HOT WORK

Prepared by: Sylvie Rice
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Contents

Purpose

This procedure applies to anyone who performs welding, cutting, brazing, soldering, grinding, or any duty that produces a spark. The intent of this program is to prevent injury and loss of property from fire when using heat producing equipment such as heat guns, soldering tools, oxy-fuel gas, and electric arc cutting and welding equipment.

Hot work shall be permitted in approved areas and permits will be issued to both Keene State College (KSC) personnel and outside contractors by the KSC Environmental Health and Safety (EHS) office or a qualified KSC employee. On occasion, a blanket permit can be granted for a long duration project and in approved hot work areas such as at the Whitcomb Garage, Plumbing Shop, and Sculpture Studio. These areas will be inspected annually by EHS.

A hot work permit is required for the following activities: **brazing, cutting, heating, soldering**[1]**, welding, or similar type work** in accordance OSHA 20 CFR 1910.252. Low temperature soldering (e.g., hot air pencils and soldering irons) are exempt from permit requirements unless the location or nature of the work poses a significant fire hazard. However, it is still important to ensure that the general procedures outlined in this document are followed when performing any type of soldering operation.

Hot work permits can be obtained from the EHS office (358-2879). A permit must also be obtained from the City of Keene for any welding or cutting operations performed by an outside contractor (http://www.ci.keene.nh.us/departments/fire-department).

General Guidelines

- Work should be performed using alternative methods other than hot work whenever possible.
- Hot work should be performed in designated hot work rooms whenever it is practical.

Permit

In order to obtain a Hot Work Permit, the following shall be ensured:

- ☐ The area shall be inspected by EHS or a qualified KSC employee
- ☐ The type of hot work must be approved for the project being performed

[1] Contact electricians to arrange for bagging smoke detectors whenever soldering is required. A fire watch shall be maintained for at least ½ hour after soldering is completed.

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- Containers and/or pipes must be properly cleaned, purged and inspected
- All combustible and flammable material shall be protected with flame resistant tarps or relocated 35 feet away from the hot work area
- Floor and wall openings (within 35 ft) shall be covered and sealed to prevent fire spread
- Fire detection and suppression equipment must remain operational at all times, unless otherwise protected or approved by KSC Physical Plant
- Fire extinguishers of proper size and type shall be located within 25 ft of the hot work area
- Hot work equipment such as gas cylinders, hoses, leads, and torches shall be properly maintained, secured, stored, transported, and used at all times
- Proper personal protective equipment (i.e. clothing, face shields, goggles, gloves, head and foot protection) shall be worn, as required
- Other health and safety hazards such as asbestos, chemical storage/usage, confined space, electrical, fire, heat, ventilation must be considered and evaluated prior to hot work
- A work-specific evacuation plan must be in place
- A fire watch (not less than ½ hour) shall be performed whenever any hot work is performed.
- Bags for smoke detectors shall be supplied and installed by the contractor when necessary
- Permanent or portable curtains and screens must be used if persons are or could be exposed to direct or reflected radiation
- Exhaust ventilation must be provided unless ventilation is determined to be sufficient

Fire Watch

A fire watch shall be maintained for at least one hour after the hot work has been completed (1/2 hour if approved by EH&S or a qualified KSC employee). A fire watch is required whenever any one of the following conditions exist.

- Combustible material is less than 35 feet to the point of operation
- Combustible material is more than 35 feet away, but is easily ignited by sparks
- Wall or floor openings within a 35 foot radius expose combustible material in adjacent areas
- Combustible materials are adjacent to the opposite side of metal partitions, walls, ceilings, or roofs and are likely to be ignited by excessive heat

Firewatcher’s duties:
- Have fire extinguishing equipment available and ready for use
- Be trained in using the fire equipment
- Know where to go to sound an alarm in case of an emergency
- Watch for fires and only extinguish them if it is within their capability.
- When a fire is beyond their capability, they need to sound an alarm
- Watch for fires for at least a half hour after the completion of hot work

General Welding and Cutting Controls

- Welding and cutting operations should be restricted to workers who have been properly trained.

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- Whenever possible, hot work should be performed in a properly designed shop area equipped with all necessary controls and adequate ventilation.

- Combustible materials, such as building construction materials or other building contents, must be located at least 35 feet from the hot work area or properly protected to prevent hot sparks from contacting them. Floors within this area must also be swept clean of all combustible materials.

- All openings in floors and wall within 35 feet of the hot work area must be covered to prevent hot sparks from entering walls or falling beneath floors or to a lower level.

