the easiest way to join copper and brass. You can even use solder to join copper or brass to stainless steel, you just need the proper flux. But there are a couple tips to keep in mind to make it work right the first time:

1. Use a liquid flux instead of a paste flux. The paste flux tends to leave tacky residue that is difficult to clean off. If you must use a paste flux, use it sparingly.
2. Use plumbing (silver) solder only. Do not use electrical or jeweler's solder because these often contain lead or cadmium. These are toxic metals.
3. Apply solder separately to each of your parts before joining them. This practice is known as "tinning" and makes joining the parts easier.
4. Heat the parts, not the solder. Play the flame all around the joint to get it good and hot before you apply the solder. This allows the solder to flow evenly over the joint.

Brazing is like soldering but it is done at higher temperatures and is applicable to more metals. It can readily join stainless steel to itself, and is an alternative to welding. The recommended filler rod for brewing service is AWS type BAg-5, and its temperature range 1370-1550°F (743-843°C). While brazing can provide a stronger joint, the high brazing temperatures can be bad for stainless steel. At those temperatures, carbon in the stainless steel can form chromium carbides which takes the chromium out of solution, making the steel non-stainless near the joint. This area is prone to rust and cracking after it is in service. The problem cannot be fixed by re-passivation so it is best to avoid excessively heating the parts during the braze and keep the total time at temperature to four minutes or less. Propane torches are usually not adequate for brazing. You will need to use MAPP gas or acetylene.

Types of Brazing

Torch brazing is the most common form of mechanized brazing. In some countries it is the method used for the majority of the brazing that is done. Specialized operations or small production volumes are often where this method is used. The three categories of torch brazing are machine, manual, and automatic.

Manual torch brazing has heat applied with a gas flame near or on the joint. It can be a hand held torch or held in a fixed position, depending on the method. Usually it is used where other methods are impossible or for small production volumes. Flux is required. Machine torch brazing is used when the operation is repetitive. It is a mix of manual and automated methods and uses flux, reduces the cost and works for small to medium production projects. Automatic torch brazing has a high production rate, reduced costs, and a uniform braze quality. A worker is needed just for unloading and loading the machine.

Furnace Brazing
This method is semi-automatic and is used in industrial operations. It can produce large numbers of small parts, has a controlled heat cycle, and post braze cleaning is not needed. To prevent oxidation, inert, vacuum, or reducing atmospheres are used. It is cost efficient to run but uses a lot of power compared to other methods, is more difficult to design, and the equipment is expensive. The kinds of furnaces used are batch type, vacuum, retort with controlled atmosphere, and continuous.

Batch type furnaces have relatively low costs and heat each load separately. It can be turned on and off easily, has a large degree of flexibility, and is suited to medium or large productions. Flux or a controlled atmosphere can be used. Vacuum furnaces are fairly economical, work well with such oxides as aluminum or titanium, and is often used with refractory materials or alloys that can't be brazed in atmosphere furnaces. It is vital to clean because there is no protective atmosphere. Continuous type furnaces work by making a steady flow of parts go through the furnace on a conveyor. These are good for large productions. Retort-type furnaces have a sealed lining where the atmosphere can be completely changed inside and is best for semi-continuous or batch productions and alloys that resist oxidation.

Silver Brazing
This method uses silver alloy based filler for brazing. It is also known as hard soldering or silver soldering. The silver alloys have a lot of variety and different percentages of silver and other metals in them, such as cadmium, zinc, and copper. A special method of silver brazing is pin brazing (pinbrazing). It is used especially for cathodic protection installations or for connecting cables to railway track. It can be used in the tool industry to do such jobs as fasten hardmetal (like carbide) to such tools as saw blades.

Braze Welding
This method uses a brass or bronze filler rod that is coated with flux in order to join steel workpieces. It requires more heat than basic brazing and acetylene or methylacetylene-propadiene (MPS) gas fuel is often used. The name comes from the fact that this method does not have capillary action. Dissimilar metals are able to be joined with this method, there is a reduced need for pre-heating, and minimal heat distortion. However, there is a loss of strength when the work is under high temperatures and it cannot withstand high stress.

Cast Iron "Welding"
Welding cast iron is actually a type of brazing. Filler rods that are mainly nickel are used but there are cast iron rods available. Cast iron is a difficult metal to work with and many find the skill extremely difficult to learn. It is used often in repairs.

Vacuum Brazing
In this technique the brazing process is done inside of a vacuum. There are many advantages such as flux-free joints that are very strong and have high integrity, are superior to other joins and are extremely clean. It can be an expensive process. Residual stresses are greatly reduced because of the slow heating and cooling cycles in this process. The material's thermal and mechanical properties are improved and things such as heat treating or age hardening can be done during the metal joining process. The process is done in a furnace and heat is transferred with radiation.

Dip Brazing
This particular technique is very suited for brazing aluminum because there is no air and therefore no oxidation. The brazing compound is usually applied in slurry form and the assembly dropped into a molten salt bath that will work as both a flux and heat transfer.

You can weld in several ways, but all the processes boil down to the same basic premise: Apply enough heat to melt metal parts so they fuse together, and then let the weld area cool. The heat can come from a burning gas, such as acetylene, or from a high-voltage electric spark that jumps (arcs) from the welding tool to the metal you're welding. Regardless of the heat source, good welds are stronger than the surrounding metal, in part because metal is added to the weld from a rod or wire that melts into it. With the proper equipment and materials, you can weld cast iron, stainless steel, aluminum and other metals.

When it comes to acquiring welding gear, you've got three main options to consider: oxygen/acetylene torches, stick-type electric arc welders and wire-feed electric arc welders. Each option varies in cost, size and effectiveness. The best system for you depends on your expected usage and your budget.

Gas welding is like brazing in that it's done with a torch, but instead of using molten bronze to "glue" metal parts together; welding generates enough heat to actually melt the metal on each side of the joint.

To weld, you use a hand-held steel welding rod that melts, adding metal to the weld pool. This added steel fills gaps and boosts joint strength.

You hold the torch in one hand and the welding rod in the other, then heat the metal parts at the joint line until a pool of molten steel develops.

Move the torch and rod in half-inch diameter circles to keep the weld pool moving along the joint.

You need a really hot flame for gas welding, and that's where the oxygen/acetylene torch comes in. Two cylinders of compressed gas feed this welding system to create an extremely hot, blue flame that's suitable for work with all kinds of ferrous metals.

Oxygen/acetylene torch systems are available for less than $250-300 and include gas regulators, hoses and different torch heads for brazing, welding and cutting. The torch heads used for both brazing and welding are relatively simple.

Oxygen/acetylene torches and hoses include standardized fittings. This means the same set of torches can hook up to a variety of tank sizes. You can get sets ranging from small, portable tanks that fit into a carrying caddy to large, semi-stationary tanks meant for use in a workshop. All but the smallest tanks are available as refillable rental units. You pay an annual leasing fee for the tank, plus the cost of whatever gas you use.

Brazing Tips

Above, A typical oxy-acetylene welding set-up. Be very careful opening the gas gauges, for many have been injured and killed simply by opening the gauges too fast or standing near the gauge's face. You can find the proper gas pressures online for your specific welding or cutting torch's tip. Direct sunlight and heat will affect the tank's pressure and increase acetylene's pressure, an empty tank will seem to have gas if placed in the Sun. Never trust anything or anyone when welding. Below, Starting with the acetylene gas, open the hand valve slightly and strike your striker, adjust the hand valve until you see a little soot, then slowly and gently add Oxygen until you see the inner cone.

Above, The inner cone is being formed. It takes a gentle and careful turning of the Oxygen valve to get this to properly form. Below, You can see the blue flame from the Oxygen, this is too much Oxygen, but can be used if you know how to use a hot flame. The Neutral flame is the preferred starting point. Notice the blue-green shirt or jacket, this is 1000 percent cotton designed for light welding and will protect the arms and chest from most fires and sparks from small welding jobs. There is also a leather sleeved cotton jacket available.

MIG Welding Section

MIG welding is an abbreviation for Metal Inert Gas Welding. It is a process developed in the 1940's, and is considered semi-automated. This means that the welder still requires skill, but that the MIG welding machine will continuously keep filling the joint being welded. MIG welders consist of a handle with a trigger controlling a wire feed, feeding the wire from a spool to the weld joint. The wire is similar to an endless bicycle brake cable. The wire runs through the liner, which also has a gas feeding through the same cable to the point of arc, which protects the weld from the air.

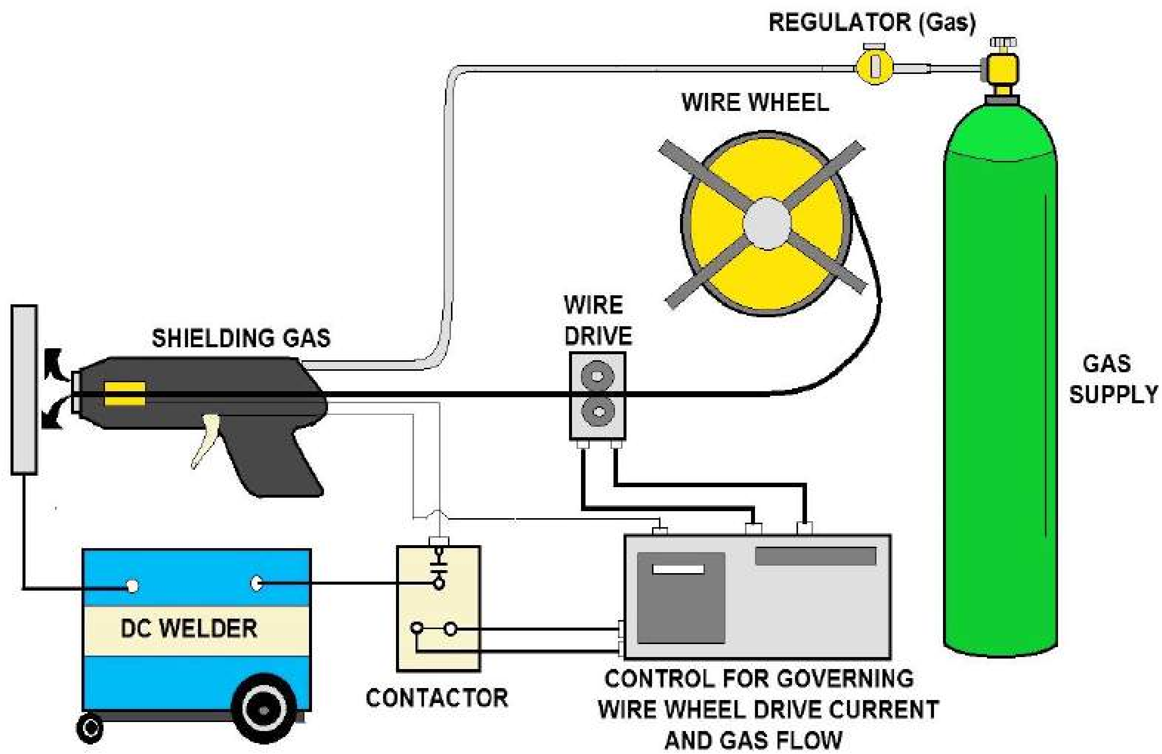
MIG welding is most commonly used in fabrication shops where production is high, and the possibility of wind blowing away your gas shielding is unlikely.

MIG welding is by far the easiest to learn. With a few minutes of practice, you'll be making professional welds. MIG welding is similar to arc welding, but the wire is automatically fed from the end of the gun at a preset rate. A gas bottle provides gas, which is expelled from the end of the gun to shield the weld from the ambient atmosphere and avoid the oxidation caused by oxygen. You can make unshielded welds (without gas), but the welds will be highly oxidized which will make them weak and brittle. If your system is not equipped with gas, you must use flux cored wire to avoid highly oxidized welds. The key to good MIG welding is to set the wire feed-rate and the electric arc intensity at the correct values for the material. You can do this only by experimentation.

The size of the wire in MIG welding is also important, and the tip must match the wire size. Follow the instructions that came with your machine. Your machine will probably come with tips and wire for thin-wall material (roughly 0.0625 to 0.120 inch thick). You might have to buy larger wire and the appropriate tip for thicker material..

MIG Welding Names

When it was first developed it was called (GMA) Gas Metal Arc. It is also known as; GMAW or Gas Metal Arc Welding. Technically the differences in the names are the type of gas used, Inert gas versus non-inert gas.



MIG WELDING PROCESS DIAGRAM

How MIG Welding Works

MIG weld welding requires three things, electricity to produce heat, an electrode to fill the joint, and shielding gas to protect the weld from the air. MIG welding is done using a very small electrode that is fed continuously, while the operator controls the amount of weld being done. In some cases when a robot takes over this process, it becomes automatic welding.

MIG Voltage Type and Welding Polarity

MIG welding unlike most other welding processes has one standard voltage type and polarity type. The voltage used is D/C direct current, much like the current in a car battery. Direct current flows in one direction, from the negative (-) to the positive (+).

The polarity used is also standard and that is D/C electrode (+) positive. This means that the handle is the positive side of the circuit, or it may be said, the electricity flows from the metal in to the welding handle.

The power source used for MIG welding is called a “constant voltage power supply”. In MIG welding the voltage is what is controlled and adjusted. When comparing MIG welding to Arc or TIG welding, MIG welding machines use voltage settings to set the machine. TIG and Arc welding machines use amperage to set the machine or a “constant amperage power supply”.

MIG Welding Equipment and Accessories
MIG Electrode Types
When choosing the proper MIG wire or electrode you need to match the type of wire to the type of metal being welded. Some other considerations are the type of transfer, position to be welded, and resistance to abrasion. Most of the times when working as a welder the welding engineers specify the weld size and electrode type to be used.

The most common wire used for welding carbon steel is ER 70S-6. In some cases you can weld two different metals together. An example of this is welding 304 stainless steel to A36 carbon steel using an electrode made of 309 stainless steel “ER 309L”.

Typical MIG welding electrodes are a solid wire ranging from a thickness of .023 to .045. Some are much thicker for heavy industrial applications. The most common sizes are:
- .023
- .030
- .035
- .045

The manufactures of these electrodes use a standard code to identify the type of electrode. For example the code on the label ER 70S-6 represents the following:
- ER- An electrode or filler rod that is used in either a wire feed or TIG welding.
- 70- A minimum of 70,000 pounds of tensile strength per square inch of weld.
- S -Solid wire.
- 6- The amount of deoxidizing agent and cleansing agent on the electrode.

MIG Welding Gasses
MIG welding requires a shielding gas to be used. As the name states “Metal Inert Gas Welding” there is no shielding on the electrode or filler wire. MIG welding would not be possible without shielding gas. The way the shielding gas works is it is feed through the MIG gun and it literally suffocates the weld area from any air. This provides an air free zone where the welding arc and filler wire can do their work to get the joint welded.

MIG welding typically three types of gas for shielding and they are:
- Argon
- Carbon Dioxide
- Helium

These three gases are typically used as a mixture depending on the metals that are being welded. The shielding gas needs to be matched to the electrode and base metal. If they are not compatible then the welds will either not be strong or it just won’t weld properly.

The type of gas uses also determines:

- How deep the weld penetrates the metal welded
- The characteristics of the welding arc
- The mechanical properties of the weld.

When choosing the type of gas to be used, it is best to seek input from a welding supply store. The store will recommend the proper gas to match the welding wire to be used.

Transfer Types

MIG welding has four ways of transferring the wire to the joint.

- Short circuit
- Globular
- Spray
- Pulsed spray

The transfer types used to MIG weld are determined by the metal type, shielding gas used and machine settings. MIG welding transfer types are more of a machine set-up issue then a welding issue.

Almost any Metal may be MIG Welded

MIG welding is a welding process that can weld almost any metal. It may not always be the best choice for weld quality but MIG welding is a fast, cost efficient, and produces results that are more than acceptable for most manufacturing and fabrication needs! Not everybody is building a space station.

The three most common metals welded with a MIG welder are:

- Carbon steel.
- Stainless steel.
- Aluminum, with a special feeder because aluminum wire is very soft.

MIG Welding Carbon Steel

Carbon steel welds are almost flawlessly done with a MIG welder. There are very few problems, beside the downside of the design of a MIG welding machine. The wire stiffness is just right to pass through the liner from the machine with minimal friction to cause problems and has enough stiffness to be feed without coiling up. Depending on how much voltage the MIG welding machine is running at, the weld can be set to one of three transfer types, short circuit, globular, or spray.

Joint Setup and Preparation

Metal Preparation

Unlike Stick and Flux-Cored electrodes, which have higher amounts of special additives, the solid MIG wire does not combat rust, dirt, oil or other contaminants very well. Use a metal brush or grinder and clean down to bare metal before striking an arc. Make sure your work clamp connects to clean metal, too; any electrical impedance will affect wire feeding performance. To ensure strong welds on thicker metal, bevel the joint to ensure the weld fully penetrates to the base metal. This is especially important for butt joints.

With MIG welding it is very critical that the weld area is clean. MIG welding will not be successful with a dirty joint. Unlike some stick welding / SMAW rods that can burn through rust, MIG welding has a lot of difficulties welding dirtier metals.

It also does not have slag to protect the weld when the gas is gone. When MIG welding make sure you have a clean joint by removing any foreign substance. With MIG welding a slight bit of dirt or rust is Okay but anything more is asking for trouble. MIG welding painted or coated metals does not work well at all.

MIG Equipment Preparation

- Check your cables: Before striking an arc, check your welding equipment to make sure all of the cable connections are tight fitting and free of fraying or other damage.
- Select electrode polarity: MIG welding requires DC electrode positive or reverse polarity. The polarity connections are usually found on the inside of the machine.
- Set gas flow: Turn on the shielding gas and set the flow rate to 20 to 25 cubic feet per hour. If you suspect leaks in your gas hose, apply a soapy water solution and look for bubbles. If you spot a leak, discard the hose and install a new one.
- Check tension. Too much or too little tension on either the drive rolls or the wire spool hub can lead to poor wire feeding performance. Adjust according to your owner's manual.
- Inspect consumables. Remove excess spatter from contact tubes, replace worn contact tips and liners and discard the wire if it appears rusty.

Wire Selection

For steel, there are two common wire types. Use an AWS classification ER70S-3 for all-purpose welding. Use ER70S-6 wire when more deoxidizers are needed for welding on dirty or rusty steel. As for wire diameter, .030-in. diameter makes a good all-around choice for welding a wide range of metal thicknesses in home and motorsports applications. For welding thinner material, use a .023-in. wire to reduce heat input.

For welding thicker material at higher total heat levels, use .035-in. (or .045-in. wire if it's within your welder's output range).

Gas Selection

- ✓ A 75 percent argon/25 percent CO_2 blend (also called "75/25" or "C25") works as the best "all purpose" shielding gas for carbon steel. It produces the least amount spatter, best bead appearance and won't promote burn-through on thinner metals.
- ✓ 100 percent CO_2 provides deeper penetration, but also increases spatter and the bead will be rougher than with 75/25.

Voltage and Amperage

How much voltage and amperage a weld requires depends on numerous variables, including metal thicknesses, type of metal, joint configuration, welding position, shielding gas and wire diameter speed (among others).

MIG Wire Stick-out

Stick-out is the length of unmelted electrode extending from the tip of the contact tube, and it does not include arc length. Generally, maintain a stick-out of 3/8 in. and listen for that "sizzling bacon" sound. If the arc sounds irregular, one culprit could be that your stick-out is too long, which is an extremely common error.

Push or Pull?

- ✓ The push or forehand technique involves pushing the gun away from (ahead of) the weld puddle. Pushing usually produces lower penetration and a wider, flatter bead because the arc force is directed away from the weld puddle.
- ✓ With the drag or backhand technique (also called the, pull or trailing technique), the welding gun is pointed back at the weld puddle and dragged away from the deposited metal. Dragging typically produces deeper penetration and a narrower bead with more buildup.

There's an old saying that goes, "If there's slag, you drag," which means use the drag technique for Stick and Flux Cored welding. When MIG welding mild steel you can use either technique, but note that pushing usually offers a better view and enables you to better direct wire into the joint.

Travel Angle

Travel angle is defined as the angle relative to the gun in a perpendicular position. Normal welding conditions in all positions call for a travel angle of 5 to 15 degrees. Travel angles beyond 20 to 25 degrees can lead to more spatter, less penetration and general arc instability.

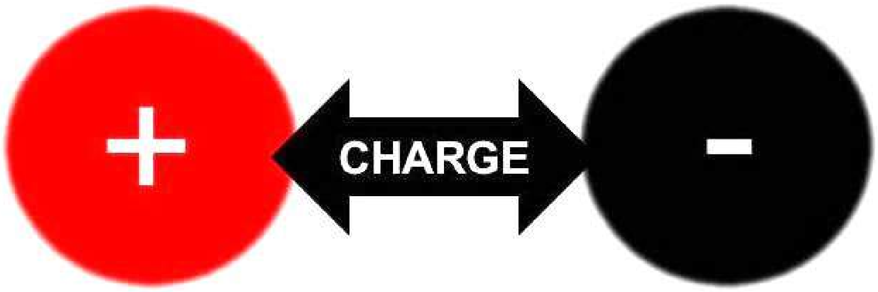
MIG Welding Summary

With MIG Welding just like all other welding processes it is the same techniques. Whip, circles, or weave for most joints. The best MIG welders begin as Shielded Metal Arc Welders. They learn the basics on a harder process then pick MIG welding, it then seems like child's play to them. Even though MIG welding is very easy to do, if you do not have basic welding skills the machine set-up can very aggravating.

Carbon steel welds best with MIG because the stiffness of the wire is perfect for the liner. MIG welding is the best choice for spot welding and tack welds. When welding soft metals like aluminum there is special equipment that is needed to be added to the MIG welder. Harder metals like stainless steel work fine on any MIG welding machine as long as you pay attention to keeping the cord straight. Almost any metal can be MIG welded as long as the type of wire and gas are properly chosen.

Most welding techniques that are used for other welding processes still apply here. The whip of a weld, circles, and weaves for wider welds. What changes here is typically the forehand method is used but sometimes the backhand method may be needed. To be an excellent MIG welder the main thing is to master machine set-up. This is the biggest factor when it comes to MIG welding and the one thing many people overlook.

Electric Charge Section
Understanding the Electric Charge



POSTITIVE CHARGE **NEGATIVE CHARGE**

The presence of charge gives rise to an electrostatic force: charges exert a force on each other, an effect that was known, though not understood, in antiquity. A lightweight ball suspended from a string can be charged by touching it with a glass rod that has itself been charged by rubbing with a cloth. If a similar ball is charged by the same glass rod, it is found to repel the first: the charge acts to force the two balls apart. Two balls that are charged with a rubbed amber rod also repel each other.

However, if one ball is charged by the glass rod and the other by an amber rod, the two balls are found to attract each other. These phenomena were investigated in the late eighteenth century by Charles-Augustin de Coulomb, who deduced that charge manifests itself in two opposing forms. This discovery led to the well-known axiom: like-charged objects repel and opposite-charged objects attract.

The force acts on the charged particles themselves, hence charge has a tendency to spread itself as evenly as possible over a conducting surface. The magnitude of the electromagnetic force, whether attractive or repulsive, is given by Coulomb's law, which relates the force to the product of the charges and has an inverse-square relation to the distance between them.

The electromagnetic force is very strong, second only in strength to the strong interaction, but unlike that force it operates over all distances. In comparison with the much weaker gravitational force, the electromagnetic force pushing two electrons apart is 10^{42} (10 to the 42 power) times that of the gravitational attraction pulling them together.

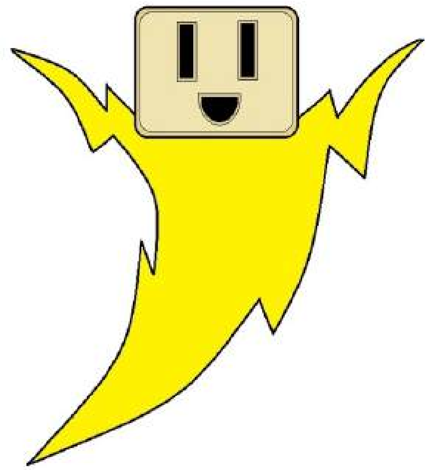
Study has shown that the origin of charge is from certain types of subatomic particles which have the property of electric charge. Electric charge gives rise to and interacts with the electromagnetic force, one of the four fundamental forces of nature. The most familiar carriers of electrical charge are the electron and proton.

Experiment has shown charge to be a conserved quantity, that is, the net charge within an isolated system will always remain constant regardless of any changes taking place within that system. Within the system, charge may be transferred between bodies, either by direct contact, or by passing along a conducting material, such as a wire.

The informal term static electricity refers to the net presence (or 'imbalance') of charge on a body, usually caused when dissimilar materials are rubbed together, transferring charge from one to the other.

Electric Current
The movement of electric charge is known as an electric current, the intensity of which is usually measured in amperes. Current can consist of any moving charged particles; most commonly these are electrons, but any charge in motion constitutes a current.

By historical convention, a positive current is defined as having the same direction of flow as any positive charge it contains, or to flow from the most positive part of a circuit to the most negative part.



Current defined in this manner is called conventional current. The motion of negatively charged electrons around an electric circuit, one of the most familiar forms of current, is thus deemed positive in the opposite direction to that of the electrons. However, depending on the conditions, an electric current can consist of a flow of charged particles in either direction, or even in both directions at once. The positive-to-negative convention is widely used to simplify this situation.

The process by which electric current passes through a material is termed electrical conduction, and its nature varies with that of the charged particles and the material through which they are travelling.

Examples of electric currents include metallic conduction, where electrons flow through a conductor such as metal, and electrolysis, where ions (charged atoms) flow through liquids, or through plasmas such as electrical sparks.

While the particles themselves can move quite slowly, sometimes with an average drift velocity only fractions of a millimeter per second, the electric field that drives them itself propagates at close to the speed of light, enabling electrical signals to pass rapidly along wires.

Current causes several observable effects, which historically were the means of recognizing its presence. That water could be decomposed by the current from a voltaic pile was discovered by Nicholson and Carlisle in 1800, a process now known as electrolysis. Their work was greatly expanded upon by Michael Faraday in 1833. Current through a resistance causes localized heating, an effect James Prescott Joule studied mathematically in 1840.

One of the most important discoveries relating to current was made accidentally by Hans Christian Ørsted in 1820, when, while preparing a lecture, he witnessed the current in a wire disturbing the needle of a magnetic compass. He had discovered electromagnetism, a fundamental interaction between electricity and magnetics.

The level of electromagnetic emissions generated by electric arcing is high enough to produce electromagnetic interference, which can be detrimental to the workings of adjacent equipment.

Electric Shock

Electric shock occurs upon contact of a (human) body part with any source of electricity that causes a sufficient current through the skin, muscles, or hair. Typically, the expression is used to describe an injurious exposure to electricity. Very small currents can be imperceptible. Larger current passing through the body may make it impossible for a shock victim to let go of an energized object. Still larger currents can cause fibrillation of the heart and damage to tissues. Death caused by an electric shock is called electrocution. Wiring or other metalwork which is at a hazardous voltage which can constitute a risk of electric shock is called "live", as in "live wire".

Magnitude
The minimum current a human can feel depends on the current type (AC or DC) and frequency. A person can feel at least 1 mA (rms) of AC at 60 Hz, while at least 5 mA for DC. At around 10 milliamperes, AC current passing through the arm of a 68 kg (150 lb) human can cause powerful muscle contractions; the victim is unable to voluntarily control muscles and cannot release an electrified object. This is known as the "let go threshold" and is a criterion for shock hazard in electrical regulations.

The current may, if it is high enough, cause tissue damage or fibrillation which leads to cardiac arrest; more than 30 mA of AC (rms, 60 Hz) or 300 – 500 mA of DC can cause fibrillation. A sustained electric shock from AC at 120 V, 60 Hz is an especially dangerous source of ventricular fibrillation because it usually exceeds the let-go threshold, while not delivering enough initial energy to propel the person away from the source. However, the potential seriousness of the shock depends on paths through the body that the currents take.

