

## Purpose

The purpose of this procedure is to outline minimum requirements for when Hot Work is being performed by employees or contractors (see items 38-40) on City property, at facilities or when Hot Work can affect City personnel, property, facilities and/or equipment.

## Hazards

<ul style="list-style-type: none"><li>• Heat, Fire, Explosion</li><li>• Hazardous Atmosphere</li><li>• Noxious gases and fumes</li><li>• Flying debris/hot sparks</li></ul>	<ul style="list-style-type: none"><li>• Failing to identify and isolate or remove flammable/combustible substances/materials</li><li>• Lack of, or inadequate, fire watch during or following Hot Work</li></ul>
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## Scope

1. City staff, contractors, and subcontractors require a **valid, authorized Hot Work Permit** for: **Hot Work** - defined as work involving open flame, producing hot surfaces and/or generating sparks or molten material. This includes, but is not limited to, welding, cutting, soldering, brazing, grinding, torch-applied roofing, adhesive bonding, thermal spraying, thawing pipes and the use of non-explosion proof equipment or tools.
  - For ignition-sensitive materials (such as low-flash point ignitable liquids, flammable gas/vapour, and some combustible dusts) it can also include the use of lighting and communication equipment that is not intrinsically safe, drilling, chiseling, sand blasting, hot-air blowers, and ungrounded personnel or equipment.

The above requirement includes:

- a) **High-risk Locations** made hazardous by the presence of:
  - i. Flammable gases or vapours that may be present in the air in quantities sufficient to produce an explosive or ignitable mixture
  - ii. Combustible or electrically conductive dust, or easily ignitable fibers or flyings
  - iii. Substances/materials that may explode, or that can become easily ignited (includes a "hazardous room" as defined by the O. Reg. 67/93, s. 18.)
- b) **Places or Equipment identified** by the City of Toronto as requiring Hot Work Permits:
  - iv. Identified Hot Work Locations include confined spaces, digester buildings with associated areas, gas control buildings, flammables or combustibles storage or handling areas (e.g. hazardous waste depot, fuelling station, warehouses, etc.) or other locations as may be applicable
  - v. Identified Hot Work on Equipment - an assessment shall be made by the designated management personnel responsible for the work, when Hot Work is to be performed on or around equipment which has been potentially

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contaminated with flammable or combustible solids, liquids, vapours or dust. This may apply to heavy equipment (such as loaders, bulldozers, tractor trailers, trucks, etc.) and vessels/containers, drums or pipes.

2. **A permit is not required when Hot Work is performed within a designated and purposefully built facility** (e.g. a welding or maintenance shop) while combustible, ignitable, or flammable materials remain controlled or safeguarded (e.g. combustible materials stored in metal cabinets, and ignitable and flammable materials in approved storage cabinets for flammable and combustible liquids).

NOTE: Outdoor locations may require a permit where combustible construction and combustible material (yard storage, etc.) may be present.

### General Requirements

3. **Avoid Hot Work whenever possible.** Consider using alternative cold work methods (examples below), or relocating the work to a Hot Work designated area/facility.

<b><u>Instead of:</u></b>	<b><u>Use cold work methods:</u></b>
• Saw or torch cutting	• Manual hydraulic shears
• Welding	• Mechanical bolting
• Sweat soldering	• Screwed or flanged pipe
• Torch or radial saw cutting	• Mechanical pipe cutter

**NOTE: Do not perform Hot Work when the fire protection system (if present) is impaired.**

4. Supervisors shall evaluate work operations, machinery and equipment to determine appropriate application of this Hot Work Permit procedure, and develop written safe work procedures as needed for specific tasks, particularly for unusual or unique situations. Consult with work crews, Joint Health and Safety Committees, People & Equity Occupational Health and Safety staff, if required.
5. Locations known/identified to require Hot Work permit shall have appropriate signage (see Section 8).
6. Supervisors shall provide instructions to workers prior to commencing work on the potential fire/explosion hazards, and plan a safe course of action to be followed, including emergency response provisions.
7. Prior to signing the permit and initiating work, the Supervisor (or designated person) is responsible for verifying that the necessary precautions are implemented:
- If a designated person takes on this role, the Supervisor shall ensure the designated person has all necessary competency and authority to adequately manage the Hot Work
  - Minimum precautions** to be observed (see listed in the Hot Work Permit):
    - Ensure the Hot Work area, and the equipment/material to be worked on are free of combustible materials and accumulations:
      - Thoroughly clean** debris, dust/lint, or residues, and pooling of ignitable liquid (due to spills or leaks)

- Look for accumulations in spaces hidden from sight, such as trenches or pits, underneath equipment, within partially-enclosed equipment, and atop cable trays, ductwork, or suspended ceilings
- When needed, use wet-down as an additional precaution, not as an alternative, to remove combustibles
- **Ensure all flammable/combustible materials are at least 11 m (35 ft.) away** from the Hot Work area (horizontally and vertically)
 

NOTE: Consider extending the Hot Work area to 15 m horizontally when performing elevated work or in windy conditions
- **Cover/shield** any combustible material/equipment that cannot be moved, to protect them from ignition. Cover/shield materials can include sheet metal and/or approved fire/heat-resistant welding pads, blankets or curtains.
- Cover tightly all floor, wall, and ceiling openings within 11 m of the operation to prevent sparks from entering an unobserved area (e.g. penetrations for cables, piping, conveyors, ventilation ductwork, stairways, doors, windows, etc.)
- Cover/close vents, shut-down ventilation and conveying systems to prevent the passage of sparks or flames to adjacent areas (lock-out might be required)
- Do not perform Hot Work on partitions, walls, ceilings or roofs with combustible layers or cores, or on equipment with combustible lining; seek alternative cold work method
- Ensure the Hot Work activity remains confined to the area or equipment specified on the permit, and that the implemented safety precautions remain in place during work
- Verify that fire extinguishing equipment is available in the immediate work area, in good working order and appropriate for the potential type of fire
 

NOTE: This extinguishing equipment shall be supplied in addition to any that is already present in the immediate area.
- Check that sprinklers, where provided, are in commission and will not be taken out of service while the Hot Work is being done
- Inspect the Hot Work equipment to ensure it is in good working condition
- Isolate Hot Work area with tape, barricades, etc. and have signage to warn against walking into/under the area

8. Hazard identification shall be provided at or near the Hot Work area to warn others of associated or residual hazards (examples below):



9. The Hot Work operator(s) shall install, maintain and operate the equipment safely, so as not to endanger people or property, in compliance with CAN/CSA-W117.2, "Safety in Welding, Cutting and Allied Processes" and the Ontario Fire Code
10. The operator(s) shall check that the work area is fire-safe before vacating
11. The operator(s) shall report to the Supervisor any fire occurrence. Any discharged fire extinguisher must be replaced without delay.

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12. Should the conditions change, or for conditions not covered by this procedure, the operator shall consult with the Supervisor.

### **Fire Watch and Monitoring**

13. A person other than the operator shall perform Fire Watch duties for Hot Work, including:
- Any area where combustible materials used in building construction or contents are located within 5 m of the Hot Work area;
  - Any area of the building exposed as a result of unprotected roof or wall openings located within 5 m of persons;
  - Any area where combustibles on the underside of roofs or the opposite side of walls might ignite
14. The Fire Watch must:
- Understand the inherent hazards of the Hot Work area and operation
  - Watch for fire development and hazardous conditions (e.g. stray sparks, smoldering fires, smoke, etc.)
  - Check the other side of the wall, when Hot Work is performed on or near a wall, as heat might transfer or radiate through the wall
  - Ensure required precautions remain in place
  - Have suitable fire-extinguishing equipment readily available and be trained in its use
  - Know the location of and how to activate the nearest fire alarm
  - Call or direct someone to call 911 and activate fire alarm before attempting to put out a fire
  - Stop the Hot Work immediately, if a fire or hazardous condition develops
15. **The Fire watch is required continuously during the Hot Work, and for 1 (one) hour immediately after** the Hot Work ceases (since the vast majority of fires start in this period)
16. **Fire monitoring is required for an additional 3 hours**
- NOTE: More than 3 hours might be needed for combustible construction with unprotected concealed cavities.
- The Supervisor can designate a trained person to intermittently tour (at least once every hour, recommended every 15 minutes) the Hot Work area and all adjacent areas (including floors above and below)
  - Other monitoring methods might include: automatic smoke detection system with remote alarm that sounds in a staffed location; security video cameras with clear coverage of the Hot Work area, re-routing security/maintenance rounds when needed; workers routinely present in the Hot Work area instructed to watch for fire development or hazardous conditions.
17. More than one Fire Watch may be required if the Hot Work area is not visible from a single vantage point:
- It is large, multi-level, congested, etc.
  - It extends to the other side due to an opening or thermally conductive penetration (e.g. metal piping, steel structural members)

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18. The Supervisor (or designated person) should conduct a final check of the Hot Work area for fire-safe conditions after the post-work fire watch and/or fire monitoring periods have concluded

The City's Hot Work Permit is an approved tag (see Appendix A for sample) that can be obtained from [City Stores](#).

### How to complete the Hot Work Permit

The Hot Work Permit is a two-page form (self-copying) with a back cover:

- Page 1 documents the plan prior to hot work, and must be retained as an indicator of an open Hot Work Permit.
- Page 2 documents each step during and after hot work, and must be posted visibly at the hot work area together with the back cover to alert that active Hot Work is happening.
  - Both Page 1 and 2 include the recommendation to consider alternatives to hot work, information about the work and precautions.
  - On the back cover there are a warning sign and the emergency information.

19. **Permit Authorizer:** if the work cannot be done by other means, or at a Hot Work designated area, then the issuing Supervisor (or designated person) must review and verify implementation of all the applicable safety precautions before signing the permit, then provide Page 2 (and back cover) to the person performing the Hot Work.

20. **Person performing hot work:** must record time started and sign Page 1 and display Page 2 of the permit at hot work area. After hot work is completed, record time and leave Page 2 permit displayed for fire watch. This provides a start time for the post-work fire watch.

21. **Fire Watch:** sign Page 1, watch area during hot work and after work completion. Prior to leaving area, perform final inspection, sign Page 2, leave permit displayed and notify Fire Monitor or Permit Authorizer.

22. **Fire Monitor:** monitor area after post-work fire watch completion. Perform final inspection, sign Page 2 and return to Permit Authorizer.

23. Upon completion of the work, fire watch and monitoring, the Supervisor (or designated person) conducts a final inspection of the area and signs off to confirm the area is fire-safe. The Permit Authorizer must review Page 2 including signed confirmation of post-work fire watch and fire monitoring, sign off the final check on Page 2 that the permit is closed out, and retain together with Page 1 for the records.

24. If the job has not been completed by the end of the shift, a new permit shall be issued.

25. Used permits (both pages) should be retained for a minimum of 2 (two) years.

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## Specific Requirements

### Cutting and Welding

26. Cutting and welding operations are to be restricted to authorized, properly trained individuals

27. A properly rated fire extinguisher must be attached to all cutting and welding carts

28. All painted surfaces, which may be welded or cut, must be known to be non-toxic; otherwise the paint must be removed first, or appropriate respiratory protection shall be worn

NOTE: In welding, oxygen and acetylene present the most common hazards of fire and explosion:

- Pure oxygen will not burn or explode, but supports the combustion of other materials, causing them to burn much more rapidly than they would in air
- Never use oxygen to blow dust off of clothing. Oxygen will form an explosive mixture with acetylene, hydrogen, and other combustible gases.

29. Welders should wear flameproof gauntlet gloves, aprons, leggings, shoulder and arm covers, welding helmets, eye and hearing protection. Clothing should be made from fire-rated material, free from oil and grease to be less likely to ignite.

30. To keep out sparks and slag, have sleeves rolled down and collars buttoned up, wear shirts with flaps over pockets, pants with no cuffs and boots secured to the top. Remove rings, watches, and other jewelry, never carry matches or lighters in pockets.

31. Install protective screens or barriers to protect people from arc flash, radiation, or spatter. Barriers should be non-reflective and allow air circulation at floor and ceiling levels.

- a) Where barriers are not feasible or effective, workers near a welding area should wear proper eye protection and any other equipment required.

