



Code of Practice

Safety and Health at Work for Gas Welding and Flame Cutting



CODE OF PRACTICE

**Safety and Health at Work
for**

Gas Welding and Flame Cutting



**Occupational Safety and Health Branch
Labour Department**

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Labour Department

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1 Introduction

1.1 Purpose

- 1.1.1 This Code of Practice (the “COP”) recommends safe practices in gas welding and flame cutting. It also describes the steps and measures to be taken in protecting workers from the hazards arising from the work, and in reducing injuries and damage caused by fire and explosion. The COP is intended to be read by proprietors, contractors, line management personnel, safety personnel and workers of industrial undertakings where work with gas welding or flame cutting is involved.
- 1.1.2 This COP is issued by the Commissioner for Labour under Section 7A(1) of the Factories and Industrial Undertakings Ordinance (Chapter 59) (“F&IUO”). It provides practical guidance to proprietors of industrial undertakings and to persons employed therein who are required to comply with the requirements set out in Section 6A and 6B of the F&IUO for the protection of the safety and health of persons at work. It is important to note that compliance with the COP does not of itself confer immunity from legal obligations in Hong Kong. The statutory provisions referred to or cited in the COP are those in force as at 19 June 2000.
- 1.1.3 This COP has a special legal status. Although failure to observe any guidance given in the COP is not itself an offence, such failure may be taken into account by a court in criminal proceedings in determining whether or not a person has breached the relevant safety and health provision under the F&IUO.

1.2 Scope and application

- 1.2.1 In this COP, gas welding and flame cutting refer to a welding or cutting operation with a flame produced by mixing a fuel gas and an oxidant gas in a blowpipe. The flame is hot enough to fuse the metal surfaces together for welding, whereas in the case of cutting, hot enough for the formation of molten oxides of the metal concerned.
- 1.2.2 This COP recommends safe practices in gas welding or flame cutting with the commonly used oxy-acetylene flame in which acetylene is the fuel gas and oxygen is the oxidant gas. The safe practices are also applicable to welding or cutting with flames using other fuel gases such as propane (commonly known as 'liquefied petroleum gas' or 'LPG') or hydrogen, or other oxidant gas such as compressed air.

1.3 Interpretation

- 1.3.1 For the purpose of this COP —

“Blowpipe” (吹管) means the burner device in which separate supplies of fuel gas and oxidant gas are mixed in appropriate proportions to obtain the required flame for the welding or cutting operation. It consists essentially of gas inlet connections, gas control valves, mixing chamber and a nozzle.

“Flashback” (回火) refers to the retrogression of the flame from the nozzle of the blowpipe upstream along the gas supply line back to the gas cylinder, with possible subsequent explosion.

“Sustained backfire” (持續後燃) refers to the retrogression of the flame into the blowpipe neck or body, the flame remaining alight causing heating up of the blowpipe. This

manifests itself either as 'popping' or 'squealing' with a small pointed flame issuing from the nozzle, or as a rapid series of minor explosions inside an overheated nozzle.

2 Responsibilities of Persons Concerned

2.1 Overview

- 2.1.1 Securing safety and health at work in an industrial undertaking requires the full commitment and co-operation of everybody concerned, from the proprietor to the workers. It is the duty of the proprietor of an industrial undertaking to ensure, so far as is reasonably practicable, the safety and health at work of all persons employed by him at the industrial undertaking.
- 2.1.2 The proprietor often employs line management personnel to discharge his responsibilities for management or control of the industrial undertaking. In this regard, the authority and responsibility of each member of the line management should be precisely set down and made known to all persons concerned.

2.2 Responsibilities of proprietor

- 2.2.1 The proprietor, including contractor and top management, should demonstrate the commitment in managing safety and health and bear the final responsibility and accountability for the safety and health in the industrial undertaking. The responsibilities of the proprietor include:
- (a) providing a safe and healthy working environment;
 - (b) providing the necessary resources for managing safety and health in the industrial undertaking;

- (c) issuing safety rules and safe working procedures, and ensuring that the rules and procedures comply with relevant legislation;
- (d) ensuring that the experience and training of the persons employed are commensurate with the assigned task;
- (e) ensuring that the responsibilities for managing safety and health are appropriately assigned, and the duties are effectively carried out by the staff concerned; and
- (f) ensuring that all accidents and dangerous occurrences are investigated and recommendations made are properly followed-up.