If the voltage is less than 200 V, then the human skin, more precisely the stratum corneum, is the main contributor to the impedance of the body in the case of a macroshock—the passing of current between two contact points on the skin. The characteristics of the skin are non-linear however. If the voltage is above 450–600 V, then dielectric breakdown of the skin occurs. The protection offered by the skin is lowered by perspiration, and this is accelerated if electricity causes muscles to contract above the let-go threshold for a sustained period of time.

If an electrical circuit is established by electrodes introduced in the body, bypassing the skin, then the potential for lethality is much higher if a circuit through the heart is established. This is known as a microshock. Currents of only 10 μA can be sufficient to cause fibrillation in this case.

Signs and Symptoms
Burns
Heating due to resistance can cause extensive and deep burns. Voltage levels of 500 to 1000 volts tend to cause internal burns due to the large energy (which is proportional to the duration multiplied by the square of the voltage divided by resistance) available from the source. Damage due to current is through tissue heating. For most cases of high-energy electrical trauma, the Joule heating in the deeper tissues along the extremity will reach damaging temperatures in a few seconds.

Arc-flash Hazards
The arc flash in an electrical fault produces the same type of light radiation from which electric welders protect themselves using face shields with dark glass, heavy leather gloves, and full-coverage clothing. The heat produced may cause severe burns, especially on unprotected flesh.

The *arc blast* produced by vaporizing metallic components can break bones and damage internal organs. The degree of hazard present at a particular location can be determined by a detailed analysis of the electrical system, and appropriate protection worn if the electrical work must be performed with the electricity on.

Body Resistance
The voltage necessary for electrocution depends on the current through the body and the duration of the current. Ohm's law states that the current drawn depends on the resistance of the body. The resistance of human skin varies from person to person and fluctuates between different times of day.

The NIOSH states "Under dry conditions, the resistance offered by the human body may be as high as 100,000 Ohms. Wet or broken skin may drop the body's resistance to 1,000 Ohms," adding that "high-voltage electrical energy quickly breaks down human skin, reducing the human body's resistance to 500 Ohms."

Point of Entry

- **Macroshock**: Current across intact skin and through the body. Current from arm to arm, or between an arm and a foot, is likely to traverse the heart, therefore it is much more dangerous than current between a leg and the ground. This type of shock by definition must pass into the body through the skin.
- **Microshock:** Very small current source with a pathway directly connected to the heart tissue. The shock is required to be administered from inside the skin, directly to the heart i.e. a pacemaker lead, or a guide wire, conductive catheter etc. connected to a source of current. This is a largely theoretical hazard as modern devices used in these situations include protections against such currents.

Electrocution
The term "electrocution," coined about the time of the first use of the electric chair in 1890, originally referred only to **electr**ical exe**cution** (from which it is a portmanteau word), and not to accidental or suicidal electrical deaths.

However, since no English word was available for non-judicial deaths due to electric shock, the word "electrocution" eventually took over as a description of all circumstances of electrical death from the new commercial electricity. The word is often used incorrectly as a synonym of electric shock.

Understanding Alternating Current

In alternating current (AC, also ac), the movement of electric charge periodically reverses direction. In direct current (DC, also dc), the flow of electric charge is only in one direction.

AC is the form in which electric power is delivered to businesses and residences. The usual waveform of an AC power circuit is a sine wave. In certain applications, different waveforms are used, such as triangular or square waves. Audio and radio signals carried on electrical wires are also examples of alternating current. In these applications, an important goal is often the recovery of information encoded (or modulated) onto the AC signal.

Occurrences
Natural observable examples of electrical current include lightning, static electricity, and the solar wind, the source of the polar auroras.

Man-made occurrences of electric current include the flow of conduction electrons in metal wires such as the overhead power lines that deliver electrical energy across long distances and the smaller wires within electrical and electronic equipment. Eddy currents are electric currents that occur in conductors exposed to changing magnetic fields. Similarly, electric currents occur, particularly in the surface, of conductors exposed to electromagnetic waves. When oscillating electric currents flow at the correct voltages within radio antennas, radio waves are generated.

In electronics, other forms of electric current include the flow of electrons through resistors or through the vacuum in a vacuum tube, the flow of ions inside a battery or a neuron, and the flow of holes within a semiconductor.

Current Measurement
At the circuit level, there are various techniques that can be used to measure current:

- Shunt resistors
- Hall effect current sensor transducers
- Transformers (however DC cannot be measured)
- Magnetoresistive field sensors

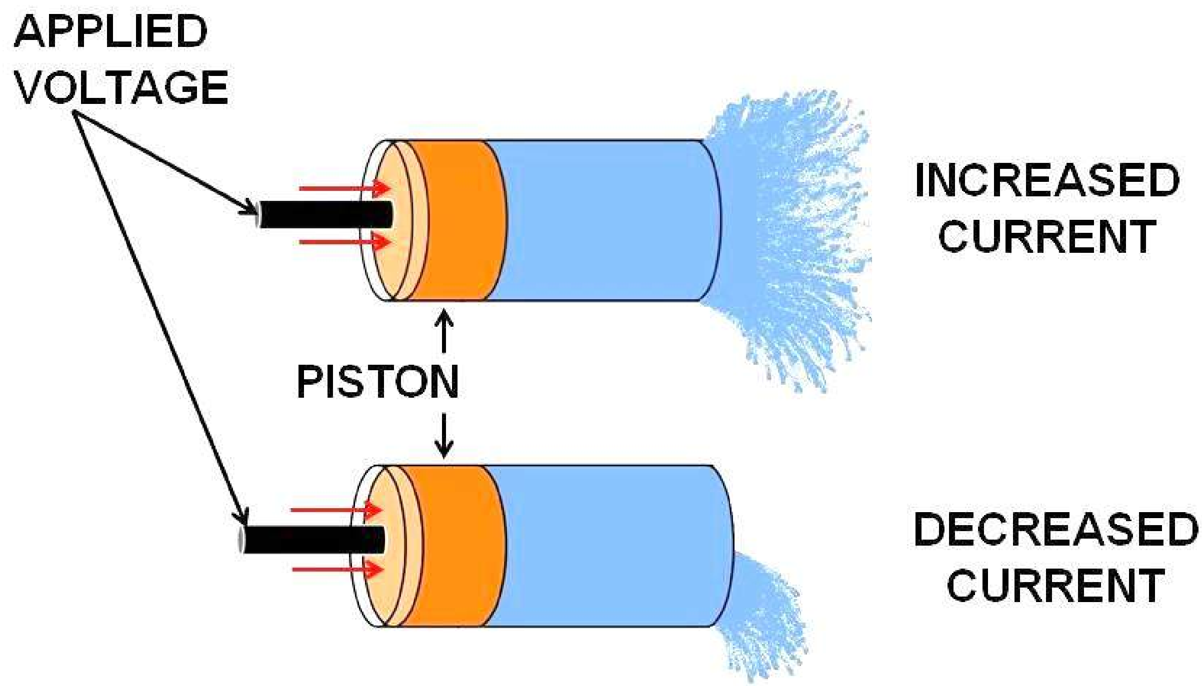
Resistive Heating
Joule heating, also known as *ohmic heating* and *resistive heating*, is the process by which the passage of an electric current through a conductor releases heat. It was first studied by James Prescott Joule in 1841. Joule immersed a length of wire in a fixed mass of water and measured the temperature rise due to a known current through the wire for a 30 minute period. By varying the current and the length of the wire he deduced that the heat produced was proportional to the square of the current multiplied by the electrical resistance of the wire.

$$Q \propto I^2 R$$

This relationship is known as Joule's First Law. The SI unit of energy was subsequently named the joule and given the symbol *J*. The commonly known unit of power, the watt, is equivalent to one joule per second.

Understanding Volts and Voltage

The **volt** (symbol: **V**) is the SI derived unit for electric potential (voltage), electric potential difference, and electromotive force. The volt is named in honor of the Italian physicist Alessandro Volta (1745–1827), who invented the voltaic pile, possibly the first chemical battery.



VOLTAGE AND CURRENT DIAGRAM

Definition
A single volt is defined as the difference in electric potential between two points of a conducting wire when an electric current of one ampere dissipates one watt of power between those points. It is also equal to the potential difference between two parallel, infinite planes spaced 1 meter apart that create an electric field of 1 newton per coulomb.

Additionally, it is the potential difference between two points that will impart one joule of energy per coulomb of charge that passes through it. It can be expressed in terms of SI base units (m, kg, s, and A) as:

$$V = \frac{kg \cdot m^2}{A \cdot s^3}.$$

It can also be expressed as amps × ohms (Ohm's law), power per unit current (Joule's law), or energy per unit charge:

$$\mathrm{V} = \mathrm{A} \cdot \Omega = \frac{\mathrm{W}}{\mathrm{A}} = \frac{\mathrm{J}}{\mathrm{C}}.$$

Josephson Junction Definition

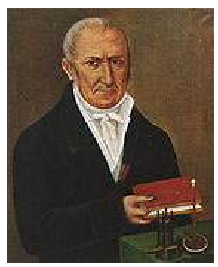
Between 1990 and 1997, the volt was calibrated using the Josephson effect for exact voltage-to-frequency conversion, combined with cesium-133 time reference, as decided by the 18th General Conference on Weights and Measures. The following value for the Josephson constant is used:

$$K_{\{J\text{-}90\}} = 2e/h = 0.4835979 \text{ GHz/μV},$$

where e is the elementary charge and h is the Planck constant.

This is typically used with an array of several thousand or tens of thousands of junctions, excited by microwave signals between 10 and 80 GHz (depending on the array design). Empirically, several experiments have shown that the method is independent of device design, material, measurement setup, etc., and no correction terms are required in a practical implementation.

History



Alessandro Volta

In 1800, as the result of a professional disagreement over the galvanic response advocated by Luigi Galvani, Alessandro Volta developed the so-called Voltaic pile, a forerunner of the battery, which produced a steady electric current. Volta had determined that the most effective pair of dissimilar metals to produce electricity is zinc and silver. In the 1880s, the International Electrical Congress, now the International Electrotechnical Commission (IEC), approved the volt as the unit for electromotive force. They made the volt equal to 10^8 cgs units of voltage, the cgs system at the time being the customary system of units in science. They chose such a ratio because the cgs unit of voltage is inconveniently small and one volt in this definition is approximately the emf of a Daniell cell, the standard source of voltage in the telegraph systems of the day. At that time, the volt was defined as the potential difference [i.e., what is nowadays called the "voltage (difference)"] across a conductor when a current of one ampere dissipates one watt of power.

The international volt was defined in 1893 as 1/1.434 of the emf of a Clark cell. This definition was abandoned in 1908 in favor of a definition based on the international ohm and international ampere until the entire set of "reproducible units" was abandoned in 1948. Prior to the development of the Josephson junction voltage standard, the volt was maintained in national laboratories using specially constructed batteries called standard cells. The United States used a design called the Weston cell from 1905 to 1972.

Understanding Ampere and Amperage

The **Ampere** (SI unit symbol: A; SI dimension symbol: I), often shortened to **amp**, is the SI unit of electric current (quantity symbol: *I*, *i*) and is one of the seven SI base units. It is named after André-Marie Ampère (1775–1836), French mathematician and physicist, considered the father of electrodynamics.

In practical terms, the Ampere is a measure of the amount of electric charge passing a point in an electric circuit per unit time, with 6.241×10^{18} electrons (or one coulomb) per second constituting one ampere.

The practical definition may lead to confusion with the definition of the coulomb (i.e., 1 Ampere-second) and the ampere-hour (A·h), but in practical terms this means that measures of a constant current (e.g., the nominal flow of charge per second through a simple circuit) will be defined in amperes (e.g., "a 20 mA circuit") and the flow of charge through a circuit over a period of time will be defined in coulombs (e.g., "a variable-current circuit that flows a total of 10 coulombs over 5 seconds"). In this way, amperes can be viewed as a flow rate, i.e. number of (charged) particles transiting per unit time, and coulombs simply as the number of particles.

Definition

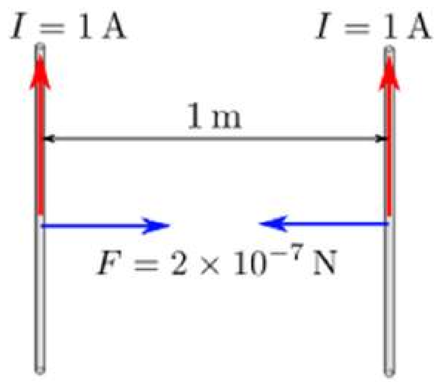


Illustration of the definition of the ampere unit

Ampère's force law states that there is an attractive or repulsive force between two parallel wires carrying an electric current. This force is used in the formal definition of the ampere, which states that it is "the constant current that will produce an attractive force of 2×10^{-7} newton per meter of length between two straight, parallel conductors of infinite length and negligible circular cross section placed one meter apart in a vacuum".

The SI unit of charge, the coulomb, "is the quantity of electricity carried in 1 second by a current of 1 ampere". Conversely, a current of one Ampere is one coulomb of charge going past a given point per second:

$$1 \text{ A} = 1 \frac{\text{C}}{\text{s}}.$$

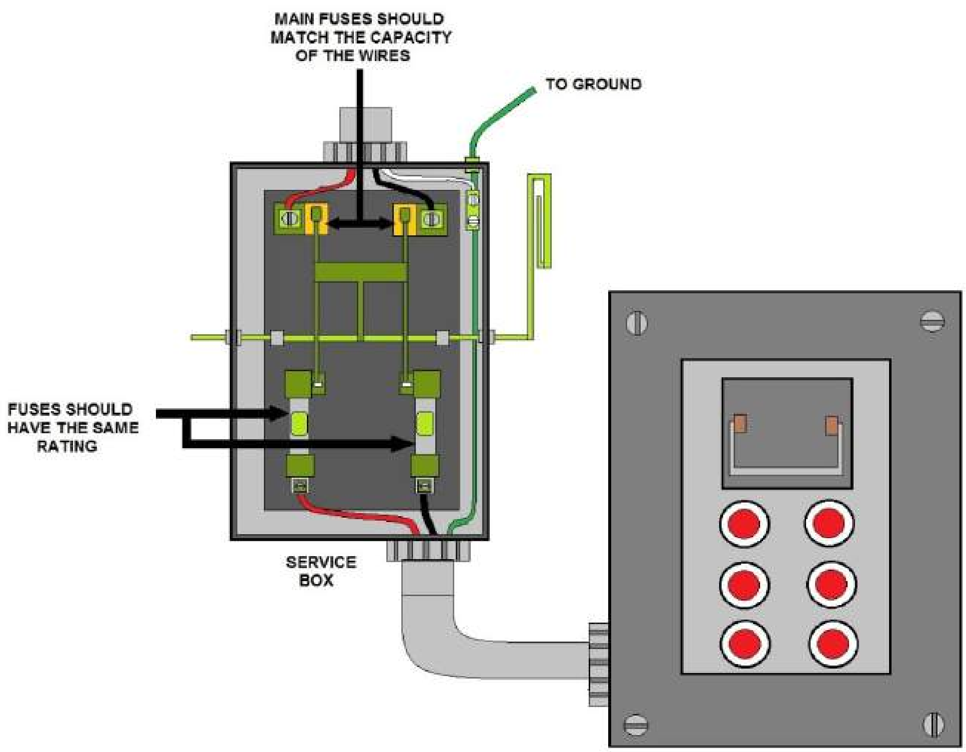
In general, charge *Q* is determined by steady current *I* flowing for a time *t* as *Q* = *It*.

History
The ampere was originally defined as one tenth of the CGS system electromagnetic unit of current (now known as the abampere), the amount of current that generates a force of two dynes per centimeter of length between two wires one centimeter apart. The size of the unit was chosen so that the units derived from it in the MKSA system would be conveniently sized.

The "international ampere" was an early realization of the ampere, defined as the current that would deposit 0.001118 grams of silver per second from a silver nitrate solution. Later, more accurate measurements revealed that this current is 0.99985 A.

Realization
The standard ampere is most accurately realized using a watt balance, but is in practice maintained via Ohm's law from the units of electromotive force and resistance, the volt and the ohm, since the latter two can be tied to physical phenomena that are relatively easy to reproduce, the Josephson junction and the quantum Hall effect, respectively.

At present, techniques to establish the realization of an ampere have a relative uncertainty of approximately a few parts in 10^7, and involve realizations of the watt, the ohm and the volt.



PROPERLY SIZING FUSES DIAGRAM

Electricity Travels in Circuits

Electricity travels in closed loops, or circuits. It must have a complete path before the electrons can move. If a circuit is open, the electrons cannot flow. When we flip on a light switch, we close a circuit. The electricity flows from an electric wire, through the light bulb, and back out another wire.

When we flip the switch off, we open the circuit. No electricity flows to the light. When we turn a light switch on, electricity flows through a tiny wire in the bulb. The wire gets very hot. It makes the gas in the bulb glow. When the bulb burns out, the tiny wire has broken. The path through the bulb is gone.

When we turn on the TV, electricity flows through wires inside the TV set, producing pictures and sound. Sometimes electricity runs motors — in washers or mixers. Electricity does a lot of work for us many times each day.

Testers and How They Work

If the thought of working on an electrical circuit makes you cringe because the circuit may still be on or “hot”, then investing in a multi-meter, voltmeter or a neon-light tester should be your first order of business. These testers are relatively inexpensive and can protect you from electrical shock.

Neon testers, voltmeters and tick-tracers consist of a neon light bulb that is attached to two leads used for checking a circuit. When you press these two leads into an outlet, the bulb will light if the circuit is “hot” or on. If it doesn’t light, then the circuit is “dead” or off. Multi-meters come in analog or digital display. They test voltage, ohms and amperage while displaying the results on a screen or dial.

Always check to see if the tester is working properly by checking a circuit that you know is working properly before moving on. To double-check that an outlet is actually off, remove the outlet cover and test the screws on the sides of the outlet. You can also plug a lamp or vacuum into the outlet just to put your mind at ease.

Outlets and Testing

A typical outlet has three holes built into it. The shorter straight slot is the “hot” lead. The longer straight slot is the “neutral” lead. The slot that looks like a small circle hole is the ground.

To test the ground, test between the “hot” and “ground” slots. If the circuit is working and you have a good “ground” connection, the tester will light. The tester will also light if you test between the “hot” and “neutral” slots.

Plug-in circuit testers are available that will test your circuit for you via three neon lights. They test for an open neutral, lack of a ground, wires on the wrong terminals, and no power.

Switches and Testing

To test a switch, remove the cover plate and check from one of the screws on the side of the switch to the bare copper wire (ground) or the metal box. Keep in mind that the box may not be grounded, especially if it’s a plastic box.

Testing Light Fixtures

When checking light fixture wiring, take down the light and using a "tick-tracer", test the circuit to see if it working. This tester lights when you place it close to a wire that has current flowing through it.

To double-check the circuit, first turn off the power to that circuit. Now, remove the wire nuts from both the black "hot" wires and the white "neutral" wires. Separate these sets of wires so that they are not touching one another.

Turn the circuit back on and check between the black and white wires with the voltmeter or neon tester. Be careful not to touch the exposed wires. The voltmeter should show a reading of around 120 volts. Likewise, the neon tester should light if the circuit is working properly.

One of the easiest ways to check for faulty devices and parts, is to use a multi-tester, sometimes called a multi-meter. Testing continuity by using the ohm setting will tell you if the connection through the device is complete or if it has opened and is no longer usable.

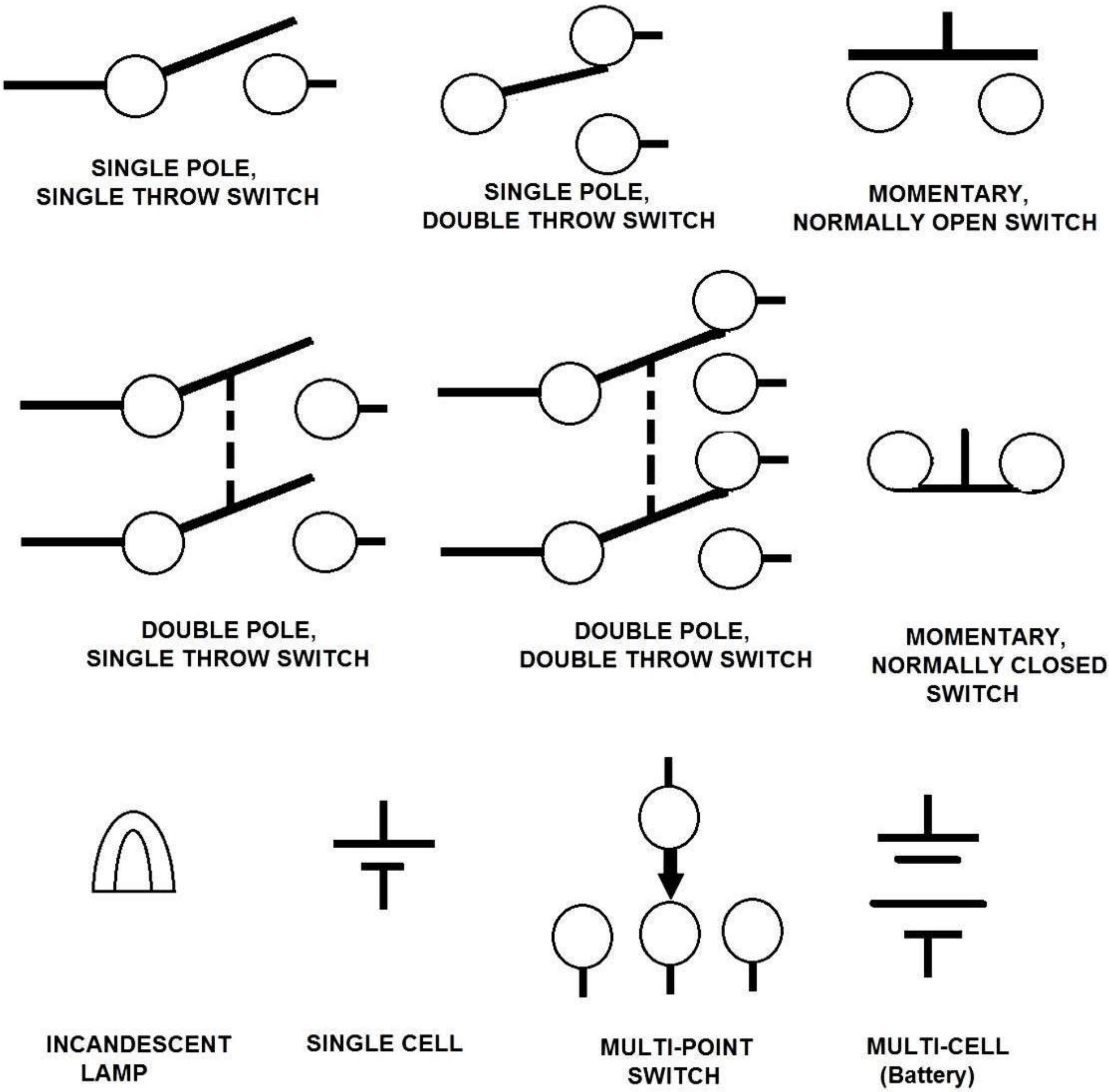
For instance, if you place one of the test leads on one side of a fuse and the other lead on the other side of the fuse, you should show a short circuit or 0 ohms. If your meter shows infinite resistance, the fuse is bad and should be replaced.

To test something, turn the dial of the tester to the ohm setting. This portion of the dial has markings like X1, X10, XK1, etc... This simply means that on the X1 setting, the value of ohms shown on the dial is taken times 1 and that is the amount of ohms.

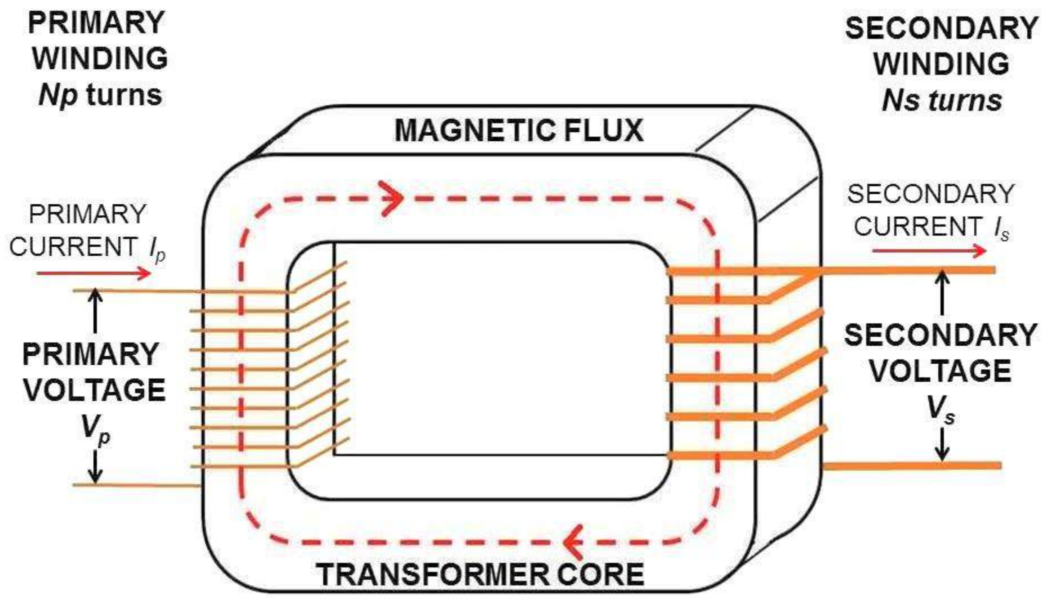
Let's say it shows 50 ohms. That means 50x1=50 ohms. With the dial set at X10, if the dial shows 50, 50x10=500 ohms. You can see the theory here. By adjusting the dial to another setting the multiples increase.

With the test leads apart and not touching, the meter needle should be all the way to the right, showing maximum ohms. On a digital meter, the screen will show infinite resistance.

By touching the two test leads together, either tester should show a 0 ohms reading. The digital will likely show a 0.00 reading. Sometimes meters have an audible continuity setting that looks like a diode. With this setting, when the test leads are touched together, the meter will show the reading and an audible alarm will sound. My tester has a constant beep sound.



COMMON ELECTRICAL SYMBOLS



TRANSFORMER EXAMPLE

Transformers

Help To Move Electricity Efficiently Over Long Distances

To solve the problem of sending electricity over long distances, William Stanley developed a device called a transformer. The transformer allowed electricity to be efficiently transmitted over long distances. This increased delivery range made it possible to supply electricity to homes and businesses located far from the electric generating plant.

The electricity produced by a generator travels along cables to a transformer, which changes electricity from low voltage to high voltage. Electricity can be moved long distances more efficiently using high voltage. Transmission lines are used to carry the electricity to a substation. Substations have transformers that change the high voltage electricity into lower voltage electricity. From the substation, distribution lines carry the electricity to homes, offices, and factories, which require low voltage electricity.

