

**SAFE WORK PROCEDURE****Insert Reference  
Code: UBC-FUBC-  
SWP-W1-001****Formula UBC, Rusty Hut 120H**Effective date: January 23, 2018  
Review date: January 23, 2018  
Supersedes: None**RUSTY HUT 120H WELDING****1. SCOPE**

The procedures contained in this document apply to members of the Formula UBC team who are performing welding at all times.

**2. PURPOSE**

The purpose of this document is to outline the rules and procedure that must be followed for students to weld in the Formula UBC shop (RH 120H). The procedures will ensure that the welder is operated in a safe manner and that adequate precautions are taken to address potential hazards.

**3. RESPONSIBILITY**

The responsibility of ensuring that the procedures outlined in this document are followed falls on the supervisor. The operator is responsible for understanding and following the procedures. The supervisor is responsible for correcting the operator if the procedures are not being followed. If there is unsafe behaviour every user of the shop is responsible for reporting it to the safety officer or the team captain. Incidents and near misses should be reported to the UBC CAIRS system.

Access to the welder will be restricted to approved users. Every user needs to be trained on safe practices and potential hazards specific to welding in our shop before using the welder regardless of their previous experience. They should be told of all of the procedures that are contained in this document that they must follow. For the first few times a user welds in the shop, they must be supervised



by someone who is already 'approved' to use the welder to ensure that they are following all procedures and operating safely. If they fail to demonstrate safe operation of the equipment, their privilege to use the welder will be re-considered. These rules will also be shared with the rest of the team. If they witness these rules being broken they shall report it to the safety officer or team captain or their on-site designate who is responsible for site safety.

The approval process will consist of two steps. Team captain and the safety officer are responsible for deciding who is allowed to perform welding in the shop. The captain and safety officer must then submit as much information as possible about this person's qualifications, experience, endorsements, and types of projects (even pictures of their weld quality from those projects) to the APSC safety officer. The APSC Safety officer will review the person's qualifications and experience and approve them for welding on a case-by-case basis. The team captain or safety officer will ensure the list of people approved for welding is copied to MECH and posted near the welding station in RH120H. The team captain and safety officer are responsible for ensuring that the operators of the welder are trained in the procedures outlined in this SOP. People performing welding in our shop should have prior experience with the process and be comfortable using the equipment.

Approval of team and individual welding permissions will be reviewed and renewed on a year-by-year basis. Review of procedures and approval will occur as part of the Mechanical Engineering space inspection at the beginning of each winter term. The previous year's activities and complaints from other users of Rusty Hut facilities will be taken into consideration during the annual review of welding permissions.

#### 4. REFERENCES AND DEFINITIONS

- CSA W117.2-12: Safety in welding, cutting, and allied processes
  - This standard covers welding safety and procedures
  - Tables from this standard are included in the SOP for reference
- Miller TIG Handbook. Process 215994 E.
  - This handbook provides best practices, process descriptions, TIG welding procedures, and troubleshooting advice.



- The handbook references CSA 117.2 and relevant ANSI, American Welding Society (AWS), and other safety standards relevant to welding processes and equipment.
- Safe working with LPG-fuelled motor vehicles – UK Health and Safety Executive
  - Sections of this document provide best practices for “hot work” processes on vehicles fuelled by liquefied petroleum gas (LPG).
- TIG (Tungsten Inert Gas) / GTAW (Gas Tungsten Arc Welding)
  - The main type of welding that is used by the team
- “The shop” or “Formula UBC Shop” refers to Rusty Hut 120H
- “The vehicle” any Formula UBC vehicle in which any subsystem contains or has ever contained combustible fuel.
- “Shall” and “must” are used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the SOP.
- “Should” is used to express a recommendation or that which is advised but not required.

## 5. TRAINING REQUIRED

- In shop orientation
- Engineering Design Team Safety Orientation
- WHMIS Training Course
- Floor Warden Training Course
- Preventing and Addressing Workplace Bullying and Harassment Training Course
- In person orientation to welder and reviewing this SOP
  - Approval from both team captain, safety officer, and APSC safety officer

## 6. MATERIALS/EQUIPMENT

- Miller Dynasty 200 TIG Welder
- Shielding Gas
- Welding Rod
- Argon Gas
- Tungsten Electrodes
  - Do not use thoriated tungsten (Marked with a red end)



- Thoriated tungsten contains thorium which is carcinogenic and radioactive
- Fume Extractor: Available from EDC composites room, see controls and pre-procedure setup for details. The APSC safety officer must be notified prior to moving the extractor from the EDC and it must be returned immediately after welding operations are complete.