For more information and specific safety precautions for these operations see Appendix B "*Welding and Cutting*" from Infrastructure Health & Safety Association.

### Hot Work in the Presence of Flammable Atmospheres

32. In order to perform Hot Work in the presence of an explosive or flammable gas or vapour, the following precautions must be taken:

- a. The atmosphere in the Hot Work area is continuously monitored for the presence of combustible gas, toxic gas and oxygen deficiency
- b. The space is purged and continuously ventilated to maintain an atmosphere of less than 5% of the LEL and an oxygen concentration of less than 23%; and an adequate warning system and exit procedure must be in place to provide adequate warning and allow safe escape if the levels above are exceeded:
  - i. If the LEL exceeds 5%, all Hot Work shall immediately stop and the source of the explosive gas shall be identified, eliminated and purged before work resumes
  - ii. Between LEL 5% and 10%, the area shall be evacuated and the source of the explosive gas should be controlled from outside the area (e.g. shutting off gas valves). If it is necessary to control the source inside the high gas area, it shall be done only by qualified personnel wearing all appropriate PPE, grounded and using non-sparking tools.

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- iii. If the LEL exceeds 25%, the area shall be evacuated and no one shall enter the high gas area. The source of the explosive gas shall be controlled only from outside the area. Call 911 immediately in case of emergency.
33. For safety precautions when working in Confined Spaces, follow I&DS safety procedure SP09:
- a. Workers must wear adequate respiratory protection and equipment to allow persons outside the confined space to locate and rescue them, if necessary
  - b. Alternatively, the space must be rendered safe by inerting with an inert gas and continuously monitoring the atmosphere, particularly with regard to oxygen concentration

### **Hot Work on Empty Tank/Pipe or Equipment**

34. For any Hot Work, such as welding or cutting, on a container that may have contained flammable or combustible material, the following minimum precautions must be taken:
- a. Make sure that fittings, such as baffles, will not interfere with cleaning or purging
  - b. Drain and clean the container using appropriate methods (e.g. steam cleaning, water down the equipment, etc.)
  - c. Test its interior with a gas detector, both before Hot Work begins, and periodically during the work
35. For containers that cannot be drained and cleaned, they must be made safe by purging and inerting with an inert gas, but only if these precautions are taken:
- a. Use recognized procedures and proper equipment, and understand the limitations of the inerting process
  - b. Monitor the oxygen level inside the container and maintain levels at essentially zero for the duration of the work
  - c. When draining and purging is warranted, ensure all low-points are identified and verified clear
36. Never assume a container is clean or safe, test before any Hot Work begins.

The Regulations for Industrial Establishments (R.R.O. 1990, Reg. 851, s. 78) require that where repairs or alterations are made on a drum, tank, pipeline or other container, it must be drained and cleaned or otherwise made free from any explosive, flammable or harmful substance. See Appendix C - Ministry of Labour *Engineering Data Sheet 4-14 "Welding and Other Hot Work on Containers"*.

### **Contracted Work**

37. Where the contractor is the constructor, the contract should determine safe Hot Work procedures and practices to be followed, as well as the responsibility for training, managing and conducting Hot Work.
38. Where the City of Toronto is the constructor and the contractor/employer, management shall communicate the Hot Work requirements of this procedure to all contractors/contract employees and provide them with Appendix D – *How to Fill-in the Hot Work Permit*. Contractor supervision and workers shall be competent and fully trained to meet or exceed the City's requirements and to perform this work.
39. The City project/facility representatives (as agreed or specified in the contract) must be notified prior to Hot Work, and be provided with a copy of the Hot Work Permit(s).

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## Training

- 40. All workers performing tasks related to Hot Work must be trained (e.g. permit authorizers; staff performing Hot Work, fire watch, and/or fire monitoring)
- 41. Permit authorizers must be competent persons and have received the related training.
- 42. Hot Work training and instruction must include the following :
  - a. Implementation and control of required precautions, and how to escalate any problems identified
  - b. Inspection of the Hot Work area for fire-safe conditions, and the emergency response if a fire is detected (e.g. call 911 before attempting to extinguish)
  - c. Safe use of the fire extinguisher if expected to use it in response to a fire
  - d. The proper use of the Hot Work Permit

NOTE: A refresher is recommended every 3 (three) years.

## Legislative Requirements

Occupational Health and Safety Act, RSO 1990  
Regulation for Industrial Establishments, Reg. 851  
Regulation for Construction Projects, Reg. 213/91  
Regulation for Confined Spaces, Reg. 632/05  
Fire Protection and Prevention Act, 1997, S.O. 1997, c. 4 and O. Reg. 213/07: FIRE CODE

## Standards and Guidelines

Ministry of Labour, Training and Skills Development - Engineering Data Sheet 4-14 "*Welding and Other Hot Work on Containers*"  
CAN/CSA-W117.2-12 - *Safety in welding, cutting, and allied processes*

## Appendices

Appendix A – Sample Hot Work Permit  
Appendix B – Infrastructure Health & Safety Association - "*Welding and Cutting*"  
Appendix C – Ministry of Labour, Training and Skills Development - Engineering Data Sheet 4-14, "*Welding and Other Hot Work on Containers*"  
Appendix D – "*How to Fill-in the Hot Work Permit*"

## Related Safety Policies/Procedures

SP 04      Eye and Face Protection  
SP 09      Confined Space Entry  
SP 12      Lockout, Tag & Test

Distribution – Infrastructure & Development Services Division Heads, Directors, Managers, Supervisors, People & Equity OH&S/DM Managers and Consultants



# HOT WORK PERMIT

**STOP!****Avoid hot work when possible! Consider using an alternative cold work method.****PAGE 1 – PART 1****Instructions for Permit Authorizer**

1. Specify the precautions to take.
2. Fill out and keep **Part 1** during the hot work process.
3. Issue **Part 2** to the person doing the job.
4. Sign off the final check on Part 2
5. Keep **Part 1 and Part 2** on file for future reference including signed confirmation that the post-work fire watch and monitoring have been completed.

**HOT WORK BY**

- ☐ Employee
- ☐ Contractor

**DATE****JOB NUMBER****LOCATION OF WORK (BUILDING/FLOOR/OBJECT)****WORK TO BE PERFORMED:****NATURE OF TASK:**

- ☐ Cutting ☐ Welding ☐ Brazing ☐ Grinding ☐ Soldering
- ☐ Thawing Pipe ☐ Torch Applied Roofing ☐ Other

**PERSON PERFORMING HOT WORK**

PRINT NAME

SIGNATURE

**PERSON PERFORMING FIRE WATCH**

PRINT NAME

SIGNATURE

I verify the above location has been examined, the required precautions have been taken, and permission is authorized for this work.

**PERMIT AUTHORIZER**

PRINT NAME

SIGNATURE

**THIS PERMIT EXPIRES ON** (LIMIT AUTHORIZATION TO ONE SHIFT):

DATE:

TIME:

☐ AM ☐ PM**REQUIRED PRECAUTIONS CHECKLIST**

- ☐ Review of the standard operations/tasks and of any temporary changes/conditions/new hazards has been conducted.
- ☐ Any other Work Permits have been reviewed and issued as necessary.
- ☐ The fire pump is in operation and switched to automatic (where present). Control valves to water supply for sprinkler system are open.
- ☐ Extinguishers are in service/operable.
- ☐ Hot work equipment is in good working condition.

**Requirements within 11 m (35 ft.) of task area(s)**

- ☐ Shield combustible construction using certified welding pads, blankets and curtains.
- ☐ Remove or shield non-removable combustibles using certified welding pads, blankets and curtains.
- ☐ Isolate potential sources of flammable gas, ignitable liquid or combustible dust/lint and combustible residues (e.g. shut down equipment).
- ☐ Remove ignitable liquid, combustible dust/lint and combustible residues.
- ☐ Shut down ventilation and conveying systems.
- ☐ Remove combustibles and consider a second fire watch on opposite side of floor, wall, ceiling or roof when openings exist or thermally conductive materials pass through.
- ☐ Is work on a combustible building assembly (e.g. torch-applied roofing)? If yes, provide **Additional Required Precautions** below.

**Work on/in closed equipment, ductwork or piping**

- ☐ Equipment having stored energy or electrical energy removed from service and isolated (LOCK OUT, TAG & TEST).
- ☐ Pressurized vessels, piping removed from service, isolated and vented (LOCK OUT, TAG & TEST).
- ☐ Remove ignitable liquid and purge flammable gas/vapor.
- ☐ Prior to work, and/or during work, monitor for flammable gas/vapour. LEL reading(s) \_\_\_\_\_
- ☐ Remove combustible dust/lint or other combustible materials.
- ☐ Equipment having stored energy or electrical energy removed from service and isolated (LOCK OUT, TAG & TEST).

**Fire Watch/Fire Monitoring the hot work area**

(Times listed are sufficient for majority)

- ☐ Perform a continuous fire watch during hot work.
- ☐ Perform a continuous fire watch post-work for  
☐ 1 hour or Other \_\_\_\_\_ hours.
- ☐ Perform fire monitoring for: ☐ 3 hours or Other \_\_\_\_\_ hours.
- ☐ Trained in use of and provided with portable fire extinguisher or charged fire hose line(s)?
- ☐ Trained how to report fire alarm via plant fire alarm procedures or fire alarm system?

**ADDITIONAL REQUIRED PRECAUTIONS**

PERMIT NUMBER

0000001

# HOT WORK PERMIT



## STOP!

**Avoid hot work when possible! Consider using an alternative cold work method.**

PAGE 2 – PART 2

### Instructions

**Person performing hot work:** Record time started and display permit at hot work area. After hot work is completed, record time and leave permit displayed for Fire Watch.

**Fire Watch:** Watch area during hot work and after work completion. Prior to leaving area, perform final inspection, sign, leave permit displayed and notify Fire Monitor or Permit Authorizer.

**Fire Monitor:** Monitor area after post-work fire watch completion. Perform final inspection, sign and return to Permit Authorizer.

#### HOT WORK BY

- ☐ Employee  
☐ Contractor

DATE

JOB NUMBER

#### LOCATION OF WORK (BUILDING/FLOOR/OBJECT)

#### WORK TO BE PERFORMED:

##### NATURE OF TASK:

- ☐ Cutting ☐ Welding ☐ Brazing ☐ Grinding ☐ Soldering  
☐ Thawing Pipe ☐ Torch Applied Roofing ☐ Other

#### PERSON PERFORMING HOT WORK

PRINT NAME

SIGNATURE

#### PERSON PERFORMING FIRE WATCH

PRINT NAME

SIGNATURE

I verify the above location has been examined, the required precautions have been taken, and permission is authorized for this work.

#### PERMIT AUTHORIZER

PRINT NAME

SIGNATURE

#### THIS PERMIT EXPIRES ON (LIMIT AUTHORIZATION TO ONE SHIFT):

DATE: TIME: ☐ AM ☐ PM

Hot Work Date: START TIME: ☐ AM ☐ PM  
FINISH TIME: ☐ AM ☐ PM

#### Post-Work Fire Watch FINISH TIME: ☐ AM ☐ PM

Name

**Fire Monitor** ☐ Person ☐ Other

FINISH TIME

Name: ☐ AM ☐ PM

**Final Check** TIME: ☐ AM ☐ PM

Name

PERMIT NUMBER

0000001

### REQUIRED PRECAUTIONS CHECKLIST

- ☐ Review of the standard operations/tasks and of any temporary changes/conditions/new hazards has been conducted.
- ☐ Any other Work Permits have been reviewed and issued as necessary.
- ☐ The fire pump is in operation and switched to automatic (where present). Control valves to water supply for sprinkler system are open.
- ☐ Extinguishers are in service/operable.
- ☐ Hot work equipment is in good working condition.

#### Requirements within 11 m (35 ft.) of task area(s)

- ☐ Shield combustible construction using certified welding pads, blankets and curtains.
- ☐ Remove or shield non-removable combustibles using certified welding pads, blankets and curtains.
- ☐ Isolate potential sources of flammable gas, ignitable liquid or combustible dust/lint and combustible residues (e.g. shut down equipment).
- ☐ Remove ignitable liquid, combustible dust/lint and combustible residues.
- ☐ Shut down ventilation and conveying systems.
- ☐ Remove combustibles and consider a second fire watch on opposite side of floor, wall, ceiling or roof when openings exist or thermally conductive materials pass through.
- ☐ Is work on a combustible building assembly (e.g. torch-applied roofing)? If yes, provide **Additional Required Precautions** below.