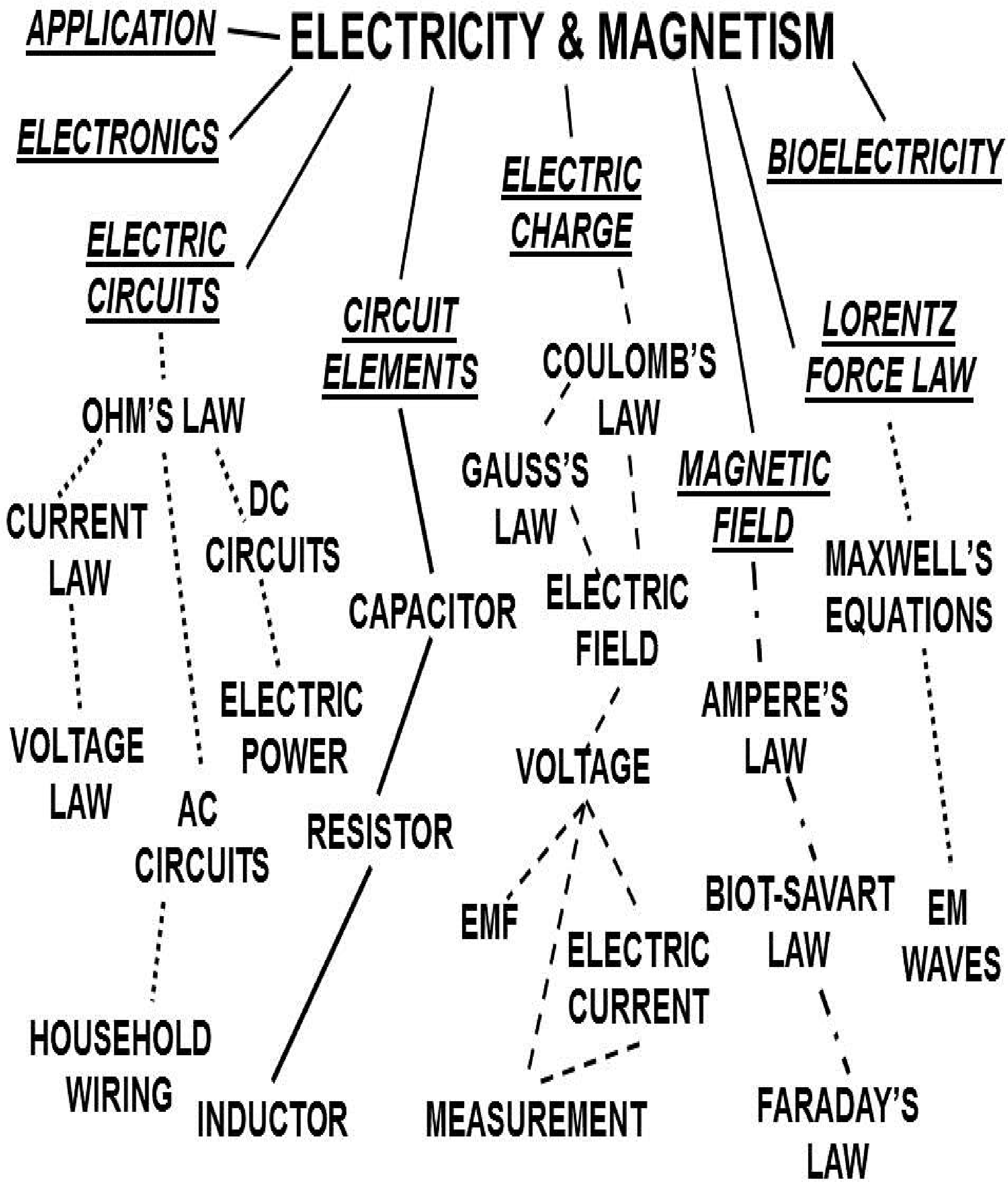
Electricity Is Measured in Watts and Kilowatts

Electricity is measured in units of power called watts. It was named to honor James Watt, the inventor of the steam engine. One watt is a very small amount of power. It would require nearly 750 watts to equal one horsepower. A kilowatt is the same as 1,000 watts.

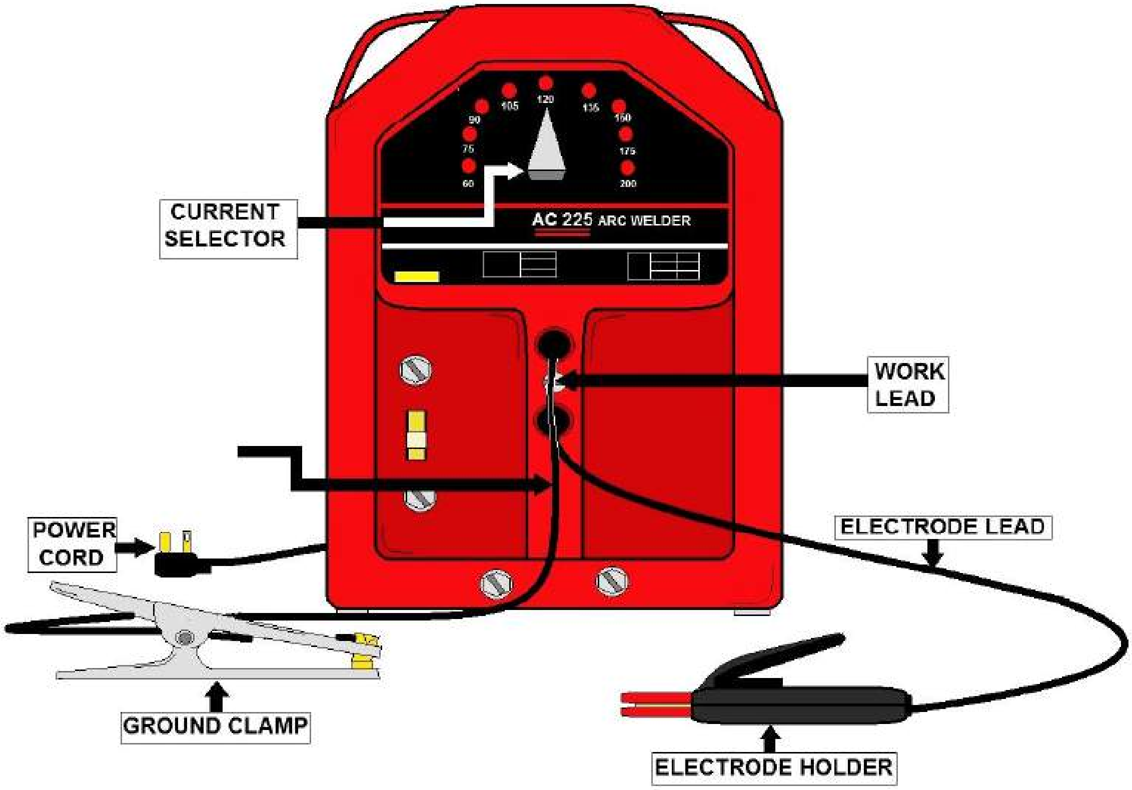
Electricity Use Over Time Is Measured in Kilowatt-hours

A kilowatt-hour (kWh) is equal to the energy of 1,000 watts working for one hour. The amount of electricity a power plant generates or a customer uses over a period of time is measured in kilowatt-hours (kWh). Kilowatt-hours are determined by multiplying the number of kilowatts required by the number of hours of use.

For example, if you use a 40-watt light bulb for 5 hours, you have used 200 watt-hours, or 0.2 kilowatt-hours, of electrical energy.


APPLICATION
ELECTRICITY & MAGNETISM
ELECTRONICS
BIOELECTRICITY
ELECTRIC CHARGE
ELECTRIC CIRCUITS
CIRCUIT ELEMENTS
LORENTZ FORCE LAW
COULOMB'S LAW
OHM'S LAW
GAUSS'S LAW
MAGNETIC FIELD
CURRENT LAW
DC CIRCUITS
MAXWELL'S EQUATIONS
CAPACITOR
ELECTRIC FIELD
ELECTRIC POWER
AMPERE'S LAW
VOLTAGE LAW
VOLTAGE
AC CIRCUITS
RESISTOR
BIOT-SAVART LAW
EM WAVES
EMF
ELECTRIC CURRENT
HOUSEHOLD WIRING
INDUCTOR
MEASUREMENT
FARADAY'S LAW

Arc Welding Section



COMMON ARC WELDER EXAMPLE

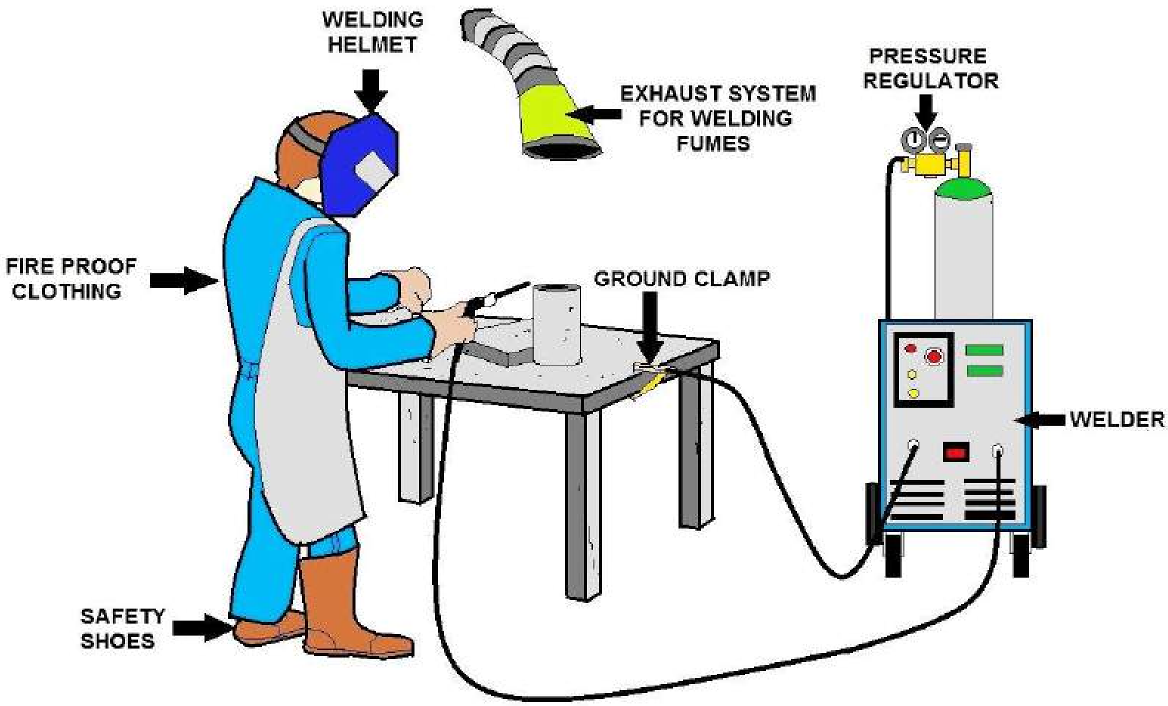
Arc welding is the most widely used form of welding as it is fast and produces strong welds. Arc welding is often used for commercial work. An electric welding machine is used which consists of an electric circuit that produces a high current/low voltage output. The parts to be welded are connected to one terminal of the circuit, and an electrode is connected to the other. The electrode is a rod of filler metal and this metal is usually about the same composition as the metal being worked on.

When the electrode is touched to the workpiece and slightly withdrawn, an arc (like a tiny lightning bolt) is produced. This happens because the two ends of the electric circuit are close enough for the current to jump the gap.

The temperature of the arc is about 5500 degrees C which will melt most metals. As the arc is drawn along the joint, the tip of the electrode melts together with the electrode. The most common form of arc welding is manual shielded metal arc welding.

The electrode is coated with chemicals which partly turn into gas and partly melt in the arc. The melted chemicals are called a slag which forms a protective blanket over the new weld. The gas acts as a shield by keeping out the atmosphere.

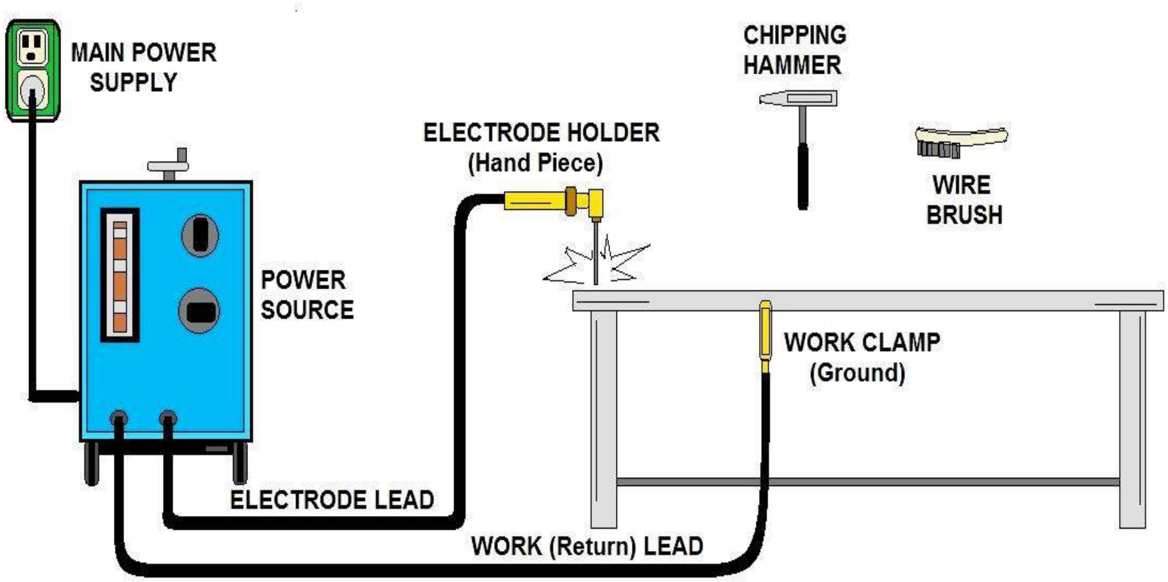
These processes use a welding power supply to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is sometimes protected by some type of inert or semi-inert gas, known as a shielding gas, and filler material is sometimes used as well.



SAFE ARC WELDING STATION EXAMPLE

Arc Power Supply
To supply the electrical power necessary for arc welding processes, a variety of different power supplies can be used. The most common welding power supplies are constant current power supplies and constant voltage power supplies. In arc welding, the length of the arc is directly related to the voltage, and the amount of heat input is related to the current. Constant current power supplies are most often used for manual welding processes such as gas tungsten arc welding and shielded metal arc welding, because they maintain a relatively constant current even as the voltage varies. This is important because in manual welding, it can be difficult to hold the electrode perfectly steady, and as a result, the arc length and thus voltage tend to fluctuate.

Constant voltage power supplies hold the voltage constant and vary the current, and as a result, are most often used for automated welding processes such as gas metal arc welding, flux cored arc welding, and submerged arc welding. In these processes, arc length is kept constant, since any fluctuation in the distance between the wire and the base material is quickly rectified by a large change in current. For example, if the wire and the base material get too close, the current will rapidly increase, which in turn causes the heat to increase and the tip of the wire to melt, returning it to its original separation distance.



BASIC ARC WELDING DIAGRAM

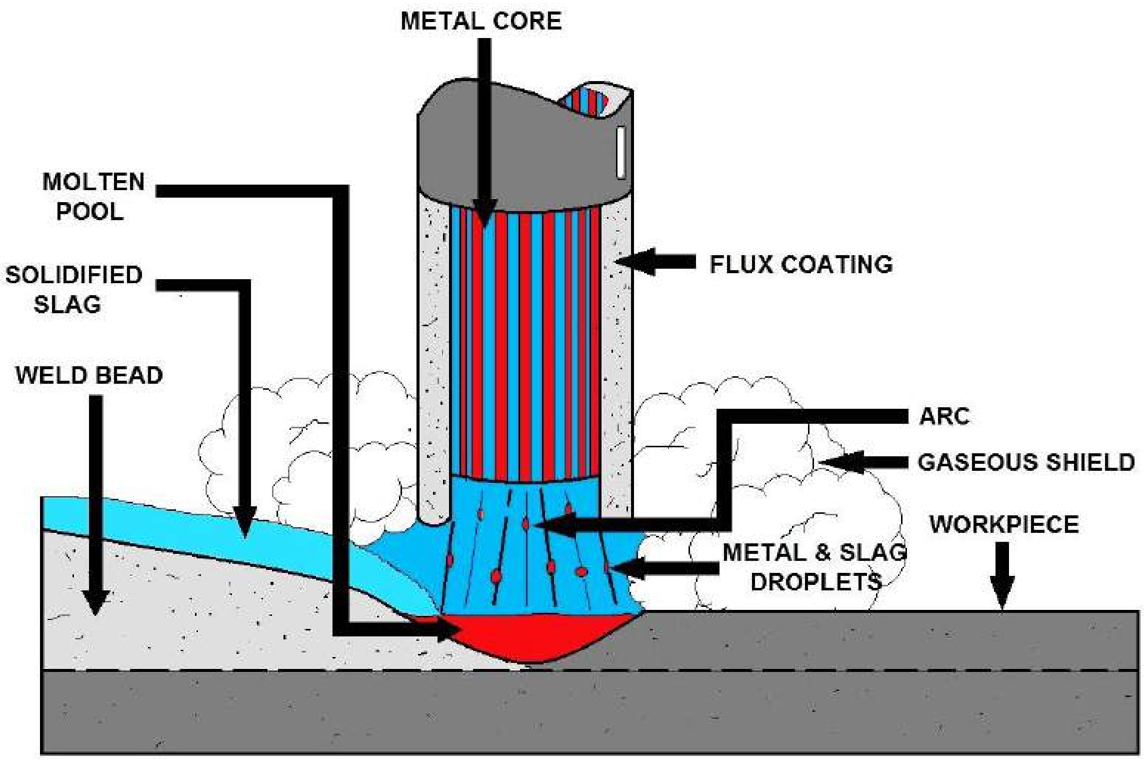
Current and Electrodes

The type of current used plays an important role in arc welding. Consumable electrode processes such as shielded metal arc welding and gas metal arc welding generally use direct current, but the electrode can be charged either positively or negatively. In welding, the positively charged anode will have a greater heat concentration, and as a result, changing the polarity of the electrode has an impact on weld properties.

If the electrode is positively charged, the base metal will be hotter, increasing weld penetration and welding speed. Alternatively, a negatively charged electrode results in more shallow welds.

Nonconsumable electrode processes, such as gas tungsten arc welding, can use either type of direct current, as well as alternating current. However, with direct current, because the electrode only creates the arc and does not provide filler material, a positively charged electrode causes shallow welds, while a negatively charged electrode makes deeper welds. Alternating current rapidly moves between these two, resulting in medium-penetration welds.

One disadvantage of AC, the fact that the arc must be re-ignited after every zero crossing, has been addressed with the invention of special power units that produce a square wave pattern instead of the normal sine wave, making rapid zero crossings possible and minimizing the effects of the problem.



CLOSE-UP VIEW OF ARC WELDING

Different Arc Welding Processes

One of the most common types of arc welding is shielded metal arc welding (SMAW); it is also known as manual metal arc welding (MMA) or stick welding. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of filler material (typically steel) and is covered with a flux that protects the weld area from oxidation and contamination by producing carbon dioxide (CO_2) gas during the welding process. The electrode core itself acts as filler material, making a separate filler unnecessary.

The process is versatile and can be performed with relatively inexpensive equipment, making it well suited to shop jobs and field work. An operator can become reasonably proficient with a modest amount of training and can achieve mastery with experience. Weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding.

Furthermore, the process is generally limited to welding ferrous materials, though special electrodes have made possible the welding of cast iron, nickel, aluminum, copper, and other metals.

Gas metal arc welding (GMAW), also known as metal inert gas or MIG welding, is a semi-automatic or automatic process that uses a continuous wire feed as an electrode and an inert or semi-inert gas mixture to protect the weld from contamination. Since the electrode is continuous, welding speeds are greater for GMAW than for SMAW.

A related process, flux-cored arc welding (FCAW), uses similar equipment but uses wire consisting of a steel electrode surrounding a powder fill material. This cored wire is more expensive than the standard solid wire and can generate fumes and/or slag, but it permits even higher welding speed and greater metal penetration.

Gas tungsten arc welding (GTAW), or tungsten inert gas (TIG) welding, is a manual welding process that uses a nonconsumable tungsten electrode, an inert or semi-inert gas mixture, and a separate filler material. Especially useful for welding thin materials, this method is characterized by a stable arc and high quality welds, but it requires significant operator skill and can only be accomplished at relatively low speeds.

GTAW can be used on nearly all weldable metals, though it is most often applied to stainless steel and light metals. It is often used when quality welds are extremely important, such as in bicycle, aircraft and naval applications.

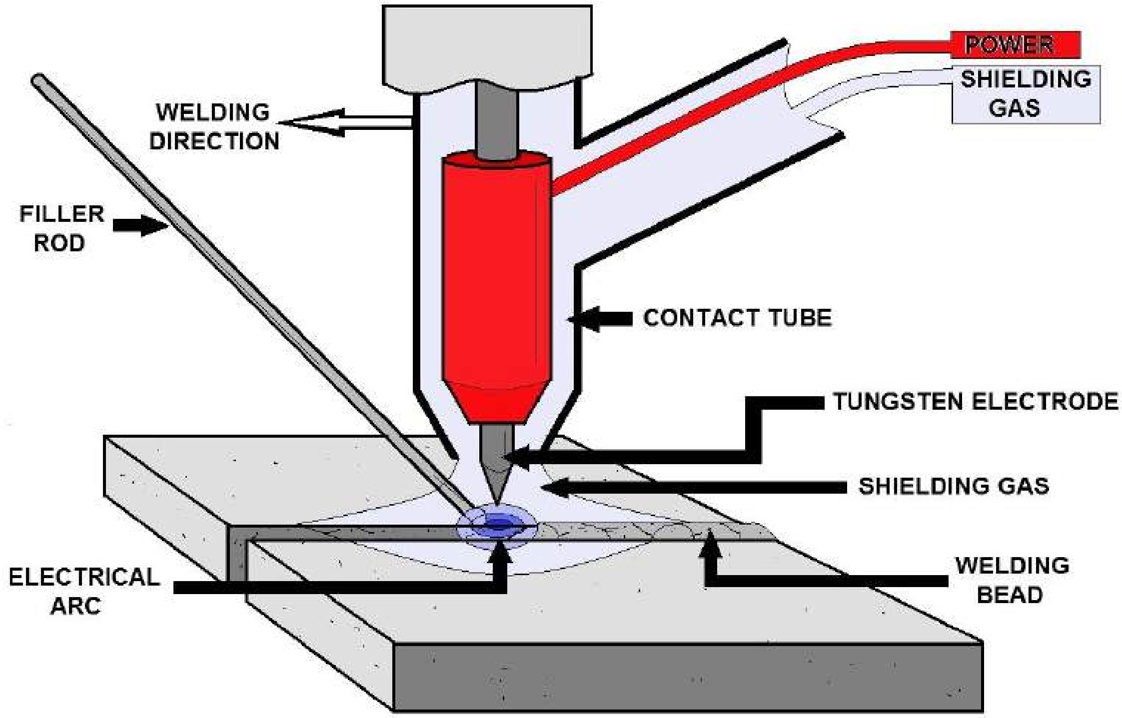
A related process, plasma arc welding, also uses a tungsten electrode but uses plasma gas to make the arc.

The arc is more concentrated than the GTAW arc, making transverse control more critical and thus generally restricting the technique to a mechanized process. Because of its stable current, the method can be used on a wider range of material thicknesses than can the GTAW process and it is much faster. It can be applied to all of the same materials as GTAW except magnesium, and automated welding of stainless steel is one important application of the process. A variation of the process is plasma cutting, an efficient steel cutting process.

Submerged arc welding (SAW) is a high-productivity welding method in which the arc is struck beneath a covering layer of flux. This increases arc quality, since contaminants in the atmosphere are blocked by the flux.

The slag that forms on the weld generally comes off by itself, and combined with the use of a continuous wire feed, the weld deposition rate is high. Working conditions are much improved over other arc welding processes, since the flux hides the arc and almost no smoke is produced.

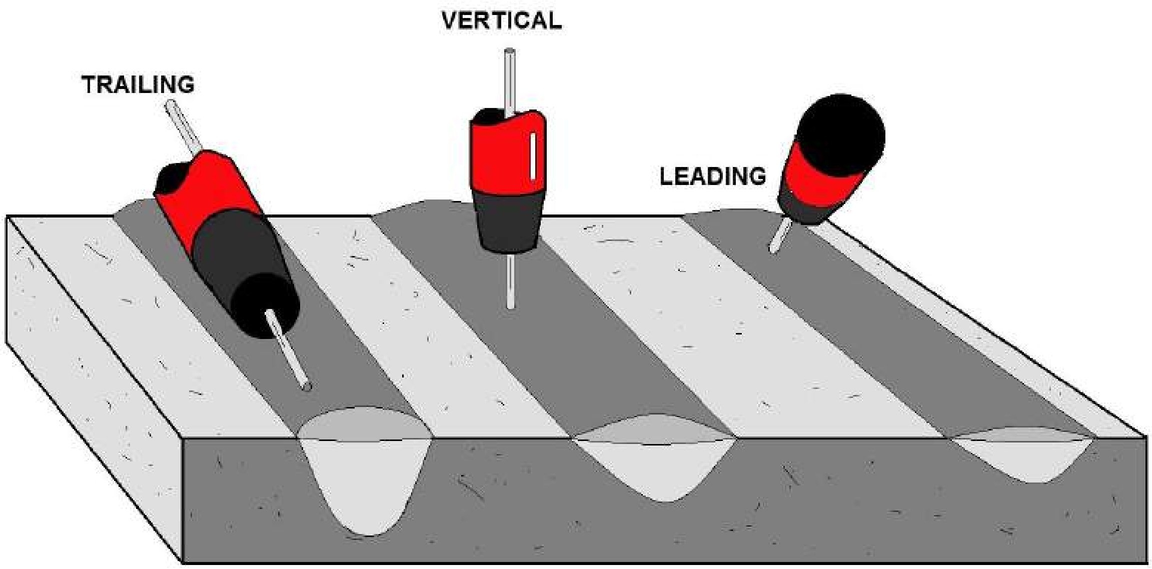
The process is commonly used in industry, especially for large products and in the manufacture of welded pressure vessels. Other arc welding processes include atomic hydrogen welding, electroslag welding, electrogas welding, and stud arc welding.



GAS TUNGSTEN ARC WELDING DIAGRAM

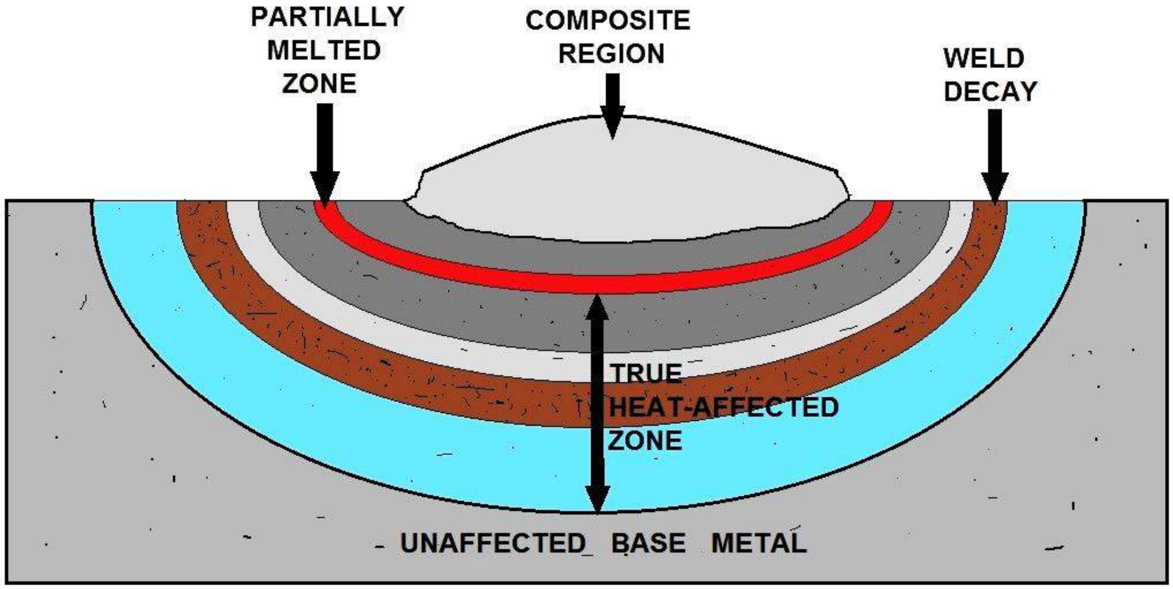
Some of the Best Known Welding Methods include:

- ✓ Shielded metal arc welding (SMAW) - also known as "stick welding", uses an electrode that has flux, the protectant for the puddle, around it. The electrode holder holds the electrode as it slowly melts away. Slag protects the weld puddle from atmospheric contamination.
- ✓ Gas tungsten arc welding (GTAW) - also known as TIG (tungsten, inert gas), uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas such as Argon or Helium.
- ✓ Gas metal arc welding (GMAW) - commonly termed MIG (metal, inert gas), uses a wire feeding gun that feeds wire at an adjustable speed and flows an argon-based shielding gas or a mix of argon and carbon dioxide ($CO2$) over the weld puddle to protect it from atmospheric contamination.
- ✓ Flux-cored arc welding (FCAW) - almost identical to MIG welding except it uses a special tubular wire filled with flux; it can be used with or without shielding gas, depending on the filler.
- ✓ Submerged arc welding (SAW) - uses an automatically fed consumable electrode and a blanket of granular fusible flux. The molten weld and the arc zone are protected from atmospheric contamination by being "submerged" under the flux blanket.
- ✓ Electroslag welding (ESW) - a highly productive, single pass welding process for thicker materials between 1 inch (25 mm) and 12 inches (300 mm) in a vertical or close to vertical position.