2.3 Responsibilities of line management personnel

2.3.1 The line management personnel, including managers, agents, engineers, safety personnel, foremen or supervisors, are responsible for managing safety and health in the industrial undertaking on a day-to-day basis, and should take up their supervisory role in discharging their duties. The responsibilities of the line management personnel include:

- (a) managing safety and health in the industrial undertaking;
- (b) assessing the risk in performing the gas welding or flame cutting operation, and establishing appropriate safety measures;
- (c) establishing safety rules and safe working procedures;
- (d) ensuring equipment to be regularly checked and properly maintained;
- (e) investigating accidents and dangerous occurrences, and undertaking follow-up actions;

- (f) establishing emergency response plans, and conducting drills whenever necessary; and
- (g) providing necessary information and instructions, as well as providing and arranging training to the workers and supervising them to follow safety rules and safe working procedures strictly.

2.4 Responsibilities of persons employed

2.4.1 The persons employed (“staff”), including workers and line management personnel, are required to take reasonable care for the safety and health of themselves and of others who may be affected by their acts or omissions at work. The responsibilities of the staff include:

- (a) understanding and acting in accordance with the safety rules, safe working procedures and emergency response procedures;
- (b) making full use of the safety equipment and personal protective equipment necessary to perform the assigned task, and reporting all equipment defects to the management immediately;
- (c) providing feedback on effectiveness of safety measures and emergency response plans; and
- (d) reporting to the management all hazards or defects observed during daily operation, injury, accident or incidents at work.

3 The Hazards and Assessment of Risks

3.1 The hazards

3.1.1 The hazards in gas welding and flame cutting can be broadly grouped into the following major categories:

- (a) fire and explosion hazards;
- (b) health hazards; and
- (c) other hazards specific to the operation, such as loss of stability to structures.

3.1.2 *Fire and explosion hazards*

Fire and explosion hazards in gas welding and flame cutting are mainly caused by problems with the gas supply system, the high temperature of the flame used or the hot slag produced in the process. These hazards include:

- (a) fires and explosions resulted from the release of flammable fuel gases or oxygen into the atmosphere from damaged gas hose or piping, or from leaks at joints, hose connections or fittings of the gas supply system, or as a result of valves of the gas supply line or blowpipe being left open inadvertently;
- (b) fires and explosions in the gas supply system caused by
 - (i) flashback from the blowpipe due to fuel gas supply lines not completely purged before lighting up, or back-feeding of fuel gas into the oxygen line or vice versa,
 - (ii) decomposition or detonation of acetylene in the absence of oxygen or air due to flashback at the blowpipe or overheating of gas cylinder, or

- (iii) high-pressure oxygen gas (without fuel gas) which promotes combustion of materials such as oil, grease, organic compounds, aluminium and its alloys, and elastomers used in valve seats and seals;
- (c) explosions from over-pressurisation of the gas supply system;
- (d) fires arising from the flammable or combustible residue in the workpiece; and
- (e) fires from the ignition of flammable or combustible materials in the vicinity by the flame of the blowpipe, hot surfaces of the workpiece or hot slag from the process.

Some common unsafe acts concerning misuse of oxygen and mishandling of gas cylinders are described in Appendix I.

3.1.3 Health hazards

Health hazards of gas welding and flame cutting are mainly due to the radiation and toxic fumes or gases emitted during the process. The resultant health problems include:

- (a) eye injuries, such as
 - (i) eye discomfort and burns from the intense light and heat emitted from the operation,
 - (ii) heat cataract caused by radiation from molten metal, leading to inability to see things clearly, or
 - (iii) corneal ulcer and conjunctivitis from foreign particles e.g. slag and cutting sparks;
- (b) skin irritation and reddening due to over exposure to radiation;
- (c) illness due to inhalation of fumes or gases formed during the process, such as
 - (i) metal fume fever from freshly formed metal oxide

- fumes,
- (ii) illness from toxic fumes of metals such as lead, cadmium, beryllium,
 - (iii) bronchial and pulmonary irritation from toxic gases such as oxides of nitrogen, fluorides;
- (d) burns from the blowpipe flame, hot slag or hot surfaces of the workpiece;
- (e) heat-stroke from prolong operation with the flame, especially in confined space; and
- (f) personal injuries arising from handling gas cylinders or large workpieces.