#### Work on/in closed equipment, ductwork or piping

- ☐ Equipment having stored energy or electrical energy removed from service and isolated (LOCK OUT, TAG & TEST).
- ☐ Pressurized vessels, piping removed from service, isolated and vented (LOCK OUT, TAG & TEST).
- ☐ Remove ignitable liquid and purge flammable gas/vapor.
- ☐ Prior to work, and/or during work, monitor for flammable gas/vapour. LEL reading(s)
- ☐ Remove combustible dust/lint or other combustible materials.
- ☐ Equipment having stored energy or electrical energy removed from service and isolated (LOCK OUT, TAG & TEST).

#### Fire Watch/Fire Monitoring the hot work area

(Times listed are sufficient for majority)

- ☐ Perform a continuous fire watch during hot work.
- ☐ Perform a continuous fire watch post-work for  
☐ 1 hour or Other hours.
- ☐ Perform fire monitoring for: ☐ 3 hours or Other hours
- ☐ Trained in use of and provided with portable fire extinguisher or charged fire hose line(s)?
- ☐ Trained how to report fire alarm via plant fire alarm procedures or fire alarm system?

#### ADDITIONAL REQUIRED PRECAUTIONS

**WARNING**  
**HOT WORK IN PROGRESS!**  
**Watch for fire!**

In case of emergency, call the contacts listed below before attempting to extinguish the fire:

Contact	Number

**WARNING!**

## 41 WELDING AND CUTTING

Welding is a method of joining metal parts together by heating them until they melt and pressing them together.

Arc welding is the most common type of welding process used in construction. Arc welding uses intense heat to melt metal, causing the molten metal to intermix, usually with a filler metal from an electrode. Once the liquid metal cools, a bond is formed, joining two pieces of metal together.

Flame cutting (i.e., oxyacetylene or oxyfuel cutting) is an allied process that requires the use of a torch, fuel gas, and oxygen to cut metals—primarily steel.

For some of the information in this chapter, IHSA gratefully acknowledges its use of the Canadian Standards Association standard CAN/CSA W117.2-12: *Safety in Welding, Cutting and Allied Processes*, © CSA.

### Welding Methods

**Shielded Metal Arc Welding (SMAW)** is the most common arc welding process in construction (Figure 41-1).

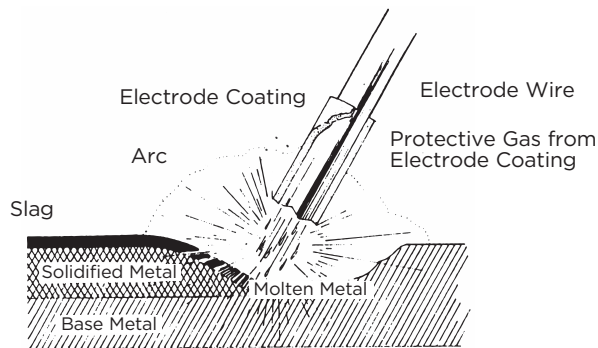


Figure 41-1: Shielded Metal Arc Welding

SMAW uses a short length of consumable electrode, which melts as it maintains the arc. Melted metal from the electrode is carried across the arc to become the filler metal of the weld.

The electrode is coated with a complex mix of chemicals that release a shielding gas such as carbon dioxide to keep air out of the arc zone and protect the weld from oxidation. The composition of the coating varies with the metal being welded.

**Gas Metal Arc (GMAW) or Metal Inert Gas Welding (MIG)** uses an uncoated consumable wire that is fed continuously down the middle of the welding torch. A ring-like tube around the wire transports an inert gas such as argon, helium, or carbon dioxide from an outside source to the arc zone to prevent oxidation of the weld (Figure 41-2).

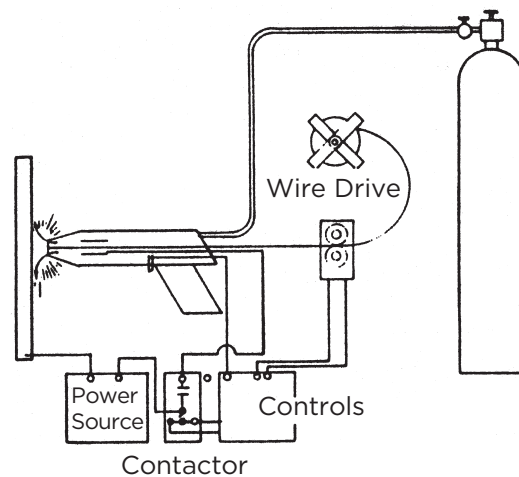


Figure 41-2: Gas Metal Arc Welding

**Flux Cored Arc Welding (FCAW)** is a variation of MIG welding. It uses a hollow consumable wire whose core contains various chemicals that generate shielding gases to strengthen the weld (Figure 41-3).

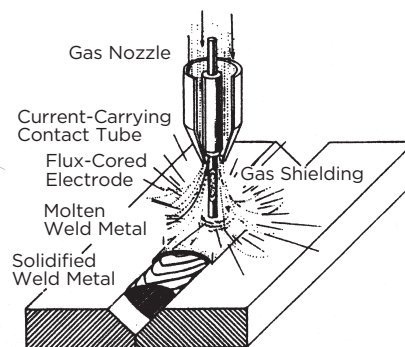


Figure 41-3: Flux Cored Arc Welding

**Gas Tungsten Arc Welding (GTAW) or Tungsten Inert Gas Welding (TIG)** uses a non-consumable tungsten electrode that maintains the arc and provides enough heat to join metals (Figure 41-4). Filler metal is added in the form of a rod held close to the arc. The rod melts and deposits filler metal at the weld. Shielding gases may or may not be used, depending on the metal being welded.

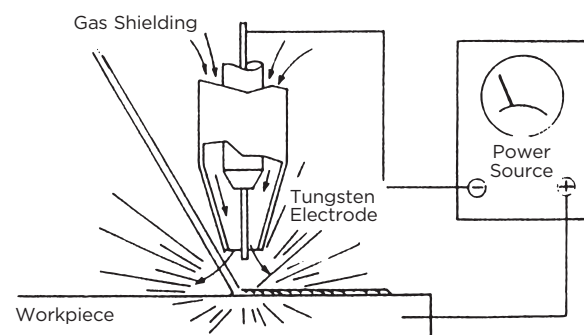
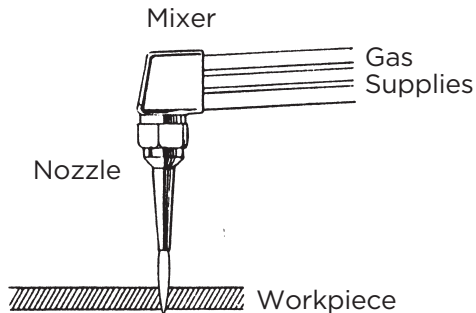


Figure 41-4: Gas Tungsten Arc Welding

**Oxyacetylene Welding and Cutting** burns a mixture of gases—oxygen and acetylene—to generate heat for welding metals (Figure 41-5). It's the most common fuel gas cutting and welding used in construction. The process may also employ the use of a filler metal.



**Figure 41-5: Oxyacetylene Welding**

## Welding Gases

Fuel gases for welding are used alone or with oxygen. Examples include propane, propylene, and natural gas.

Acetylene is a mixture of carbon and hydrogen. Its stored energy is released as heat when it burns. When burned with oxygen, acetylene can produce a higher flame temperature (3,300°C) than any other gas used commercially. The wide flammable range of acetylene (2.5% to 81% in air) is greater than that of other commonly used gases, with consequently greater hazard.

## Base Metals

Because each metal and metal alloy responds to heat in a distinct way, different base metals are used for specific purposes and applications. Below are the common base metals used for welding.

- **Mild Steel** – an alloy of iron, carbon, silicon, and occasionally molybdenum or manganese
- **Stainless and High Alloy Steels** – containing iron, nickel, chromium, and occasionally cobalt, vanadium, manganese, and molybdenum
- **Aluminum** – either pure or as an alloy containing magnesium, silicon, and occasionally chromium
- **Galvanized steel** – steel that has been coated with a layer of zinc to prevent corrosion.

## Welding Hazards

Welders in construction are exposed to a wide range of hazards such as inhalation of toxic fumes and gases, serious burns from hot metal, and electric shocks from welding cable. Eye protection is a must for welders and others who may be exposed to the welding process.

### Welding Hazards

- |                   |  |
|-------------------|--|
| <b>Physical</b>   | <ul style="list-style-type: none"> <li>- Ionizing radiation (x-rays, gamma rays)</li> <li>- Non-ionizing radiation (ultraviolet, infrared)</li> <li>- Visible light</li> <li>- Temperature extremes</li> <li>- Fire</li> <li>- Noise</li> <li>- Electrical energy</li> </ul> |
| <b>Chemical</b>   | <ul style="list-style-type: none"> <li>- Flammable/combustible products</li> <li>- Welding fumes</li> <li>- Toxic gases</li> <li>- Dust</li> </ul>   |
| <b>Biological</b> | <ul style="list-style-type: none"> <li>- Bacteria</li> <li>- Fungi</li> <li>- Viruses</li> </ul>   |

Once a chemical from welding has entered the body it may have a toxic effect. Effects can range from mild irritation to death and are influenced by a number of factors. Different organs may also be affected, such as the lungs, kidneys, and brain.

The two major types of effects are **acute** and **chronic**, as described in the Occupational Health chapter in this manual.

## Physical Hazards

### Radiation

Both ionizing and non-ionizing radiation may be encountered by welders and their helpers. Ionizing is more hazardous because it can contribute directly to cancer.

**Ionizing** — A common source is the emission of x-rays and gamma rays from equipment used to gauge the density and thickness of pipes and to check welds.

**Non-ionizing** — A major source is ultraviolet, infrared, and visible light radiation from sunlight or welding.

Radiation produced by the welding process is mainly non-ionizing, which includes electromagnetic fields, infrared radiation, visible light, and ultraviolet radiation.

Exposure to ultraviolet (UV) radiation can result directly from the arc or from a reflection off bright objects such as shiny metal or white clothing. It can cause "arc eye" when sight is not adequately protected. Eyes become watery and painful anywhere from 2 to 24 hours after exposure. The condition may last 1-5 days but is usually reversible with no lasting effects. However, repeated exposure may result in scar tissue that can impair vision.

UV exposure may also cause a temporary loss of visual sharpness called "fluorescence." It may eventually lead to the development of cataracts in the eye if eye protection is not worn.

Skin reddening, commonly known as sunburn, is another hazard of UV exposure. Blistering may occur in extreme cases. Although excessive exposure to UV radiation from the sun has been linked to skin cancer, there are no reports of increased skin cancer rates from welding exposure.

The intensity of UV radiation varies with the type of welding. Generally, the higher the temperature of the welding process the higher the UV radiation.

**Infrared radiation** is hazardous for its thermal or heating effects. Excessive exposure to the eye may cause damage.

**Visible light** is released at high intensity by welding. Short-term exposure can produce “flash blindness” in which vision is affected by after-images and temporary blind spots. Repeated exposure to high-intensity visible light can produce chronic conjunctivitis, characterized by red, tearful eyes.

**X-rays and gamma rays** are invisible forms of *ionizing* radiation used to inspect welds during radiographic testing. Exposure to these rays can be extremely damaging to unprotected parts of the body. Keep all personnel away from any area where this type of testing is being done. X-rays are also produced during electron beam welding. The welding chamber must be completely shielded to confine the x-rays and protect the operator.

### Extreme Temperatures

Very high temperatures are caused by the welding process. Gas flames may reach 3,300°C. Metals melt in a range from 260°C to 2,760°C. Welded materials, the work environment, and weather are sources of excessive heat, which can cause muscle cramps, dehydration, sudden collapse, and unconsciousness.