### Personal Protective Equipment

All PPE shall be in good condition. User must protect skin from exposure to radiation from the welder in accordance with WorkSafeBC OHS Regulations and CSA W117.2-12

#### Required PPE

- Non-flammable clothing (e.g. cotton, woollen or leather)
  - Must cover all skin exposed to light
  - Welding gloves
- Safety Glasses
  - Meeting CAN/CSA-Z94.3
- Welding Mask
  - Meeting CAN/CSA-Z94.3
- Ear plugs or ear muffs
  - Required if noise level exceeds 85 dBA

#### Optional PPE

- Leather welding sleeves if arms are not already covered by clothing

## **7. HAZARDS**

Hazards present during welding are:

- Electric Shock: Electric shock can be lethal. It can occur with any welding and cutting process that uses electrical power. Typically, it results from faulty or improperly maintained equipment and/or operator inattention, error, or lack of awareness (e.g., moist clothing in contact with a workpiece).



- Radiation: Radiant energy from the welding arc consists of ultraviolet, visible light, and infrared radiation. Infrared radiation can cause operator discomfort and, when severe, can result in skin burns. Ultraviolet radiation causes skin burns and eye irritation.
- Slag and Sparks: Slag and sparks may drip or shoot off the workpiece during the welding process. Debris could also be an eye hazard during material preparation and post weld cleaning.
- Burns: Burns can also result from contact with hot parts or welding sparks and spatter. Welding sparks and spatter can ignite combustible material causing serious fires. Hot metal parts and welding sparks and spatter can present an explosion hazard when in the presence of explosive mixtures of dusts or vapours.
- Fumes and Gasses: Welding and cutting operations can produce smoke-like fumes. Welding and cutting processes generate gaseous by-products including shielding gasses.
- Electromagnetic forces: Electromagnetic fields and high frequency voltages generated by the various types of welding equipment can cause interference with cardiac pacemakers or other implanted electromedical devices. People with metal implants in their body (including pacemakers, defibrillators, steel plates and pins, etc.) should be cautious of any effect on these devices.
- Ignition source for flammables and combustibles
  - Both in general and while working on a vehicle fuelled by liquefied petroleum gas.
- Compressed Gas Cylinders

The hazards present during various welding processes are summarized in Table 1 (from CSA W117.2-12). The only welding process permitted in RH120H is Gas Tungsten Arc Welding (MTAW) also known as Tungsten Inert Gas (TIG) welding.



**Table 1**  
**Safety considerations in arc welding, arc cutting, and arc gouging**  
 (See Clause 5.1.1.)

| Process  |  | Hazards (1)          |                |               |           |               |       |
|--|--|----------------------|----------------|---------------|-----------|---------------|-------|
| Title  | Abbreviation                           | Arc exposure         | Electric shock | Radiation (2) | Burns (3) | Fume (4)      | Noise |
| Shielded metal arc welding   | SMAW                                   | Open                 | x              | x             | x         | x             | — (9) |
| Gas tungsten arc welding   | GTAW or TIG welding                    | Open                 | x              | x             | x         | x (5)         | — (9) |
| Gas metal arc welding  | GMAW or MIG or CO <sub>2</sub> welding | Open                 | x              | x             | x         | x (5)         | — (9) |
| Flux-cored arc welding<br>– with gas shield<br>– without gas shield<br>Metal-cored arc welding | FCAW                                   | Open                 | x              | x             | x         | x (5)         | — (9) |
|  |  | Open                 | x              | x             | x         | x             | — (9) |
|  | MCAW                                   | Open                 | x              | x             | x         | x (5)         | — (9) |
| Submerged arc welding  | SAW                                    | Enclosed             | x              | — (6)         | x         | — (7)         | —     |
| Electroslag welding (consumable guide)   | ESW (CG)                               | Effectively enclosed | x              | x (6)         | x         | x (7) and (8) | —     |
| Plasma arc welding   | PAW                                    | Open                 | x              | x             | x         | x             | x     |
| Plasma arc cutting   | PAC                                    | Open                 | x              | x             | x         | x             | x     |
| Plasma arc gouging   | PAG                                    | Open                 | x              | x             | x         | x             | x     |
| Plasma arc cutting<br>– water shrouded<br>– submerged  | PAC                                    | Enclosed             | x              | —             | x         | —             | x     |
|  |  | Enclosed             | x              | —             | x         | —             | —     |
| Arc air cutting  | AAC                                    | Open                 | x              | x             | x         | x             | x     |
| Arc air gouging  | —                                      | Open                 | x              | x             | x         | x             | x     |

**Notes:**

- (1) "x" indicates a hazard.
- (2) Ultraviolet, visible, and infrared radiation.
- (3) Includes hot objects and particles.
- (4) Due to consumables, materials, and coatings.
- (5) Shielding gas also introduces the risk of asphyxiation in confined spaces.
- (6) Slight risk of accidental exposure. Limited protection is advisable.
- (7) Fume level is low and welder is remote from arc.
- (8) Welder is also remote from fume.
- (9) Noise levels are relatively low; main source is motor-driven equipment.