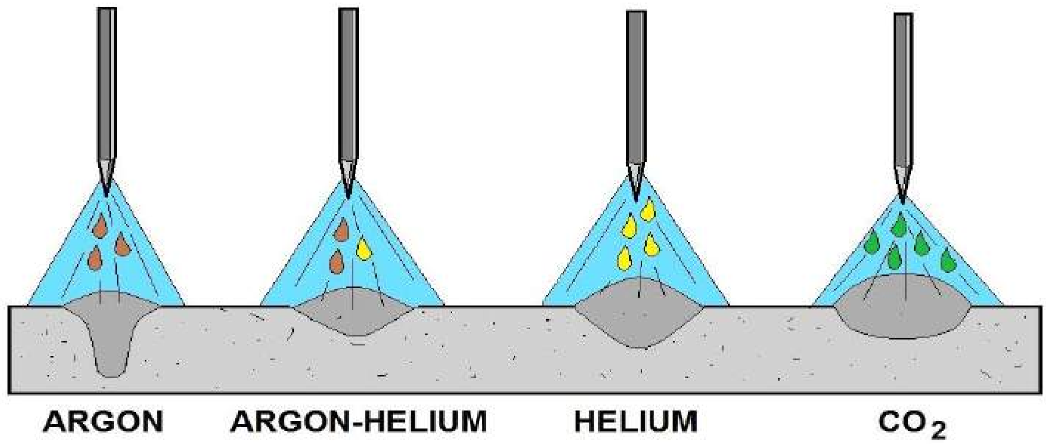


PENETRATION:	DEEP	MODERATE	SHALLOW
REINFORCEMENT:	MAXIMUM	MODERATE	MINIMUM
LIKELIHOOD OF UNDERCUTTING:	SEVERE	MODERATE	MINIMUM

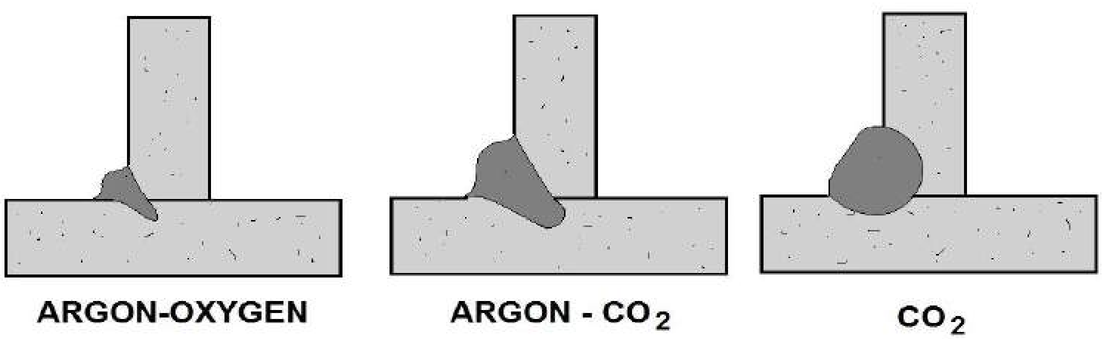
EFFECT OF THE ELECTRODE ANGLE ON BUTT WELDS



CORROSION AFFECT ON WELDS



BEAD CONTOUR AND PENETRATION PETTERNS FOR THE VARIOUS SHIELDING GASES



RELATIVE EFFECTS OF OXYGEN VS. CO_2 ADDITIONS TO ARGON SHIELD

New Welding Technologies
New technologies in welding, such as laser welding and electron beam welding, bring new hazards to the welder's environment. Special precautions must be taken when using these welding methods.

Laser Welding
Laser welding uses a focused beam of light to achieve very precise welds. The major hazard of this powerful beam is to the eyes, which can be partially blinded when hit with the beam. Special eye protection must be used, and care must be taken with any reflective surfaces since both the original and reflected beam are extremely dangerous.

Electron Beam Welding
This method uses a focused beam of electrons to produce high precision and deep penetration welds. Since x-rays are produced as a by-product, the process should be enclosed and shielded with lead or other materials suitable for preventing x-ray exposure. All doors, ports, and other openings must have proper seals and should be checked periodically to prevent x-ray leakage.

Operators should wear film badges to detect accidental radiation exposure. The high voltages required also present an electrical hazard.

Arc Welding Steps

Above, Start with proper adjustment of the welder. Most problems are with incorrect amperage. Too little amperage and the rod will stick, too much amperage and the rod will burn through. Below, You'll need to wear proper clothing and faceshield. This is an auto darkening faceshield and it difficult to imagine not having this type of equipment in the past. No matter what type of welding, you have a super chance of being burned and or killed. Welding is very dangerous.

Above, After welding a bead, you'll need to chip away the slag. You'll need to allow it to cool first. Below, A stuck Rod, usually you can jerk the Stinger to release the rod, but sometimes the rod is welded to the workpiece. The Rod will be superhot so be careful. Just like anything, practice will make perfect.

Welding Environment Section

Ideally, welding should be carried out in specially designated areas of a workshop. To reduce any fire hazard, these areas should have:

- ✓ Concrete floors
- ✓ Fire extinguishers
- ✓ Arc filter screens
- ✓ Protective drapes or curtains
- ✓ Adequate ventilation

Also, whenever any welding/cutting operation is carried out, the area should be free from any combustible material that may fuel a fire.

When the work cannot be done in a specially designed workshop, other precautions must be taken to minimize the fire risk. If the floors or roofs are combustible, they should be wet down with damp sand and/or covered with metal shields or fire-resistant tarps. The walls should also be protected if they are combustible.

Also, any openings in the walls or floor should be covered with non-combustible shields to prevent hot metal travelling through these openings.

If this is not possible, for example when the opening is too large, and the opening exposes flammable material in nearby areas, then the opening should be guarded by firewatchers. Sometimes it is necessary to suspend fire-resistant tarps beneath the work area to catch any hot/molten metal that may fall through. This is especially important when the work is being conducted above an area which contains combustible materials.

Resistance Welding
Resistance welding involves the generation of heat by passing current through the resistance caused by the contact between two or more metal surfaces. Small pools of molten metal are formed at the weld area as high current (1000–100,000 A) is passed through the metal. In general, resistance welding methods are efficient and cause little pollution, but their applications are somewhat limited and the equipment cost can be high.

Spot welding is a popular resistance welding method used to join overlapping metal sheets of up to 3 mm thick. Two electrodes are simultaneously used to clamp the metal sheets together and to pass current through the sheets. The advantages of the method include efficient energy use, limited workpiece deformation, high production rates, easy automation, and no required filler materials. Weld strength is significantly lower than with other welding methods, making the process suitable for only certain applications. It is used extensively in the automotive industry—ordinary cars can have several thousand spot welds made by industrial robots. A specialized process, called shot welding, can be used to spot weld stainless steel.

Like spot welding, seam welding relies on two electrodes to apply pressure and current to join metal sheets. However, instead of pointed electrodes, wheel-shaped electrodes roll along and often feed the workpiece, making it possible to make long continuous welds. In the past, this process was used in the manufacture of beverage cans, but now its uses are more limited. Other resistance welding methods include butt welding, flash welding, projection welding, and upset welding.

Energy Beam
Energy beam welding methods, namely laser beam welding and electron beam welding, are relatively new processes that have become quite popular in high production applications. The two processes are quite similar, differing most notably in their source of power. Laser beam welding employs a highly focused laser beam, while electron beam welding is done in a vacuum and uses an electron beam. Both have a very high energy density, making deep weld penetration possible and minimizing the size of the weld area. Both processes are extremely fast, and are easily automated, making them highly productive. The primary disadvantages are their very high equipment costs (though these are decreasing) and a susceptibility to thermal cracking. Developments in this area include laser-hybrid welding, which uses principles from both laser beam welding and arc welding for even better weld properties, laser cladding, and x-ray welding.

Solid-State
Like the first welding process, forge welding, some modern welding methods do not involve the melting of the materials being joined. One of the most popular, ultrasonic welding, is used to connect thin sheets or wires made of metal or thermoplastic by vibrating them at high frequency and under high pressure. The equipment and methods involved are similar to that of resistance welding, but instead of electric current, vibration provides energy input. Welding metals with this process does not involve melting the materials; instead, the weld is formed by introducing mechanical vibrations horizontally under pressure.

When welding plastics, the materials should have similar melting temperatures, and the vibrations are introduced vertically. Ultrasonic welding is commonly used for making electrical connections out of aluminum or copper, and it is also a very common polymer welding process.

Another common process, explosion welding, involves the joining of materials by pushing them together under extremely high pressure. The energy from the impact plasticizes the materials, forming a weld, even though only a limited amount of heat is generated. The process is commonly used for welding dissimilar materials, such as the welding of aluminum with steel in ship hulls or compound plates. Other solid-state welding processes include friction welding (including friction stir welding), magnetic pulse welding, co-extrusion welding, cold welding, diffusion bonding, exothermic welding, high frequency welding, hot pressure welding, induction welding, and roll welding.

Geometry

Welds can be geometrically prepared in many different ways. The five basic types of weld joints are the butt joint, lap joint, corner joint, edge joint, and T-joint (a variant of this last is the cruciform joint). Other variations exist as well—for example, double-V preparation joints are characterized by the two pieces of material each tapering to a single center point at one-half their height. Single-U and double-U preparation joints are also fairly common—instead of having straight edges like the single-V and double-V preparation joints, they are curved, forming the shape of a U. Lap joints are also commonly more than two pieces thick—depending on the process used and the thickness of the material, many pieces can be welded together in a lap joint geometry.

Many welding processes require the use of a particular joint design; for example, resistance spot welding, laser beam welding, and electron beam welding are most frequently performed on lap joints. Other welding methods, like shielded metal arc welding, are extremely versatile and can weld virtually any type of joint. Some processes can also be used to make multipass welds, in which one weld is allowed to cool, and then another weld is performed on top of it. This allows for the welding of thick sections arranged in a single-V preparation joint, for example.

After welding, a number of distinct regions can be identified in the weld area. The weld itself is called the fusion zone—more specifically, it is where the filler metal was laid during the welding process. The properties of the fusion zone depend primarily on the filler metal used, and its compatibility with the base materials. It is surrounded by the heat-affected zone, the area that had its microstructure and properties altered by the weld. These properties depend on the base material's behavior when subjected to heat. The metal in this area is often weaker than both the base material and the fusion zone, and is also where residual stresses are found.

Quality

Many distinct factors influence the strength of welds and the material around them, including the welding method, the amount and concentration of energy input, the weldability of the base material, filler material, and flux material, the design of the joint, and the interactions between all these factors. To test the quality of a weld, either destructive or nondestructive testing methods are commonly used to verify that welds are free of defects, have acceptable levels of residual stresses and distortion, and have acceptable heat-affected zone (HAZ) properties.

Types of welding defects include cracks, distortion, gas inclusions (porosity), non-metallic inclusions, lack of fusion, incomplete penetration, lamellar tearing, and undercutting.

The metalworking industry has instituted specifications and codes to guide welders, weld inspectors, engineers, managers, and property owners in proper welding technique, design of welds, how to judge the quality of Welding Procedure Specification, how to judge the skill of the person performing the weld, and how to ensure the quality of a welding job. Methods such as visual inspection, radiography, ultrasonic testing, phased-array ultrasonics, dye penetrant inspection, magnetic particle inspection, or industrial computed tomography can help with detection and analysis of certain defects.

Heat-Affected Zone
The effects of welding on the material surrounding the weld can be detrimental—depending on the materials used and the heat input of the welding process used, the HAZ can be of varying size and strength. The thermal diffusivity of the base material plays a large role—if the diffusivity is high, the material cooling rate is high and the HAZ is relatively small.

Conversely, a low diffusivity leads to slower cooling and a larger HAZ. The amount of heat injected by the welding process plays an important role as well, as processes like oxyacetylene welding have an unconcentrated heat input and increase the size of the HAZ. Processes like laser beam welding give a highly concentrated, limited amount of heat, resulting in a small HAZ. Arc welding falls between these two extremes, with the individual processes varying somewhat in heat input.

Lifetime Extension with After Treatment Methods
The durability and life of dynamically loaded, welded steel structures is determined in many cases by the welds, particular the weld transitions. Through selective treatment of the transitions by grinding (abrasive cutting), shot peening, High Frequency Impact Treatment, etc. the durability of many designs increase significantly.

In recent years, in order to minimize labor costs in high production manufacturing, industrial welding has become increasingly more automated, most notably with the use of robots in resistance spot welding (especially in the automotive industry) and in arc welding. In robot welding, mechanized devices both hold the material and perform the weld and at first, spot welding was its most common application, but robotic arc welding increases in popularity as technology advances. Other key areas of research and development include the welding of dissimilar materials (such as steel and aluminum, for example) and new welding processes, such as friction stir, magnetic pulse, conductive heat seam, and laser-hybrid welding.

Progress is desired in making more specialized methods like laser beam welding practical for more applications, such as in the aerospace and automotive industries. Researchers also hope to better understand the often unpredictable properties of welds, especially microstructure, residual stresses, and a weld's tendency to crack or deform.

The trend of accelerating the speed at which welds are performed in the steel erection industry comes at a risk to the integrity of the connection. Without proper fusion to the base materials provided by sufficient arc time on the weld, a project inspector cannot ensure the effective diameter of the puddle weld therefore he or she cannot guarantee the published load capacities unless they witness the actual installation.

Arc Welding Troubleshooting

Keep Your Amperage High
One of the most common welding instructors' tips you'll find both in welding shops and online is to keep your amperage on the upper end of what's recommended. That means you won't have a huge margin for error. You need to strike up and get moving before you burn through, create too much spatter, or lose control of your puddle.

However, once you've got your machine running good and hot so that you can weld efficiently, you'll find that your rod will stick far less. Running too low an amperage is typically one of the most common reasons for a stuck electrode while stick welding.

Too Short an Arc
Another reason for a stuck electrode is you're welding with too short an arc. Pay attention to your spatter if you get too far from your work piece.

Recommendations vary depending on the thickness of your electrode and could be anywhere from a quarter to a half inch. If you keep getting stuck, try pulling back a little bit with the arc.

Don't Use a Hot Rod
We're getting to the part about how to remove a stuck electrode soon, but here is another tip that may save you a ton of aggravation. If you do get stuck while you're welding and your rod heated up, a really hot rod will stick all of the time—you want a dry rod but not a hot rod. So give your rod time to cool if you can still use it.

Naturally, if you're a beginner, keep a bunch of dry rods handy so that you can keep learning from your mistakes as you adjust your settings and welding technique. Sometimes a rod will be ruined if it gets too hot, so be prepared to toss a rod if it overheats.

Pulling an Electrode from a Work Piece
The most common way to remove a stuck electrode is to give the electrode holder (often called a stinger) a sharp jerk. Don't let it stay put too long. As soon as you're stuck, get the electrode off because it's going to draw a lot of current and heat up.

If your first jerk doesn't work, twist it back and forth to try to work your rod loose. Sometimes the first twist will loosen it up enough that a few more twists can make the difference.

If you can't get it loose, try depressing the rod release lever at the same time that you pull the holder quite hard. That's a more dramatic way to get the rod loose, but you want to avoid touching the rod or work piece.

Remember that your metal work piece has an electrical current running through it from your welder. So you don't want to touch the metal unless you have a solid ground and the welding machine is off. Plenty of welders have lived to tell of pulling an electrode loose with their gloved hands while a machine is running, but it's generally a good idea to avoid any kind of electrical shock, especially if you may have overlooked some water in your vicinity.

COMMON GENERAL HAZARD SYMBOLS

Metallurgy Section

Most solids used are engineering materials consisting of crystalline solids in which the atoms or ions are arranged in a repetitive geometric pattern which is known as a lattice structure. The only exception is material that is made from glass which is a combination of a super cooled liquid and polymers which are aggregates of large organic molecules.

Crystalline solids cohesion is obtained by a metallic or chemical bond which is formed between the constituent atoms. Chemical bonds can be grouped into two types consisting of ionic and covalent. To form an ionic bond, either a valence or bonding electron separates from one atom and becomes attached to another atom to form oppositely charged ions. The bonding in the static position is when the ions occupy an equilibrium position where the resulting force between them is zero. When the ions are exerted in tension force, the inter-ionic spacing increases creating an electrostatic attractive force, while a repulsing force under compressive force between the atomic nuclei is dominant.

Covalent bonding takes place when one of the constituent atoms loses one or more electrons, with the other atom gaining the electrons, resulting in an electron cloud that is shared by the molecule as a whole. In both ionic and covalent bonding the location of the ions and electrons are constrained relative to each other, thereby resulting in the bond being characteristically brittle.

Metallic bonding can be classified as a type of covalent bonding for which the constituent atoms of the same type and do not combine with one another to form a chemical bond. Atoms will lose an electron(s) forming an array of positive ions. These electrons are shared by the lattice which makes the electron cluster mobile, as the electrons are free to move as well as the ions. For this, it gives metals their relatively high thermal and electrical conductivity as well as being characteristically ductile.

Three of the most commonly used crystal lattice structures in metals are the body-centered cubic, face-centered cubic and close-packed hexagonal. Ferrite steel has a body-centered cubic structure and austenitic steel, non-ferrous metals like aluminum, copper and nickel have the face-centered cubic structure.

Ductility is an important factor in ensuring the integrity of structures by enabling them to sustain local stress concentrations without fracture. In addition, structures are required to be of an acceptable strength, which is related to a material's yield strength. In general, as the yield strength of a material increases, there is a corresponding reduction in fracture toughness.

A reduction in fracture toughness may also be attributed to the embitterment effect of impurities, or for body-centered cubic metals, from a reduction in temperature. Metals and in particular steels have a transitional temperature range where above this range the metal has acceptable notch-ductility while below this range the material becomes brittle. Within the range, the materials behavior is unpredictable. The reduction in fracture toughness is accompanied by a change in the fracture appearance. When above the transition, the fracture is primarily due to micro-void coalescence, which results in the fracture appearing fibrous. When the temperatures falls the fracture will show signs of cleavage facets.

These two appearances are visible by the naked eye. Brittle fracture in steel plates may appear as chevron markings under the microscope. These arrow-like ridges on the crack surface point towards the origin of the fracture.

Fracture toughness is measured using a notched and pre-cracked rectangular specimen, of which the dimensions are specified in standards, for example ASTM E23. There are other means of estimating or measuring fracture toughness by the following: The Charpy impact test per ASTM A370; The crack-tip opening displacement (CTOD) test per BS 7448-1; The J integral test per ASTM E1820; The Pellini drop-weight test per ASTM E208.

Unusual Welding Conditions

While many welding applications are done in controlled environments such as factories and repair shops, some welding processes are commonly used in a wide variety of conditions, such as open air, underwater, and vacuums (such as space). In open-air applications, such as construction and outdoors repair, shielded metal arc welding is the most common process. Processes that employ inert gases to protect the weld cannot be readily used in such situations, because unpredictable atmospheric movements can result in a faulty weld.

Shielded metal arc welding is also often used in underwater welding in the construction and repair of ships, offshore platforms, and pipelines, but others, such as flux cored arc welding and gas tungsten arc welding, are also common. Welding in space is also possible—it was first attempted in 1969 by Russian cosmonauts, when they performed experiments to test shielded metal arc welding, plasma arc welding, and electron beam welding in a depressurized environment. Further testing of these methods was done in the following decades, and today researchers continue to develop methods for using other welding processes in space, such as laser beam welding, resistance welding, and friction welding.

Welding Trends

As an industrial process, the cost of welding plays a crucial role in manufacturing decisions. Many different variables affect the total cost, including equipment cost, labor cost, material cost, and energy cost.] Depending on the process, equipment cost can vary, from inexpensive for methods like shielded metal arc welding and oxyfuel welding, to extremely expensive for methods like laser beam welding and electron beam welding. Because of their high cost, they are only used in high production operations.

Similarly, because automation and robots increase equipment costs, they are only implemented when high production is necessary. Labor cost depends on the deposition rate (the rate of welding), the hourly wage, and the total operation time, including time spent fitting, welding, and handling the part. The cost of materials includes the cost of the base and filler material, and the cost of shielding gases. Finally, energy cost depends on arc time and welding power demand.

For manual welding methods, labor costs generally make up the vast majority of the total cost. As a result, many cost-saving measures are focused on minimizing operation time. To do this, welding procedures with high deposition rates can be selected, and weld parameters can be fine-tuned to increase welding speed. Mechanization and automation are often implemented to reduce labor costs, but this frequently increases the cost of equipment and creates additional setup time. Material costs tend to increase when special properties are necessary, and energy costs normally do not amount to more than several percent of the total welding cost.

Glass and Plastic Welding Section

Glasses and certain types of plastics are commonly welded materials. Unlike metals, which have a specific melting point, glasses and plastics have a melting range, called the glass transition. When heating the solid material into this range, it will generally become softer and more pliable. When it crosses through the glass transition, it will become a very thick, sluggish, viscous liquid. Typically, this viscous liquid will have very little surface tension, becoming a sticky, honey-like consistency, so welding can usually take place by simply pressing two melted surfaces together. The two liquids will generally mix and join at first contact. Upon cooling through the glass transition, the welded piece will solidify as one solid piece of amorphous material.

Glass Welding

Glass welding is a common practice during glassblowing. It is used very often in the construction of lighting, neon signs, flashtubes, scientific equipment, and the manufacture of dishes and other glassware. It is also used during glass casting for joining the halves of glass molds, making items such as bottles and jars. Welding glass is accomplished by heating the glass through the glass transition, turning it into a thick, formable, liquid mass. Heating is usually done with a gas or oxy-gas torch, or a furnace, because the temperatures for melting glass are often quite high. This temperature may vary, depending on the type of glass.

For example, lead glass becomes a weldable liquid at around 1,600 °F (870 °C), whereas quartz glass (fused silica) must be heated to over 3,000 °F (1,650 °C). Sometimes a tube may be attached to the glass, allowing it to be blown into various shapes, such as bulbs, bottles, or tubes. When two pieces of liquid glass are pressed together, they will usually weld very readily. Welding a handle onto a pitcher can usually be done with relative ease. However, when welding a tube to another tube, a combination of blowing and suction, and pressing and pulling is used to ensure a good seal, to shape the glass, and to keep the surface tension from closing the tube in on itself. Sometimes a filler rod may be used, but usually not.

Because glass is very brittle in its solid state, it is often prone to cracking upon heating and cooling, especially if the heating and cooling are uneven. This is because the brittleness of glass does not allow for uneven thermal expansion. Glass that has been welded will usually need to be cooled very slowly and evenly through the glass transition, in a process called annealing, to relieve any internal stresses created by a temperature gradient.

There are many types of glass, and it is most common to weld using the same types. Different glasses often have different rates of thermal expansion, which can cause them to crack upon cooling when they contract differently. For instance, quartz has very low thermal expansion, while soda-lime glass has very high thermal expansion. When welding different glasses to each other, it is usually important to closely match their coefficients of thermal expansion, to ensure that cracking does not occur. Also, some glasses will simply not mix with others, so welding between certain types may not be possible.

Glass can also be welded to metals and ceramics, although with metals the process is usually more adhesion to the surface of the metal rather than a commingling of the two materials. However, certain glasses will typically bond only to certain metals. For example, lead glass bonds readily to copper or molybdenum, but not to aluminum.

Tungsten electrodes are often used in lighting but will not bond to quartz glass, so the tungsten is often wetted with molten borosilicate glass, which bonds to both tungsten and quartz. However, care must be taken to ensure that all materials have similar coefficients of thermal expansion to prevent cracking both when the object cools and when it is heated again. Special alloys are often used for this purpose, ensuring that the coefficients of expansion match, and sometimes thin, metallic coatings may be applied to a metal to create a good bond with the glass.

Plastic Welding

Plastics are generally divided into two categories, which are "thermosets" and "thermoplastics." A thermoset is a plastic in which a chemical reaction sets the molecular bonds after first forming the plastic, and then the bonds cannot be broken again without degrading the plastic. Thermosets cannot be melted, therefore, once a thermoset has set it is impossible to weld it. Examples of thermosets include epoxies, silicone, vulcanized rubber, polyester, and polyurethane.

Thermoplastics, by contrast, form long molecular chains, which are often coiled or intertwined, forming an amorphous structure without any long-range, crystalline order. Some thermoplastics may be fully amorphous, while others have a partially crystalline/partially amorphous structure. Both amorphous and semi-crystalline thermoplastics have a glass transition, above which welding can occur, but semicrystallines also have a specific melting point which is above the glass transition. Above this melting point, the viscous liquid will become a free-flowing liquid (see rheological weldability for thermoplastics). Examples of thermoplastics include polyethylene, polypropylene, polystyrene, polyvinylchloride (PVC), and fluoroplastics like Teflon and Spectralon.

Welding thermoplastic is very similar to welding glass. The plastic first must be cleaned and then heated through the glass transition, turning the weld-interface into a thick, viscous liquid. Two heated interfaces can then be pressed together, allowing the molecules to mix through intermolecular diffusion, joining them as one. Then the plastic is cooled through the glass transition, allowing the weld to solidify.

A filler rod may often be used for certain types of joints. The main differences between welding glass and plastic are the types of heating methods, the much lower melting temperatures, and the fact that plastics will burn if overheated. Many different methods have been devised for heating plastic to a weldable temperature without burning it. Ovens or electric heating tools can be used to melt the plastic. Ultrasonic, laser, or friction heating are other methods. Resistive metals may be implanted in the plastic, which respond to induction heating. Some plastics will begin to burn at temperatures lower than their glass transition, so welding can be performed by blowing a heated, inert gas onto the plastic, melting it while, at the same time, shielding it from oxygen.

A common use for solvent welding is for joining PVC or ABS (acrylonitrile butadiene styrene) pipes during plumbing, or for welding styrene and polystyrene plastics in the construction of models.

Solvent welding is especially effective on plastics like PVC which burn at or below their glass transition, but may be ineffective on plastics that are resistant to chemical decomposition.

Fire Safety Section

Facts on Fire

Fire in the United States

- ✓ The U.S. has one of the highest fire death rates in the industrialized world. For 1998, the U.S. fire death rate was 14.9 deaths per million population.
- ✓ Between 1994 and 1998, an average of 4,400 Americans lost their lives and another 25,100 were injured annually as the result of fire.
- ✓ About 100 firefighters are killed each year in duty-related incidents.
- ✓ Each year, fire kills more Americans than all natural disasters combined.
- ✓ Fire is the third leading cause of accidental death in the home; at least 80 percent of all fire deaths occur in residences.
- ✓ About 2 million fires are reported each year. Many others go unreported, causing additional injuries and property loss.
- ✓ Direct property loss due to fires is estimated at $8.6 billion annually.
- ✓ Where Fires Occur
- ✓ There were 1,755,000 fires in the United States in 1998. Of these:
- ✓ 41% were Outside Fires
- ✓ 29% were Structure Fires
- ✓ 22% were Vehicle Fires
- ✓ 8 % were fires of other types
- ✓ Residential fires represent 22 percent of all fires and 74 percent of structure fires.

Fires in 1-2 family dwellings most often start in the:

1. Kitchen 23.5%
2. Bedroom 12.7%
3. Living Room 7.9%
4. Chimney 7.1%
5. Laundry Area 4.7%

Apartment fires most often start in the:

1. Kitchen 46.1%
2. Bedroom 12.3%
3. Living Room 6.2%
4. Laundry Area 3.3%
5. Bathroom 2.4%

The South has the highest fire death rate per-capita with 18.4 civilian deaths per million population.

80 percent of all fatalities occur in the home. Of those, approximately 85 percent occur in single-family homes and duplexes.