3.2 Risk assessment

- 3.2.1 Risk assessment in gas welding or flame cutting is an evaluation process to assess the likelihood of the hazards mentioned in Section 3.1 causing harm and the severity of that harm. This provides the necessary information for establishing appropriate safety measures, safe working procedures and emergency response procedures before commencing the operation. The scale and depth of the risk assessment depend on the working environment and the complexity of the welding or cutting operation.
- 3.2.2 Risk assessment should be conducted by a person with the appropriate knowledge and experience and the relevant training to enable him to assess the risks arising from the operation. The person should have appropriate understanding of the welding or cutting operation as well as good knowledge of the safe practices and safety measures required. He may not be an expert in that area but should be aware of his own limitations and should know when he needs to seek expert advice.

3.2.3 The basic steps in risk assessment include:

- (a) identifying the hazards;
- (b) considering who may be affected and how;
- (c) evaluating the risks arising from the hazards, and considering whether existing safety measures are adequate or more should be done;
- (d) recording the findings unless it is easily explicable; and
- (e) reviewing the assessment from time to time and revising if necessary.

3.2.4 Risk assessment should be specific to the required task. Factors to be considered in assessing risks associated with gas welding or flame cutting operation include:

- (a) the fuel gas and oxidant gas required and the gas supply system;
- (b) the working environment, such as
 - (i) ventilation of the workplace,
 - (ii) working in specific environments, such as confined space, pressurized or oxygen-rich environment,
 - (iii) working space restricting body movement,
 - (iv) working nearby flammable or combustible materials, and
 - (v) the possibility of slag or sparks reaching or coming into contact with combustible materials;
- (c) particulars of the work, such as
 - (i) duration and frequency of the welding or cutting operation,
 - (ii) operation on workpieces with possible flammable or combustible residues,

(iii) working at height, and

(iv) size, shape and weight of the workpieces.

3.2.5 Risk assessment should be reviewed regularly and whenever there has been a significant change in the operation to which the assessment relates, such as changes in working environment or the particulars of the work.

4 Safety Measures

4.1 Overall strategy

- 4.1.1 The primary objective of adopting safety measures is to contain or reduce to as low as reasonably practicable the risks encountered in gas welding and flame cutting operations in protecting staff against injury or ill health. Based on the result of risk assessment, appropriate safety measures should be established, implemented and maintained. The primary consideration in selecting appropriate safety measures is to control hazards at source by control measures, whereas protective measures should be considered only as supplementary means in protecting staff against the hazards.
- 4.1.2 Control measures, such as using appropriate ventilation and safety devices for the gas supply system, are effective means in controlling hazards at source. Protective measures using personal protective equipment provide protection to the workers concerned against the hazards during the welding or cutting process. However, the use of personal protective equipment should be a supplement to, and not in lieu of, effective control measures and the equipment should be selected appropriate to the required protection.
- 4.1.3 Establishment, implementation and maintenance of safety measures should also include:
- (a) proper design, construction and installation of plant and equipment, such as ventilation system, gas installation and associated piping;

- (b) establishing safe work systems and procedures, including safety rules and safe working procedures;
- (c) provision of appropriate information, instruction and training to the staff;
- (d) measures to ensure that equipment are properly used and maintained, safety rules are complied with and safe working procedures are followed by the staff, such as providing appropriate supervision to the workers; and
- (e) regularly reviewing the effectiveness of the safety measures, safety rules and safe working procedures and revising the measures, rules and procedures whenever necessary.

4.2 Ventilation

4.2.1 Ventilation is a means by which contaminated air is removed from and fresh air is supplied to the workplace, and is an effective control measure to control fire and explosion hazards as well as the health hazards. The major functions of ventilation in the workplace include:

- (a) removing gas from leakage, if any, so as to prevent accumulation of flammable/explosive mixtures in the atmosphere;
- (b) removing heat as well as hazardous fumes and gases such as metal and metal oxide fumes, oxides of nitrogen, fluorides arising from the welding or cutting operation; and
- (c) supplying fresh air to meet the respiratory needs of persons inside the workplace.

4.2.2 For a workplace involving gas welding or flame cutting operations, the major types of ventilation are:

- (a) general dilution ventilation in which fresh air is introduced into the workplace by mechanical means and is mixed thoroughly with the contaminants in the air before removing the contaminants out of the workplace; and
- (b) local exhaust ventilation in which air contaminants are captured and removed by forced air current through hood and duct near the point of emission and discharged to the atmosphere outside the workplace.