## 8. CONTROLS (for above listed hazards)

Provide a list engineering controls and personal protective equipment (PPE) necessary to ensure the procedure is done safely.

The procedures outlined in CSA W117.2-12 should be followed when performing welding. The following table provides key points from the standard that address particular hazards present in our shop as well as general best practice.



In addition to the following controls, no welding process shall take place while the boundary layer wind tunnel is in use or while research activities are carried out by personal at the West end of the boundary layer wind tunnel (beside the entry to RH120H).

- Electric Shock (Adapted from CSA W117.2-12 Clause 6)
  - The welder or welding operator shall not allow live metal parts to touch bare skin or any wet clothing.
  - Dry welding gloves shall be worn.
  - The welding machine shall powered down when electrodes are removed or replaced.
  - Welders or welding operators shall not weld in wet or damp clothing.
  - Welding cables shall not be run through wet areas. Electrode holders, whip cables, and the welding power supply shall be kept dry.
  - Welding cable that has damaged electrical connections, conductors, or insulation shall not be used.
  - Welding machines left unattended shall be turned off.
  - Jewellery, keys, and tools that might conduct current, heat up, or reflect light shall be removed before welding.
  - The workpiece lead shall be connected as closely as practicable to the location being welded upon to ensure that the welding current returns directly to the source through the workpiece lead. Painted surfaces must be abraded to metal for successful connection.
  - Tungsten electrodes shall be removed or retracted within holders only when the welding machine is powered off.
- Radiation: (Adapted from CSA W117.2-12 Clause 11)
  - CSA W117.2-12 Clause 11.1.3: Non-combustible or flame-resistant booths, screens, or shields shall be erected to protect workers or others in the vicinity of a welding area from arc radiation and spatter. The barriers shall have a non-reflective surface and shall permit the circulation of air at floor and ceiling levels. Where barriers are not feasible or effective, workers and other personnel in the vicinity of a welding area shall be provided with eye



protection and protective equipment as appropriate. If RH120H doors are open, welding curtains must be hung over the door to prevent radiation from leaving the room.

- Signage must be posted at the west Rusty Hut entrance and at the door of RH120E (the room on the north side of the Boundary Layer Wind Tunnel) to notify all other working near or passing by RH120H that welding processes will be occurring in the room.
- Helmets or hand shields with filter lenses (see Table 7) and cover plates shall be used by welders, welding personnel, and others viewing the arc. An auto-darkening helmet is also available and should be used.
- All welders shall wear woollen, cotton or leather clothing to prevent skin burns caused by UV radiation. No bare skin shall be exposed.
- Contact lenses should not be worn by welders and welding personnel. Contact lenses do not provide protection from ultraviolet radiation and flying objects. All workers in proximity to welding procedures must wear appropriate eye protection according to the circumstances
- Slag, Sparks and Burns (Adapted from CSA W117.2-12 Clause 11)
  - Goggles or safety glasses with side shields shall be worn by all welders and welding personnel at all times in the workplace, even when other eye and face protection is also worn.
  - Non-flammable clothing (woollen, cotton or leather) must be worn at all times to protect against ignition or trapping of sparks. Unless specifically designed for welding conditions, synthetic clothing should not be used. Clothing shall be free of oil and grease.
  - Welding gloves shall be worn while welding.
  - Welders shall not carry flammable or combustible materials (e.g. a butane cigarette lighter).
  - After welding is complete, hot parts that are left unattended must be marked "HOT" to prevent injury to personnel. Formula UBC Members in the shop shall be verbally warned of hot parts.
- Fumes and Gasses (Adapted from CSA W117.2-12 Clauses 11 and 12)
  - The welder shall position their head out of any smoke plumes.