Causes of Fires and Fire Deaths

- ✓ Cooking is the leading cause of home fires in the U.S. It is also the leading cause of home fire injuries. Cooking fires often result from unattended cooking and human error, rather than mechanical failure of stoves or ovens.
- ✓ Careless smoking is the leading cause of fire deaths. Smoke alarms and smolder-resistant bedding and upholstered furniture are significant fire deterrents.
- ✓ Heating is the second leading cause of residential fires and the second leading cause of fire deaths. However, heating fires are a larger problem in single family homes than in apartments. Unlike apartments, the heating systems in single family homes are often not professionally maintained.
- ✓ Arson is both the third leading cause of residential fires and residential fire deaths. In commercial properties, arson is the major cause of deaths, injuries and dollar loss.

Who is Most at Risk?

- ✓ Senior citizens age 70 and over and children under the age of 5 have the greatest risk of fire death.
- ✓ The fire death risk among seniors is more than double the average population.
- ✓ The fire death risk for children under age 5 is nearly double the risk of the average population.
- ✓ Children under the age of 10 accounted for an estimated 17 percent of all fire deaths in 1996.
- ✓ Men die or are injured in fires almost twice as often as women.
- ✓ African Americans and American Indians have significantly higher death rates per capita than the national average.
- ✓ Although African Americans comprise 13 percent of the population, they account for 26 percent of fire deaths.

People with Special Needs
More than 4,000 Americans die each year in fires, and more than 25,000 are injured.

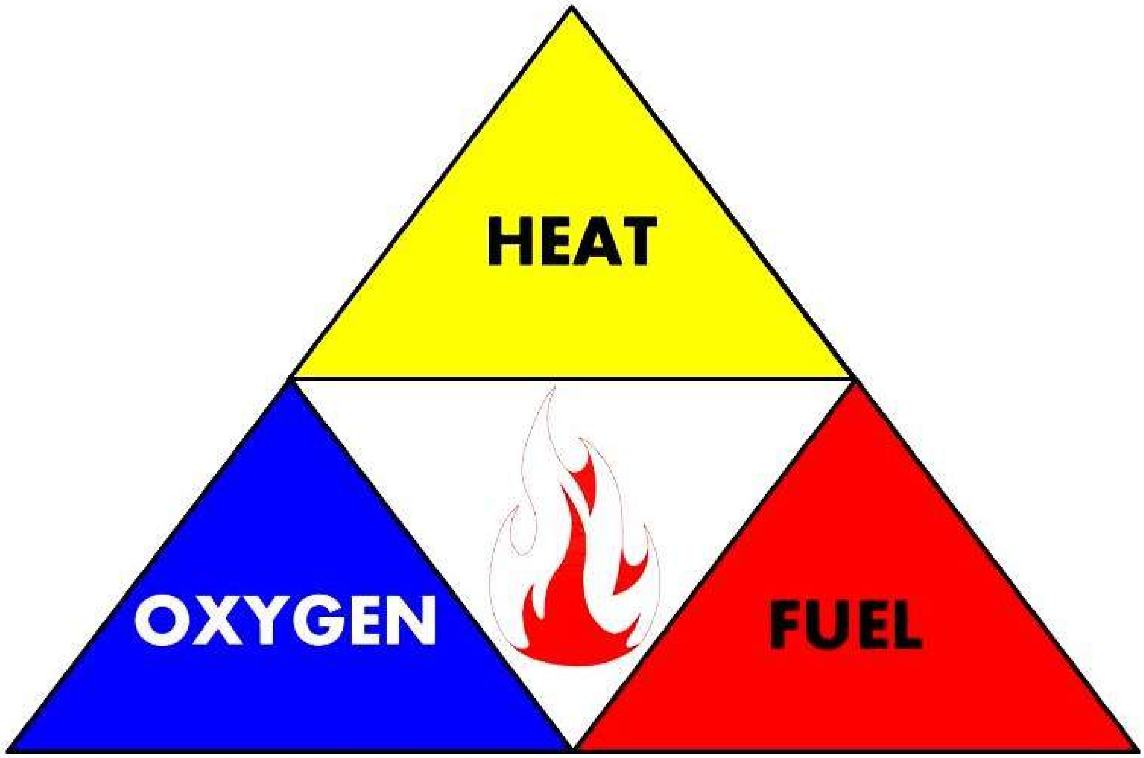
Special populations such as older adults, people with disabilities, the deaf and hard of hearing and the visually impaired can significantly increase their chances of surviving a fire by practicing proven fire safety precautions.

Why are Special Populations at Risk?
Special populations are at risk for a number of reasons:

- ✓ Decreased mobility, health, sight, and hearing may limit a person's ability to take the quick action necessary to escape during a fire emergency.

- ✓ Depending on physical limitations, many of the actions an individual can take to protect themselves from the dangers of fire may require help from a caretaker, neighbor, or outside source.

What Exactly is Fire?



FIRE TRIANGLE DIAGRAM

Fire is a chemical reaction involving rapid oxidation or burning of fuel. It needs three elements to occur:

Fuel can be any combustible material: solid, liquid or gas. Most solids and liquids become a vapor or gas before they will burn.

Oxygen The air we breathe is about 21% oxygen. Fire only needs an atmosphere with at least 16% oxygen.

Heat is the energy necessary to increase the temperature of the fuel to a point where sufficient vapors are given off for ignition to occur.

Fire is Fast!

- ✓ There is little time!
- ✓ In less than 30 seconds a small flame can get completely out of control and turn into a major fire. It only takes minutes for thick black smoke to fill a house. In minutes, a house can be engulfed in flames. Most fires occur in the home when people are asleep. If you wake up to a fire, you won't have time to grab valuables because fire spreads too quickly and the smoke is too thick.
- ✓ There is only time to escape.

Fire is HOT!

- ✓ Heat is more threatening than flames.
- ✓ A fire's heat alone can kill. Room temperatures in a fire can be 100 degrees at floor level and rise to 600 degrees at eye level. Inhaling this super-hot air will scorch your lungs. This heat can melt clothes to your skin. In five minutes a room can get so hot that everything in it ignites at once: this is called flashover.

Fire is DARK!

- ✓ Fire isn't bright, its pitch black.
- ✓ Fire starts bright, but quickly produces black smoke and complete darkness. If you wake up to a fire you may be blinded, disoriented and unable to find your way around the home you've lived in for years.

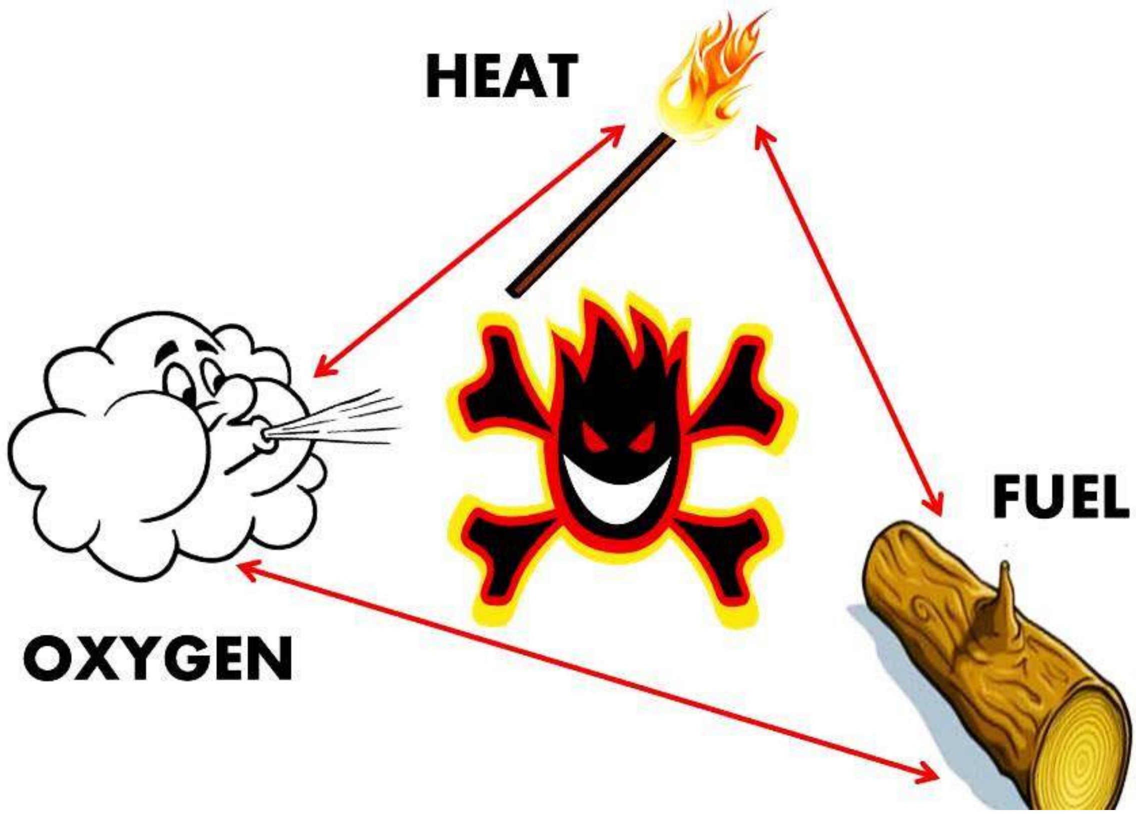
Fire is DEADLY!

- ✓ Smoke and toxic gases kill more people than flames do.
- ✓ Fire uses up the oxygen you need and produces smoke and poisonous gases that kill. Breathing even small amounts of smoke and toxic gases can make you drowsy, disoriented and short of breath. The odorless, colorless fumes can lull you into a deep sleep before the flames reach your door. You may not wake up in time to escape.

Fire Safety Tips

- ✓ In the event of a fire, remember time is the biggest enemy and every second counts!
- ✓ Escape first, and then call for help. Develop a home fire escape plan and designate a meeting place outside. Make sure everyone in the family knows two ways to escape from every room. Practice feeling your way out with your eyes closed.
- ✓ Never stand up in a fire, always crawl low under the smoke and try to keep your mouth covered. Never return to a burning building for any reason; it may cost you your life.
- ✓ Finally, having a working smoke alarm dramatically increases your chances of surviving a fire. And remember to practice a home escape plan frequently with your family.

Understanding Fire



COMBUSTION TRIANGLE DIAGRAM

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products. Slower oxidative processes like rusting or digestion are not included by this definition.

The flame is the visible portion of the fire. If hot enough, the gases may become ionized to produce plasma. Depending on the substances alight, and any impurities outside, the color of the flame and the fire's intensity will be different.

Fire in its most common form can result in conflagration, which has the potential to cause physical damage through burning. Fire is an important process that affects ecological systems around the globe.

The positive effects of fire include stimulating growth and maintaining various ecological systems. Fire has been used by humans for cooking, generating heat, light, signaling, and propulsion purposes. The negative effects of fire include hazard to life and property, atmospheric pollution, and water contamination.

Fire Tetrahedron
Fires start when a flammable or a combustible material, in combination with a sufficient quantity of an oxidizer such as oxygen gas or another oxygen-rich compound (though non-oxygen oxidizers exist), is exposed to a source of heat or ambient temperature above the flash point for the fuel/oxidizer mix, and is able to sustain a rate of rapid oxidation that produces a chain reaction. This is commonly called the fire tetrahedron.

Fire cannot exist without all of these elements in place and in the right proportions. For example, a flammable liquid will start burning only if the fuel and oxygen are in the right proportions. Some fuel-oxygen mixes may require a catalyst, a substance that is not consumed, when added, in any chemical reaction during combustion, but which enables the reactants to combust more readily.

Once ignited, a chain reaction must take place whereby fires can sustain their own heat by the further release of heat energy in the process of combustion and may propagate, provided there is a continuous supply of an oxidizer and fuel.

If the oxidizer is oxygen from the surrounding air, the presence of a force of gravity, or of some similar force caused by acceleration, is necessary to produce convection, which removes combustion products and brings a supply of oxygen to the fire. Without gravity, a fire rapidly surrounds itself with its own combustion products and non-oxidizing gases from the air, which exclude oxygen and extinguish the fire.

Because of this, the risk of fire in a spacecraft is small when it is coasting in inertial flight.
Of course, this does not apply if oxygen is supplied to the fire by some process other than thermal convection.

Fire can be extinguished by removing any one of the elements of the fire tetrahedron. Consider a natural gas flame, such as from a stovetop burner. The fire can be extinguished by any of the following:

- ✓ turning off the gas supply, which removes the fuel source;
- ✓ covering the flame completely, which smothers the flame as the combustion both uses the available oxidizer (the oxygen in the air) and displaces it from the area around the flame with CO_2;
- ✓ application of water, which removes heat from the fire faster than the fire can produce it (similarly, blowing hard on a flame will displace the heat of the currently burning gas from its fuel source, to the same end), or
- ✓ application of a retardant chemical such as Halon to the flame, which retards the chemical reaction itself until the rate of combustion is too slow to maintain the chain reaction.

Stoichiometric Proportions
In contrast, fire is intensified by increasing the overall rate of combustion. Methods to do this include balancing the input of fuel and oxidizer to stoichiometric proportions, increasing fuel and oxidizer input in this balanced mix, increasing the ambient temperature so the fire's own heat is better able to sustain combustion, or providing a catalyst; a non-reactant medium in which the fuel and oxidizer can more readily react.

What is a Flame?

A flame is a mixture of reacting gases and solids emitting visible, infrared, and sometimes ultraviolet light, the frequency spectrum of which depends on the chemical composition of the burning material and intermediate reaction products. In many cases, such as the burning of organic matter, for example wood, or the incomplete combustion of gas, incandescent solid particles called soot produce the familiar red-orange glow of 'fire'. This light has a continuous spectrum.

Complete combustion of gas has a dim blue color due to the emission of single-wavelength radiation from various electron transitions in the excited molecules formed in the flame. Usually oxygen is involved, but hydrogen burning in chlorine also produces a flame, producing hydrogen chloride (HCl). Other possible combinations producing flames, amongst many, are fluorine and hydrogen, and hydrazine and nitrogen tetroxide.

The glow of a flame is complex. Black-body radiation is emitted from soot, gas, and fuel particles, though the soot particles are too small to behave like perfect blackbodies. There is also photon emission by de-excited atoms and molecules in the gases. Much of the radiation is emitted in the visible and infrared bands. The color depends on temperature for the black-body radiation, and on chemical makeup for the emission spectra. The dominant color in a flame changes with temperature.

Near the ground, where most burning is occurring, the fire is white, the hottest color possible for organic material in general, or yellow. Above the yellow region, the color changes to orange, which is cooler, then red, which is cooler still. Above the red region, combustion no longer occurs, and the uncombusted carbon particles are visible as black smoke.

The common distribution of a flame under normal gravity conditions depends on convection, as soot tends to rise to the top of a general flame, as in a candle in normal gravity conditions, making it yellow. In micro gravity or zero gravity, such as an environment in outer space, convection no longer occurs, and the flame becomes spherical, with a tendency to become more blue and more efficient (although it may go out if not moved steadily, as the CO_2 from combustion does not disperse as readily in micro gravity, and tends to smother the flame).

There are several possible explanations for this difference, of which the most likely is that the temperature is sufficiently evenly distributed that soot is not formed and complete combustion occurs.

In combustion engines, various steps are taken to eliminate a flame. The method depends mainly on whether the fuel is oil, wood, or a high-energy fuel such as jet fuel.

Flame Temperatures
It is true that objects at specific temperatures do radiate visible light. Objects whose surface is at a temperature above approximately 400 °C (752 °F) will glow, emitting light at a color that indicates the temperature of that surface. It is a misconception that you can judge the temperature of a fire by the color of its flames or the sparks in the flames.

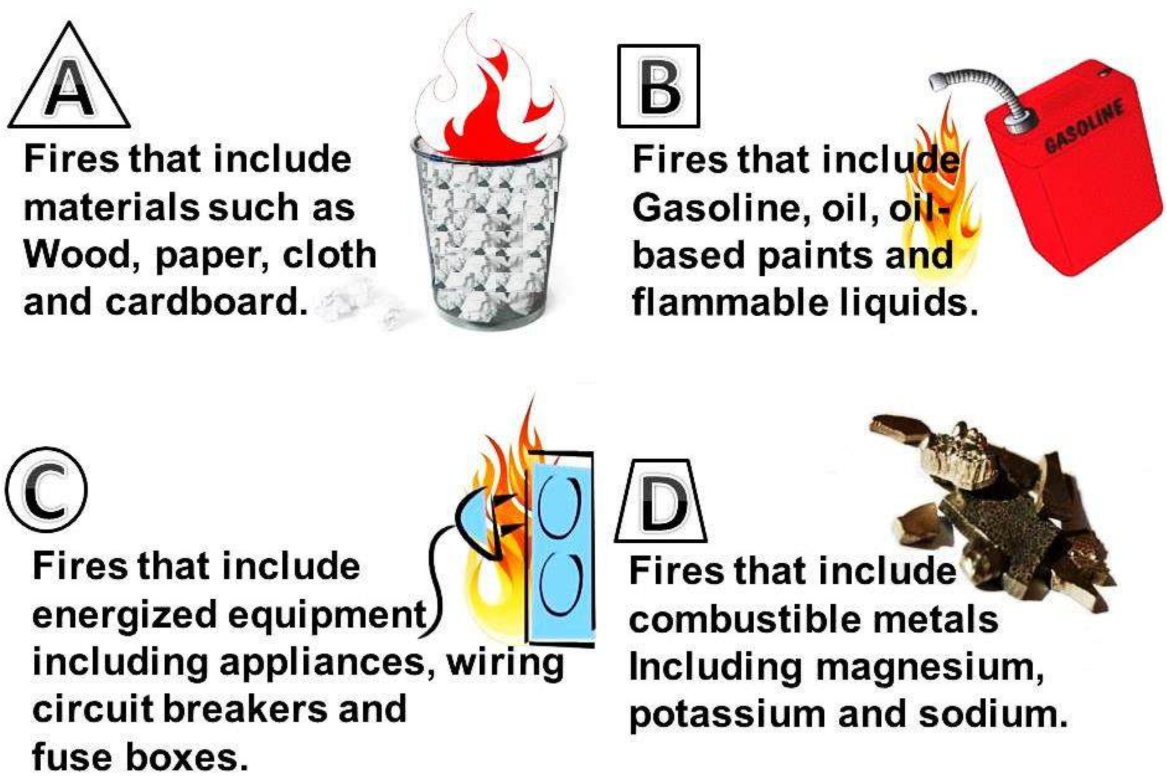
Typical Temperatures of Flames

The "adiabatic flame temperature" of a given fuel and oxidizer pair indicates the temperature at which the gases achieve stable combustion.

- Oxy-dicyanoacetylene 4,990 °C (9,000 °F)
- Oxy-acetylene 3,480 °C (6,300 °F)
- Oxyhydrogen 2,800 °C (5,100 °F)
- Air-acetylene 2,534 °C (4,600 °F)
- Blowtorch (air-mapp gas) 2,200 °C (4,000 °F)
- Bunsen burner (air-natural gas) 1,300 to 1,600 °C (2,400 to 2,900 °F)
- Candle (air-paraffin) 1,000 °C (1,800 °F)

Smoldering cigarette:

- Temperature without drawing: side of the lit portion; 400 °C (750 °F); middle of the lit portion: 585 °C (1,100 °F)
- Temperature during drawing: middle of the lit portion: 700 °C (1,300 °F)
- Always hotter in the middle.

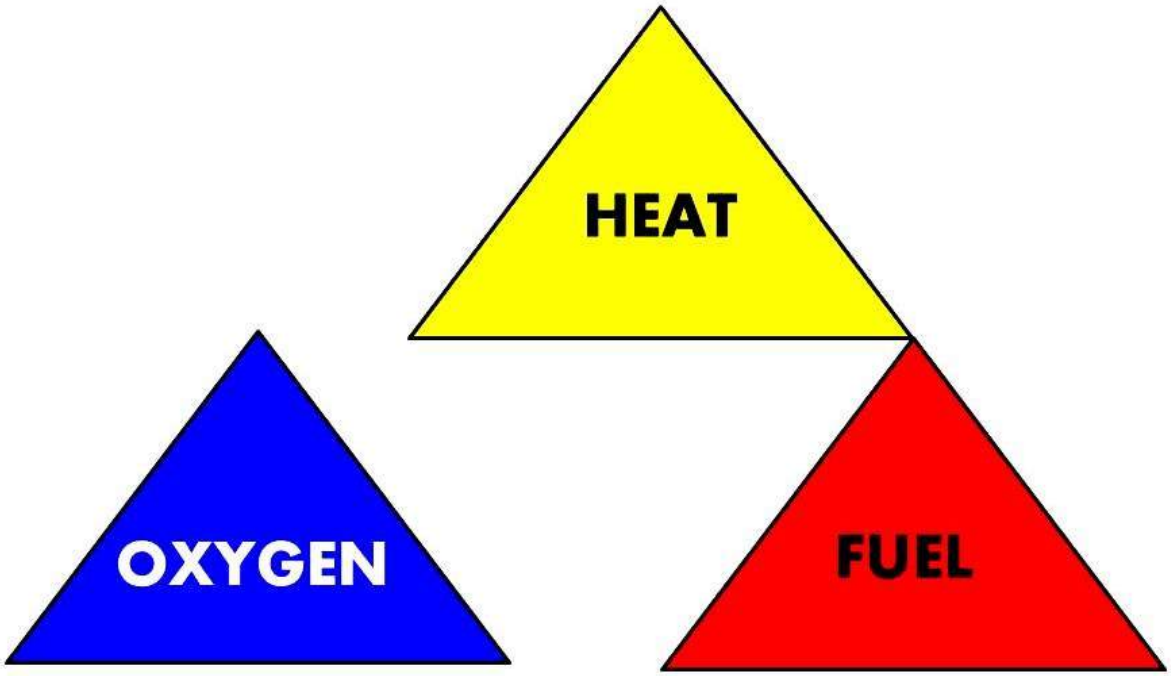


The Fire Triangle

In order to understand how fire extinguishers work, you first need to know a little bit about fire.

Four things must be present at the same time in order to produce fire:

- Enough **oxygen** to sustain combustion,
- Enough **heat** to raise the material to its ignition temperature,
- Some sort of **fuel** or combustible material, and
- The **chemical, exothermic reaction** that is fire.



NO COMBUSTION TRIANGLE

Oxygen, heat, and fuel are frequently referred to as the "**fire triangle**." Add in the fourth element, the chemical reaction, and you actually have a fire "**tetrahedron**." The important thing to remember is: **take any of these four things away, and you will not have a fire** or **the fire will be extinguished**.

Essentially, fire extinguishers put out fire by taking away one or more elements of the fire triangle/tetrahedron.

Fire safety, at its most basic, is based upon the principle of keeping fuel sources and ignition sources separate.

The percentage of combustible gas in the air is important, too. For example, a manhole filled with fresh air is gradually filled by a leak of combustible gas such as methane or natural gas, mixing with the fresh air. As the ratio of gas to air changes, the sample passes through three ranges: lean, explosive and rich.

In the lean range there isn't enough gas in the air to burn. On the other hand, the rich range has too much gas and not enough air. However, the explosive range has just the right combination of gas and air to form an explosive mixture.

Care must be taken, however, when a mixture is too rich, because dilution with fresh air could bring the mixture into the flammable or explosive range. An analogy is the automobile that won't start on a cold morning (a lean atmosphere because the liquid gasoline has not vaporized sufficiently), but can be flooded with too much gasoline (a rich atmosphere with too much vaporization). Eventually, when the right mixture of gas and air finally exists (explosive), the car starts.

The Fire Tetrahedron

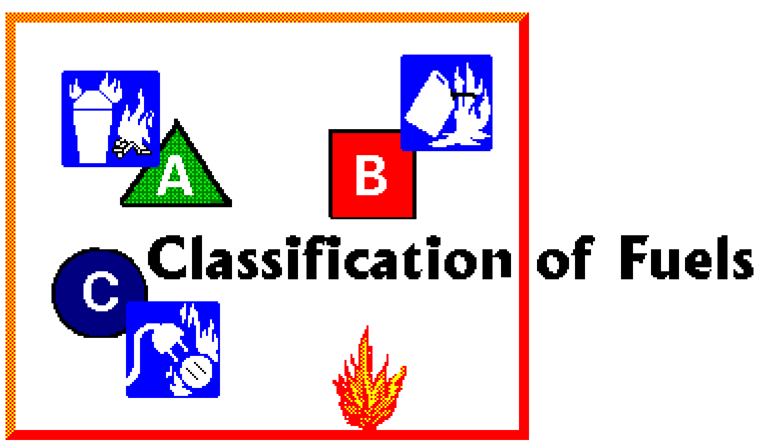
Modern day thinking now accepts there is a forth element required to sustain combustion. It is **Chemical Reaction** and must be present with all the other elements at the same time in order to produce fire. The four elements are:-

- Enough **oxygen** to sustain combustion,
- Enough **heat** to raise the material to its ignition temperature,
- Some sort of **fuel** or combustible material, and
- The **chemical, exothermic reaction** that is fire.

Once you have three sides of the fire triangle you promote a fourth element, a chemical reaction, consequently you have a fire "***Tetrahedron."*** The important thing to remember is, **take any of these four things away, and you will not have a fire** or **the fire will be extinguished**.

To extinguish a fire by the forth element you need to interfere with the chemical reaction. One way, is to mop up the free radicals in the chemical reaction using certain chemicals. BCF and other Halon extinguishers will achieve this, it also creates an inert gas barrier, however this type of extinguisher is being phased out.

In the future other extinguishing agents may be found using this principle.



Not all fires are the same, and they are classified according to the type of fuel that is burning. If you use the wrong type of fire extinguisher on the wrong class of fire, you can, in fact, make matters worse. It is therefore very important to understand the four different fire classifications.

Class A - **Wood, paper, cloth, trash, plastics**
Solid combustible materials that are not metals.

Class B - **Flammable liquids: gasoline, oil, grease, acetone**
Any non-metal in a liquid state, on fire. This classification also includes flammable gases.

Class C - **Electrical: energized electrical equipment**
As long as it's "plugged in," it would be considered a class C fire.

Class D - **Metals: potassium, sodium, aluminum, magnesium**
Unless you work in a laboratory or in an industry that uses these materials, it is unlikely you'll have to deal with a Class D fire. It takes special extinguishing agents (Metal-X, foam) to fight such a fire.

Most fire extinguishers will have a pictograph label telling you which classifications of fire the extinguisher is designed to fight. For example, a simple water extinguisher might have a label like the one below, indicating that it should only be used on Class A fires.

An empty fire extinguisher, commonly found in business settings. Bad news!

Fire Extinguisher without a discharge hose, a disaster waiting to happen.

Dangerous electrical wiring,   fire waiting to happen.

Fire Protection and Prevention

Wildfire prevention programs around the world may employ techniques such as wildland fire use and prescribed or controlled burns. Wildland fire use refers to any fire of natural causes that is monitored but allowed to burn. Controlled burns are fires ignited by government agencies under less dangerous weather conditions.

Firefighting services are provided in most developed areas to extinguish or contain uncontrolled fires. Trained firefighters use fire apparatus, water supply resources such as water mains and fire hydrants or they might use A and B class foam depending on what is feeding the fire.

Fire prevention is intended to reduce sources of ignition. Fire prevention also includes education to teach people how to avoid causing fires. Buildings, especially schools and tall buildings, often conduct fire drills to inform and prepare citizens on how to react to a building fire. Purposely starting destructive fires constitutes arson and is a crime in most jurisdictions.

Model building codes require passive fire protection and active fire protection systems to minimize damage resulting from a fire. The most common form of active fire protection is fire sprinklers. To maximize passive fire protection of buildings, building materials and furnishings in most developed countries are tested for fire-resistance, combustibility and flammability. Upholstery, carpeting and plastics used in vehicles and vessels are also tested.

Fire Safety

Fire safety is the set of practices intended to reduce the destruction cause by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts.

Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building.

Threats to fire safety are referred to as fire hazards. A fire hazard may include a situation that increases the likelihood a fire may start or may impede escape in the event a fire occurs.