Welders may suffer frostbite and hypothermia when working in extreme cold climates or with welding gases stored at temperatures as low as -268°C. Exposure to freezing temperatures can lead to fatigue, irregular breathing, lowered blood pressure, confusion, and loss of consciousness. Heat stress and cold stress are both life-threatening and, if not treated in time, can be fatal.

### Noise

Sound waves over 85 dBA emitted at high intensity by welding equipment can lead to hearing loss. Noise has also been linked to headaches, stress, increased blood pressure, nervousness, and excitability. (See Chapter 14: Hearing Protection for information on maximum exposures for workers not equipped with hearing protection.)

Welding noise is produced by the power source, the welding process, and by secondary activities such as grinding and hammering. Gasoline power sources may lead to sound exposures over 95 dBA. Arc gouging may produce sound levels over 110 dBA. Grinding, machining, polishing, hammering, and slag removal all contribute to high levels of noise. Substantial hearing loss has been observed in welders.

### Electrical Energy

Electrical shock is the effect produced by current on the nervous system as it passes through the body. Electrical shock may cause violent muscular contractions, leading to falls and injuries. It may also have fatal effects on the heart and lungs.

Electrical shock may occur as a result of improper grounding and/or contact with current through damp clothing, wet floors, and other humid conditions. Even if the shock itself is not fatal, the jolt may still cause welders to fall from their work positions.

Electrical burns are an additional hazard. The burns often occur below the skin surface and can damage muscle and nerve tissue. In severe cases, the results can be fatal.

The extent of injury due to electrical shock depends on voltage and the body's resistance to the current passing through it (see the Electrical Hazards chapter in this manual). Even low voltages used in arc welding can be dangerous under damp or humid conditions. Welders should keep clothing, gloves, and boots dry and stay well insulated from work surfaces, the electrode, the electrode holder, and grounded surfaces.

**Stray welding current** may cause extensive damage to equipment, buildings, and electrical circuits under certain conditions.

### Chemical Hazards

Chlorinated solvents for degreasing, zinc chromate-based paint for anti-corrosion coatings, cadmium or chromium dusts from grinding, and welding fumes are all classified as chemical hazards.

Arc welders are at particular risk since the high temperatures generated by the arc can release heavy concentrations of airborne contaminants.

Chemical hazards may injure welders through inhalation, skin absorption, ingestion, or injection into the body. Damage to respiratory, digestive, nervous, and reproductive systems may result. Symptoms of overexposure to chemicals may include nosebleeds, headaches, nausea, fainting, and dizziness.

Read the manufacturer's safety data sheet (SDS) for information on protective measures for any chemical you encounter in the workplace.

The most common chemical hazards from welding are airborne contaminants that can be subdivided into the following groups:

1. Fumes
2. Gases and Vapours
3. Dusts.

The amount and type of air contamination from these sources depends on the welding process, the base metal, and the shielding gas. Toxicity depends on the concentration of the contaminants and the physiological response of individual workers.



## Fumes

Some of the metal melted at high temperatures during welding vaporizes. The metal vapour then oxidizes to form a metal oxide. When this vapour cools, suspended solid particles called fume particles are produced. Welding fumes consist primarily of suspended metal particles invisible to the naked eye.

Metal fumes are the most common and the most serious health hazard to welders. Fume particles may reach deep into the lungs and cause damage to lung tissue or enter the bloodstream and travel to other parts of the body. The following are some common welding fumes.

**Beryllium** is a hardening agent found in copper, magnesium, and aluminum alloys. Overexposure may cause **metal fume fever**. Lasting for 18–24 hours, the symptoms include fever, chills, coughing, dryness of mouth and throat, muscular pains, weakness, fatigue, nausea, vomiting, and headaches. Metal fume fever usually occurs several hours after the exposure and the signs and symptoms usually abate 12–24 hours after the exposure with complete recovery. Immunity is quickly acquired if exposure occurs daily, but is quickly lost during weekends and holidays. For this reason, metal fume fever is sometimes called “Monday morning sickness.”

Long-term (chronic) exposure to beryllium fumes can result in respiratory disease. Symptoms may include coughing and shortness of breath. Beryllium is a suspected carcinogen—that is, it may cause cancer in human tissue. It is highly toxic. Prolonged exposure can be fatal.

**Cadmium** coatings can produce a high concentration of cadmium oxide fumes during welding. Cadmium-plated or cadmium-containing parts resemble, and are often mistaken for, galvanized metal. Cadmium is also found in solders (especially silver solder) and brazes.

Overexposure to cadmium can cause **metal fume fever**. Symptoms include respiratory irritation, a sore, dry throat, and a metallic taste followed by cough, chest pain, and difficulty in breathing. Overexposure may also make fluid accumulate in the lungs (pulmonary edema) and may cause death. The liver, kidneys, and bone marrow can also be injured by the presence of this metal.

**Chromium** is found in many steel alloys. Known to be a skin sensitizer, it may cause skin rashes and skin ulcers with repeated exposure. Chromium also irritates mucous membranes in areas such as eyes and nose and may cause perforation of the nasal septa. Inhaled chromium may cause edema and bronchitis.

**Lead** can be found in lead-based paints and some metal alloys. Lead poisoning results from inhalation of lead fumes from these lead-based materials. The welding and cutting of lead or lead-coated materials is the primary source of lead poisoning for welders. Symptoms include loss of appetite, anemia, abdominal pains, and kidney and nerve damage. Under Ontario law, lead is a **designated substance** requiring special precautions for use and handling.

**Nickel** is found in many steel alloys including stainless steel and monel. It is a sensitizing agent and in certain forms is toxic and carcinogenic. Nickel fumes can also produce cyanosis, delirium, and death 4 to 11 days after exposure.

**Zinc** is found in aluminum and magnesium alloys, brass, corrosion-resistant coatings such as galvanized metal, and brazing alloys. Inhaling zinc fumes during the cutting or welding of these metals may cause metal fume fever.

## Gases and Vapours

A **gas** is a low-density chemical compound that normally fills the space in which it is released. It has no physical shape or form. **Vapour** is a gas produced by evaporation.

Several hazardous vapours and gases may be produced by welding. Ultraviolet radiation, surface coatings, shielding gases, and rod coatings are primary sources of vapours and gases. Overexposure may produce one or more of the following respiratory effects:

- Inflammation of the lungs
- Pulmonary edema (fluid accumulation in the lungs)
- Emphysema (loss of elasticity in lung tissue)
- Chronic bronchitis
- Asphyxiation.

**Hydrogen fluoride (HF) gas** can be released by the decomposition of rod coatings during welding and irritates the eyes and respiratory system. Overexposure can injure lungs, kidney, liver, and bones. Continued low-level exposures can result in chronic irritation of nose, throat, and bronchial tubes.

**Nitrogen oxide (NOx) gas** is released through a reaction of nitrogen and oxygen promoted by high heat and/or UV radiation. It is severely irritating to the mucous membranes and the eyes. High concentrations may produce coughing and chest pain. Accumulation of fluid in the lungs can occur several hours after exposure and may be fatal.

**Ozone gas** is formed by the reaction of oxygen in air with the ultraviolet radiation from the welding arc. It may be a problem during gas-shielded metal arc welding in confined areas with poor ventilation. Overexposure can result in an accumulation of fluid in the lungs (pulmonary edema) which may be fatal.

**Phosgene gas** is formed by the heating of chlorinated hydrocarbon degreasing agents. It is a severe lung irritant and overexposure may cause excess fluid in the lungs. Death may result from cardiac or respiratory arrest. The onset of symptoms may be delayed for up to 72 hours.

**Phosphine or hydrogen phosphide** is produced when steel with a phosphate rustproofing coating is welded. High concentrations irritate eyes, nose, and skin.

**Asphyxiants** are chemicals that interfere with the body's ability to transfer oxygen to the tissues. The exposed individual suffocates because the bloodstream cannot supply enough oxygen for life.

There are two main classes of asphyxiants:

1. **Simple asphyxiants** displace oxygen in air, thereby leaving little or none for breathing. In welding, simple asphyxiants include commonly used fuel and shielding gases such as acetylene, hydrogen, propane, argon, helium, and carbon dioxide. When the normal oxygen level of 21% drops to 16%, breathing as well as other problems begin, such as lightheadedness, buzzing in the ears, and rapid heartbeat.
2. **Chemical asphyxiants** interfere with the body's ability to transport or use oxygen. Chemical asphyxiants can be produced by the flame-cutting of metal surfaces coated, for instance, with rust inhibitors. Hydrogen cyanide, hydrogen sulphide, and carbon monoxide are examples of chemical asphyxiants—all highly toxic.

## Dusts

Dusts are fine particles of a solid that can remain suspended in air and are less than 10 micrometres in size. This means they can reach the lungs. Dusts may be produced by fluxes and rod coatings, which release phosphates, silicates, and silica. The most hazardous of these is silica which can produce silicosis—a disease of the lung which causes shortness of breath and can shorten life expectancy.

## Biological Hazards

Biological hazards are a relatively minor concern for construction welders. However, exposure to bacteria may occur in sewer work, while air handling systems contaminated by bacteria and fungi can cause legionnaires' disease and other conditions. A fungus that grows on bird or bat droppings is responsible for a disease called histoplasmosis, producing flu-like symptoms. Contact may occur where buildings contaminated with droppings are being renovated or demolished.

## Fires/Explosions

There is always a threat of fire with welding. Fires may result from chemicals reacting with one another to form explosive or flammable mixtures. Many chemicals by themselves have low ignition points and are subject to burning or exploding if exposed to the heat, sparks, slag, or flame common in welding. Even sparks from cutting and grinding may be hot enough to cause a fire.

In welding, oxygen and acetylene present the most common hazards of fire and explosion. Pure oxygen will not burn or explode but supports the combustion of other materials, causing them to burn much more rapidly than they would in air.

Never use oxygen to blow dust off your clothing. Oxygen will form an explosive mixture with acetylene, hydrogen, and other combustible gases.

Acetylene cylinders are filled with a porous material soaked with acetone, the solvent for acetylene. Because acetylene is highly soluble in acetone at cylinder pressure, large quantities can be stored in comparatively small cylinders at relatively low pressures. When exposed to high temperature, excess pressure, or mechanical shock, acetylene gas can undergo an explosive decomposition reaction. In addition, if this reaction or an ignition of acetylene occurs within the torch base or supply hose, it can circulate back into the storage cylinder, causing it to explode.

## Preventive Measures

Welding hazards must be recognized, evaluated, and controlled to prevent injury to personnel and damage to property. The WHMIS chapter in this manual explains the information on hazardous materials that can be provided by WHMIS symbols, labels, and safety data sheets. Once a welding hazard has been identified, controls can be implemented at its source, along its path, or at the worker.

## Exposure Factors

Types and effects of airborne contaminants produced by welding depend on the working environment, the kind of welding being done, the material being welded, and the welder's posture and welding technique.

The **environment** for welding is a very important factor in the degree of exposure to fumes, vapours, and gases. Welding is best done outside or in open areas with moderate air movement. Air movement is necessary to dissipate fumes before they reach the welder. Enclosed areas with little ventilation can lead to very high exposure levels because the contaminant is not dispersed. In confined spaces, fume, vapour, and gas levels that are dangerous to life and health may result. Welding may also use up the oxygen in a confined space, causing the welder to lose unconsciousness or even die.



The **base metal** to be welded is an important factor in the production of fumes, vapours, and gases. The base metal will vaporize and contribute to the fume.

**Coatings** such as rust inhibitors have been known to cause increased fume levels which may contain toxic metals. All paints and coatings should be removed from areas to be welded as they can contribute to the amount and toxicity of the welding fume.

**Welding rod** is responsible for up to 95% of the fume. Rods with the fewest toxic substances can't always be used because the chemistry of the rod must closely match that of the base metal.

**Shielding gas** used during SMAW can effect the contaminants produced. Using a mixture of argon and carbon dioxide instead of straight carbon dioxide has been found to reduce fume generation by up to 25%. Nitric oxide in the shielding gas for aluminum during GMAW has been found to reduce ozone levels.

**Welding process variables** can have a big effect on the fume levels produced. Generally, fume concentrations increase with higher current, larger rods, and longer arc length. Arc length should be kept as short as possible while still producing good welds. Polarity is also a factor. Welding with reverse polarity (workpiece negative) will result in higher fumes than welding with straight polarity (workpiece positive).