- Fumes and gasses from welding processes must be controlled with adequate ventilation (see below).
- As shown in CSA W117.2-12 Table 5, the Formula UBC shop is considered an open work area if the shop and external Rusty Hut doors are open. For normal production level GTAW, natural dilution in this environment is acceptable for welding steel with less than 3% chromium content and 5% total alloying content. For added safety against welding fumes, a mechanical fan shall be used to introduce airflow above and beyond the natural air flow required by CSA W117.2-12. Alternatively, the fume extractor available in the EDC composites room may be used. When the fume extractor is in use, RH120H doors should be closed.
- If the work has coated or painted and could produce hazardous fumes when hot, the fume extractor located in the EDC composites room must be used.
- Steels not meeting the above composition requirements shall not be welded in the Formula UBC shop.
- As required by CSA W117.2-12 Table 6, welding of aluminum is permitted only if the fume extractor from the EDC composites room is used.
- Materials other than those specified above shall not be welded in the Formula UBC shop.



**Table 5**  
**Ventilation guidelines for welding, brazing, and thermal cutting**  
**of uncoated low-alloyed or unalloyed steels (with nominal**  
**chromium content not exceeding 3% and with nominal**  
**total alloying content not exceeding 5%)**

(See Clauses 5.1.5, 10.3.3.3, 10.4.4.3, 11.2.1.5, 12.1.1, 12.4, 12.5.1, and 12.5.3.1.)

| Process   | Production level (1) | Degree of confinement in work area (2) |                             |                             |                |
|---|----------------------|--|-----------------------------|-----------------------------|----------------|
|   |                      | Outdoor (3)                            | Open workspace              | Limited workspace           | Confined space |
| Gas preheating,<br>gas welding,<br>gas tungsten arc<br>welding (GTAW)   | Normal               | N                                      | N or M                      | M                           | LE             |
|   | High                 | N                                      | LE                          | LE                          | LE             |
| Brazing and soldering   |                      | N                                      | N or M                      | M                           | LE             |
| Flame cutting,<br>flame gouging   | Normal               | N                                      | N or M                      | M                           | LE             |
| Gas metal arc<br>welding (GMAW)   | Normal               | N                                      | N or M                      | LE                          | M and LE       |
|   | High                 | N                                      | LE                          | LE                          | M and LE       |
| Flux-cored arc<br>welding (FCAW),<br>shielded metal<br>arc welding (SMAW),<br>metal-cored arc welding (MCAW)          | Normal               | N                                      | N or M                      | LE                          | M and LE       |
|   | High                 | N                                      | LE                          | LE                          | M and LE       |
| Plasma arc cutting<br>and gouging<br>(assessment by air<br>sampling is often needed in limited<br>or confined spaces) | Normal               | N                                      | LE                          | LE                          | LE             |
|   | High                 | N                                      | LE or<br>water<br>table (4) | LE or<br>water<br>table (4) | LE<br>and PRP  |
| Submerged arc<br>welding (SAW),<br>electroslag welding,<br>electrogas welding   | Normal               | N                                      | N                           | N                           | M              |
|   | High                 | N                                      | N                           | N                           | M              |
| Thermite welding,<br>air carbon arc gouging   | Normal               | N                                      | M                           | LE                          | LE             |
|   | High                 | N                                      | LE                          | LE and PRP                  | LE and PRP     |
| Resistance welding  | Normal               | N                                      | N                           | M                           | LE             |
|   | High                 | N                                      | M                           | M                           | LE             |



## Table 5 (Concluded)

### Legend:

N = natural dilution ventilation (see [Clause 12.2.2](#))

M = mechanical dilution ventilation (see [Clause 12.2.3](#))

LE = local exhaust ventilation (see [Clause 12.3](#))

PRP = personal respiratory protection (see [Clause 11.4](#))

### Notes:

- (1) *High production refers to duty cycles exceeding approximately 40% or high amperage processes exceeding 350 A, or both.*
- (2) *Degree of confinement is defined as follows:*
  - (a) *Open:*
    - (i) *large work area without obstructions;*
    - (ii) *open to outdoors and wind; and*
    - (iii) *fume is free to escape;*
  - (b) *Limited:*
    - (i) *a work area that does not fit the definition of open;*
    - (ii) *fume is hindered from escaping; and*
    - (iii) *an open area may become limited when doors and windows are closed during cold weather; and*
  - (c) *Confined:*
    - (i) *inside small compartments entered through manholes, e.g., tank, chamber, boiler pressure vessel; and*
    - (ii) *fumes cannot escape.*
- (3) *Where mechanical ventilation is recommended for welding outdoors, a fan may be used to disperse fumes before they enter the breathing zone as long as the fumes are not contaminating an adjacent work area.*
- (4) *Applies to mechanized plasma arc cutting.*