Building Safety

Fire safety is often a component of building safety. Those who inspect buildings for violations of the Fire Code and go into schools to educate children on Fire Safety topics are fire department members known as Fire Prevention Officers. The Chief Fire Prevention Officer or Chief of Fire Prevention will normally train newcomers to the Fire Prevention Division and may also conduct inspections or make presentations.

Elements of a fire safety policy

- ✓ Building a facility in accordance with the version of the local building code.
- ✓ Maintaining a facility and conducting yourself in accordance with the provisions of the fire code. This is based on the occupants and operators of the building being aware of the applicable regulations and advice.

Examples of these include:
- ✓ Not exceeding the maximum occupancy within any part of the building.
- ✓ Maintaining proper fire exits and proper exit signage (e.g., exit signs pointing to them that can function in a power failure).
- ✓ Compliance with electrical codes to prevent overheating and ignition from electrical faults or problems such as poor wire insulation or overloading wiring, conductors, or other fixtures with more electric current than they are rated for.
- ✓ Placing and maintaining the correct type of fire extinguishers in easily accessible places.
- ✓ Properly storing and using, hazardous materials that may be needed inside the building for storage or operational requirements (such as solvents in spray booths).
- ✓ Prohibiting flammable materials in certain areas of the facility.
- ✓ Periodically inspecting buildings for violations, issuing Orders To Comply and, potentially, prosecuting or closing buildings that are not in compliance, until the deficiencies are corrected or condemning it in extreme cases.
- ✓ Maintaining fire alarm systems for detection and warning of fire.
- ✓ Obtaining and maintaining a complete inventory of firestops.
- ✓ Ensuring that spray fireproofing remains undamaged.
- ✓ Maintaining a high level of training and awareness of occupants and users of the building to avoid obvious mistakes, such as the propping open of fire doors.
- ✓ Conduct fire drills at regular intervals throughout the year.

Common Fire Hazards

Some common fire hazards are:
- ➢ Kitchen fires from unattended cooking, such as frying, broiling, and simmering.
- ➢ Electrical systems that are overloaded, resulting in hot wiring or connections, or failed components.
- ➢ Combustible storage areas with insufficient protection.
- ➢ Combustibles near equipment that generates heat, flame, or sparks.
- ➢ Candles and other open flames.
- ➢ Smoking (Cigarettes, cigars, pipes, lighters, etc.).
- ➢ Equipment that generates heat and utilizes combustible materials.
- ➢ Flammable liquids and aerosols.
- ➢ Flammable solvents (and rags soaked with solvent) placed in enclosed trash cans.
- ➢ Fireplace chimneys not properly or regularly cleaned.
- ➢ Cooking appliances - stoves, ovens.
- ➢ Heating appliances - fireplaces, wood burning stoves, furnaces, boilers, portable heaters.
- ➢ Household appliances - clothes dryers, curling irons, hair dryers, refrigerators, freezers.
- ➢ Chimneys that concentrate creosote.
- ➢ Electrical wiring in poor condition.
- ➢ Leaking Batteries.
- ➢ Personal ignition sources - matches, lighters.
- ➢ Electronic and electrical equipment.
- ➢ Exterior cooking equipment - barbecue

Fire Code

In the United States, the fire code (also fire prevention code or fire safety code) is a model code adopted by the state or local jurisdiction and enforced by fire prevention officers within municipal fire departments. It is a set of rules prescribing minimum requirements to prevent fire and explosion hazards arising from storage, handling, or use of dangerous materials, or from other specific hazardous conditions. It complements the building code.

The fire code is aimed primarily at preventing fires, ensuring that necessary training and equipment will be on hand, and that the original design basis of the building, including the basic plan set out by the architect, is not compromised. The fire code also addresses inspection and maintenance requirements of various fire protection equipment in order to maintain optimal active fire protection and passive fire protection measures.

A typical fire safety code includes administrative sections about the rule-making and enforcement process, and substantive sections dealing with fire suppression equipment, particular hazards such as containers and transportation for combustible materials, and specific rules for hazardous occupancies, industrial processes, and exhibitions.

Sections may establish the requirements for obtaining permits and specific precautions required to remain in compliance with a permit. For example, a fireworks exhibition may require an application to be filed by a licensed pyrotechnician, providing the information necessary for the issuing authority to determine whether safety requirements can be met. Once a permit is issued, the same authority (or another delegated authority) may inspect the site and monitor safety during the exhibition, with the power to halt operations, when unapproved practices are seen or when unforeseen hazards arise.

List of some typical fire and explosion issues in a fire code

- ✓ Fireworks, explosives, mortars and cannons, model rockets (licenses for manufacture, storage, transportation, sale, use)
- ✓ Certification for servicing, placement, and inspecting fire extinguishing equipment
- ✓ General storage and handling of flammable liquids, solids, gases (tanks, personnel training, markings, equipment)
- ✓ Limitations on locations and quantities of flammables (e.g., 10 liters of gasoline inside a residential dwelling)
- ✓ Specific uses and specific flammables (e.g., dry cleaning, gasoline distribution, explosive dusts, pesticides, space heaters, plastics manufacturing)
- ✓ Permits and limitations in various building occupancies (assembly hall, hospital, school, theater, elderly care, child care, and those that require a smoke detector, sprinkler system, fire extinguisher, or other specific equipment or procedures
- ✓ Removal of interior and exterior obstructions to emergency exits or firefighters and removal of hazardous materials
- ✓ Permits and limitations in special outdoor applications (tents, asphalt kettles, bonfires, etc.)
- ✓ Other hazards (flammable decorations, welding, smoking, bulk matches, tire yards)
- ✓ Electrical safety codes such as the National Electrical Code (by the National Fire Protection Association) for the U.S. and some other places in the Americas
- ✓ Fuel gas code

Public Fire Safety Education
Fire prevention programs may include distribution of smoke detectors, visiting schools to review key topics with the students and implementing nationally recognized programs such as NFPAs "Risk Watch" and "Learn not to burn".

Other programs or props can be purchased by fire departments or community organizations. These are usually entertaining and designed to capture children's attention and relay important messages. Props include those that are mostly auditory, such as puppets and robots. The prop is visually stimulating but the safety message is only transmitted orally. Other props are more elaborate, access more senses and increase the learning factor. They mix audio messages and visual cues with hands-on interaction. Examples of these include mobile trailer safety houses and tabletop hazard house simulators. Some fire prevention software is also being developed to identify hazards in a home.

All programs tend to mix messages of general injury prevention, safety, fire prevention, and escape in case of fire. In most cases the fire department representative is regarded as the expert and is expected to present information in a manner that is appropriate for each age group.

Fire Safety Plan
A fire safety plan is required by all North American national, state and provincial fire codes based on building use or occupancy types. Generally, the owner of the building is responsible for the preparation of a fire safety plan. Buildings with elaborate emergency systems may require the assistance of a fire protection consultant. After the plan has been prepared, it must be submitted to the Chief Fire Official or authority having jurisdiction for approval. Once approved, the owner is responsible for implementing the fire safety plan and training all staff in their duties. It is also the owner’s responsibility to ensure that all visitors and staff are informed of what to do in case of fire. During a fire emergency, a copy of the approved fire safety plan must be available for the responding fire department's use.

Fire Safety Plan Structure
- ✓ Key contact information
- ✓ Utility services (Including shut-off valves for water, gas and electric)
- ✓ Access issues
- ✓ Dangerous stored materials
- ✓ Location of people with special needs
- ✓ Connections to sprinkler system
- ✓ Layout, drawing, and site plan of building
- ✓ Maintenance schedules for life safety systems
- ✓ Personnel training and fire drill procedure
- ✓ Create safe haven (zone)

Use of Fire Safety Plans
Fire safety plans are a useful tool for fire fighters to have because they allow them to know critical information about a building that they may have to go into. Using this, fire fighters can locate and avoid potential dangers such as hazardous material (hazmat) storage areas and flammable chemicals.

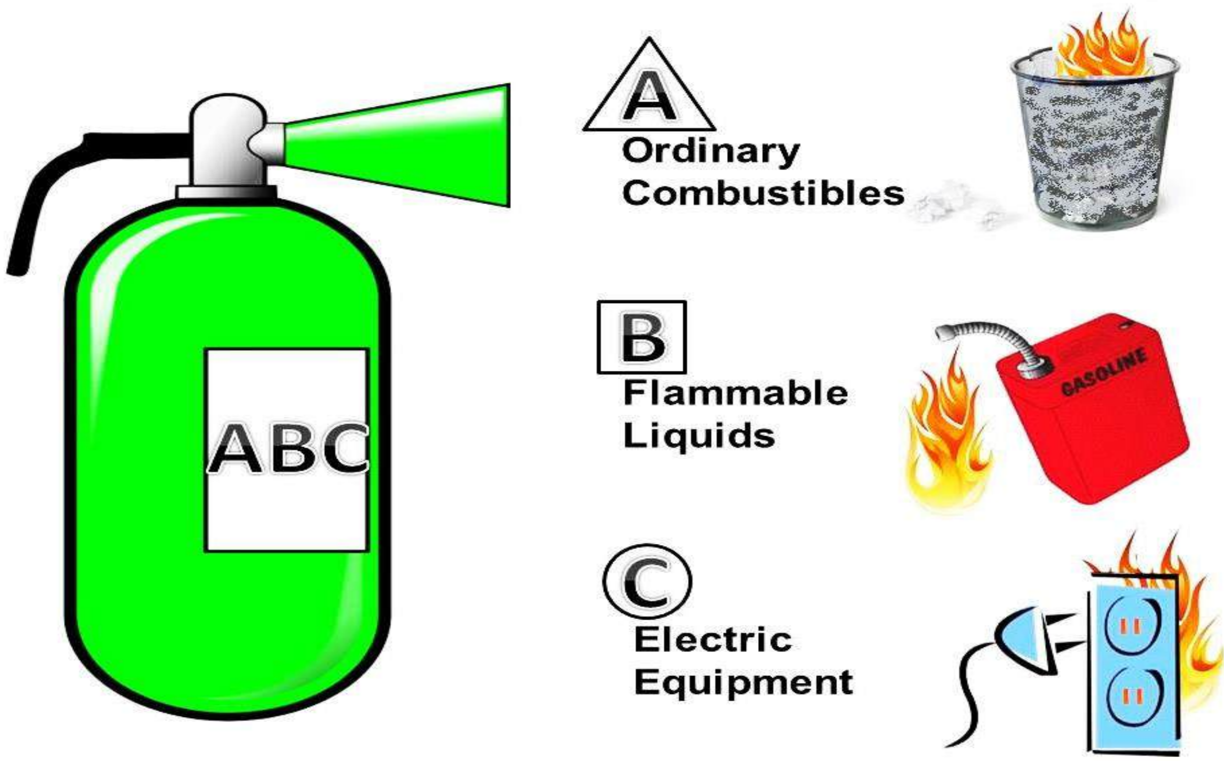
In addition to this, fire safety plans can also provide specialized information that, in the case of a hospital fire, can provide information about the location of things like the nuclear medicine ward. In addition to this, fire safety plans also greatly improve the safety of fire fighters. According to FEMA, 16 percent of all fire fighter deaths in 2002 occurred due to a structural collapse or because the fire fighter got lost. Fire safety plans can outline any possible structural hazards, as well as give the fire fighter knowledge of where he is in the building.

Fire Safety Plans in the Fire Code

In North America alone, there are around 8 million buildings that legally require a fire safety plan, be it due to provincial or state law. Not having a fire safety plan for buildings which fit the fire code occupancy type can result in a fine, and they are required for all buildings, such as commercial, industrial, assembly, etc.

Advances in Fire Safety Planning

As previously stated, a copy of the approved fire safety plan shall be available for the responding fire department. This, however, is not always the case. Up until now, all fire plans were stored in paper form in the fire department. The problem with this is that sorting and storing these plans is a challenge, and it is difficult for people to update their fire plans. As a result, only half of the required buildings have fire plans, and of those, only around 10 percent are up-to-date. This problem has been solved through the introduction of digital fire plans. These fire plans are stored in a database and can be accessed wirelessly on site by firefighters and are much simpler for building owners to update.



Never fight a fire larger than a trash can size.

Fire Prevention Measures

Fire prevention measures propose to reduce the incidence of fires by eliminating opportunities for ignition of flammable materials.

Flammable and Combustible Materials
A. Substitution
Flammable liquids sometimes may be substituted by relatively safe materials in order to reduce the risk of fires. Any substituted material should be stable and nontoxic and should either be nonflammable or have a high flashpoint.

B. Storage
Flammable and combustible liquids require careful handling at all times. The proper storage of flammable liquids within a work area is very important in order to protect personnel from fire and other safety and health hazards.

1) **Cabinets**

Not more than 120 gallons of Class I, Class II, and Class IIIA liquids may be stored in a storage cabinet. Of this total, not more than 60 gallons may be Class I and II liquids. Not more than three such cabinets (120 gallons each) may be located in a single fire area except in an industrial area.

Table 1. Maximum allowable capacity of containers and portable tanks

	Flammable Liquids		Combustible Liquids		
Container	**1A**	**1B**	**1C**	**II**	**III**
Glass or approved plastic1	1 pt[2]	1 qt[2]	1 gal	1 gal	1 gal
Metal (Other than DOT drums)	1 gal	5 gal	5 gal	5 gal	5 gal
Safety Cans	2 gal	5 gal	5 gal	5 gal	5 gal
Metal drums (DOT specifications)	60 gal	60 gal	60 gal	60 gal	60 gal
Approved portable tanks	660 gal	660 gal	660 gal	660 gal	660 gal
(1) Nearest metric size is also acceptable for the glass and plastic (2) One gallon or nearest metric equivalent size may be used if metal and labeled with their contents.					

A fire resistant file cabinet that is burned completely and beside it are modern flammable liquids storage cabinets.

2) **Containers**
The capacity of flammable and combustible liquid containers will be in accordance with Table 1.

3) **Storage Inside Buildings.**
Where approved storage cabinets or rooms are not provided, inside storage will comply with the following basic conditions:
a. The storage of any flammable or combustible liquid shall not physically obstruct a means of egress from the building or area.

b. Containers of flammable or combustible liquids will remain tightly sealed except when transferred, poured or applied. Remove only that portion of liquid in the storage container required to accomplish a particular job.

c. If a flammable and combustible liquid storage building is used, it will be a one-story building devoted principally to the handling and storing of flammable or combustible liquids. The building will have 2-hour fire-rated exterior walls having no opening within 10 feet of such storage.

d. Flammable paints, oils, and varnishes in 1 or 5 gallon containers, used for building maintenance purposes, may be stored temporarily in closed containers outside approved storage cabinets or room if kept at the job site for less than 10 calendar days.

C. Ventilation
Every inside storage room will be provided with a continuous mechanical exhaust ventilation system. To prevent the accumulation of vapors, the location of both the makeup and exhaust air openings will be arranged to provide, as far as practical, air movement directly to the exterior of the building and if ducts are used, they will not be used for any other purpose.

Firefighter preparing PPE or “Turnouts”.

Inspecting SCBA equipment.

Flammable and Combustible Materials Checklist

	Are combustible scrap, debris, and waste materials (oily rags, etc.) stored in covered metal receptacles and removed from the worksite promptly?
	Is proper storage practiced to minimize the risk of fire including spontaneous combustion?
	Are approved containers and tanks used for the storage and handling of flammable and combustible liquids?
	Are all connections on drums and combustible liquid piping, vapor and liquid tight?
	Are all flammable liquids kept in closed containers when not in use (for example, parts cleaning tanks, pans, etc.)?
	Are bulk drums of flammable liquids grounded and bonded to containers during dispensing?
	Do storage rooms for flammable and combustible liquids have explosion-proof lights?
	Do storage rooms for flammable and combustible liquids have mechanical or gravity ventilation?
	Is liquefied petroleum gas stored, handled, and used in accordance with safe practices and standards?
	Are "NO SMOKING" signs posted on liquefied petroleum gas tanks?
	Are liquefied petroleum storage tanks guarded to prevent damage from vehicles?
	Are all solvent wastes and flammable liquids kept in fire-resistant, covered containers until they are removed from the worksite?
	Is vacuuming used whenever possible rather than blowing or sweeping combustible dust? Are firm separators placed between containers of combustibles or flammables, when stacked one upon another, to assure their support and stability?
	Are fuel gas cylinders and oxygen cylinders separated by distance, and fire-resistant barriers, while in storage?
	Are fire extinguishers selected and provided for the types of materials in areas where they are to be used?

		Class A Ordinary combustible material fires.
		Class B Flammable liquid, gas or grease fires.
		Class C Energized-electrical equipment fires.

	Are appropriate fire extinguishers mounted within 75 feet of outside areas containing flammable liquids, and within 10 feet of any inside storage area for such materials?
	Are extinguishers free from obstructions or blockage?
	Are all extinguishers serviced, maintained and tagged at intervals not to exceed 1 year?
	Are all extinguishers fully charged and in their designated places?
	Where sprinkler systems are permanently installed, are the nozzle heads so directed or arranged that water will not be sprayed into operating electrical switch boards and equipment?
	Are "NO SMOKING" signs posted where appropriate in areas where flammable or combustible materials are used or stored?
	Are safety cans used for dispensing flammable or combustible liquids at a point of use?
	Are all spills of flammable or combustible liquids cleaned up promptly?
	Are storage tanks adequately vented to prevent the development of excessive vacuum or pressure as a result of filling, emptying, or atmosphere temperature changes?
	Are storage tanks equipped with emergency venting that will relieve excessive internal pressure caused by fire exposure?
	Are "NO SMOKING" rules enforced in areas involving storage and use of hazardous materials?

Elimination of Ignition Sources

D. All nonessential ignition sources must be eliminated where flammable liquids are used or stored. The following is a list of some of the more common potential ignition sources:

- Open flames, such as cutting and welding torches, furnaces, matches, and heaters-these sources should be kept away from flammable liquids operations. Cutting or welding on flammable liquids equipment should not be performed unless the equipment has been properly emptied and purged with a neutral gas such as nitrogen.

- Chemical sources of ignition such as D.C. motors, switched, and circuit breakers-these sources should be eliminated where flammable liquids are handled or stored. Only approved explosion-proof devices should be used in these areas.

- Mechanical sparks-these sparks can be produced as a result of friction. Only non-sparking tools should be used in areas where flammable liquids are stored or handled.

- Static sparks-these sparks can be generated as a result of electron transfer between two contacting surfaces. The electrons can discharge in a small volume, raising the temperature to above the ignition temperature. Every effort should be made to eliminate the possibility of static sparks. Also proper bonding and grounding procedures must be followed when flammable liquids are transferred or transported.

E. Removal of Incompatibles
Materials that can contribute to a flammable liquid fire should not be stored with flammable liquids. Examples are oxidizers and organic peroxides, which, on decomposition, can generate large amounts of oxygen.

F. Flammable Gases
Generally, flammable gases pose the same type of fire hazards as flammable liquids and their vapors. Many of the safeguards for flammable liquids also apply to flammable gases, other properties such as toxicity, reactivity, and corrosivity also must be taken into account.
Also, a gas that is flammable could produce toxic combustion products.


DANGER
CONFINED SPACE
ENTRY BY PERMIT ONLY
DRIVE SAFELY
AUTHORIZED PERSONNEL

Fire Extinguisher Section

A portable fire extinguisher is a "**first aid**" device and is very effective when used while the fire is small. The use of fire extinguisher that matches the class of fire, by a person who is well trained, can save both lives and property. Portable fire extinguishers must be installed in workplaces regardless of other firefighting measures. The successful performance of a fire extinguisher in a fire situation largely depends on its proper selection, inspection, maintenance, and distribution.

A. Classification of Fires and Selection of Extinguishers
Fires are classified into four general categories depending on the type of material or fuel involved. The type of fire determines the type of extinguisher that should be used to extinguish it.

1) Class A fires involve materials such as wood, paper, and cloth which produce glowing embers or char.
2) Class B fires involve flammable gases, liquids, and greases, including gasoline and most hydrocarbon liquids which must be vaporized for combustion to occur.
3) Class C fires involve fires in live electrical equipment or in materials near electrically powered equipment.
4) Class D fires involve combustible metals, such as magnesium, zirconium, potassium, and sodium.

Extinguishers will be selected according to the potential fire hazard, the construction and occupancy of facilities, hazard to be protected, and other factors pertinent to the situation.

B. Location and Marking of Extinguishers
Extinguishers will be conspicuously located and readily accessible for immediate use in the event of fire. They will be located along normal paths of travel and egress. Wall recesses and/or flush-mounted cabinets will be used as extinguisher locations whenever possible.

Extinguishers will be clearly visible. In locations where visual obstruction cannot be completely avoided, directional arrows will be provided to indicate the location of extinguishers and the arrows will be marked with the extinguisher classification.

If extinguishers intended for different classes of fire are located together, they will be conspicuously marked to ensure that the proper class extinguisher selection is made at the time of a fire.

Extinguisher classification markings will be located on the front of the shell above or below the extinguisher nameplate. Markings will be of a size and form to be legible from a distance of 3 feet.

Portable Fire Extinguishers

A fire extinguisher is **NO** substitute for the Fire Department. One third of all people injured by fire are hurt while trying to control it.

Virtually all fires are small at first and might easily be contained if the correct type of extinguisher is readily available and properly used. Fire extinguishers are the first line of defense against unfriendly fires, and should be installed in all homes and businesses.

When used properly, portable fire extinguishers can save lives and property by putting out a small fire or containing it until the fire department arrives.

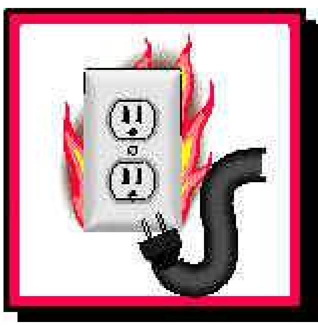
- ✓ Portable fire extinguishers for home use, however, are not designed to fight large or spreading fires. Even for small fires they are useful only under certain conditions:
- ✓ The operator must know how to use the extinguisher. There is no time to read directions during an emergency.
- ✓ The extinguisher must be within easy reach, in working order, and fully charged.
- ✓ The operator must have a clear escape route that will not be blocked by fire.
- ✓ The extinguisher must match the type of fire being fought. Extinguishers that contain water are unsuitable for use of grease and electrical fires.
- ✓ The extinguisher must be large enough to put out the fire. Many portable extinguishers discharge completely in as few as 8 to 10 seconds.

The four classes of fire extinguishers are:

Class A: Fires that involve ordinary materials such as wood, paper, cloth, and cardboard.

Class B: Fires that involve flammable liquids such as gasoline, oil, and oil-based paint.

Class C: Fires that involve energized electrical equipment, such as appliances, wiring, fuse boxes, and circuit breakers.



Class D fires involve combustible metals, such as magnesium, zirconium, potassium, and sodium.

The fire extinguisher must be appropriate for the type of fire being fought. If you use the wrong kind of fire extinguisher, you can make the fire worse and endanger yourself.

For example, if a water extinguisher is used on an electrical fire, there will be a risk of electrical shock.

Multipurpose fire extinguishers can be used on **A, B, C** classes of fires.

Portable Fire Extinguishers Rules

- ✓ Each workplace building must have a full complement of the proper type of fire extinguisher for the fire hazards present, excepting when employer wish to have employees evacuate instead of fighting small fires.

- ✓ Employees expected or anticipated to use fire extinguishers must be instructed on the hazards of fighting fire, how to properly operate the fire extinguishers available, and what procedures to follow in alerting others to the fire emergency.

- ✓ Only approved fire extinguishers are permitted to be used in workplaces, and they must be kept in good operating condition. Proper maintenance and inspection of this equipment is required of each employer.

- ✓ Where the employer wishes to evacuate employees instead of having them fight small fires there must be written emergency plans and employee training for proper evacuation.

What sizes of fire extinguisher are available?
Portable fire extinguishers are also rated for the size of fire they can handle. This rating will appear on the label - for example, **2A:10B:C**. The larger the numbers, the larger the fire that the extinguisher can put out. Higher-rated models are often much heavier. Make sure you can hold and operate an extinguisher before you buy it.

What should I know about installing and maintaining fire extinguishers?
- ✓ Fire extinguishers should be installed in plain view, above the reach of children, near an escape route and away from stoves and heating appliances.
- ✓ Fire extinguishers require some routine care. Make sure you read your operator's manual to learn how to inspect your fire extinguisher. Follow the manufacturer's instructions on maintaining the extinguisher.
- ✓ Rechargeable models must be serviced after every use (look in the Yellow Pages of your telephone directory under "**Fire Extinguishers**" for local companies that service them). The disposable fire extinguishers can be used only one time and must be replaced after use.



Should I Try to Fight the Fire?

Before you begin to fight a fire:

Make sure everyone has left or is leaving the building.

Make sure the fire department has been called. The Fire Department will be on the way in case the fire cannot be controlled.

Make sure the fire is confined to a small area and is not spreading.

Make sure you have an unobstructed escape route to which the fire will not spread.

Make sure you have read the instructions and know how to use the extinguisher.

Make sure the fire extinguisher is the right type for the fire.

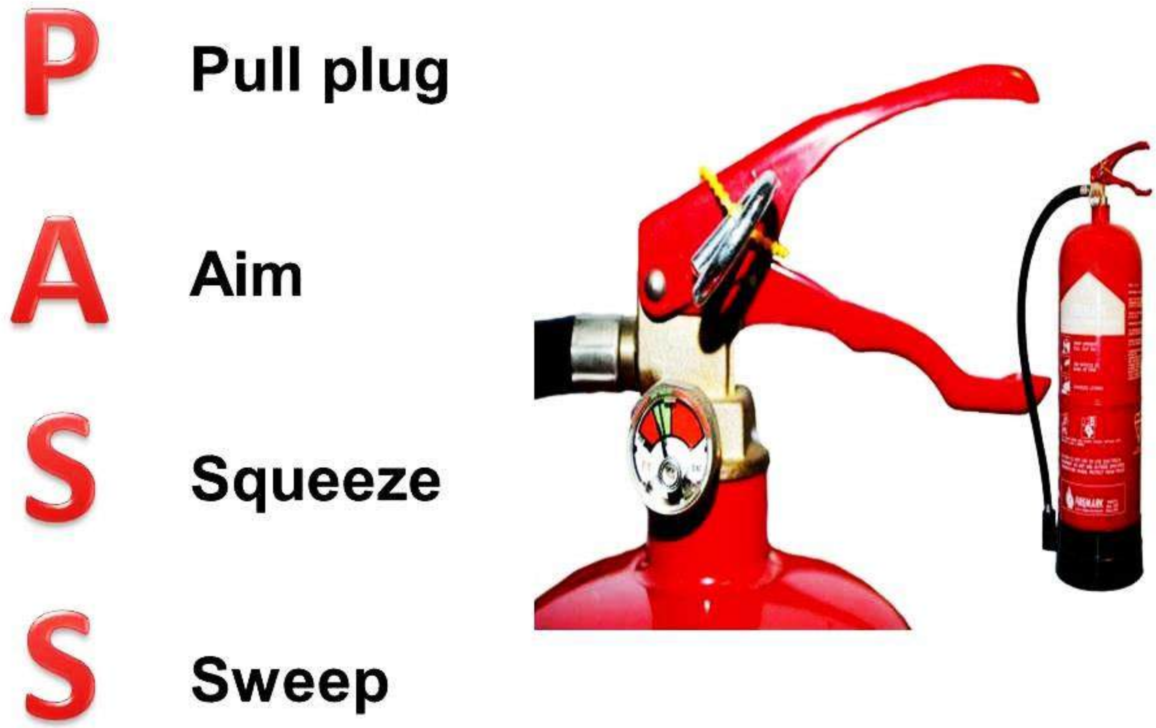
It is reckless to fight a fire in any other circumstances. Instead, leave immediately and close off the area.

Important Tips to Remember
Most fires start small. Except for explosions, fires can usually by brought under control if they are attacked correctly with the right type and size of extinguisher within the first two minutes!

A portable fire extinguisher can save lives and property by putting out a small fire or containing it until the fire department arrives. Before attempting to fight a small fire be sure everyone is out of the building. It is important to have someone call the fire department. If the fire starts to spread or threatens your escape path, get out immediately!