4.2.3 A ventilation system appropriate to the workplace as well as to the welding or cutting activities should be selected and designed. Factors to be considered in selecting and designing the appropriate ventilation system include:

- (a) natural air movement if the workplace is in the open air, otherwise the enclosed nature of the workplace such as the effectiveness of air moving in and out, height and floor dimensions of the workplace;
- (b) the required air movement to prevent accumulation of flammable/explosive mixture in localized regions in the air as a result of gas leakage, taking into account of matters including the location of the gas supply line and the gas cylinders; and
- (c) the quantity and toxicity of the fumes generated from the welding or cutting operation, and the location of the emission source.

4.2.4 *General dilution ventilation*

General dilution ventilation is required for a workplace in a building or structure where gas welding or flame cutting activity is involved. The dilution ventilation should effect air movement both at high level and at low level of the workplace in order to prevent accumulation of

flammable/explosive mixture in localized regions in the air as a result of gas leakage. Regarding health hazards, general dilution ventilation may be adequate for infrequent and short duration welding or cutting operations which do not emit toxic fumes and which are performed in the open air or in large well-ventilated workshops. Toxic fumes include those derived from metals such as lead, cadmium, beryllium and zinc.

4.2.5 *Local exhaust ventilation*

Notwithstanding that general dilution ventilation is used in the workplace, local exhaust ventilation is required for welding or cutting operations that emit toxic fumes or gases, or which involve heavy in-door production work. The local exhaust hood should be placed as close as possible to the work for effective removal of the fumes before the fumes disperse to other parts of the workplace.

4.3 Gas supply system and associated safety devices

4.3.1 In general, each one of the two gases (the fuel gas or the oxidant gas) for gas welding or flame cutting is supplied from a single gas cylinder. Basically, gas from the cylinder is supplied through a gas hose to the blowpipe where the fuel and oxidant gases are mixed in an appropriate proportion and combusted to form the required flame. The gas supply should be adjusted and monitored by a pressure regulator with pressure gauge connected to each gas cylinder. Other associated safety devices, incorporated in the gas supply system for reducing the risk of fire and explosion in the gas supply system, should include:

- (a) a non-return valve at each gas inlet of the blowpipe to prevent back-feeding of oxidant gas to the fuel gas line

and vice versa; and

- (b) flashback arrester (also known as flame arrester) incorporating pressure or temperature cut-off valve to prevent propagation of flashback from the blowpipe and gas supply lines into the cylinders.

The typical equipment and related safety devices for oxy-acetylene flame are illustrated in Part 1 of Appendix II. The equipment and associated safety devices should meet national or international standards (refer to Part 2 of Appendix II).

4.3.2 Alternatively, a gas installation may be used in which each gas is supplied from several cylinders connected in a manifold or from a bulk supply through pressure regulator with pressure gauge, associated piping and gas hose to the blowpipe. Such gas installation and associated piping should comply with relevant legislation, such as the Dangerous Goods Ordinance (Chapter 295), Gas Safety Ordinance (Chapter 51).

4.3.3 Gas installation and the associated piping should be designed by a professional engineer with the appropriate training and experience in gas safety. Factors to be considered in designing and installing gas installations and associated piping include:

- (a) the provision of appropriate ventilation to prevent localized accumulation of flammable mixture in the air due to minor gas leakage, if any, from the gas installation and associated piping;
- (b) the choice of appropriate materials for the gas installation and associated piping to prevent formation of explosive mixtures (note: copper is not compatible with acetylene, while aluminium and its alloy are not suitable for conveying oxygen);

- (c) the use of safety devices to prevent fire and explosion, including flashback arrester, non-return valve, pressure relief device, vent and purge device;
- (d) the provision of appropriate gas leakage detecting devices, fire alarm and fire-fighting equipment to cope with the large quantity of fuel and oxidant gases involved;
- (e) the protection of the gas installation and associated piping against corrosion and other physical damage; and
- (f) the arrangement of the gas installation and associated piping to facilitate routine inspection and maintenance.

The proprietor should ensure that the gas installation and associated piping are properly installed and tested before use.

4.3.4 Gas cylinders in use and outlet valves of the gas installation should be located in a convenient place, easily accessible to the worker so that the gas supplies can be shut off immediately in case of emergency.

4.3.5 Gas hoses should be as short and hose connections should be as few as reasonably practicable to reduce the chance of gas leakage. Staff should pay attention to the following points when placing the gas hoses:

- (a) Gas hoses should be easily inspected and should not be easily damaged by other activities in the workplace, such as being run over or struck by heavy equipment.
- (b) Gas hoses should not be placed in sleeves, or should not be permanently hidden in grooves, pipe ducts or in other structures. Hoses in sleeves or hiding the hose hinders checking for possible damage mentioned in Section 6.3 and may create voids for localized

accumulation of flammable/explosive mixtures in the event of gas leakage.