**Table 6**  
**Ventilation guidelines for welding, brazing, soldering, and thermal cutting of coated and alloyed steels and non-ferrous metals (1)(2) (with nominal chromium content over 3% and with nominal total alloying content over 5%)**

(See Clauses 5.1.5, 10.3.3.3, 12.1.1, 12.2.2, 12.3.2, 12.4, 12.5.1, and 12.5.3.1.)

| Material   | Contaminant (3)                           | Production level (4) | Degree of confinement in work area (2)                       |                |                                   |                |
|------------|---|----------------------|--|----------------|-----------------------------------|----------------|
|            |   |                      | Outdoor (5)  | Open workspace | Limited workspace*                | Confined space |
| Aluminum   | Aluminum oxides, ozone                    | Normal               | N  | M              | LE                                | LE             |
|            |   | High (GTAW)          | —  | M              | M                                 | LE             |
|            |   | High (GMAW)          | —  | M              | M and LE                          | LE and PRP     |
| Barium     | Barium oxides and fume                    | Normal (FCAW)        | LE or PRP  | LE             | LE                                | LE and PRP     |
| Beryllium  | Beryllium oxides and fume                 | Any                  | All locations should have LE and PRP or a special glove box. |                |                                   |                |
| Cadmium    | Cadmium oxide                             | Any                  | LE or PRP  | LE             | LE and PRP or a special glove box |                |
| Chromium   | Chromium VI oxide                         | Normal               | M  | LE             | LE                                | LE and PRP     |
|            |   | High                 | LE or PRP  | LE             | LE                                | LE and PRP     |
|            |   | High (SAW)           | —  | N              | M                                 | LE             |
| Copper     | Copper oxides                             | Normal               | M  | M              | LE                                | LE and PRP     |
|            |   | High                 | LE or PRP  | LE             | LE                                | LE and PRP     |
| Fluorine   | Fluorides (of calcium, sodium, potassium) | Normal               | N  | N              | M                                 | LE             |
|            |   | High                 | —  | M              | LE                                | LE             |
|            |   | High (SAW)           | —  | N              | N                                 | LE             |
| Lead       | Lead fumes                                | Normal               | M  | M              | LE                                | LE and PRP     |
|            |   | High                 | LE or PRP  | LE             | LE                                | LE and PRP     |
| Manganese  | Manganese oxides                          | Any                  | N  | M              | LE                                | LE and PRP     |
| Nickel (6) | Nickel fumes                              | Normal               | M  | LE             | LE                                | LE and PRP     |
|            |   | High                 | LE or PRP  | LE             | LE                                | LE and PRP     |
|            |   | High (SAW)           | —  | N              | N                                 | LE and PRP     |
| Zinc       | Zinc oxide                                | Any                  | N  | M              | LE                                | LE             |

**Table 6 (Concluded)****Legend:**

- N = natural ventilation (see [Clause 12.2.2](#))  
M = mechanical ventilation (see [Clause 12.2.3](#))  
LE = local exhaust ventilation (see [Clause 12.3](#))  
PRP = personal respiratory protection (see [Clause 11.4](#))  
GMAW = gas metal arc welding (MIG)  
GTAW = gas tungsten arc welding (TIG)  
FCAW = flux-cored arc welding  
SAW = submerged arc welding  
\*Limited — see [Table 5](#) definition.

**Notes:**

- (1)** Due to health concerns, the recirculation of exhaust air from the welding of these materials is not recommended; see [Clause 12.4](#).
- (2)** Degree of confinement is defined as follows:
  - (a) Open:
    - (i) a large work area without obstructions;
    - (ii) open to outdoors and wind; and
    - (iii) fumes are free to escape;
  - (b) Limited:
    - (i) a work area that does not fit the definition of open;
    - (ii) fume is hindered from escaping; and
    - (iii) an open area may become limited when doors and windows are closed during cold weather; and
  - (c) Confined:
    - (i) inside small compartments entered through a manhole, e.g., tank, chamber, boiler pressure vessel; and
    - (ii) fumes cannot escape.
- (3)** For more details on the origin of these contaminants, see [Clause 5](#).
- (4)** Unless otherwise specified, all processes are included. "High" production refers to duty cycles exceeding approximately 40% or high amperage processes exceeding 350 A, or both.
- (5)** Where mechanical ventilation is recommended for welding outdoors, a fan may be used to disperse fumes before they enter the breathing zone, as long as the fumes are not contaminating an adjacent work area.
- (6)** When nickel and chromium occur together (e.g., stainless steel), ventilate for chromium.