The welder's **posture and technique** are crucial factors in influencing exposure. Studies have shown that different welders performing the exact same task can have radically different exposures. Welders who bend over close to the welding location, those who position themselves in the smoke fume, and those who use a longer arc than required will have a much greater exposure. The welder should try to take advantage of existing ventilation (cross drafts, natural, or mechanical) to direct the fume away from the breathing zone.

## Ventilation

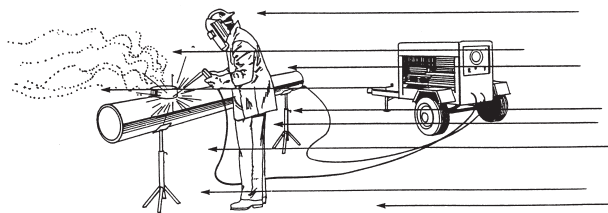
Ventilation is required for all cutting, welding, and brazing. Adequate ventilation is defined as the use of air movement to

- Reduce concentrations of airborne contaminants below the acceptable limits in the worker's breathing zone and the work area
- Prevent the accumulation of combustible gases and vapours, and
- Prevent oxygen-deficient or oxygen-enriched atmospheres.

You need to take special steps to provide ventilation in the following locations.

- Spaces with less than 283 cubic metres per welder
- Rooms with a ceiling lower than 4.9 metres
- Confined spaces or where the area contains partitions or other structures that significantly obstruct cross-ventilation.

**Natural dilution ventilation** — The majority of construction projects depend on natural dilution ventilation (i.e., welding outside in a light breeze or inside with doors and windows open). When using natural dilution ventilation, you must make sure to "keep your head out of the fume" (Figure 41-6).

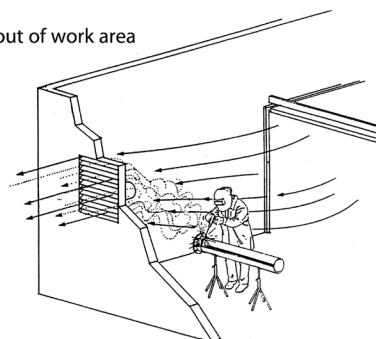


NOTE: Welder must stay to one side of fume.

**Figure 41-6: Natural Dilution Ventilation**

**Mechanical dilution ventilation** is common in most welding shops. Fans such as roof exhaust fans and wall fans force outside air into and out of the building. General mechanical ventilation in most cases will deflect the fume out of the welder's breathing zone (Figure 41-7). Welders need different amounts of fresh-air ventilation depending on the specific task and the size of rod they're using. For air volume recommendations, see the American Conference of Governmental Industrial Hygienists' *Industrial Ventilation: A Manual of Recommended Practice*.

- Air forced into and out of work area
- Roof exhaust fans
- Wall fans



NOTE: Air volume should deflect fume out of welders breathing zone.

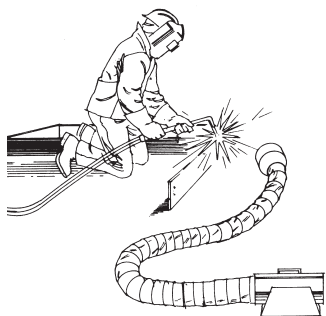
**Figure 41-7: Mechanical Dilution Ventilation**

**Local exhaust ventilation** consists of an exhaust fan, air cleaner, and ducted system dedicated to removing airborne contaminants at the source and exhausting them outdoors. Local exhaust ventilation is preferred over dilution ventilation because it is better able to prevent airborne contaminants from entering the welder's breathing zone.

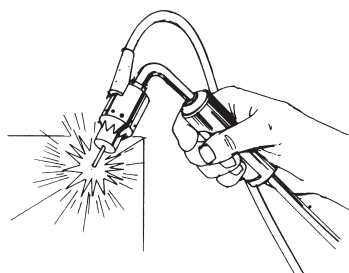
Local exhaust ventilation is recommended for welding where toxic airborne contaminants are produced and/or where a high rate of fume is produced—for instance, during GMAW in confined areas with little ventilation where the shielding gases can build up to toxic levels.

There are three types of local exhaust ventilation systems for welding:

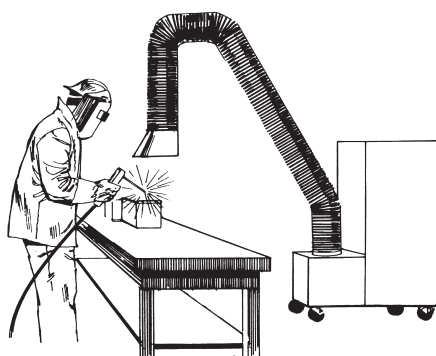
- 1) Portable fume extractor with flexible ducting (Figure 41-8)
- 2) Fume extraction gun (Figure 41-9)
- 3) Welding bench with portable or fixed hood (Figure 41-10).



**Figure 41-8: Portable Fume Extractor**



**Figure 41-9: Fume Extraction Gun**



**Figure 41-10: Bench with Portable Hood**

The effectiveness of local exhaust ventilation depends on the distance of the hood from the source, air velocity and volume, and hood placement. Hoods should be located close to the source of airborne contaminants. The hood is placed above and to the side of the arc to capture airborne contaminants.

**Warning:** In all processes that use shielding gas, air velocities in excess of 30 metres/minute may strip away shielding gas.

## Ventilation Requirements

There are two methods for determining ventilation requirements. One uses air sampling to measure the welder's exposure to airborne contaminants and to determine the effectiveness of the ventilation provided. Monitoring is not well suited to construction because site conditions are constantly changing.

The other method uses tables to select the type of ventilation according to the process, materials, production level, and degree of confinement used in the welding operation.

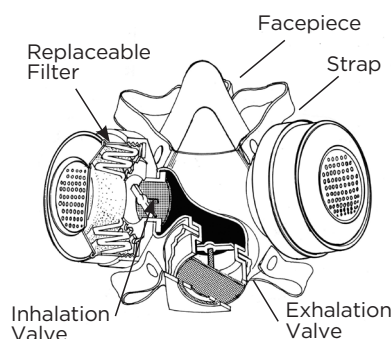
Ventilation guidelines for different welding processes are spelled out in Canadian Standards Association standard CAN/CSA W117.2-12: *Safety in Welding, Cutting and Allied Processes*, © CSA.

## Other Controls

An isolation chamber is a metal box with built-in sleeves and gloves. The work is welded inside the box and viewed through a window. This method is used to weld metals that produce extremely toxic fumes. The fumes are extracted from the isolation chamber and ducted outdoors.

**Respiratory protection** will not be required for most welding operations if adequate ventilation is provided. However, when ventilation or other measures are not adequate, or when the welding process creates toxic fumes (as with stainless steel and beryllium), respiratory protection must be worn.

Select respiratory protection based on estimated exposure and the toxicity of the materials. Disposable fume respirators are adequate for low fume levels and relatively non-toxic fumes. For higher exposures or for work involving toxic fumes, a half-mask respirator with cartridges suitable for welding fume should be used (Figure 41-11).



**Figure 41-11: Half-Mask Respirator**

In areas where fume or gas concentrations may be immediately dangerous to life and health, a self-contained breathing apparatus (SCBA) or a supplied-air respirator with a reserve cylinder should be used. Use only supplied air or self-contained respirators in areas where gases may build up or where there can be a reduction in oxygen.

A welder required to wear a respirator must be instructed in its proper fitting, use, and maintenance. For more information, refer to Chapter 15: Respiratory Protection in this manual.

## Fire Prevention

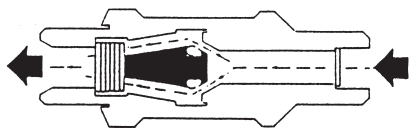
Sparks and slag from cutting, grinding, and welding can travel great distances and disappear through cracks in walls and floors or into ducts. They may contact flammable materials or electrical equipment. Fires have started in smoldering materials that went undetected for several hours after work was done.

Take the following steps to prevent fires and explosions.

- Obtain a hot work permit through the safety officer if required.
- Keep welding area free of flammable and explosive material.
- Use a flammable gas and oxygen detector to determine whether a hazardous atmosphere exists.
- Provide fire barriers such as metal sheets or fire blankets and fill cracks or crevices in floors to prevent sparks and slag from passing through.
- Provide fire extinguishers suitable for potential types of fire. Know where the extinguishers are and how to use them.
- Provide a firewatch where necessary—a worker to watch for fires as the welder works and for at least thirty minutes afterward. The person must be fully trained in the location of fire alarms and the use of fire-fighting equipment. Some situations may require more than one firewatch, such as on both sides of a wall or on more than one floor.

Cutting torches should be equipped with reverse flow check valves and flame arrestors to prevent flashback and explosion (Figure 41-12). These valves must be installed according to the manufacturer's instructions.

Normal Flow Condition Check Valve



Reverse Flow Condition Check Valve

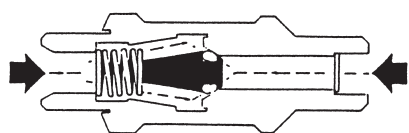


Figure 41-12: Reverse Flow Check Valves

Drums, tanks, and closed containers that have held flammable or combustible materials should be thoroughly cleaned before welding or cutting. As an added precaution, purge with an inert gas such as nitrogen or carbon dioxide and fill with water to within an inch or two of the place to be welded or cut and vent to atmosphere (Figure 41-13).

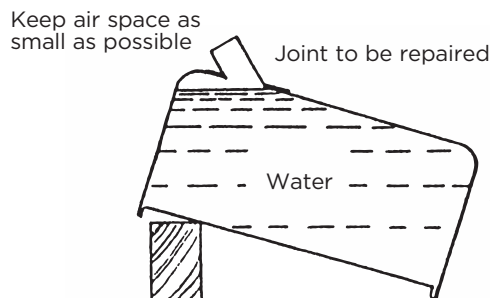


Figure 41-13: Fill Tanks that Previously Contained Flammable Material with Water

Many containers that have held flammable or combustible materials present special problems. Consult the manufacturer or the product SDS for detailed information.

## Arc Welding and Cutting

### Equipment

Use only manual electrode holders that are specifically designed for arc welding and cutting and can safely handle the maximum-rated current capacity required by the electrodes.

Any current-carrying parts passing through the portion of the holder in the welder or cutter's hand, and the outer surfaces of the jaws of the holder, should be fully insulated against the maximum voltage encountered to ground.

Arc welding and cutting cables should be completely insulated, flexible, and capable of handling the maximum current requirements of the work as well as the duty cycle under which the welder or cutter is working.

Avoid repairing or splicing cable within 10 feet of the cable end to which the electrode holder is connected. If necessary, use standard insulated connectors or splices which have the same insulating qualities as the cable being used.

Connections made with cable lugs must be securely fastened together to give good electrical contact. The exposed parts of the lugs must be completely insulated. Do not use cables with cracked or damaged insulation, or exposed conductors or end connectors.

A welding cable should have a safe current carrying capacity equal to or exceeding the maximum capacity of the welding or cutting machine.

The work lead, often incorrectly referred to as the ground lead, should be connected as close as possible to the location being welded to ensure that the current returns directly to the source through the work lead.

**WARNING:** Never use the following as part of the current path:

- Cranes or hoists
- Chains or wire ropes
- Elevator structures
- Pipelines containing gases or flammable liquids
- Conduits containing electrical circuits.

A structure employed as a work lead must have suitable electrical contact at all joints. Inspect the structure periodically to ensure that it is still safe. Never use any structure as a circuit when it generates arc, sparks, or heat at any point.

The frames on all arc welding and cutting machines must be grounded according to the CSA standard or the regulatory authority. Inspect all ground connections to ensure that they are mechanically sound and electrically adequate for the required current.