The operator must know how to use the extinguisher, quickly without taking time to read directions during an emergency. Remember that the extinguishers need care and must be recharged after every use.

P.A.S.S.



PULL the pin: this unlocks the operating lever and allows you to discharge the extinguisher. Some extinguishers may have other lever release mechanisms.

AIM low: point the extinguisher nozzle (or hose) at the BASE of the fire.

SQUEEZE the lever above the handle: this discharges the extinguishing agent. Releasing the lever will stop the discharge (some extinguishers have a button instead of a lever).

SWEEP from side to side: moving carefully toward the fire, keep the extinguisher aimed at the base of the fire and sweep back and forth until the flames appear to be out. Watch the fire area. If the fire ignites again, repeat the process.

ALWAYS make sure the fire department is called and inspects the fire site, even if you think you have extinguished the fire!

Important tips to remember
Most fires start small. Except for explosions, fires can usually by brought under control if they are attacked correctly with the right type and size of extinguisher within the first two minutes!

A portable fire extinguisher can save lives and property by putting out a small fire or containing it until the fire department arrives. Before attempting to fight a small fire be sure everyone is out of the building. It is important to have someone call the fire department. If the fire starts to spread or threatens your escape path, get out immediately!

The operator must know how to use the extinguisher, quickly without taking time to read directions during an emergency. Remember that the extinguishers need care and must be recharged after every use.

The steps to use a fire extinguisher are P.A.S.S. Pull, Aim, Squeeze, and Sweep. Most portable extinguishers work according to these directions, but some do not. Read and follow the directions on your extinguisher.

If you have the slightest doubt about whether or not to fight a fire - **DON'T!** Get out and close the door behind you.

Portable fire extinguishers can be a useful component of a home fire safety plan, but they aren't the only component. A comprehensive home fire safety plan should include smoke detectors and an evacuation plan.

It is also important to talk about fire safety with your family regularly to re-enforce the evacuation plan, check your smoke detectors' batteries, and review where your fire extinguishers are kept, and how to use them.

C. Condition

Portable extinguishers will be maintained in a fully charged and operable condition. They will be kept in their designated locations at all times when not being used.

When extinguishers are removed for maintenance or testing, a fully charged and operable replacement unit will be provided.

D. Mounting and Distribution of Extinguishers

Extinguishers will be installed on hangers, brackets, in cabinets, or on shelves.

Extinguishers having a gross weight not exceeding 40 pounds will be so installed that the top of the extinguisher is not more than 3-1/2 feet above the floor.

Extinguishers mounted in cabinets or wall recesses or set on shelves will be placed so that the extinguisher operating instructions face outward. The location of such extinguishers will be made conspicuous by marking the cabinet or wall recess in a contrasting color which will distinguish it from the normal decor.

Extinguishers must be distributed in such a way that the amount of time needed to travel to their location and back to the fire does not allow the fire to get out of control. OSHA requires that the travel distance for Class A and Class D extinguishers not exceed 75 feet.

The maximum travel distance for Class B extinguishers is 50 feet because flammable liquid fires can get out of control faster that Class A fires.

There is no maximum travel distance specified for Class C extinguishers, but they must be distributed on the basis of appropriate patterns for Class A and B hazards.

E. Inspection and Maintenance

Once an extinguisher is selected, purchased, and installed, it is the responsibility of the facility manager to oversee the inspection, maintenance, and testing of fire extinguishers to ensure that they are in proper working condition and have not been tampered with or physically damaged.

OSHA Fire Prevention Rule 1910.38(a)

"Emergency action plan" - 1910.38(a)(1)
"Scope and application." This paragraph (a) applies to all emergency action plans required by a particular OSHA standard. The emergency action plan shall be in writing (except as provided in the last sentence of paragraph (a)(5)(iii) of this section) and shall cover those designated actions employers and employees must take to ensure employee safety from fire and other emergencies.

1910.38(a)(2)
"Elements." The following elements, at a minimum, shall be included in the plan:
1910.38(a)(2)(i)
Emergency escape procedures and emergency escape route assignments;
1910.38(a)(2)(ii)
Procedures to be followed by employees who remain to operate critical plant operations before they evacuate;
1910.38(a)(2)(iii)
Procedures to account for all employees after emergency evacuation has been completed;
..1910.38(a)(2)(iv)
1910.38(a)(2)(iv)
Rescue and medical duties for those employees who are to perform them;
1910.38(a)(2)(v)
The preferred means of reporting fires and other emergencies; and
1910.38(a)(2)(vi)
Names or regular job titles of persons or departments who can be contacted for further information or explanation of duties under the plan.

1910.38(a)(3)
"Alarm system."
1910.38(a)(3)(i)
The employer shall establish an employee alarm system which complies with 1910.165.
1910.38(a)(3)(ii)
If the employee alarm system is used for alerting fire brigade members, or for other purposes, a distinctive signal for each purpose shall be used.

1910.38(a)(4)
"Evacuation." The employer shall establish in the emergency action plan the types of evacuation to be used in emergency circumstances.

1910.38(a)(5)
"Training."
1910.38(a)(5)(i)
Before implementing the emergency action plan, the employer shall designate and train a sufficient number of persons to assist in the safe and orderly emergency evacuation of employees.
..1910.38(a)(5)(ii)

1910.38(a)(5)(ii)
The employer shall review the plan with each employee covered by the plan at the following times:
1910.38(a)(5)(ii)(A)
Initially when the plan is developed,
1910.38(a)(5)(ii)(B)
Whenever the employee's responsibilities or designated actions under the plan change, and
1910.38(a)(5)(ii)(C)
Whenever the plan is changed.
1910.38(a)(5)(iii)
The employer shall review with each employee upon initial assignment those parts of the plan which the employee must know to protect the employee in the event of an emergency. The written plan shall be kept at the workplace and made available for employee review. For those employers with 10 or fewer employees the plan may be communicated orally to employees and the employer need not maintain a written plan.

1910.38(b)
"Fire prevention plan" -
1910.38(b)(1)
"Scope and application." This paragraph (b) applies to all fire prevention plans required by a particular OSHA standard. The fire prevention plan shall be in writing, except as provided in the last sentence of paragraph (b)(4)(ii) of this section.
..1910.38(b)(2)

1910.38(b)(2)
"Elements." The following elements, at a minimum, shall be included in the fire prevention plan:
1910.38(b)(2)(i)
A list of the major workplace fire hazards and their proper handling and storage procedures, potential ignition sources (such as welding, smoking and others) and their control procedures, and the type of fire protection equipment or systems which can control a fire involving them;
1910.38(b)(2)(ii)
Names or regular job titles of those personnel responsible for maintenance of equipment and systems installed to prevent or control ignitions or fires; and
1910.38(b)(2)(iii)
Names or regular job titles of those personnel responsible for control of fuel source hazards.

1910.38(b)(3)
"Housekeeping." The employer shall control accumulations of flammable and combustible waste materials and residues so that they do not contribute to a fire emergency. The housekeeping procedures shall be included in the written fire prevention plan.
1910.38(b)(4)
"Training."
1910.38(b)(4)(i)
The employer shall apprise employees of the fire hazards of the materials and processes to which they are exposed.
..1910.38(b)(4)(ii)

1910.38(b)(4)(ii)
The employer shall review with each employee upon initial assignment those parts of the fire prevention plan which the employee must know to protect the employee in the event of an emergency. The written plan shall be kept in the workplace and made available for employee review. For those employers with 10 or fewer employees, the plan may be communicated orally to employees and the employer need not maintain a written plan.

1910.38(b)(5)
"Maintenance." The employer shall regularly and properly maintain, according to established procedures, equipment and systems installed on heat producing equipment to prevent accidental ignition of combustible materials. The maintenance procedures shall be included in the written fire prevention plan.
[45 FR 60703, Sept. 12, 1980]

Blocked Fire Exit. Death trap.

The employer shall review with each employee upon initial assignment those parts of the fire prevention plan which the employee must know to protect the employee in the event of an emergency. The written plan shall be kept in the workplace and made available for employee review. For those employers with 10 or fewer employees, the plan may be communicated orally to employees and the employer need not maintain a written plan.

OSHA Definitions used in the Fire Planning and Evacuation Rules

"Approved" means equipment that has been listed or approved by a nationally recognized testing laboratory such as Factory Mutual Engineering Corp., or Underwriters' Laboratories, Inc., or Federal agencies such as Bureau of Mines, or U.S. Coast Guard, which issue approvals for such equipment.

"Closed container" means a container so sealed by means of a lid or other device that neither liquid nor vapor will escape from it at ordinary temperatures.

"Combustible liquid" means any liquid having a flash point at or above 140 deg. F (60 deg. C), and below 200 deg. F (93.4 deg. C).

"Combustion" means any chemical process that involves oxidation sufficient to produce light or heat.

"Fire brigade" means an organized group of employees that are knowledgeable, trained, and skilled in the safe evacuation of employees during emergency situations and in assisting in firefighting operations.

"Fire resistance" means so resistant to fire that, for specified time and under conditions of a standard heat intensity, it will not fail structurally and will not permit the side away from the fire to become hotter than a specified temperature. For purposes of this part, fire resistance shall be determined by the *Standard Methods of Fire Tests of Building Construction and Materials*, NFPA 251-1969.

"Flammable" means capable of being easily ignited, burning intensely, or having a rapid rate of flame spread.

"Flammable liquid" means any liquid having a flash point below 140 deg. F and having a vapor pressure not exceeding 40 pounds per square inch (absolute) at 100 deg. F.

"Flash point" of the liquid means the temperature at which it gives off vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the vessel used as determined by appropriate test procedure and apparatus as specified below.

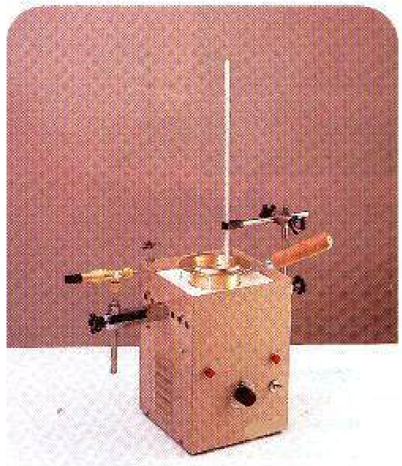
> (1) The flash point of liquids having a viscosity less than 45 Saybolt Universal Second(s) at 100 deg. F (37.8 deg. C) and a flash point below 175 deg. F (79.4 deg. C) shall be determined in accordance with the *Standard Method of Test for Flash Point by the Tag Closed Tester*, ASTM D-56-69.
>
> (2) The flash point of liquids having a viscosity of 45 Saybolt Universal Second(s) or more at 175 deg. F. (79.4 deg. C) or higher shall be determined in accordance with the *Standard Method of Test for Flash Point by the Pensky Martens Closed Tester*, ASTM D-93-69.

"Liquefied petroleum gases," "LPG" and "LP Gas" mean and include any material which is composed predominantly of any of the following hydrocarbons, or mixtures of them, such as propane, propylene, butane (normal butane or isobutene), and butylenes.

"Portable tank" means a closed container having a liquid capacity more than 60 U.S. gallons, and not intended for fixed installation.

"Safety can" means an approved closed container, of not more than 5 gallons capacity, having a flash-arresting screen, spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

"Vapor pressure" means the pressure, measured in pounds per square inch (absolute), exerted by a volatile liquid as determined by the *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method),* ASTM D-323-58.



MANUAL CLEVELAND FLASH POINT TESTER
ASTM D92 - NF EN 22592 - ISO 2592 - IP 36

DEFINITION

This test method covers determination of flash and fire points of petroleum products by means of a Cleveland Open Cup tester.

CHARACTERISTICS

- ✓ Electronic regulation
- ✓ Requires external supply of butane/propane or town gas
- ✓ Needle valve for a fine adjustment of the flame
- ✓ Delivered with open cup and thermometer

SPECIFICATION

MANUAL CLEVELAND OPEN CUP TESTER in stainless steel comprising electronic regulation, pilot burner with needle valve for fine adjustment of the flame, thermometer support, Cleveland open cup and ASTM 11C thermometer.

FIRE PROTECTION RULE - §1926.150

General Requirements
The employer shall be responsible for the development of a fire protection program to be followed throughout all phases of the construction and demolition work, and shall provide for the firefighting equipment as specified in this subpart. As fire hazards occur, there shall be no delay in providing the necessary equipment.

Access to all available firefighting equipment shall be maintained at all times. All firefighting equipment, provided by the employer, shall be conspicuously located.

All firefighting equipment shall be periodically inspected and maintained in operating condition.

Defective equipment shall be immediately replaced.

As warranted by the project, the employer shall provide a trained and equipped firefighting organization (Fire Brigade) to assure adequate protection to life.

Water Supply
A temporary or permanent water supply, of sufficient volume, duration, and pressure, required to properly operate the firefighting equipment shall be made available as soon as combustible materials accumulate.

Where underground water mains are to be provided, they shall be installed, completed, and made available for use as soon as practicable.

Portable Firefighting Equipment
Fire Extinguishers and Small Hose Lines
A fire extinguisher, rated not less than 2A, shall be provided for each 3,000 square feet of the protected building area, or major fraction thereof. Travel distance from any point of the protected area to the nearest fire extinguisher shall not exceed 100 feet.

One 55-gallon open drum of water with two fire pails may be substituted for a fire extinguisher having a 2A rating.

A ½-inch diameter garden-type hose line, not to exceed 100 feet in length and equipped with a nozzle, may be substituted for a 2A-rated fire extinguisher, providing it is capable of discharging a minimum of 5 gallons per minute with a minimum hose stream range of 30 feet horizontally.

The garden-type hose lines shall be mounted on conventional racks or reels. The number and location of hose racks or reels shall be such that at least one hose stream can be applied to all points in the area.

One or more fire extinguishers, rated not less than 2A, shall be provided on each floor. In multistory buildings, at least one fire extinguisher shall be located adjacent to stairway.

Extinguishers and Water Drums
Extinguishers and water drums, subject to freezing, shall be protected from freezing.

A fire extinguisher, rated not less than 10B, shall be provided within 50 feet of wherever more than 5 gallons of flammable or combustible liquids or 5 pounds of flammable gas are being used on the jobsite. This requirement does not apply to the integral fuel tanks of motor vehicles.

Carbon tetrachloride and other toxic vaporizing liquid fire extinguishers are prohibited.

Portable fire extinguishers shall be inspected periodically and maintained in accordance with *Maintenance and Use of Portable Fire Extinguishers*, NFPA No. 10A-1970. Fire extinguishers which have been listed or approved by a nationally recognized testing laboratory, shall be used to meet the requirements of this subpart.

Table F-1 in §1926.150(c)(1)(x) may be used as a guide for selecting the appropriate portable fire extinguishers.

Fire Hose and Connections
One hundred feet, or less, of 1½-inch hose, with a nozzle capable of discharging water at 25 gallons or more per minute, may be substituted for a fire extinguisher rated not more than 2A in the designated area provided that the hose line can reach all points in the area.

If fire hose connections are not compatible with local firefighting equipment, the contractor shall provide adapters, or equivalent, to permit connections.

During demolition involving combustible materials, charged hose lines, supplied by hydrants, water tank trucks with pumps, or equivalent, shall be made available.

Fixed Firefighting Equipment

Sprinkler Protection
If the facility being constructed includes the installation of automatic sprinkler protection, the installation shall closely follow the construction and be placed in service as soon as applicable laws permit following completion of each story.

During demolition or alterations, existing automatic sprinkler installations shall be retained in service as long as reasonable. The operation of sprinkler control valves shall be permitted only by properly authorized persons.

Modification of sprinkler systems to permit alterations or additional demolition should be expedited so that the automatic protection may be returned to service as quickly as possible.

Sprinkler control valves shall be checked daily at close of work to ascertain that the protection is in service.

Standpipes
In all structures in which standpipes are required, or where standpipes exist in structures being altered, they shall be brought up as soon as applicable laws permit, and shall be maintained as construction progresses in such a manner that they are always ready for fire protection use.

The standpipes shall be provided with Siamese fire department connections on the outside of the structure, at the street level, which shall be conspicuously marked. There shall be at least one standard hose outlet at each floor.

Fire Alarm Devices
An alarm system, e.g., telephone system, siren, etc., shall be established by the employer whereby employees on the site and the local fire department can be alerted for an emergency. The alarm code and reporting instructions shall be conspicuously posted at phones and at employee entrances.

Fire Cutoffs
Fire walls and exit stairways, required for the completed buildings, shall be given construction priority.

Fire doors, with automatic closing devices, shall be hung on openings as soon as practicable.

Fire cutoffs shall be retained in buildings undergoing alterations or demolition until operations necessitate their removal.

The employer shall be responsible for the development of a fire protection program to be followed throughout all phases of the construction and demolition work, and shall provide for the firefighting equipment as specified in this subpart. As fire hazards occur, there shall be no delay in providing the necessary equipment.

Access to all available firefighting equipment shall be maintained at all times. All firefighting equipment, provided by the employer, shall be conspicuously located.

All firefighting equipment shall be periodically inspected and maintained in operating condition.

Defective equipment shall be immediately replaced.

As warranted by the project, the employer shall provide a trained and equipped firefighting organization (Fire Brigade) to assure adequate protection to life.

FIXED FIRE PREVENTION - §1926.151

Ignition Hazards
Electrical wiring and equipment for light, heat, or power purposes shall be installed in compliance with the requirements of Subpart K, *Electrical*.

Internal combustion engine powered equipment shall be so located that the exhausts are well away from combustible materials. When the exhausts are piped to outside the building under construction, a clearance of at least 6 inches shall be maintained between such piping and combustible material.

Smoking shall be prohibited at or in the vicinity of operations which constitute a fire hazard, and shall be conspicuously posted: "No Smoking or Open Flame."

Portable battery powered lighting equipment, used in connection with the storage, handling, or use of flammable gases or liquids, shall be of the type approved for the hazardous locations.

The nozzle of air, inert gas, and steam lines or hoses, when used in the cleaning or ventilation of tanks and vessels that contain hazardous concentrations of flammable gases or vapors, shall be bonded to the tank or vessel shell. Bonding devices shall not be attached or detached in hazardous concentrations of flammable gases or vapors.

Temporary Buildings
No temporary building shall be erected where it will adversely affect any means of exit.

Temporary buildings, when located within another building or structure, shall be of either noncombustible construction or of combustible construction having a fire resistance of not less than 1 hour.

Temporary buildings, located other than inside another building and not used for the storage, handling, or use of flammable or combustible liquids, flammable gases, explosives, or blasting agents, or similar hazardous occupancies, shall be located at a distance of not less than 10 feet from another building or structure.

Groups of temporary buildings, not exceeding 2,000 square feet in aggregate, shall, for the purposes of this part, be considered a single temporary building.

Open Yard Storage
Combustible materials shall be piled with due regard to the stability of piles and in no case higher than 20 feet.

Driveways between and around combustible storage piles shall be at least 15 feet wide and maintained free from accumulation of rubbish, equipment, or other articles or materials.

Driveways shall be so spaced that a maximum grid system unit of 50 feet by 150 feet is produced.

Storage Site
The entire storage site shall be kept free from accumulation of unnecessary combustible materials. Weeds and grass shall be kept down and a regular procedure provided for the periodic cleanup of the entire area. When there is a danger of an underground fire, that land shall not be used for combustible or flammable storage.

Method of piling shall be solid wherever possible and in orderly and regular piles. No combustible material shall be stored outdoors within 10 feet of a building or structure.

Portable fire extinguishing equipment, suitable for the fire hazard involved, shall be provided at convenient, conspicuously accessible locations in the yard area. Portable fire extinguishers, rated not less than 2A, shall be placed so that maximum travel distance to the nearest unit shall not exceed 100 feet.

Indoor Storage
Storage shall not obstruct, or adversely affect, means of exit. All materials shall be stored, handled, and piled with due regard to their fire characteristics.

Non-compatible materials, which may create a fire hazard, shall be segregated by a barrier having a fire resistance of at least 1 hour.

Material shall be piled to minimize the spread of fire internally and to permit convenient access for firefighting.

Stable piling shall be maintained at all times. Aisle space shall be maintained to safely accommodate the widest vehicle that may be used within the building for firefighting purposes.

Clearance of at least 36 inches shall be maintained between the top level of the stored material and the sprinkler deflectors.

Clearance shall be maintained around lights and heating units to prevent ignition of combustible materials.

A clearance of 24 inches shall be maintained around the path of travel of fire doors unless a barricade is provided, in which case no clearance is needed. Material shall not be stored within 36 inches of a fire door opening.

FLAMMABLE AND COMBUSTIBLE LIQUIDS - §1926.152

General Requirements
Only approved containers and portable tanks shall be used for storage and handling of flammable and combustible liquids. Approved metal safety cans shall be used for the handling and use of flammable liquids in quantities greater than one gallon, except that this shall not apply to those flammable liquid materials which are highly viscid (extremely hard to pour), which may be used and handled in original shipping containers. For quantities of one gallon or less, only the original container or approved metal safety cans shall be used for storage, use, and handling of flammable liquids.

Flammable or combustible liquids shall not be stored in areas used for exits, stairways, or normally used for the safe passage of people.

Indoor Storage of Flammable and Combustible Liquids
No more than 25 gallons of flammable or combustible liquids shall be stored in a room outside of an approved storage cabinet. For storage of liquefied petroleum gas, see §1926.153.

Quantities of flammable and combustible liquid in excess of 25 gallons shall be stored in an acceptable or approved cabinet meeting the following requirements:

(i) Acceptable wooden storage cabinets shall be constructed in the following manner, or equivalent: The bottom, sides, and top shall be constructed of an exterior grade of plywood at least 1 inch in thickness, which shall not break down or delaminate under standard fire test conditions. All joints shall be rabbeted and shall be fastened in two directions with flathead wood screws.

When more than one door is used, there shall be a rabbeted overlap of not less than 1 inch. Steel hinges shall be mounted in such a manner as to not lose their holding capacity due to loosening or burning out of the screws when subjected to fire. Such cabinets shall be painted inside and out with fire retardant paint.
(ii) Approved metal storage cabinets will be acceptable.
(iii) Cabinets shall be labeled in conspicuous lettering, "Flammable-Keep Fire Away."

Not more than 60 gallons of flammable or 120 gallons of combustible liquids shall be stored in any one storage cabinet. Not more than three such cabinets may be located in a single storage area. Quantities in excess of this shall be stored in an inside storage room.

Inside storage rooms shall be constructed to meet the required fire-resistive rating for their use.

Such construction shall comply with the test specifications set forth in *Standard Methods of Fire Test of Building Construction and Material*, NFPA 251-1969.

Where an automatic extinguishing system is provided, the system shall be designed and installed in an approved manner. Openings to other rooms or buildings shall be provided with noncombustible liquid-tight raised sills or ramps at least 4 inches in height, or the floor in the storage area shall be at least 4 inches below the surrounding floor. Openings shall be provided with approved self-closing fire doors. The room shall be liquid-tight where the walls join the floor.

A permissible alternate to the sill or ramp is an open-grated trench, inside of the room, which drains to a safe location.

Where other portions of the building or other buildings are exposed, windows shall be protected as set forth in the *Standard for Fire Doors and Windows*, NFPA No. 80-1970, for Class E or F openings. Wood of at least 1-inch nominal thickness may be used for shelving, racks, dunnage, scuffboards, floor overlay, and similar installations.

Materials which will react with water and create a fire hazard shall not be stored in the same room with flammable or combustible liquids.

Storage in inside storage rooms shall comply with Table F-2:

TABLE F-2			
Fire Protection Provided	**Fire Resistance**	**Maximum Size**	**Total Allowable Quantities (gal./sq. ft. floor area)**
Yes	2 hrs.	500 sq. ft.	10
No	2 hrs.	500 sq. ft.	4
Yes	1 hr.	150 sq. ft.	5
No	1 hr.	150 sq. ft.	2

NOTE: Fire protection system shall be sprinkler, water spray, carbon dioxide or other system approved by a nationally recognized testing laboratory for this purpose.

Electrical wiring and equipment located in inside storage rooms shall be approved for Class I, Division 1, Hazardous Locations. For definition of Class I, Division 1, Hazardous Locations, see §1926.449.

Every inside storage room shall be provided with either a gravity or a mechanical exhausting system. Such system shall commence not more than 12 inches above the floor and be designed to provide for a complete change of air within the room at least 6 times per hour. If a mechanical exhausting system is used, it shall be controlled by a switch located outside of the door. The ventilating equipment and any lighting fixtures shall be operated by the same switch. An electric pilot light shall be installed adjacent to the switch if flammable liquids are dispensed within the room. Where gravity ventilation is provided, the fresh air intake, as well as the exhausting outlet from the room, shall be on the exterior of the building in which the room is located.

In every inside storage room there shall be maintained one clear aisle at least 3 feet wide. Containers over 30 gallons capacity shall not be stacked one upon the other.

Storage Outside Buildings
Flammable and combustible liquids in excess of that permitted in inside storage rooms shall be stored outside of buildings in accordance with paragraph "Storage Outside Buildings" of this section.

The quantity of flammable or combustible liquids kept in the vicinity of spraying operations shall be the minimum required for operations and should ordinarily not exceed a supply for 1 day or one shift. Bulk storage of portable containers of flammable or combustible liquids shall be in a separate, constructed building detached from other important buildings or cut off in a standard manner.

Storage Outside Buildings
Storage of containers (not more than 60 gallons each) shall not exceed 1,100 gallons in any one pile or area. Piles or groups of containers shall be separated by a 5-foot clearance. Piles or groups of containers shall not be nearer than 20 feet to a building.

Within 200 feet of each pile of containers, there shall be a 12-foot-wide access way to permit approach of fire control apparatus.

The storage area shall be graded in a manner to divert possible spills away from buildings or other exposures, or shall be surrounded by a curb or earth dike at least 12 inches high. When curbs or dikes are used, provisions shall be made for draining off accumulations of ground or rain water, or spills of flammable or combustible liquids. Drains shall terminate at a safe location and shall be accessible to operation under fire conditions.

Outdoor portable tank storage:
(i) Portable tanks shall not be nearer than 20 feet from any building. Two or more portable tanks, grouped together, having a combined capacity in excess of 2,200 gallons, shall be separated by a 5-foot-clear area. Individual portable tanks exceeding 1,100 gallons shall be separated by a 5-foot-clear area.

(ii) Within 200 feet of each portable tank, there shall be a 12-foot-wide access way to permit approach of fire control apparatus.

Storage areas shall be kept free of weeds, debris, and other combustible material not necessary to the storage.

Portable tanks, not exceeding 660 gallons, shall be provided with emergency venting and other devices, as required by chapters III and IV of NFPA 30-1969, *The Flammable and Combustible Liquids Code*.

Portable tanks, in excess of 660 gallons, shall have emergency venting and other devices, as required by chapters II and III of *The Flammable and Combustible Liquids Code*, NFPA 30-1969.

Fire Control for Flammable or Combustible Liquid Storage
At least one portable fire extinguisher, having a rating of not less than 20-B units, shall be located outside of, but not more than 10 feet from, the door opening into any room used for storage of more than 60 gallons of flammable or combustible liquids.

At least one portable fire extinguisher having a rating of not less than 20-B units shall be located not less than 25 feet, nor more than 75 feet, from any flammable liquid storage area located outside.

When sprinklers are provided, they shall be installed in accordance with the *Standard for the Installation of Sprinkler Systems*, NFPA 13-1969.

At least one portable fire extinguisher having a rating of not less than 20-B:C units shall be provided on all tank trucks or other vehicles used for transporting and/or dispensing flammable or combustible liquids.

Dispensing Liquids
Areas in which flammable or combustible liquids are transferred at one time, in quantities greater than 5 gallons from one tank or container to another tank or container, shall be separated from other operations by 25-feet distance or by construction having a fire resistance of at least 1 hour. Drainage or other means shall be provided to control spills. Adequate natural or mechanical ventilation shall be provided to maintain the concentration of flammable vapor at or below 10 percent of the lower flammable limit.

Transfer of flammable liquids from one container to another shall be done only when containers are electrically interconnected (bonded).