- Electromagnetic Forces:
  - Persons with pacemakers should contact the manufacturer for direction
  - Persons with metal implants should be aware that at least one case has been reported in which the welder experienced a burning sensation around the metal implant while using a high frequency welding process.



- Ignition of Flammables and Combustibles – General (Adapted from CSA W117.2-12 Clause 11)
  - Basic precautions Before beginning any welding operation, the following precautions shall be taken to prevent unintended fires or explosions that can result from the welding process:
    - a) Move the work to a designated hot work area or to a location that is free from combustibles and fire hazards within a 15 m (50 ft) radius.
    - b) If the work cannot be moved, remove all movable combustibles and fire hazards to a minimum distance of 15 m (50 ft) from the work location.
    - c) Where neither the work nor all the fire hazards can be moved, install appropriate guarding in order to protect any immovable combustibles and fire hazards remaining within a 15 m (50 ft) radius of the work from heat, sparks, and hot slag, and take additional fire safety precautions (see below)Due to the size of the Formula UBC Shop, (c) will most likely apply.
  - All gasoline containers and containers that have or may have contained gasoline in the past must be removed from the shop prior to any welding process. This includes all jerry cans and fuel tanks.
  - A type ABC fire extinguisher shall be nearby during any welding process.
  - If welding near titanium or magnesium, a class D fire extinguisher shall be nearby.
  - The entire shop must be swept clean to remove all flammable debris prior to any welding process.
  - Flammable materials must be moved as far as possible from the welding location and protected from heat, sparks and slag by appropriate guarding.
  - No container that has or may have ever contained combustible or unknown liquids shall be welded. (Note, this is more stringent than CSA W117.2-12 Clause 11.8 which allows welding of containers after cleaning and inert gas purging).



- In addition to the welder, a Fire Watch must also be present during all welding processes. The Fire Watch is responsible for observing the surroundings to ensure no combustible material ignites. Once welding is complete a fire watch must be present in the shop for one hour to insure that no smouldering fires exist.
- Ignition of Flammables and Combustibles – Hot work where heat is applied to a vehicle
  - In addition to the above precautions required by CSA W117.2-12, the precautions in this section shall be followed when welding is to occur on the vehicle.
  - Any batteries or other electrical sources shall be removed from the vehicle prior to any welding process.
  - If the fuel system is installed on the vehicle and contains or has contained fuel either
    - a) The fuel tank must be removed from the vehicle and moved outside of the shop prior to any welding process.
    - b) The fuel tank must be purged with an inert gas (e.g. Nitrogen) prior to any welding process.
- Compressed Gas Cylinders (Adapted from CSA W117.2-12 Clause 11)
  - Cylinder valves shall be closed when equipment is unattended.
  - Where cylinders are designed to be equipped with valve protection caps, the caps shall be in place except when the cylinders are in service or connected, ready for service.
  - Cylinders shall be located or secured in such a manner that they cannot be knocked over.
  - A cylinder cart shall be used whenever moving cylinders.
  - Cylinders, regulators or lines that have been damaged shall not be used.
  - Welding shall not occur on or against a gas cylinder.
  - Welding torches shall not be draped over a gas cylinder.



- Welding electrodes shall not be allowed to touch or otherwise contact any cylinder.

**Table 7**  
**Guide for shade numbers**

(See Clauses 10.3.3.5, 11.2.1.3, 11.2.1.4, 11.2.5, and 11.10.5.3.)

| Operation                                   | Electrode size |          | Arc current,<br>A | Minimum<br>protective shade | Suggested shade no.<br>(comfort) |
|---|----------------|----------|-------------------|-----------------------------|----------------------------------|
|   | mm             | (in)     |                   |                             |                                  |
| SMAW  | < 2.5          | < (3/32) | < 60              | 7                           | —                                |
|   | 2.5–4.0        | (3-5/32) | 60–160            | 8                           | 10                               |
|   | 4.0–6.4        | (5-1/4)  | 160–250           | 10                          | 12                               |
|   | > 6.4          | > (8/32) | 250–550           | 11                          | 14                               |
| GMAW and<br>FCAW/MCAW                       | —              | —        | < 60              | 7                           | —                                |
|   | —              | —        | 60–160            | 10                          | 11                               |
|   | —              | —        | 160–250           | 10                          | 12                               |
|   | —              | —        | 250–500           | 10                          | 14                               |
| GTAW  | —              | —        | < 50              | 8                           | 10                               |
|   | —              | —        | 50–150            | 8                           | 12                               |
|   | —              | —        | 150–500           | 10                          | 14                               |
| Air carbon arc cutting (light)              |                | < 500    | 10                | 12                          |                                  |
| Air carbon arc cutting (heavy)              |                | 500–1000 | 11                | 14                          |                                  |
| Plasma arc welding                          |                |          | < 20              | 6                           | 6–8                              |
|   |                |          | 20–100            | 8                           | 10                               |
|   |                |          | 100–400           | 10                          | 12                               |
|   |                |          | 400–800           | 11                          | 14                               |
| Plasma arc cutting and gouging (very light) |                |          | approx. 20        | 5                           | 5                                |
|   |                | (light)  | 20–100            | 8                           | 9                                |
|   |                | (medium) | 100–400           | 9                           | 12                               |
|   |                | (heavy)  | 400–800           | 10                          | 14                               |