### Procedures

- When electrode holders are to be left unattended, remove electrode and place holder so it will not make contact with other workers or conducting objects.
- Never change electrodes with bare hands or with wet gloves.
- Do not dip hot electrode holders in water to cool them off.
- Keep cables dry and free of grease to prevent premature breakdown of insulation.
- Cables that must be laid on the floor or ground should be protected from damage and entanglement.
- Keep welding cables away from power supply cables and high tension wires.
- Never coil or loop welding cables around any part of your body.
- Do not weld with cables that are coiled up or on spools. Unwind and lay cables out when in use.
- Before moving an arc welding or cutting machine, or when leaving machine unattended, turn the power supply OFF.
- Report any faulty or defective equipment to your supervisor.
- Read and follow the equipment manufacturer's instructions carefully.
- Prevent shock by using well-insulated electrode holders and cables, dry clothing and gloves, rubber-soled safety boots, and insulating material (such as a board) if working on metal.
- All arc welding and cutting operations should be shielded by non-combustible or flame-proof screens to protect other workers from direct rays of the arc.
- Shut off the power supply before connecting the welding machine to the building's electrical power.
- Keep chlorinated solvents shielded from the exposed arc or at least 60 m (200 ft) away. Surfaces prepared with chlorinated solvents must be thoroughly dry before being welded. This is especially important when using gas-shielded metal-arc welding, since it produces high levels of ultraviolet radiation.
- Check for the flammability and toxicity of any preservative coating before welding, cutting, or heating. Highly flammable coatings should be stripped from the area to be welded. In enclosed spaces, toxic preservative coatings should be stripped several inches back from the area of heat application or the welder should be protected by an airline respirator. In the open air, a suitable cartridge respirator should be used. Generally, with any preservative coating, check the manufacturer's SDS for specific details regarding toxicity and personal protection required.

## Oxyacetylene Welding and Cutting

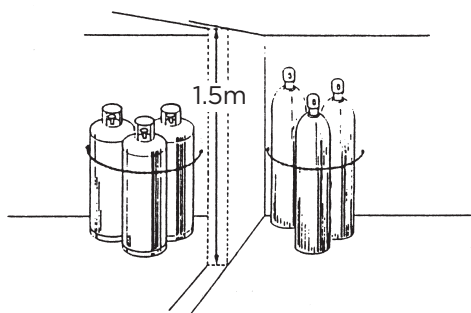
### Handling Cylinders

- Do not accept or use any compressed gas cylinder which does not have proper identification of its contents.
- Transport cylinders securely on a hand truck whenever possible. Never drag them.
- Protect cylinders and any related piping and fittings against damage.
- Do not use slings or magnets for hoisting cylinders. Use a suitable cradle or platform.
- Never drop cylinders or let them strike each other violently.
- Chalk EMPTY or MT on cylinders that are empty. Close valves and replace protective caps.
- Secure transported cylinders to prevent movement or upset.
- Always regard cylinders as full and handle accordingly.
- For answers about handling procedures, consult the manufacturer, supplier, or the SDS.

### Storing Cylinders

- Store cylinders upright in a safe, dry, well-ventilated location maintained specifically for this purpose.
- Never store flammable and combustible materials such as oil and gasoline in the same area.
- Do not store cylinders near elevators, walkways, stairwells, exits, or in places where they may be damaged or knocked over.
- Do not store oxygen cylinders within 6 m (20 ft) of cylinders containing flammable gases unless they are separated by a partition at least 1.5 m (5 ft) high and having a fire-resistance rating of at least 30 minutes (Figure 41-14).
- Store empty and full cylinders separately.
- Prohibit smoking in the storage area.

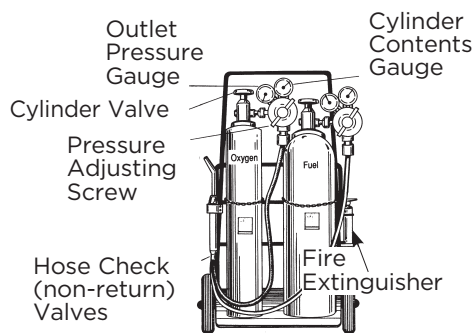




**Figure 41-14: Keep Oxygen and Gas Cylinders Separated**

## Using Cylinders

- Use oxygen and acetylene cylinders in a proper buggy equipped with a fire extinguisher (Figure 41-15). Secure cylinders upright.
- Keep the cylinder valve cap in place when the cylinder is not in use.
- Do not force connections on cylinder threads that do not fit.
- Open cylinder valves slowly. Only use the handwheel, spindle key, or special wrench provided by the supplier.
- Always use a pressure-reducing regulator with compressed gases. For more information, see the box below.
- Before connecting a regulator to a cylinder, crack the cylinder valve slightly to remove any debris or dust that may be lodged in the opening. Stand to one side of the opening and make sure the opening is not pointed toward anyone else, other welding operations, or sparks or open flame.
- Open the fuel gas cylinder valve not more than  $1\frac{1}{2}$  turns unless marked back-seated.
- Do not use acetylene pressure greater than 15 psig.
- Never allow sparks, molten metal, electric current, or excessive heat to come in contact with cylinders.
- Never bring cylinders into unventilated rooms or enclosed areas.
- Never use oil or grease as a lubricant on the valves or attachments of oxygen cylinders. Do not handle with oily hands, gloves, or clothing. The combination of oxygen and oil or grease can be highly combustible.
- Do not use oxygen in place of compressed air for pneumatic tools.
- Release pressure from the regulator before removing it from the cylinder valve.
- When gas runs out, extinguish the flame and connect the hose to the new cylinder. Purge the line before re-igniting the torch.
- When work is finished, purge regulators, then turn them off. Use a proper handle or wrench to turn off cylinders.



**Figure 41-15: Buggy Equipped with a Fire Extinguisher**

## Pressure Regulators

Pressure regulators must be used on both oxygen and fuel gas cylinders to maintain a uniform and controlled supply of gas to the torch. The oxygen regulator should be designed with a safety relief valve so that, should the diaphragm rupture, pressure from the cylinder will be released safely and the regulator will not explode.

Each regulator (both oxygen and fuel gas) should be equipped with a high-pressure contents gauge and working pressure gauge. Always stand to one side of regulator gauge faces when opening the cylinder valves.

To prevent regulators from being installed on the wrong cylinders, oxygen cylinders and regulators have *right-hand* threads while most fuel gas cylinders and regulators have *left-hand* threads. Internal and external threads and different diameters also help to prevent wrong connections.

**Hoses and hose connections** for oxygen and acetylene should be different colours. Red is generally used to identify the fuel gas and green the oxygen. The acetylene union nut has a groove cut around the centre to indicate left-hand thread.

- Protect hoses from traffic, flying sparks, slag, and other damage. Avoid kinks and tangles.
- Repair leaks properly and immediately. Test for leaks by immersing hose in water.
- Use backflow check valves and flame arrestors according to the manufacturer's instructions. (See Figure 41-12.)
- Do not use a hose that has been subject to flashback or that shows evidence of wear or damage without proper and thorough testing.

**Backfires** occur when the flame burns back into the torch tip, usually accompanied by a loud popping sound. Backfires are usually caused by touching the tip against the work or by using pressures that are too low.

**Flashback** is much more serious. The flame burns back inside the torch itself with a squealing or hissing sound. If this happens, follow the torch manufacturer's instructions to extinguish the torch in proper sequence.

## Oxyacetylene Summary

### Startup

- Keep cylinders away from sources of heat or damage and secure them upright.
- Stand to one side and slightly crack cylinder valves to blow out dust.
- Attach regulators to respective cylinders. Tighten nuts with a proper wrench.
- Release pressure adjusting screws on regulators.
- Connect green hose to oxygen regulator and red hose to fuel gas regulator.
- Connect hoses to the torch—green to oxygen inlet and red to fuel gas inlet.
- Connect mixer and welding tip assembly to torch handle.
- Open oxygen cylinder valve slowly and fully.
- Open fuel gas cylinder 3/4 to 1 1/2 turns.
- Open oxygen torch valve. Turn oxygen regulator pressure adjusting screw to desired pressure. Continue oxygen purge for about 10 seconds for each 100 feet of hose. Close oxygen torch valve.
- Open fuel gas torch valve. Turn fuel gas regulator pressure adjusting screw to desired pressure and purge for about 10 seconds for each 100 feet of hose. Close fuel gas torch valve.
- To light torch, follow the manufacturer's instructions. DO NOT USE MATCHES.
- Adjust to desired flame.

### Closedown

- Close torch valves according to the manufacturer's instructions.
- Close fuel gas cylinder valve.
- Close oxygen cylinder valve.
- Drain fuel gas cylinder line by opening torch fuel gas valve briefly. Close valve. Drain oxygen line in the same way.
- Re-open both torch valves.
- Release pressure adjusting screws on both regulators.

Regulators and torches can now be disconnected.

Many different makes, models, and designs of torches are available. There is no single procedure or sequence to follow in igniting, adjusting, and extinguishing the torch flame. Always follow the manufacturer's instructions.

## Silver Solder Brazing

Silver solder brazing is used for joining metals and steel and dissimilar metal combinations where it is necessary to perform the joining of these metals at low temperatures. Applications include medical and laboratory systems, refrigeration, aerospace, and electronic equipment. In brazing, the major hazards are heat, chemicals, and fumes.

Fumes generated during brazing can be a serious hazard. Brazing fluxes generate fluoride fumes when heated. Cadmium in silver brazing alloys vaporizes when overheated and produces cadmium oxide, a highly toxic substance. Cadmium oxide fumes inhaled into the respiratory tract can cause pulmonary distress, shortness of breath, and in cases of severe exposure may cause death.

The most serious cause of cadmium oxide fumes is overheating the silver brazing filler metal. Care must be taken to control the temperature of the silver brazing operation. The torch flame should never be applied directly to the silver brazing filler rod. The heat of the base metal should be used to melt and flow the brazing filler metal.

Cadmium-plated parts can be an even more hazardous source of cadmium fumes, since in brazing these parts the torch flame is applied directly to the base metal. Cadmium plating should be removed before heating or brazing. When in doubt about a base metal, check with the supplier of the part.

### Safe Silver Solder Brazing

- Do not heat or braze on cadmium-plated parts.
- Read warning labels on filler metals and fluxes and follow instructions carefully.
- Work in a well-ventilated area or use a supplied-air respirator.
- Apply heat directly to the base metal—not to the brazing filler metal.
- Do not overheat either the base metal or the brazing filler metal.
- Wash hands thoroughly after handling brazing fluxes and filler metals.

## Confined Spaces

Welding in enclosed or confined areas creates additional hazards for the welder. The employer must have a written rescue procedure for confined spaces.

In addition to the procedures outlined in the chapter on confined spaces in this manual, take the following precautions.

- Inspect all electrical cables and connections that will be taken into the confined space.
- Perform leak tests on gas hoses and connections to eliminate the risk of introducing gases into the confined space.
- Check for live electrical systems and exposed conductors.
- Use inspection ports, dipsticks, or a knowledgeable person to evaluate hazards from any liquids, solids, sludge, or scale left in the space.
- Ventilate space with clean air before entry and maintain ventilation as long as necessary to prevent the accumulation of hazardous gases, fumes, and vapours.

- Different gases have different weights and may accumulate at floor, ceiling, or in between. Air monitoring should be done throughout the confined space.
- Isolate the space from any hydraulic, pneumatic, electrical, and steam systems which may introduce hazards into the confined area. Use isolation methods such as blanks, blinds, bleeding, chains, locks, and blocking of stored energy. Tag isolated equipment.
- A competent person must test and evaluate the atmosphere before workers enter a confined space, and at all times during work there. A hazardous atmosphere may already exist or gases and vapours may accumulate from cutting or welding. Oxygen content may become enriched or depleted.
- Keep compressed gas cylinders and welding power sources outside the confined space.
- Where practical, ignite and adjust flame for oxy-fuel applications outside the space, then pass the torch inside. Similarly, pass the torch outside the space, then extinguish it.
- When leaving a confined space, remove the torch and hoses and shut off gas supply.
- If adequate ventilation cannot be maintained, use a suitable supplied-air respirator.

It is the responsibility of the employer to have a written **emergency rescue plan** and communicate the plan to all involved. Each person should know what to do to and how to do it quickly. (See Chapter 33: Confined Spaces in this manual.)

## Personal Protective Equipment

In addition to the protective equipment required for all construction workers (see chapters on personal protective equipment in this manual), welders should wear flame-proof gauntlet gloves, aprons, leggings, shoulder and arm covers, skull caps, and ear protection.