- Hot work should not be conducted in the presence of explosive mixtures of flammable gases, vapors, liquids, or dusts or where explosive mixtures could develop inside improperly prepared tanks or equipment. Atmospheric testing and monitoring for combustible gases and vapors should be conducted before work begins and at predetermined intervals thereafter.

- Fire resistant curtains and tinted shields should be used to prevent fire, employee burns, and ultra-violet light exposure.

- Personal protective equipment specifically designed for hot work should be provided to and used by workers. Potential for material being worked on or surface coatings to emit toxic fumes should be considered.

- A fire extinguisher rated at not less than 2-A:20-B:C must be available in shop areas where hot work is performed. A fire extinguisher rated at not less than 2-A:10-B:C must be attached to all portable welding carts. Contact EHS for additional guidance in fire extinguisher selection.

- The building's sprinkler system, if so equipped, must be operational before hot work can begin.

- A person other than the operator should perform fire watch duties and should remain at the worksite for at least 30 minutes after hot work operations have ended.

Welding or Cutting in Confined Spaces

- Confined space procedures must be followed when performing work in a confined space.

- When working in poorly ventilated spaces, exposure to air contaminants generated by welding or cutting must be controlled by ventilation, respiratory protection, or a combination of the two.

- Gas cylinders and welding machines must be left outside the space when work is performed in spaces such as boilers, tanks, or pressure vessels. Heavy portable equipment mounted on wheels must be securely blocked to prevent movement.

Gas Storage and Transportation

- All cylinders must be secured at all times by either an approved chain or strap

- All cylinders must have either a cap or regulator[2] in place at all times
- All cylinders must be stored, transported, and used in an upright position.
- All cylinders and attached equipment must be free of damage and leaks
- All cylinders must be properly labeled.
- Except when in use, oxygen and fuel gas cylinders should be stored separately, at least 20 feet apart or separated by a noncombustible wall at least 5 feet high.

Training

Workers should be trained in personal protective equipment selection and use, proper equipment operation, handling and storage of welding materials, compressed gas safety, chemical hazards, confined spaces, and in hot work procedures including the written hot work permit. Contact EHS for training.

Definitions

Air carbon arc cutting (CAC-A, previously known as **air arc cutting)**, A cutting process by which metals are cut and melted by the heat of an arc using a carbon electrode. Molten metal is forced away from the cut by a blast of forced air. This can be dangerous as the molten material can be blown substantial distances.[I] The process is also very noisy It is most often used for cutting and gouging aluminum, copper, iron, magnesium, and carbon and stainless steels. This process differs from plasma cutting operations because in air carbon cutting, an open, or un-constricted, arc is used, and the arc operates separately from the air jet.

Arc welding uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. Arc welding uses either direct (DC) or alternating (AC) current, and either consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, and/or slag. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of 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.

Brazing is a metal-joining process whereby a filler metal is heated above and distributed between two or more close-fitting parts by capillary action. The filler metal is brought slightly above its melting temperature while protected by a suitable atmosphere, usually a flux. It then flows over the base metal (known as wetting) and is then cooled to join the work pieces together. It is similar to soldering, except the temperatures used to melt the filler metal are above 450°C (842 °F).

Flux-cored arc welding (FCAW) is a variation of the GMAW technique. FCAW wire is actually a fine metal tube filled with powdered flux materials. An externally supplied shielding gas is sometimes used, but often the flux itself is relied upon to generate the necessary protection from the atmosphere. The process is widely used in construction because of its high welding speed and portability.

Gas metal arc welding (GMAW), commonly called MIG (metal inert gas), is a semi-automatic or automatic welding process with a continuously fed consumable wire acting as both electrode and filler metal, along with

[2] Many regulators are similar in design and construction. Ensure that regulators are designed for the cylinder used by checking the manufacturer's model number and comparing that with the gas supplier's requirements.

an inert or semi-inert shielding gas that flows around the wire to prevent the weld site from contamination. GMAW offers relatively high welding speeds but the more complicated equipment reduces convenience and versatility in comparison to the SMAW process. GMAW is commonly used in the automobile industry for its quality, versatility and speed. Because of the need to maintain a stable shroud of shielding gas around the weld site, it can be problematic to use the GMAW process in areas of high air movement such as outdoors.

Grinding, drilling, and sanding and other types of mechanical operations can produce sparks that can ignite debris and flammable vapors. In some cases, a hot work permit may be required.

Hot work is any process that can be a source of ignition when flammable material is present or can be a fire hazard regardless of the presence of flammable material in the workplace. Common hot work processes are welding, soldering, cutting and brazing. When flammable materials are present other mechanical processes, such as grinding and drilling, become hot work processes.