- (c) Gas leakage from hoses, if any, can be easily and effectively removed by the ventilation of the workplace and will not accumulate in localized regions in the air.
- (d) Gas hoses should not be coiled around the gas cylinder or the pressure regulator. A fire in a coiled hose is very difficult to extinguish. The gas hose should be positioned behind the operator to keep them clear of slag or sparks, and arranged in a tidy manner so as not to create tripping hazard to other persons.

- 4.3.6 Gas cylinders should be suitably labelled and/or coloured in accordance with the relevant legislation, such as the Dangerous Goods Ordinance (Cap. 295), Factories and Industrial Undertakings (Dangerous Substances) Regulations (Cap. 59 sub. leg.). Gas hoses and piping should also be appropriately coloured for easy identification.

4.4 Personal protective equipment

- 4.4.1 In gas welding and flame cutting, the primary objective of using personal protective equipment is to provide protection to the workers against the risk of injury from hot objects and radiation as well as ill health from inhaling hazardous fumes, as a supplement to control measures. Suitable personal protective equipment should be selected appropriate to the hazards encountered, and should be properly used and maintained. Personal protective equipment, if wrongly selected, or improperly used or maintained, may do more harm than good. The user may have a false sense of security and the risk of injury or ill health may be higher than in a situation where no personal protective equipment is

used. Suitable training should be provided to workers for the proper use of personal protective equipment before they start the operation.

4.4.2 *Eye protection*

Eye protection equipment protects the eye from injuries by radiation and foreign objects such as slag and sparks arising from the welding or cutting operation. Welding or cutting of metals by means of oxy-acetylene flame is a specified process under the Factories and Industrial Undertakings (Protection of Eyes) Regulations (Cap. 59 sub. leg.). Workers engaged in the process and other persons that may be affected shall be provided with, as appropriate:

- (a) approved eye protectors such as goggles, visors, spectacles, face screens;
- (b) approved shield such as hand shield; or
- (c) approved fixed shield such as screen.

4.4.3 *Skin and body protection*

Skin and body protection includes protection to the face, hands, feet, body and personal clothing. The major objective is to protect workers against burns by the flame of the blowpipe, hot slag or workpiece. Appropriate gears should be made of fire retardant materials and should be selected according to the nature, volume and location of the welding or cutting work. These include facemasks, aprons, gloves, gauntlets, safety shoes and spats.

4.4.4 *Respiratory protection*

Respirators provide additional protection to workers from inhaling toxic fumes, and should be used in supplement to, but not in lieu of, the use of an efficient ventilation system. When welding or cutting is performed in a confined space,

workers may be required to wear respirators (refer to Section 5.6). In such circumstances, the worker should be physically fit before working with a respirator.

5 General Safe Practices

5.1 Overview

- 5.1.1 Safety rules and safe working procedures, covering general safe practices in the industrial undertaking and safe practices in specialized operations, provide instructions to staff in ensuring safety and health at work. It may be necessary to display important rules and procedures in the form of notices and posters in the work area to arouse special attention.
- 5.1.2 The safe practices outlined below serve as a guide for establishing safety rules and safe working procedures on the general safety aspects regarding gas welding and flame cutting operations. The rules and procedures should be tailor-made according to the range of welding or cutting activities carried out in the industrial undertaking. The management of the industrial undertaking should ensure that the staff fully understand and comply with the rules and follow the procedures.

5.2 Preparation before commencement of welding or cutting

- 5.2.1 The risks associated with a gas welding or flame cutting operation should be assessed and appropriate safety measures established and implemented before commencing the operation. Preparation before the operation should appropriately include:
- (a) assessing the risks associated with the operation, and establishing appropriate safety measures, safe working

procedures and emergency procedures, paying special attention to specific work conditions such as handling of large workpieces, working at height, working in confined spaces;

- (b) ensuring that appropriate equipment and safety devices are used, necessary control measures are implemented (such as turning on the ventilation system) and personal protective equipment is ready in hand;
- (c) providing appropriate information, instructions and training to the workers;
- (d) ensuring cleanliness of the work area and that measures have been taken to prevent fire (refer to Section 5.4); and
- (e) conducting pre-use equipment check (refer to Section 6.3).