Clothing should be made of non-synthetic materials such as wool. Woollen clothing is preferable to cotton because it is less likely to ignite. Keep sleeves rolled down and collars buttoned up. Wear shirts with flaps over pockets and pants with no cuffs. Remove rings, watches, and other jewelry. Never carry matches or lighters in pockets. Clothing should be free from oil and grease. Wear high-cut CSA grade 1 footwear laced to the top to keep out sparks and slag.

Protective screens or barriers should be erected to protect people from arc flash, radiation, or spatter. Barriers should be non-reflective and allow air circulation at floor and ceiling levels. Where barriers are not feasible or effective, workers near the welding area should wear proper eye protection and any other equipment required. Signs should be posted to warn others of welding hazards.

## Eye and Face Protection

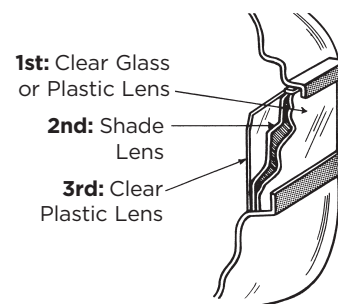
Welding helmets provide radiation, thermal, electrical, and impact protection for face, neck, forehead, ears, and eyes. Two types are available—the stationary plate helmet and the lift-front or flip-up plate helmet. There are also auto-darkening helmets that have a single pane of self-darkening glass in the visor.

The lift-front type should have a fixed impact-resistant safety lens or plate on the inside of the frame next to the eyes to protect the welder against flying particles when the front is lifted. All combination lenses should have a clear impact-resistant safety lens or plate next to the eyes.

There are also special models incorporating earmuff sound arrestors and air purification systems. Special prescription lens plates manufactured to fixed powers are available for workers requiring corrective lenses.

The typical lens assembly for arc welding is shown in Figure 41-16. The filtered or shaded plate is the radiation barrier. It is necessary to use a filter plate of the proper lens shade to act as a barrier to the harmful light rays and to reduce them to a safe intensity. Guidelines for selection are in Table 41-1.

The arc welding lens assembly consists of 3 parts. The outside lens is clear plastic or tempered glass. It protects the shade lens from damage. The centre lens is a shade lens that filters out the harmful light. The inner lens is clear and must be plastic.



**Figure 41-16: Typical Lens Assembly for Arc Welding**

In addition to common green filters, many special filters are available. Some improve visibility by reducing yellow or red flare. Others make the colour judgment of temperature easier. Some have a special gold coating on the filter lens to provide additional protection by reflecting radiation.

Welding hand shields are designed to provide radiation and impact protection for the eyes and face. They are similar to welding helmets except that there are no lift-front models.

Spectacles with full side shields designed to protect against UV radiation and flying objects and suitable filter lenses should always be worn in conjunction with full welding helmets or welding hand shields.

Where only moderate reduction of visible light is required (for instance, gas welding) use eyecup or cover goggles with filter lenses for radiation protection. Goggles should have vents to minimize fogging and baffles to prevent leakage of radiation into the eye cup.

Welders should not wear contact lenses because airborne dust and dirt may cause excessive irritation of the eyes under the lenses.

**Table 41-1: Lens Shade Selection Guide for Welding**

Process	Electrode Size mm (in)	Arc Current (Amperes)	Minimum Protective Shade	Suggested* Shade No. (Comfort)
<b>Shielded Metal Arc Welding (SMAW)</b>	less than 2.4 (3/32)	less than 60	7	–
	2.4-4 (3/32-5/32)	60-160	8	10
	4-6.4 (5/32-1/4)	160-250	10	12
	more than 6.4 (1/4)	250-550	11	14
<b>Gas Metal Arc Welding and Flux Cored (GMAW)</b>		less than 60	7	–
		60-160	10	11
		160-250	10	12
		250-550	10	14
<b>Gas Tungsten Arc Welding (GTAW)</b>		less than 50	8	10
		50-150	8	12
		150-500	10	14
<b>Air Carbon (light) Arc Cutting (heavy)</b>		less than 500	10	12
		500-1,000	11	14
<b>Plasma Arc Welding (PAW)</b>		less than 20	6	6 to 8
		20-100	8	10
		100-400	10	12
		400-800	11	14
<b>Plasma Arc Cutting (PAC)</b>		less than 20	4	4
		20-40	5	5
		40-60	6	6
		60-80	8	8
		80-300	8	9
		300-400	9	12
		400-800	10	14
<b>Torch Brazing (TB)</b>		–	–	3 or 4
<b>Torch Soldering (TS)</b>		–	–	2
<b>Carbon Arc Welding (CAW)</b>	–	–	–	14
<b>Plate Thickness</b>				
	<b>mm</b>	<b>in.</b>		
<b>Oxy-fuel Gas Welding (OFW)</b>				
Light	under 3	under 1/8		4 or 5
Medium	3 to 13	1/8 to 1/2		5 or 6
Heavy	over 13	over 1/2		6 to 8
<b>Oxygen Cutting (OC)</b>				
Light	under 25	under 1		3 or 4
Medium	25 to 150	1 to 6		4 or 5
Heavy	over 150	over 6		5 or 6

Source: ANSI Z49.1: 2012—Safety in Welding, Cutting, and Allied Processes

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**NOTE:** Shade numbers are given as a guide only and may be varied to suit individual needs.

\*As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade which gives sufficient view of the weld zone without going below the minimum. In oxy-fuel gas welding, cutting, or brazing where the torch and/or the flux produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line of the visible light spectrum.

## Hearing Protection

The employer is responsible for assessing the risk of hearing loss from exposure to noise and developing a plan to control or eliminate that risk. If hearing protection devices (HPDs) are considered appropriate, earplugs may be a better choice for welders than earmuffs, which can be cumbersome and interfere with the welding helmet. Training on the selection, use, and care of HPDs must be provided. See Chapter 14: Hearing Protection in this manual.

Welders should have their hearing checked every year or so. A simple test can be arranged through your doctor. Once hearing is damaged, the loss is likely permanent. Checkups can detect any early losses and help you to save your remaining hearing.

## Radiographic and X-Ray Testing

Some construction trades will encounter situations in which welds, metals, or special coatings require onsite non-destructive testing.

Methods include

**1) radiography** using a radioactive source for general materials

**2) x-rays** for testing thicker sections.

Radiography is federally regulated across Canada by the Atomic Energy Control Board. Users must be licensed and operators must be trained according to a Canadian Government Standards Board (CGSB) program.

X-ray testing is provincially regulated—in Ontario by Regulation 861/90. While many requirements apply to licensed users in both situations, this section will only cover the basic health and safety guidelines for field use.

## Radiographic Testing

Licensed users of radiographic testing systems are responsible for general safety in the field, transportation, emergency procedures, and record-keeping.

Radiographic testing must be carried out in the presence of persons certified to CGSB Standard 48GP4a. In general, these people are employees of a recognized testing agency.

Radiographic materials and equipment must be kept locked up in shielded storage containers accessible only to certified personnel. The containers must be conspicuously marked and kept in an area not normally occupied by the workforce. There may be other special requirements which apply, depending on the strength of the radioactive source and the location.

Radiographic cameras in the field must be used in conjunction with pocket dosimeters, survey meters, directional shields, barrier ropes, radiographic warning signs, and an emergency source container.



## General Safety Precautions

- Radiographic testing should be conducted, whenever possible, on an off-shift with as few workers as possible in the work area. The radiographic source should be no stronger than is required for the job. Determining the strength of the source is not generally the responsibility of construction site personnel.
- Equipment should be checked before use. The regulation includes a list of items to be checked, but doing so is not usually the responsibility of site personnel.
- After taking tests where the camera will be moved, the area should be checked using a survey meter.
- Licensed users are required to keep records regarding the use of sources, including dates, times, locations, and other details. These records must be made available to inspectors from the Atomic Energy Control Board. Users are also responsible for advising the local fire department when radioactive material will be in a municipality for longer than 24 hours.

Specific requirements for radiographic camera users are the responsibility of the certified persons operating the equipment.

- The survey meter must be checked to ensure that it is working and calibrated properly.
- Barrier ropes should be set up around the area where testing will be carried out unless this area is isolated and access can be controlled. Barriers must be set up according to the strength of the source.
- Warning signs must be posted along the barriers.
- A patrol must be provided to ensure that no unauthorized persons enter the testing area.
- Before the camera shutter is opened and testing is conducted, the area must be properly shielded.
- Personnel working within the testing area should carry personal dosimeters. Dosimeters may also be advisable for workers in the immediate vicinity outside the barriers.

## X-Ray Testing

The following health and safety precautions are required for the x-ray testing of welds and metals:

- A suitable means to prevent unauthorized persons from activating the equipment
- A device to indicate when the x-ray tube is energized.
- Housing that adequately shields the equipment operator.

Employers using x-ray equipment must advise the MOL that they have such equipment. They must also designate certain persons to be in charge of the x-ray equipment who are trained and competent to do so. They must give the MOL the names of these designated persons.

Measures and procedures at the x-ray testing site are similar to those required for radiographic testing. The following are the employer's responsibilities.

- Test during off-shifts.
- Cordon off the test area if it cannot be isolated or if entry cannot be controlled.
- Post warning signs along the barrier or at the entrance to the room where testing is taking place.
- Have a patrol to prevent unauthorized entry.
- Install shielding as required before any equipment is activated.
- Ensure that employees in the controlled area wear personal dosimeters.
- Keep dosimeter records.
- Keep at least one radiation survey meter of a suitable type with each portable x-ray machine and calibrate it at least once each year.

## Training

Welders, fitters, and welding supervisors should be trained in both the technical and safety aspects of their work. Health and safety training should include but not be limited to the following.

- Hazard identification
- Safe welding, brazing, and cutting practices
- Fire and safety precautions
- Control methods for welding hazards
- Use, maintenance, and limitations of personal protective equipment.

The effectiveness of health and safety training should be periodically evaluated through the following:

- A workplace inspection to ensure that safe working procedures, equipment, and conditions are implemented
- Air monitoring of common contaminants to determine the effectiveness of controls and compliance with acceptable limits
- An assessment of control performance (for instance, testing of the ventilation system)
- Review of lost-time-injuries
- Discussion of the program with the health and safety committee or representative(s).

Any corrective actions necessary should be taken immediately.

## WELDING ON CONTAINERS

Produced by:  
Industrial Health and Safety Program,  
Ontario Ministry of Labour  
Alert #I12/0395  
ISSN 1195-5228

## HAZARD SUMMARY:

In two recent incidents, explosions during welding on fuel tanks killed three workers. In the first, two workers welding a 150-gallon diesel fuel tank were fatally injured. In the second, a 500-gallon gasoline tank exploded during welding, killing a worker. These accidents would not have happened if proper cleaning, purging and testing procedures had been followed.

After the first incident, it was discovered that the diesel fuel in the tank was contaminated with gasoline. As little as two per cent of gasoline in diesel fuel can create an explosive mixture in a closed container, with the flashpoint (the temperature at which a spark or other ignition source will cause an explosion) falling below the temperature inside the container.

## REQUIRED PRECAUTIONS:

For any hot work such as welding or cutting on a container that may have contained flammable or combustible material, the following minimum precautions must be taken:

- The container's internal layout must be determined to make sure that fittings such as baffles will not interfere with cleaning or purging.
- The container must be drained and cleaned using appropriate methods.
- To determine whether draining and cleaning has made the container safe, its interior must be tested with a combustible gas detector both before hot work begins and periodically during the work.

However, some containers cannot be drained and cleaned well enough to make them safe. Such containers may be made safe by purging and inerting with an inert gas, but only if these precautions are taken:

- Recognized procedures and proper equipment must be used.
- The oxygen level inside the container must be monitored with an oxygen analyser and maintained at essentially zero for the duration of the work.
- Workers must be made aware of the limitations of the inerting process.

NEVER ASSUME A CONTAINER IS CLEAN OR SAFE. MAKE SURE THAT IT IS MADE SAFE AND THAT ITS SAFETY IS VERIFIED BY TESTING BEFORE ANY HOT WORK BEGINS. NOT FOLLOWING THIS RULE IS LIKELY TO KILL YOU.