| Operation          | Plate thickness |           | Minimum protective shade | Suggested shade no. (comfort) |
|--------------------|-----------------|-----------|--------------------------|-------------------------------|
|                    | mm              | (in)      |                          |                               |
| Gas welding        |                 |           |                          |                               |
| (light)            | < 3.2           | (< 1/8)   | 4                        | 5                             |
| (medium)           | 3.2–12.7        | (1/8–1/2) | 5                        | 6                             |
| (heavy)            | > 12.7          | (> 1/2)   | 6                        | 8                             |
| Oxygen cutting     |                 |           |                          |                               |
| (light)            | < 25            | (< 1)     | 3                        | 4                             |
| (medium)           | 25–150          | (1–6)     | 4                        | 5                             |
| (heavy)            | > 150           | (> 6)     | 5                        | 6                             |
| Operation          |                 |           | Minimum protective shade | Suggested shade no. (comfort) |
| Torch brazing      |                 |           | 4                        | 4–5                           |
| Torch soldering    |                 |           | 2                        | 2                             |
| Carbon arc welding |                 |           | 14                       | 14                            |

**Notes:**

- (1) For thermite, laser, and electron beam welding, consult the manufacturer for eye protection recommendations.
- (2) For pulsed GMAW, use peak current for selecting the appropriate shade number.
- (3) For underwater welding, the minimum shade number might not necessarily apply. Turbidity of the water can also affect the shade number to be used.

## 9. SUPERVISION AND RESPONSIBILITIES

Supervision of welding is the responsibility of the student team leaders authorizing use of the welder. Supervisors should be familiar with all of the procedures outlined in this SOP. Newly approved users shall be supervised by a qualified user designated by the team captain or safety officer until the captain or safety officer is willing to certify the worker to work without further supervision. The team captain is responsible for ensuring that the welding equipment is not used by unauthorized persons. Both the team captain and the safety officer have the authority to remove people from the list of authorized users.

Two people shall be present in the shop during all welding operations. The second person present shall be trained and responsible to act as firewatcher, monitoring for fires and shall be equipped and trained to operate suitable extinguishing equipment and shall summon emergency responders when needed. The operator of the welder is responsible for explaining the task and



explaining potential hazards. Firewatchers should read the Hazards and Controls Section of this SOP.

The team captain and safety officer are responsible for ensuring that procedures and activities are controlled and are in compliance with WorkSafeBC regulations and for cooperating with any incident investigations or inspections by university or regulatory authorities. They are responsible for the safety of team members and others affected by the activities of Formula UBC. They are also responsible for managing the list of approved users (along with the APSC safety officer), enforcing the requirements in this SOP and for disciplining members who don't comply with this SOP.



## 10. PRE PROCEDURE SET-UP

1. In order to provide adequate ventilation either
  - a) Bring the fume extractor from the EDC composites room into the shop and position near work area to extract any fumes produced. When the fume extractor is used, the shop door should be closed. The APSC safety officer must be notified prior to moving the extractor from the EDC to RH120H. OR,
  - b) Open doors of the shop and the wind tunnel door to Rusty Hut and hand welding curtains over the shop door (mild steel welding only, no paint or other coatings present on work)
2. Control access at all times to prevent entry by unqualified individuals. Post signage at the west Rusty Hut entrance and at the door of RH120E (the room on the north side of the Boundary Layer Wind Tunnel)
3. Welding activities shall not be performed while:
  - The Boundary Layer Wind Tunnel is in use.
  - A Capstone class event is taking place in RH 118
  - A tour of Rusty Hut is in progress
  - Building Operations or contractor personnel are servicing RH 120H or the area outside this space in the BLWT hallway, or servicing the HVAC system.
  - Research activities are taking place in the area outside RH120H at the west end of the BLWT
4. Welding set-ups and activities shall not impede egress through exits such as fire doors or impede access to breaker panels, pull stations or emergency shutoffs.
5. Welding activities shall cease immediately if requested by any member of the UBC community or any officer having jurisdiction over safety or security of the area.
6. Ensure airflow direction is going to take fumes out the door. If not, set up an appropriate fume extraction system.
7. Ensure access to eyewash station is available.
8. Inspect area to ensure that no flammables are present and that all items are dry. Remove all wood, paper, or fabric **within 15 m** of weld area OR install **appropriate guarding** in order to protect any immovable