MAPP gas is widely used as a generic name for UN 1060 stabilized methylacetylene-propadiene (unstabilized methylacetylene-propadiene is known as **MAPD**). MAPP gas is widely regarded as a safer and easier-to-use substitute for acetylene. Current products labeled ""MAPP" are in fact MAPP substitutes. These versions are stabilized liquefied petroleum gas (LPG) with high levels of propylene. MAPP gas can be used in combination with oxygen for heating, soldering, brazing and even welding due to its high flame temperature of 2927 °C (5300 °F) in oxygen. Although acetylene has a higher flame temperature (3160 °C, 5720 °F), MAPP has the advantage that it requires neither dilution nor special container fillers during transport, allowing a greater volume of fuel gas to be transported at the same given weight, and it is much safer in use.

MIG (metal inert gas) welding (GMAW or gas metal arc welding) - Also referred to as solid wire welding, is an arc welding process which joins metals by heating them with an arc. The arc is between a continuously fed filler metal (consumable) electrode and the work piece. Externally supplied gas or gas mixtures provide shielding. See gas metal arc welding.

Oxy-fuel (oxyacetylene gas) Oxyacetylene is the hottest burning common fuel gas. Approximately 20 percent of acetylene is consumed for oxyacetylene gas welding and cutting due to the high temperature of the flame; combustion of acetylene with oxygen produces a flame of over 3300 °C (6000 °F)[3]. The working pressures for both welding and cutting must be controlled by a regulator, because acetylene will decompose explosively above 15 psi. Oxy-fuel welding/cutting generally requires two tanks, fuel and oxygen. Torches that do not mix fuel with oxygen (combining, instead, atmospheric air) are not considered oxy-fuel torches and can typically be identified by a single tank. Most metals cannot be melted with a single-tank torch. As such, single-tank torches are typically used only for soldering and brazing, rather than welding.

Oxy-fuel welding (commonly called oxyacetylene welding, oxy welding, or gas welding.) and **oxy-fuel cutting** are processes that use fuel gases and oxygen to weld and cut metals, respectively. Pure oxygen, instead of air (20% oxygen/80% nitrogen), is used to increase the flame temperature to allow localized melting of the work piece material (e.g. steel) in a room environment. Two pieces of metal are heated to a temperature that produces a shared pool of molten metal using a welding torch. The molten pool is generally supplied with additional metal filler material. Oxy-fuel welding was a very popular welding process in previous decades; but

[3] A common propane/air flame burns at about 3,630 °F (2,000 °C), a propane/oxygen flame burns at about 4,530 °F (2,500 °C), and an acetylene/oxygen flame burns at about 6,330 °F (3,500 °C).

the development and advantages of arc-based welding processes have significantly reduced the need for oxy-fuel welding. However, the versatility of oxy-fuel welding still lends itself easily to brazing, braze-welding, metal heating (for annealing or tempering, bending or forming), the loosening of corroded nuts and bolts, and other applications. Oxy-fuel welding may also be used in areas where electricity is not readily accessible.

In **oxy-fuel cutting**, a cutting torch is used to heat metal to kindling temperature. A stream of oxygen is then trained on the metal, and metal burns in that oxygen and then flows out of the cut (kerf) as an oxide slag.

Plasma arc cutting (PAC) is an arc cutting process that is used to cut steel and other metals of different thicknesses (or sometimes other materials) by using a plasma torch to melt a small area of the work piece. In this process, an inert gas (in some units, compressed air) is blown at high speed out of a nozzle; at the same time an electrical arc is formed through that gas from the nozzle to the surface being cut, turning some of that gas to plasma. The plasma is sufficiently hot to melt the metal being cut and moves sufficiently fast to blow molten metal away from the cut. This process can cut all metals that conduct electricity. PAC differs from oxy-fuel cutting in that the plasma process operates by using the arc to melt the metal whereas in the oxy-fuel process, the oxygen oxidizes the metal and the heat from the exothermic reaction melts the metal. Unlike oxy-fuel cutting, the PAC process can be applied to cutting metals which form refractory oxides such as stainless steel, cast iron, aluminum, and other non-ferrous alloys.

Plasma arc welding (**PAW**) is an arc welding process similar to gas tungsten arc welding (GTAW). The electric arc is formed between an electrode (which is usually but not always made of sintered tungsten) and the work piece. The key difference from GTAW is that the plasma arc can be separated from the shielding gas envelope by positioning the electrode within the body of the torch. The plasma is then forced through a fine-bore copper nozzle which constricts the arc and the plasma exits the orifice at high velocities (approaching the speed of sound) and a temperature approaching 20,000 °C. This process uses a non-consumable tungsten electrode and an arc constricted through a fine-bore copper nozzle. PAW can be used to join all metals that are weldable with GTAW (i.e., most commercial metals and alloys).