The Regulations for Industrial Establishments (R.R.O 1990, Reg. 851, s.78) require that where repairs or alterations are to be made on a drum, tank, pipeline or other container, it must be

drained and cleaned or otherwise made free from any explosive, flammable or harmful substance.

See Engineering Data Sheet 4-14, "Welding and Other Hot Work on Containers" for more information (follows). For assistance, contact your nearest Ministry of Labour office.

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ENGINEERING DATA SHEET 4-14  
WELDING AND OTHER HOT WORK ON CONTAINERS

## 1. INTRODUCTION

Hot work on containers, including welding, grinding and cutting, is one of the most dangerous operations in industry.

Containers that have or may have contained a fuel or any other flammable, combustible or high-flashpoint material are potentially lethal, as are containers that may have an interior coating that becomes hazardous when heated. Hydrogen gas generated by interior corrosion and explosive dusts (for example, sugar, starch and coal dusts) may also create hazardous situations. In these cases, all that is needed to cause a container to explode is the wrong combination of temperature and oxygen, and an ignition source.

Many explosions and several recent fatalities have been caused by the use of inappropriate procedures in cleaning, purging and testing containers in preparation for hot work.

Workers have to be made aware that hot work on a container is being performed on what is essentially an unexploded bomb and that they must treat the process with suitable respect.

The basic rule that must be obeyed before performing hot work on a container is:

NEVER ASSUME THAT A CONTAINER IS CLEAN OR SAFE. MAKE SURE THAT IT IS MADE SAFE, AND THAT THIS IS VERIFIED BY TESTING.

## 2. LEGISLATION

The Regulations for Industrial Establishments (R.R.O. 851/90, made under the Occupational Health and Safety Act) address repairs on containers that have contained flammable, explosive or harmful substances. The regulations state (s. 78):

". . . where repairs or alterations are to be made on a drum, tank, pipeline or other container, the drum, tank, pipeline or other container shall,

- a) have internal pressures adjusted to atmospheric before any fastening is removed;
- b) be drained and cleaned or otherwise rendered free from any explosive, flammable or harmful substance; and
- c) not be refilled while there is any risk of vaporising or igniting the substance that is being placed in the

drum, tank, pipeline or other container.

The Ontario Fire Code also addresses welding on containers (5.17.3.3 (1)):

"Welding or cutting of metal containers shall not be undertaken until the containers and compartments within such containers have been cleaned of flammable and combustible materials and checked with an explosion meter."

### 3. CODES AND STANDARDS

A number of universally accepted codes, standards and guidelines address the hazards of hot work, including welding and cutting, on containers that have contained hazardous substances. These publications explain in detail the safety procedures to be followed before such work is carried out. The following section is a brief summary of the information in the standards referenced in section 5. Since it is an outline only, workers intending to perform hot work should review all relevant standards in detail.

### 4. MAKING A CONTAINER SAFE FOR HOT WORK

Listed below are the steps that must be taken before any hot work is performed on a container that has held a flammable or combustible liquid.

Note that any testing carried out using a combustible gas detector, oxygen analyser or carbon monoxide analyser **MUST** be carried out by a person who has been thoroughly trained in the use of such instruments and who is aware of the requirements and limitations of such testing.

All containers that may require entry of workers for any purpose are considered to be confined spaces under the Occupational Health and Safety Act and Regulations, and all applicable requirements must be satisfied before entry. See Engineering Data Sheet 7-01 "Entry Into Tanks and Other Confined Spaces".

#### 4.1 IDENTIFY CONTENTS AND CONTAINER CONSTRUCTION

The contents of the container should be identified before any work is carried out. Remember, however, that the contents may have been contaminated (e.g. with gasoline in diesel fuel) and that container labels may be misleading or incorrect. If it is not absolutely clear what the contents are, it must be assumed that a potentially explosive material may be present, and the procedures outlined below must be followed.

It is also important to determine the internal configuration of the container and to identify any fittings (e.g., baffles or tubes) that may interfere with draining, cleaning or purging. Any areas inside the container that might trap explosive mixtures must be identified. All internal fittings should be removed where possible.

If there is any possibility that the container may have contained any flammable, combustible or high flashpoint material, or if the container may have an interior lining or coating, precautions as set out in 4.2 through 4.5 MUST be taken.

#### 4.2 DRAIN CONTENTS

The contents of the container must be drained completely, either by opening the drain connection or by other means if a drain connection is not available.

#### 4.3 CLEAN CONTAINER

The container must be cleaned using the appropriate method indicated in the referenced standards. Cleaning methods include: water displacement (for water soluble substances); hot chemicals, using an appropriate hot, strong caustic solution such as sodium triphosphate solution; low pressure steam in conjunction with hot soda ash solution; or a combination of the above methods. Before a chemical detergent is used, verify with the manufacturer that it is appropriate for the intended task.

#### 4.4 TEST ATMOSPHERE

The interior of the container must be tested with a properly calibrated combustible gas detector to make sure that the cleaning operation has made the container safe. (A combustible gas detector reads the percentage of the lower explosive limit of the vapours present in the container.) If the reading on the detector indicates that flammable vapours are present, i.e. if the needle moves, the cleaning operation must be repeated. The testing procedure must be carried out immediately before beginning hot work and periodically during it.

#### 4.5 INERT GAS PURGING

In some situations it may be impossible to remove all of the potentially hazardous liquid or liquids inside a container. Liquid residues may be trapped behind heavy scale or rust or between a vessel's liner and shell and so may not be easily detected. A second possibility is that a vessel may have an interior coating or lining that will produce flammable vapours when heated.

When examination after cleaning indicates that either of these conditions exists or may exist, other precautions must be taken before beginning hot work. These may include, as a minimum, maintaining an inert atmosphere inside the container with an inert gas.

Extreme care should be taken when using an inert gas such as carbon dioxide or nitrogen to purge a container and maintain a safe atmosphere inside it. The workers must be familiar with the limitations of the inerting method and the characteristics of the inert gas being used. The oxygen content inside the container must be

maintained at essentially zero, i.e. as close to zero as possible, during the entire period that the work is in progress.

Performing inert gas purging without thorough knowledge of the process or proper equipment is extremely hazardous. Inadequate knowledge or equipment is likely to create a false sense of security, leading to serious injury or death.

The steps to be followed in the inert gas purging procedure are as follows:

1. Close all container openings except fill and vent connections.
2. Introduce the inert gas into the container through a hose extending to near the bottom of the container. All metal parts of the filling equipment must be bonded to the container.
3. When inerting with carbon dioxide, low pressure must be used to avoid the generation of static electricity. Portable carbon dioxide extinguishers must never be used for inerting because they may discharge static electricity.
4. Maintain the flow of inerting gas throughout the hot work.
5. The contents of the container must be tested before beginning hot work and during it. Its oxygen content can be measured by an oxygen analyser. When carbon dioxide is used for inerting, oxygen can be measured indirectly with a carbon dioxide indicator. Each type of instrument must be suitable for its purpose. An oxygen analyser must be capable of reading zero per cent oxygen, and a carbon dioxide analyzer must be capable of reading 100 per cent carbon dioxide. The accuracy of the instrument to be used needs to be determined and taken into account.

The concentration of flammable vapours present in the container can be measured with a combustible gas detector. Note, however, that combustible gas detectors of the catalytic filament type may not give a true reading when the oxygen content of the atmosphere tested is less than about 10 per cent. Without special adaptation, detectors of this type cannot reliably determine whether the inerting process has been successful in eliminating any explosive mixture.

## 5. REFERENCES

- a) ANSI/AWS F4.1 Recommended Safe Practices for the Preparation for Welding and Cutting of Containers That Have Held Hazardous Substances.

- b) NFPA 51B            Standard for Fire Prevention in Use of  
Cutting and Welding Processes.
- c) NFPA 327           Standard Procedures for Cleaning or  
Safeguarding Small Tanks and Containers.
- d) IAPA                Welding on Containers or in Confined  
Spaces.
- e) CSA W117.2        Safety in Welding, Cutting and Allied  
Processes.
- f) NFPA                Fire Protection Handbook, 16th Edition.

Produced by:  
Professional and Specialized  
Services and the Occupational  
Health and Safety Branch,  
Ministry of Labour  
ISSN 1201-1444

## How to Fill-in the Hot Work Permit

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### Hot Work Fire Safety

Hot work is one of the leading causes of fires at industrial facilities according to the National Fire Protection Association.

Hot work operations involve some form of open flame, produce hot surfaces and/or generate sparks or molten material. This includes, but is not limited to, welding, cutting, soldering, brazing, grinding, torch-applied roofing, adhesive bonding, thermal spraying, thawing pipes and the use of non-explosion proof equipment or tools. These operations increase the potential for a fire at a facility.

This document provides guidelines for a systematic approach to control hot work fire hazards and reduce the fire potential associated with hot work. It also explains how to properly complete and utilize City's Hot Work Permit.

**City staff, contractors, and subcontractors require a valid, authorized Hot Work Permit for Hot Work.** The permit should be issued to those conducting the hot work only after the proper precautions are taken. The hot work permits should only be issued by qualified (trained) supervisor (or designated person) at the site.

**All workers performing tasks related to Hot Work must be trained** (e.g. permit authorizers, staff performing Hot Work, fire watch and/or fire monitoring duties), including on implementation and control of required precautions, how to escalate any problems identified, inspection of the Hot Work areas for fire-safe conditions, the emergency response, use of the fire protection equipment if expected to use it, and the proper use of the Hot Work Permit.

Permit Authorizers must be competent persons and have received the related training.

### Hot Work Permit

The first step in evaluating a hot work permit is to determine if the work is truly necessary.

Can the task be accomplished safely by other means (e.g. cold work methods)?

Can the work be moved to a designated purposefully built facility where a hot work permit is not required such as the maintenance shop/area?

NOTE:

Outdoor locations may also require a permit where combustible construction and combustible material (e.g. yard storage, etc.) are present.

**Hot Work is not allowed when the fire protection system (if present) is impaired.**



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**Permit Authorizer:** If the work cannot be done by other means, or at a Hot Work designated area, then the issuing supervisor (or designated person) should review the applicable safety precautions and verify their implementation before signing the permit.

**Date Permit Expires:**

The permit should be limited to a single shift. The date and time the permit expires should be documented on the form. If the work is not completed by the date on the form, a new permit should be issued.

**Page 1** of the Permit must be filled-in, signed and retained by the Permit Authorizer as an indicator of an open Hot Work Permit.

**Page 2** of the Permit must be issued to the person conducting the hot work and be displayed at the hot work area in a visible location, together with the Warning cover to alert that active Hot Work is occurring.

**Upon work completion,** the Permit Authorizer must review Page 2 including signed confirmation of post-work fire watch and fire monitoring, sign off the final check on Page 2 that the permit is closed out, and retain together with Page 1 for the records (minimum of 2 (two) years).

**Person performing hot work:** Sign Page 1. Record time started and display permit (Page 2) at hot work area. After hot work is completed, record time and leave permit displayed for fire watch. This provides a start time for the post-work fire watch.

**Fire watch:** Sign Page 1. Watch area during hot work and after work completion. Prior to leaving area, perform final inspection, sign Page 2, leave permit displayed and notify Fire Monitor or Permit Authorizer.

**Fire monitor:** Monitor area after post-work fire watch completion. Perform final inspection, sign Page 2 and return to Permit Authorizer.

**Fire Watch and Fire Monitoring**

The Permit Authorizer should review all the items in this section and check the applicable boxes.

Fire Watch is required continuously during the Hot Work and for 1 (one) hour immediately after the Hot Work ceases, to watch for fire development or hazardous conditions.

Fire Monitoring is required for an additional 3 hours: a trained person to intermittently tour at least once every hour (recommended every 15 minutes) the Hot Work area and all adjacent areas (including floors above and below), or by using other effective monitoring methods approved by the site Supervisor.

NOTE: More than 3 hours might be needed for combustible construction with unprotected concealed cavities.

The supervisor (or designated person) should review all items in these sections and check the applicable required precautions that have been taken, including:

- Standard operations, any temporary conditions, fire protection and hot work equipment
- Within 11 m (35 ft.) of task area(s), including work on walls or ceilings
- Work on/in Enclosed Equipment, Ductwork or Piping
- Fire watch and monitoring, and training