5.3 During and after welding or cutting

- 5.3.1 During the gas welding or flame cutting operation, safe working procedures should be strictly followed, and appropriate personal protective equipment should be used.
- 5.3.2 Care should be taken in lighting up and shutting down the blowpipe to prevent flashback and backfire (refer to Appendix III for the recommended procedure). Lit blowpipes should be handled carefully and should not be hung on a gas cylinder shroud or left unattended even for a short period of time.
- 5.3.3 After the gas welding or flame cutting operation, the blowpipe should be shut down and the valves of the gas supplies should be turned off. It is necessary to ensure that slag, sparks and workpiece are completely cooled down

before leaving the work area.

5.4 Fire prevention and protection

5.4.1 Fire and explosion may arise from leakage in the gas supply line. Gas leakage causes accumulation of fuel gas or oxygen in the atmosphere. Precautionary measures should include:

- (a) appropriate ventilation to prevent gas accumulation in the workplace (refer to Section 4.2);
- (b) appropriate gas supply line (refer to Section 4.3); and
- (c) regular and pre-use equipment check for gas leakage (refer to Sections 6.2 and 6.3).

5.4.2 During the welding or cutting process, fire may arise from ignition of flammable or combustible materials not only by direct contact with the flame, but also by contact with hot slag or workpiece that may take a considerable time to cool down. Good housekeeping in the workplace is very important in preventing fire. The following precautions prior to the commencement of the welding or cutting operation are necessary to prevent fires:

- (a) Keep the working area clean and tidy. Move all flammable or combustible materials to a safe place away from the working area. Use suitable means to protect combustible materials that cannot be moved from close contact with flame, heat, hot slag or sparks such as covering with fire resistant materials.
- (b) Ensure that adjacent areas or compartments, which may be affected by the heat generated by the operation, are free from flammable or combustible materials and fire hazards. Remove or protect the flammable or combustible materials as appropriate.
- (c) Use suitable means to prevent slag or sparks from

reaching combustible materials along or down ducts, channels and through holes in walls and floors, such as covering the openings by fire resistant materials.

- (d) For welding or cutting operations in open area, implement measures to prevent slag or sparks from being carried away by wind and igniting combustible materials in the vicinity.
- (e) Prevent the equipment used in gas welding or flame cutting from being contaminated with oil or grease.
- (f) Ensure that the workpiece is free from any flammable or combustible material, such as oil, grease, paint, dirt or other residue (refer to Section 5.7).

After the work, it is necessary to ensure that the blowpipe has been properly shut down (refer to Appendix III), and sparks and slag from the work are extinguished and the workpiece cooled down before leaving the work area.

- 5.4.3 Suitable fire-fighting equipment such as fire extinguishers, buckets of sand should be provided nearby the work area. When there is an enhanced risk of fire from combustible materials that cannot be moved, it may be necessary to appoint “fire watchers” to detect and extinguish incipient fires and sound the alarm if necessary. They are needed during the operation and for a sufficient period afterwards. It may be necessary to use buckets of water to wet and cool the area surrounding the workplace.

5.5 Safe storage and handling of gas cylinders

- 5.5.1 Acetylene is supplied as a gas dissolved under pressure in a solvent, usually acetone, and is contained in a porous mass inside the gas cylinder. Propane is supplied as a liquefied gas in cylinders. Hydrogen, oxygen and air are

stored under high pressure in gas cylinders. Acetylene, propane and hydrogen are flammable gases. In case of oxygen, combustible materials ignite more easily and burn faster generating higher temperatures in an oxygen-rich atmosphere. Moreover, acetylene is potentially unstable and may decompose violently. Mechanical shock to acetylene gas cylinder due to mishandling or overheating under high pressure may cause decomposition giving rise to high temperatures and possible detonation even in the absence of oxygen or air. Gas cylinders should be handled carefully.

5.5.2 Safe practices in storing and handling of gas cylinders include the following:

- (a) Ensure that gas cylinders upon receipt are appropriately coloured and/or labelled, and have no sign of gas leakage.
- (b) Store gas cylinders in a cool and well-ventilated place, away from direct sunlight, or any heat or ignition source. Keep gas cylinders in use away from the welding or cutting work. All cylinders not in use must be removed from the working area and stored in appropriate storage.
- (c) Always keep gas cylinders in an upright position and securely anchored to strong supports, irrespective of whether they are in storage, during transportation or in use. This is particularly important for acetylene cylinders to prevent the solvent in the cylinder mentioned in Clause 5.5.1 from getting into the gas supply line.
- (d) Keep the quantity of gas cylinders in storage to a practical minimum and in compliance with the requirements under the Dangerous Goods Ordinance (Chapter 295).
- (e) Handle gas cylinders with care. Do not throw or bump

the cylinders heavily. Do not roll the cylinders or use them as support for loads even when they are empty. Inform the supplier immediately if the gas cylinder is found to be physically damaged.