Shielded metal arc welding (**SMAW**, **manual metal arc welding (MMA) or stick welding**). An electric current is used to strike an arc between the base material and a consumable electrode rod or 'stick'. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination. The electrode core itself acts as filler material, making a separate filler unnecessary. The process is very versatile, requiring little operator training and inexpensive equipment. However, 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. The versatility of the method makes it popular in a number of applications including repair work and construction.

Shielding gases are inert or semi-inert gases that are commonly used in several welding processes, most notably gas metal arc welding and gas tungsten arc welding (GMAW and GTAW, more popularly known as MIG and TIG, respectively). Their purpose is to protect the weld area from atmospheric gases, such as oxygen, nitrogen, carbon dioxide, and water vapor. Depending on the materials being welded, these atmospheric gases can reduce the quality of the weld or make the welding process more difficult to use. Shielding gases fall into two categories—inert (helium and argon) or semi-inert (carbon dioxide, oxygen, nitrogen, and hydrogen). Most of these gases, in large quantities, would damage the weld, but when used in small, controlled quantities, can improve weld characteristics. Other arc welding processes use other methods of protecting the weld from the atmosphere as well – shielded metal arc welding, uses an electrode covered in a flux that produces carbon dioxide when consumed, a semi-inert gas that is an acceptable shielding gas for welding steel.

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Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal (solder) into the joint--the filler metal having a lower melting point than the work piece. Soldering differs from welding in that soldering does not involve melting the work pieces. There are three forms of soldering, each requiring higher temperatures and each producing an increasingly stronger joint strength: **soft soldering**, which originally used a tin-lead alloy as the filler metal; **silver soldering**, which uses an alloy containing silver; and, **brazing** which uses a brass alloy for the filler. The alloy of the filler metal for each type of soldering can be adjusted to modify the melting temperature of the filler. Soldering appears to be a hot glue process, but it differs from gluing significantly in that the filler metals alloy with the work piece at the junction to form a gas- and liquid-tight bond. Soft soldering is characterized by having a melting point of the filler metal below approximately 400 °C (752 °F), whereas silver soldering and brazing use higher temperatures, typically requiring a flame or carbon arc torch to achieve the melting of the filler.

Hand-soldering tools include the electric soldering iron, which has a variety of tips available ranging from blunt to very fine to chisel heads for hot-cutting plastics, and the soldering gun, which typically provides more power, giving faster heat-up and allowing larger parts to be soldered. Hot-air guns and pencils allow rework of component packages which cannot easily be performed with electric irons and guns.

Soldering irons supply heat to melt the solder so that it can flow into the joint between two work pieces. A soldering iron is composed of a heated metal tip and an insulated handle. Heating is often achieved electrically, by passing an electric current (supplied through an electrical cord or battery cables) through the resistive material of a heating element

Hot air pencils are an alternative to a soldering iron that heats the joint with a stream of hot air. They are often used for electronic components such as circuit boards

Soldering guns use tin-based solder to achieve a highly conductive contact. The tool uses a pistol shape, and has a trigger style switch so it can be easily operated with one hand. Soldering guns are used where more heat is needed than from pencil-style soldering irons. They can be used for heavy electrical connections, stained glass assembly, and light sheet-metal work. Typical soldering guns are rated between 100 and 240 watts power. A gun may include a two-stage trigger to give two heat settings.

Soldering torches are a type of soldering device that uses a flame rather than a soldering iron tip to heat solder. Soldering torches are often powered by butane[l] and are available in sizes ranging from very small butane/oxygen units suitable for very fine but high-temperature jewelry work, to full-size oxy-fuel torches suitable for much larger work such as copper piping. Common multipurpose propane torches, the same kind used for heat-stripping paint and thawing pipes, can be used for soldering pipes and other fairly large objects either with or without a soldering tip attachment; pipes are generally soldered with a torch by directly applying the open flame.

Solid wire welding See gas metal arc welding (GMAW).

Submerged arc welding (SAW) is a high-productivity welding process in which the arc is struck beneath a covering layer of granular 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 because the flux hides the arc and no smoke is produced. The process is commonly used in industry, especially for large products.

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TIG (tungsten inert gas, or gas tungsten arc, GTAW) - This welding process joins metals by heating them with a tungsten electrode which should not become part of the completed weld. Filler metal is sometimes used and argon inert gas or inert gas mixtures are used for shielding

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.

References

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