- combustibles and fire hazards remaining within a 15 m (50 ft) radius of the work from heat, sparks, and hot slag.
9. If not welding on a vehicle, remove all containers that contain or have contained fuel from the shop (including fuel tanks and jerry cans). If welding on a vehicle, remove the fuel tank from the vehicle to a location at least 15m from the weld area OR purge the fuel tank with an inert gas (e.g. nitrogen).
  10. Make sure that clothing of any persons who could be exposed to weld spatter is non-flammable.
  11. Ensure that welder's apparel is dry and non-conductive.
  12. Set up welding curtains.
  13. Put on PPE (Welding mask, sleeves, etc.).
    - Inspect safety glasses. Replace as required.
    - Inspect mask. Check LCD function if equipped. Make sure that mask is set to the correct shade setting for type and size of the weld.
    - All people involved should not be wearing anything conductive (eg, rings, jewellery, etc.).
    - For people with electronic medical devices such as a pacemaker or other metal implants see 'Other' in the table in Section 9: Controls
    - Inspect welding jacket/sleeves and gloves. Repair or use suitable replacements if equipment is defective.
    - Put on PPE
  14. Inspect lines and covers for signs of damage to the insulation. Don't use until damage has been appropriately repaired or item has been replaced with a suitable substitute.
  15. Attach grounding clamp to work piece.
  16. Make sure that argon cylinder is properly secured and inspect pressure regulator and lines
    - Refer to CCOHS "Storage and Handling of Compressed Gas Cylinders" procedures posted near tanks when using and handling cylinders
  17. Open valve on argon tank by turning the knob a quarter to half turn
  18. Plug in welder and turn on



19. Before first weld depress the pedal while the torch is away from the work piece to purge the lines
20. Adjust flow rate regulator to appropriate level
  - Typically 15-20 CFH

## 11. PROCEDURE

1. Make sure that grounding clamp is on a clean section of metal close to the weld area
2. Make sure that weld area is clean
3. If shielding is not adequate to completely shield the welding light from others, warn others in the shop that you are about to begin a weld and to look away.
4. Start and perform weld
  - If using the high frequency impulse setting place electrode where you would like to start and press the pedal and the arc will begin.
  - If using arc-lift start place electrode on the metal in contact with where you would like to start the weld, press the pedal and lift the electrode away from the metal to start the arc.
  - Avoid long continuous welds to reduce temperature increase of the part and to limit the rate of fume generation
5. To end the weld, slowly lift off of the pedal.
6. Hold torch up to weld for 5-10 seconds after completing the weld to allow the argon post flow to continue shielding the welded area while it cools
7. Mark hot work with either soapstone crayon or signage

## 12. POST PROCEDURE/TAKE DOWN

1. Shut the valve on argon tank
2. Bleed gas from lines by depressing the pedal while the torch held away from metal
3. Turn off welder and unplug it
4. Push tungsten into the nozzle
5. neatly coil lines and put away
6. Put away welding PPE



7. Clean area of tools and materials

- o If using grinder to sharpen electrodes vacuum/clean up dust
  - i. Sweep up the dust. Do not use vacuum as it might distribute it into the air

**13. EMERGENCY PROCEDURES**

In case of emergency, follow the standard emergency procedures. If someone has been seriously injured or if there is a serious fire call 9-1-1 and activate fire pull stations for serious fires. For injuries, alert the first aid attendant if possible for assistance. Evacuate the area if necessary.

Turn off the welder and shut off argon tank valve before evacuation if it is safe to do so.

**14. REVIEW AND RETENTION**

This SOP is reviewed annually or whenever deemed necessary by the responsible departmental representative in Risk Management Services.

**15. DOCUMENT APPROVAL SIGNATURES**

|  |                   |            |           |
|--|-------------------|------------|-----------|
| <b>Initial Creation Date: January 23, 2018</b> |                   |            |           |
| <b>History:</b>                                |                   |            |           |
| <b>Revised By:</b>                             |                   |            |           |
|  | Creator           | Management | Unit Head |
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| Name   |                   |            |           |
| Date   |                   |            |           |