- (f) Move gas cylinders in wheeled trolleys designed for the purpose and ensure that they are securely fastened to the trolley during movement to prevent damaging the cylinder valves and to minimise the risk of injury.

5.5.3 Whenever possible, appropriate mechanical equipment, such as cranes, cradles, platforms or slings should be used for handling gas cylinders. Factors to be considered include the following:

- (a) The use of magnets, chains or ropes may be dangerous unless the gas cylinders are properly secured.
- (b) Gas cylinders may be moved by fork-lift truck but the cylinders should be fixed securely in a frame or other carrying structure suitable for the purpose. The method of freely balancing cylinders on the forks of the truck causes the risks of dropping them and damaging the valves, and should not be adopted.
- (c) Gas cylinders should not be lifted by the valve or valve shroud.

5.6 Welding or cutting in a confined space

5.6.1 The requirements under the Factories and Industrial Undertakings (Confined Spaces) Regulation (Cap. 59 sub. leg.) shall be complied with. Special attention should be paid to the following factors in assessing the risks associated with gas welding or flame cutting in a confined space:

- (a) limited means of access and egress;
- (b) greater risk of asphyxiation;
- (c) greater likelihood of accumulation of gases from leaks;
- (d) hazards from welding fumes more significant; and
- (e) consequences of a fire or explosion likely to be more serious.

5.6.2 Special safe practices for gas welding or flame cutting operations in a confined space should include the following:

- (a) Adopt a permit-to-work system to ensure that appropriate risk assessment is made and necessary safety measures are implemented.
- (b) Provide a system for fresh air ventilation and fume extraction. Depending on the result of risk assessment, it may be necessary to provide workers working in a confined space with supplied-air type respirator.
- (c) Do not take gas cylinders into a confined space as far as reasonably practicable. If this cannot be avoided, keep the number and size of the cylinders to be taken into the confined space to a practical minimum. The cylinders should be closely monitored during use to prevent gas leakage, and removed from the confined space when work stops.

5.7 Welding or cutting in maintenance and dismantling of plant

5.7.1 Gas welding or flame cutting on containers or piping containing combustible fluids poses great risk of fire. Under the heat of the flame, the combustible fluid may become volatile or may eject out as fine aerosol if the container or

pipng is pressurized, forming flammable mixture with air. Safe practice in welding or cutting during maintenance and dismantling of plant and equipment include the following:

- (a) Obtain full information about the plant and equipment to see whether combustible fluid is involved.
- (b) Drain off combustible fluids, including flammable ones.
- (c) Remove combustible residue from the containers or piping by washing with suitable solvents and purging with inert gas, or by using hydraulic or hot water/steam wash.

5.7.2 It is also important to ensure that before commencing the gas welding or flame cutting operation, used containers or piping are free from any residue that may emit flammable or toxic vapours upon heating. Preparation before the operation includes removing the residue by washing with suitable solvents and purging with inert gas, or by using hydraulic or hot water/steam wash. Gas monitoring should be conducted whenever necessary.

5.7.3 It should be noted that solvent wash or steam wash may give rise to other hazards associated with toxic or hot vapours. Addition safety measures should be taken as appropriate.

6 Checking and Maintenance of Plant and Equipment

6.1 Overview

- 6.1.1 All plant and equipment engaged in gas welding or flame cutting operations, including ventilation system, gas supply system, safety devices and personal protective equipment should be regularly checked for performance and maintained in good working condition. The proprietor should assign persons with appropriate training and experience to undertake the checking and maintenance work. Performance check includes general examination of plant and equipment as well as pre-use equipment check.
- 6.1.2 All defective or damaged plant or equipment should be taken out of service immediately and replaced by appropriate ones, and should be repaired or disposed of as appropriate. Plant or equipment under maintenance or found defective should be properly labelled, marked or otherwise highlighted to warn staff not to use it. Plant or equipment which has been repaired or maintained should be checked to ensure proper performance before it is used.