Flammable or combustible liquids shall be drawn from or transferred into vessels, containers, or tanks within a building or outside only through a closed piping system, from safety cans, by means of a device drawing through the top, or from a container, or portable tanks, by gravity or pump, through an approved self-closing valve.

Transferring by means of air pressure on the container or portable tanks is prohibited.

The dispensing units shall be protected against collision damage. Dispensing devices and nozzles for flammable liquids shall be of an approved type.

Handling Liquids at Point of Final Use
Flammable liquids shall be kept in closed containers when not actually in use.

Leakage or spillage of flammable or combustible liquids shall be disposed of promptly and safely.

Flammable liquids may be used only where there are no open flames or other sources of ignition within 50 feet of the operation, unless conditions warrant greater clearance.

Service and Refueling Areas
Flammable or combustible liquids shall be stored in approved closed containers, in tanks located underground, or in aboveground portable tanks.

The tank trucks shall comply with the requirements covered in the *Standard for Tank Vehicles for Flammable and Combustible Liquids*, NFPA No. 385-1966.

The dispensing hose shall be an approved type, and the dispensing nozzle shall be an approved automatic-closing type without a latch-open device.

Underground tanks shall not be abandoned.

Clearly identified and easily accessible switch(es) shall be provided at a location remote from dispensing devices to shut off the power to all dispensing devices in the event of an emergency.

Heating equipment of an approved type may be installed in the lubrication or service area where there is no dispensing or transferring of flammable liquids, provided the bottom of the heating unit is at least 18 inches above the floor and is protected from physical damage.

Heating equipment installed in lubrication or service areas, where flammable liquids are dispensed, shall be of an approved type for garages, and shall be installed at least 8 feet above the floor.

There shall be no smoking or open flames in the areas used for fueling, servicing fuel systems for internal combustion engines, receiving or dispensing of flammable or combustible liquids.

Conspicuous and legible signs prohibiting smoking shall be posted.

The motors of all equipment being fueled shall be shut off during the fueling operation.

Each service or fueling area shall be provided with at least one fire extinguisher having a rating of not less than 20-B:C located so that an extinguisher will be within 75 feet of each pump, dispenser, underground fill pipe opening, and lubrication or service area.

Scope
This section applies to the handling, storage, and use of flammable and combustible liquids with a flashpoint below 200 deg. F (93.33 deg. C). This section does not apply to: (1) Bulk transportation of flammable and combustible liquids; and (2) Storage, handling, and use of fuel oil tanks and containers connected with oil burning equipment.

Tank Storage
Refer to §1926.152(i) for design, construction, and installation requirements for flammable or combustible liquid storage tanks.

Welding Glossary

Abrasive – Slag used for cleaning or surface roughening.
Active Flux – Submerged-arc welding flux from which the amount of elements deposited in the weld metal is dependent upon welding conditions, primarily arc voltage.
Adhesive Bonding – Surfaces, solidifies to produce an adhesive bond.
Air Carbon Arc Cutting – An arc cutting process in which metals to be cut are melted by the heat of carbon arc and the molten metal is removed by a blast of air.
All-Weld-Metal Test Specimen – A test specimen with the reduction section composed wholly of weld metal.
Alloying – Adding a metal or alloy to another metal or alloy.
Alternating Current (AC) – Electric current that reverses direction periodically, usually many times per second.
Annealed Condition – A metal or alloy that has been heated and then cooled to remove internal stresses and to make the material less brittle.
Arc Blow – The deflection of an electric arc from its normal path because of magnetic forces.
Arc Cutting – A group of thermal cutting processes that severs or removes metal by melting with the heat of an arc between an electrode and the work piece.
Arc Force – The axial force developed by an arc plasma.
Arc Gouging – An arc cutting procedure used to form a bevel or groove.
Arc Length – The distance from the tip of the electrode or wire to the work piece.
Arc Time – The time during which an arc is maintained.
Arc Voltage – The voltage across the welding arc.
Arc Welding – A group of welding processes which produces coalescence of metals by heating them with an arc, with or without the application of pressure and with or without the use of filler metal.
Arc Welding Deposition Efficiency (%) – The ratio of the weight of filler metal deposited to the weight of filler metal melted.
Arc Welding Electrode – A part of the welding system through which current is conducted that ends at the arc.
As-Welded – The condition of the weld metal, after completion of welding, and prior to any subsequent thermal or mechanical treatment.
Atomic Hydrogen Welding – An arc welding process which produces coalescence of metals by heating them with an electric arc maintained between two metal electrodes in an atmosphere of hydrogen.
Austenitic – Composed mainly of gamma iron with carbon in solution.
Autogenous Weld – A fusion weld made without the addition of filler metal.
Automatic – The control of a process with equipment that requires little or no observation of the welding and no manual adjustment of the equipment controls.
Back Gouging – The removal of weld metal and base metal from the other side of a partially welded joint to assure complete penetration upon subsequent welding from that side.
Backfire – The momentary recession of the flame into the welding or cutting tip followed by reappearance or complete extinction of the flame.
Backhand Welding – A welding technique where the welding torch or gun is directed opposite to the direction of welding.
Backing – A material (base metal, weld metal, or granular material) placed at the root of a weld joint for the purpose of supporting molten weld metal.
Backing Gas – A shielding gas used on the underside of a weld bead to protect it from atmospheric contamination.
Backing Ring – Backing in the form of a ring, generally used in the welding of pipe.

Back-Step Sequence – A longitudinal sequence in which the weld bead increments are deposited in the direction opposite to the progress of welding the joint.
Base Metal (material) – The metal (material) to be welded, brazed, soldered, or cut. See also substrate.
Bend Radius – Radius of curvature on a bend specimen or bent area of a formed part. Measured on the inside of a bend.
Bevel – An angled edge preparation.
Blanking – Process of cutting material to size for more manageable processing.
Braze Welding – A method of welding by using a filler metal, having a liquidous above 840 °F (450 °C) and below the solidus of the base metals.
Brazing – A group of welding processes which produces coalescence of materials by heating them to a suitable temperature and by using a filler metal, having a liquidous above 840 °F (450 °C) and below the solidus of the base materials. The filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction.
Burr – A rough ridge, edge, protuberance, or area left on metal after cutting, drilling, punching, or stamping.
Buttering – A form of surfacing in which one or more layers of weld metal are deposited (for example, a high alloy weld deposit on steel base metal which is to be welded to a dissimilar base metal). The buttering provides a suitable transition weld deposit for subsequent completion of the butt weld on the groove face of one member.
Butt Joint – A joint between two members lying in the same plane.
Camber – Deviation from edge straightness, usually the greatest deviation of side edge from a straight line.
Cap Pass – The final pass of a weld joint.
Carrier Gas – In thermal spraying, the gas used to carry powdered materials from the powder feeder or hopper to the gun.
Capillary Action – The action by which the liquid surface is elevated or depressed where it contacts a solid because the liquid molecules are attracted to one another and to the solid molecules.
Cladding – A thin (> 0.04") layer of material applied to the base material to improve corrosion or wear resistance of the part.
Clad Metal – A composite metal containing two or three layers that have been welded together. The welding may have been accomplished by roll welding, arc welding, casting, heavy chemical deposition, or heavy electroplating.
Coalescence – The uniting of many materials into one body.
Coherent – Moving in unison.
Cold Lap – Incomplete fusion or overlap.
Collimate – To render parallels to a certain line or direction.
Complete Fusion – Fusion that has occurred over the entire base material surfaces intended for welding, and between all layer and passes.
Complete Joint Penetration – Joint penetration in which the weld metal completely fills the groove and is fused to the base metal throughout its total thickness.
Constant Current Power Source – An arc welding power source with a volt-ampere output characteristic that produces a small welding current change from a large arc voltage change.
Constant Voltage Power Source – An arc welding power source with a volt-ampere output characteristic that produces a large welding current change from a small arc voltage change.
Contact Tube – A system component that transfers current from the torch gun to a continuous electrode.
Contact Resistance – The resistance in ohms between the contacts of a relay, switch, or other device when the contacts are touching each other.
Contact Tube – A device which transfers current to a continuous electrode

Covered Electrode – A filler metal electrode used in shielded metal-arc welding, consisting of a metal-wire core with a flux covering.
Crater – In arc welding, a depression on the surface of a weld bead.
Crater Crack – A crack in the crater of a weld bead.
Cryogenic – Refers to low temperatures, usually -200 o (-130 o) or below.
Cutting Attachment – A device for converting an oxy-fuel gas-welding torch into an oxy-fuel cutting torch.
Cylinder – A portable container used for transportation and storage of a compressed gas.
Defect – A discontinuity or discontinuities that by nature or accumulated effect (for example, total crack length) renders a part or product unable to meet minimum applicable acceptance standards or specifications.
Density – The ratio of the weight of a substance per unit volume; e.g. mass of a solid, liquid, or gas per unit volume at a specific temperature.
Deposited Metal – Filler metal that has been added during welding, brazing or soldering.
Deposition Efficiency – In arc welding, the ratio of the weight of deposited metal to the net weight of filler metal consumed, exclusive of stubs.
Deposition Rate – The weight of material deposited in a unit of time. It is usually expressed as pounds/hour (lb/h) or kilograms per hour (kg/h).
Depth of Fusion – The distance that fusion extends into the base metal or previous pass from the surface melted during welding.
Dew Point – The temperature and pressure at which the liquefaction of a vapor begins. Usually applied to condensation of moisture from the water vapor in the atmosphere.
Dilution – The change in chemical composition of a welding filler material caused by the admixture of the base material or previously deposited weld material in the deposited weld bead. It is normally measured by the percentage of base material or previously deposited weld material in the weld bead.
Direct Current – Electric current that flows in one direction.
Direct Current Electrode Negative (DCEN) – The arrangement of direct current arc welding leads in where the electrode is the negative pole and work-piece is the positive pole of the welding arc.
Direct Current Electrode Positive (DCEP) – The arrangement of direct current arc welding leads in where the electrode is the positive pole and work-piece is the negative pole of the welding arc.
Duty Cycle – The percentage of time during a time period that a power source can be operated at rated output without overheating.
Dynamic Load – A force exerted by a moving body on a resistance member, usually in a relatively short time interval.
Electrode Extension – The length of electrode extending beyond the end of the contact tube.
Electrode Holder – A welding process that produces coalescence of metals with the heat obtained from a concentrated beam composed primarily of high velocity electrons
Electron Beam Welding – A welding process producing coalescence of metals with molten slag which melts the filler metal and the surfaces of the work to be welded. The molten weld pool is shielded by the slag, which moves along the full cross section of the joint as welding progresses.
Electroslag Welding – A welding process producing coalescence of metals with molten slag which melts the filler metal and the surfaces of the work to be welded. The molten weld pool is shielded by the slag, which moves along the full cross section of the joint as welding progresses.
Eutectoid Composition – A mixture of phases whose composition are determined by the eutectoid point in the solid region of an equilibrium diagram and whose constituents are formed by eutectoid reaction.

Facing Surface – The surfaces of materials in contact with each other and joined or about to be joined together.
Filler Material – The material to be added in making a welded, brazed, or soldered joint.
Fillet Weld – A weld of approximately triangular cross section that joins two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint.
Filter Plate – A transparent plate tinted in varying darkness for use in goggles, helmets and hand shields to protect workers from harmful ultraviolet, infrared and visible radiation.
Flame Spraying – A thermal spraying process using an oxy-fuel gas flame as the source of heat for melting the coating material.
Flammable Range – The range over which a gas at normal temperature (NTP) forms a flammable mixture with air.
Flat Welding Position – A welding position where the weld axis is approximately horizontal and the weld face lies in an approximately horizontal plane.
Flashback – A recession of the flame into or back of the mixing chamber of the torch.
Flashback Arrestor – A device to limit damage from a flashback by preventing the propagation of the flame front beyond the point at which the arrestor is installed.
Flashing – The violent expulsion of small metal particles due to arcing during flash butt welding.
Flux – Material used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances.
Flux Cored Arc Welding (FCAW) – An arc welding process that produces coalescence of metals by means of tubular electrode. Shielding gas may or may not be used.
Friction Welding – A solid welding process which produces coalescence of material by the heat obtained from a mechanically induced sliding motion between rubbing surfaces. The work parts are held together under pressure.
Friction Stir Welding – A solid-state welding process, which produces coalescence of material by the heat obtained from a mechanically induced rotating motion between tightly butted surfaces. The work parts are held together under pressure.
Forehand Welding – A welding technique where the welding torches or gun is pointed toward the direction of welding.
Fusion – The melting together of filler metal and base metal (substrate), or of base metal only, which results in coalescence.
Gas Metal Arc Welding (GMAW) – An arc welding process where the arc is between a continuous filler metal electrode and the weld pool. Shielding from an externally supplied gas source is required.
Gas Tungsten Arc Welding (GTAW) – An arc welding process where the arc is between a tungsten electrode (non-consumable) and the weld pool. The process is used with an externally supplied shielding gas.
Gas Welding – Welding with the heat from an oxy-fuel flame, with or without the addition of filler metal or pressure.
Globular-Spray Transition Current – In GMAW/Spray Transfer, the value at which the electrode metal transfer changes from globular to spray mode as welding current increases for any given electrode diameter.
Globular Transfer – In arc welding, a type of metal transfer in which molten filler metal is transferred across the arc in large droplets.
Groove Weld – A weld made in a groove between two members. Examples: single V, single U, single J, double bevel etc.
Hard-Facing – Surfacing applied to a workplace to reduce wear.
Heat-Affected Zone – That section of the base metal, generally adjacent to the weld zone, whose mechanical properties or microstructure, have been altered by the heat of welding.
Hermetically Sealed – Airtight. Heterogenous – A mixture of phases such as: liquid-vapor or solid-liquid-vapor.

Hot Crack – A crack formed at temperatures near the completion of weld solidification.
Hot Pass – In pipe welding, the second pass which goes over the root pass.
Inclined Position – In pipe welding, the pipe axis angles 45 degrees to the horizontal position and remains stationary.
Incomplete Fusion – A weld discontinuity where fusion did not occur between weld metal and the joint or adjoining weld beads.
Incomplete Joint Penetration – A condition in a groove weld where weld metal does not extend through the joint thickness.
Inert Gas – A gas that normally does not combine chemically with the base metal or filler metal.
Intergranular Penetration – The penetration of filler metal along the grain boundaries of a base metal.
Interpass Temperature – In a multi-pass weld, the temperature of the weld area between passes.
Ionization Potential – The voltage required to ionize (add or remove an electron) a material.
Joint – The junction of members or the edges of members that are to be joined or have been joined.
Kerf – The width of the cut produced during a cutting process.
Keyhole – A technique of welding in which a concentrated heat source penetrates completely through a work-piece forming a hole at the leading edge of the molten weld metal. As the heat source progresses, the molten metal fills in behind the hole to form the weld bead.
Lap Joint – A joint between two overlapping members in parallel planes.
Laser – A device that provides a concentrated coherent light beam. Laser is an acronym for Light Amplification by Stimulated Emission of Radiation.
Laser Beam Cutting – A process that severs material with the heat from a concentrated coherent beam impinging upon the work-piece.
Laser Beam Welding – A process that fuses material with the heat from a concentrated coherent beam impinging upon the members to be joined.
Leg of Fillet Weld – The distance from the root of the joint to the toe of the fillet weld.
Liquidous – The lowest temperature at which a metal or an alloy is completely liquid.
Mandrel – A metal bar serving as a core around which other metals are cast, forged, or extruded, forming a true, center hole.
Manifold – A multiple header for interconnection of gas or fluid sources with distribution points.
Martensitic – An interstitial, super-saturated solid solution of carbon in iron, having a body-centered tetragonal lattice.
Manual Welding – A welding process where the torch or electrode holder is manipulated by hand. MIG – See Gas Metal Arc Welding (GMAW).
Mechanical Bond – The adherence of a thermal-spray deposit to a roughened surface by particle interlocking.
Mechanized Welding – Welding with equipment where manual adjustment of controls is required in response to variations in the welding process. The torch or electrode holder is held by a mechanical device.
Melting Range – The temperature range between solidus and liquidous.
Melt-Through – Visible reinforcement produced on the opposite side of a welded joint from one side.
Metal Cored Arc Welding – A tubular electrode process where the hollow configuration contains alloying materials.
Metal Cored Electrode – A composite tubular electrode consisting of a metal sheath and a core of various powdered materials, producing no more than slag islands on the face of the weld bead. External shielding is required.
Molecular Weight – The sum of the atomic weights of all the constituent atoms in the molecule of an element or compound.

Monochromatic – The color of a surface that radiates light, containing an extremely small range of wavelengths.
Neutral Flame – An oxy-fuel gas flame that is neither oxidizing nor reducing.
Open-Circuit Voltage – The voltage between the output terminals of the welding machine when no current is flowing in the welding circuit.
Orifice Gas – In plasma arc welding and cutting, the gas that is directed into the torch to surround the electrode. It becomes ionized in the arc to form the plasma and issues from the orifice in the torch nozzle as the plasma jet.
Oxidizing Flame – An oxy-fuel gas flame having an oxidizing effect (excess oxygen).
Peening – The mechanical working of metals using impact blows.
Pilot Arc – A low current continuous arc between the electrode and the constricting nozzle of a plasma torch that ionizes the gas and facilitates the start of the welding arc.
Plasma – A gas that has been heated to at least partially ionized condition, enabling it to conduct an electric current.
Plasma Arc Cutting (PAC) – An arc cutting process using a constricted arc to remove the molten metal with a high-velocity jet of ionized gas from the constricting orifice.
Plasma Arc Welding (PAW) – An arc welding process that uses a constricted arc between a non-consumable electrode and the weld pool (transferred arc) or between the electrode and the constricting nozzle (non-transferred arc). Shielding is obtained from the ionized gas issuing from the torch.
Plasma Spraying (PSP) – A thermal spraying process in which a non-transferred arc is used to create an arc plasma for melting and propelling the surfacing material to the substrate.
Plug Weld – A circular weld made through a hole in one member of a lap or T joint.
Porosity – A hole-like discontinuity formed by gas entrapment during solidification.
Post-Heating – The application of heat to an assembly after welding, brazing, soldering, thermal spraying, or cutting operation.
Postweld Heat Treatment – Any heat treatment subsequent to welding.
Preform – The initial press of a powder metal that forms a compact.
Preheating – The application of heat to the base metal immediately before welding, brazing, soldering, thermal spraying, or cutting.
Preheat Temperature – The temperature of the base metal immediately before welding is started.
Procedure Qualification – Demonstration that a fabricating process, such as welding, made by a specific procedure can meet given standards.
Pull Gun Technique – Same as backhand welding.
Pulsed Power Welding – Any arc welding method in which the power is cyclically programmed to pulse so that the effective but short duration values of a parameter can be utilized. Such short duration values are significantly different from the average value of the parameter. Equivalent terms are pulsed voltage or pulsed current welding.
Pulsed Spray Welding – An arc welding process variation in which the current is pulsed to achieve spray metal transfer at average currents equal to or less than the globular to spray transition current.
Push Angle – The travel angle where the electrode is pointing in the direction of travel.
Rake Angle – Slope of a shear knife from end to end.
Reducing Flame – A gas flame that has a reducing effect, due to the presence of excess fuel.
Reinforcement – Weld metal, at the face or root, in excess of the metal necessary to fill the joint.
Residual Stress – Stress remaining in a structure or member, as a result of thermal and/or mechanical treatment. Stress arises in fusion welding primarily because the melted material contracts on cooling from the solidus to room temperature.

Reverse Polarity – The arrangement of direct current arc welding leads with the work as the negative pole and the electrode as the positive pole of the welding arc.
Root Opening – A separation at the joint root between the work pieces.
Root Crack – A crack at the root of a weld.
Self-Shielded Flux Cored Arc Welding (FCAW-S) – A flux-cored arc welding process variation in which shielding gas is obtained exclusively from the flux within the electrode.
Shielded Metal Arc Welding (SMAW) – A process that welds by heat from an electric arc, between a flux-covered metal electrode and the work. Shielding comes from the decomposition of the electrode covering.
Shielding Gas – Protective gas used to prevent atmospheric contamination.
Soldering – A joining process using a filler metal with a liquidous less than 840 °F and below the solidus of the base metal.
Solid State Welding – A group of welding processes which produces coalescence at temperatures essentially below the melting point of the base materials being joined, without the addition of a brazing filler metal. Pressure may or may not be used.
Solidus – The highest temperature at which a metal or alloy is completely solid.
Spatter – Metal particles expelled during welding that do not form a part of the weld.
Spray Transfer – In arc welding, a type of metal transfer in which molten filler metal is propelled axially across the arc in small droplets.
Standard Temperature and Pressure (STP) – An internationally accepted reference base where standard temperature is 0 °C (32 °f) and standard pressure is one atmosphere, or 14.6960 psia.
Stick-Out – The length of unmelted electrode extending beyond the end of the contact tube in continuous welding processes.
Straight Polarity – Direct current arc welding where the work is the positive pole.
Stress Relief Heat Treatment – Uniform heating of a welded component to a temperature sufficient to relieve a major portion of the residual stresses.
Stress Relief Cracking – Cracking in the weld metal or heat affected zone during post-weld heat treatment or high temperature service.
Stringer Bead – A weld bead made without transverse movement of the welding arc.
Submerged Arc Welding – A process that welds with the heat produced by an electric arc between a bare metal electrode and the work. A blanket of granular fusible flux shields the arc.
Substrate – Any material upon which a thermal-spray deposit is applied.
Synergistic – An action where the total effect of two active components in a mixture is greater than the sum of their individual effects.
Tack Weld – A weld made to hold parts of a weldment in proper alignment until the final welds are made.
Tenacious – Cohesive, tough.
Tensile Strength – The maximum stress a material subjected to a stretching load can withstand without tearing.
Thermal Conductivity – The quantity of heat passing through a material.
Thermal Spraying – A group of processes in which finely divided metallic or non-metallic materials are deposited in a molten or semi-molten condition to form a coating.
Thermal Stresses – Stresses in metal resulting from non-uniform temperature distributions.
Thermionic – The emission of electrons as a result of heat.
Throat – In welding, the area between the arms of a resistance welder. In a press, the distance from the slide centerline to the frame, of a gap-frame press.
TIG Welding – See Gas Tungsten Arc Welding (GTAW).
Torch Standoff Distance – The dimension from the outer face of the torch nozzle to the work piece.

Transferred Arc – In plasma arc welding, a plasma arc established between the electrode and the work-piece.
Underbead Crack – A crack in the heat-affected zone generally not extending to the surface of the base metal.
Undercut – A groove melted into the base plate adjacent to the weld toe or weld root and left unfilled by weld metal.
Vapor Pressure – The pressure exerted by a vapor when a state of equilibrium has been reached between a liquid, solid or solution and its vapor. When the vapor pressure of a liquid exceeds that of the confining atmosphere, the liquid is commonly said to be boiling.
Viscosity – The resistance offered by a fluid (liquid or gas) to flow.
Weldability – The capacity of a material to be welded under the fabrication conditions imposed into a specific, suitably designed structure and to perform satisfactorily in the intended service.
Weld Bead – The metal deposited in the joint by the process and filler wire used.
Welding Leads – The work piece lead and electrode lead of an arc welding circuit.
Welding Wire – A form of welding filler metal, normally packaged as coils or spools, which may or may not conduct electrical current depending upon the welding process used.
Weld Metal – The portion of a fusion weld that has been completely melted during welding.
Weld Pass – A single progression of welding along a joint. The result of a pass is a weld bead or layer.
Weld Pool – The localized volume of molten metal in a weld prior to its solidification as weld metal.
Weld Puddle – A non-standard term for weld pool.
Weld Reinforcement – Weld metal in excess of the quantity required to fill a joint.
Welding Sequence – The order in which weld beads are deposited in a weldment.
Wetting – The phenomenon whereby a liquid filler metal or flux spreads and adheres in a thin continuous layer on a solid base metal.
Wire Feed Speed – The rate at which wire is consumed in welding.
Work Lead – The electric conductor between the source of arc welding current and the work.

Course References

"California Contractors State License Board". State of California.
"Farmers, Flames and Climate: Are We Entering an Age of 'Mega-Fires'? – State of the Planet". Blogs.ei.columbia.edu.
"Glossary of Wildland Fire Terminology". National Wildfire Coordinating Group.
"Prescribed Fires". SmokeyBear.com.
"Share of Total Primary Energy Supply, 2002; International Energy Agency".
"UK: The Role of Fire in the Ecology of Heathland in Southern Britain". International Forest Fire News 18: 80–81.
"US Department of Homeland Security, US Fire Administration Handbook". Usfa.dhs.gov.
"What You Should Know About Your Water Damage Or Mold Removal Company:". Rapco West Environmental Services, Inc.
"WHO Disease and injury country estimates". World Health Organization.
ASM International (2003). Trends in Welding Research. Materials Park, Ohio: ASM International. ISBN 0-87170-780-2.
Begal, Bill (August 23, 2007). "Restoration With a Capital E-P-A: A Case Study". Restoration & Remediation.
Begon, M., J.L. Harper and C.R. Townsend. 1996. Ecology: individuals, populations, and communities, Third Edition. Blackwell Science Ltd., Cambridge, Massachusetts, USA.
Bowman, D. M. J. S.; Balch, J. K.; Artaxo, P.; Bond, W. J.; Carlson, J. M.; Cochrane, M. A.; d'Antonio, C. M.; Defries, R. S.; Doyle, J. C.; Harrison, S. P.; Johnston, F. H.; Keeley, J. E.; Krawchuk, M. A.; Kull, C. A.; Marston, J. B.; Moritz, M. A.; Prentice, I. C.; Roos, C. I.; Scott, A. C.; Swetnam, T. W.; Van Der Werf, G. R.; Pyne, S. J. (2009). "Fire in the Earth system". Science 324 (5926): 481–4. Bibcode:2009Sci...324..481B. doi:10.1126/science.1163886. PMID 19390038.
Cary, Howard B; Helzer, Scott C. (2005). Modern Welding Technology. Upper Saddle River, New Jersey: Pearson Education. ISBN 0-13-113029-3.
CFM-1 experiment results, National Aeronautics and Space Administration.
Federal Fire and Aviation Operations Action Plan, 4.
Fire & Life Safety Education , Manitoba Office of the Fire Commissioner
Glasspool, I.J.; Edwards, D.; Axe, L. (2004). "Charcoal in the Silurian as evidence for the earliest wildfire". Geology 32 (5): 381–383. doi:10.1130/G20363.1.
Helmenstine, Anne Marie. "What is the State of Matter of Fire or Flame? Is it a Liquid, Solid, or Gas?". About.com.
Hicks, John (1999). Welded Joint Design. New York: Industrial Press. ISBN 0-8311-3130-6.
http://io9.com/5779127/how-does-fire-behave-in-zero-gravity
https://www.youtube.com/watch?v=fuFftT6ZR4k
Jones, Timothy P.; Chaloner, William G. (1991). "Fossil charcoal, its recognition and palaeoatmospheric significance". Palaeogeography, Palaeoclimatology, Palaeoecology 97 (1–2): 39–50. doi:10.1016/0031-0182(91)90180-Y.
Kalpakjian, Serope; Steven R. Schmid (2001). Manufacturing Engineering and Technology. Prentice Hall. ISBN 0-201-36131-0.
Lincoln Electric (1994). The Procedure Handbook of Arc Welding. Cleveland: Lincoln Electric. ISBN 99949-25-82-2.
LSP-1 experiment results, National Aeronautics and Space Administration.
Morris, S. E. and Moses, T. A. (1987), Forest Fire and the Natural Soil Erosion Regime in the Colorado Front Range. Annals of the Association of American Geographers, 77: 245–254
Retallack, Gregory J. (1997). "Neogene expansion of the North American prairie". PALAIOS 12 (4): 380–90. doi:10.2307/3515337.

Scott, AC; Glasspool, IJ (2006). "The diversification of Paleozoic fire systems and fluctuations in atmospheric oxygen concentration". Proceedings of the National Academy of Sciences of the United States of America 103 (29): 10861–5. doi:10.1073/pnas.0604090103. PMC 1544139. PMID 16832054.
Spiral flames in microgravity, National Aeronautics and Space Administration.
Weman, Klas (2003). Welding processes handbook. New York, NY: CRC Press LLC. ISBN 0-8493-1773-8.

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