6.2 General examination of plant and equipment

- 6.2.1 All plant and equipment should be regularly examined for defects and malfunctions. The frequency of examination depends on the frequency of use of the plant or equipment and the conditions in which it is used, such as the aggressive nature of the working environment. Records of the examination should be maintained as far as reasonably

practicable for the purpose of providing information to facilitate maintenance work.

6.2.2 The ventilation system of the workplace should be regularly checked to ensure its proper performance. Regular examination of equipment should include inspection for the following defects:

- (a) physical damage, corrosion and gas leakage of the piping, gas hoses and connections;
- (b) internal gas leakage in pressure regulators;
- (c) incorrect operation of pressure gauges;
- (d) build-up of deposits of combustion products in flashback arresters, resulting in low gas flow rates;
- (e) incorrect operation of non-return valves, resulting in reverse flow not shutting off; and
- (f) defective blowpipe such as internal gas leakage, blockage at the nozzle.

6.3 Pre-use equipment check

6.3.1 Notwithstanding that equipment are regularly checked for performance, it is necessary to check that equipment and safety devices are correctly installed and in good working condition each time before starting a welding or cutting operation. Pre-use equipment check includes:

- (a) ensuring that each gas cylinder is fitted with regulator of the correct type and is correctly connected to the blowpipe;
- (b) checking for defective or damaged pressure gauges; replacing or repairing the gauges as appropriate;

- (c) ensuring that there is no gas leakage in the gas supply lines, such as by pressure test, or by checking hose connections for leakage using soapy water;
- (d) checking for defective or damaged gas hoses such as cuts, cracks, abrasion, animal bites or hardening of the gas hose material due to aging, and replacing or repairing the hose as appropriate; and
- (e) ensuring that the routing of the gas hoses will not cause severe bending of the hose or will not be run over by other heavy equipment so as to prevent gas flow being obscured or hose being damaged.

7 Emergency Preparedness

7.1 Overview

7.1.1 Emergency preparedness is vital, as quick and correct response is necessary in case of emergencies to reduce injuries, ill health and other damages. In gas welding and flame cutting, common emergency situations include gas leakage, fire and explosion.

7.1.2 The proprietor of an industrial undertaking, with assistance from the staff, should:

- (a) identify the effect and impact of all possible emergency situations in the industrial undertaking;
- (b) establish emergency procedures;
- (c) provide and maintain emergency equipment and other resources; and
- (d) ensure that the staff familiarize themselves with the arrangements in case of emergencies, such as providing instruction and training to the staff, organizing drills.

7.2 Emergency response procedures and equipment

7.2.1 Emergency response procedures should be established for the staff to follow in the event of a situation presenting serious and imminent danger. The procedures should include guidance for the staff explaining when and how they should stop work and move to a safe location, or even fully

evacuate the workplace. Responses to some of the possible emergency situations in gas welding and flame cutting are described in Section 7.3.

7.2.2 Appropriate emergency equipment should be provided for handling emergency situations. Such equipment include:

- (a) fire alarm;
- (b) fire-fighting equipment, such as fire hose, fire extinguishers, buckets of dry sand; and
- (c) first aid facilities, such as first aid kit.

All emergency equipment should be properly maintained. The equipment should be regularly checked for proper performance. Expired items should be disposed of or replaced. Location of emergency equipment in the industrial undertaking should be made known to the staff.

7.3 Response to some possible emergency situations

7.3.1 Gas leakage

If gas leakage is found in the gas supply line,

- (a) isolate the gas supplies by closing the valves of the gas cylinders or the gas supply systems;
- (b) inform all persons in the workplace;
- (c) isolate all ignition sources, such as distinguishing flames; and
- (d) evacuate the workplace and call the Fire Services Department.

7.3.2 Sustained backfire

If there is a sustained backfire in the blowpipe,

- (a) first close the oxygen valve of the blowpipe, followed by the fuel valve;
- (b) complete the shutting down procedure (refer to Part 2 of Appendix III);
- (c) investigate the cause and rectify the fault; and
- (d) re-light the blowpipe only after it is completely cooled down.

7.3.3 *Flashback or fire in the gas hose*

If there is a flashback into the gas hose and equipment, or a hose fire or explosion, or a fire at the pressure regulator connections,

- (a) isolate the fuel gas and oxygen supplies by closing the cylinder valves only when this can be done safely;
- (b) may attempt to control the fire by fire-fighting equipment only when there is no undue risk of personal injury; and
- (c) activate the fire alarm and call the Fire Services Department.

All staff should be evacuated if the fire is beyond control and inform the firemen of the situation when they arrive, otherwise take action as suggested in Clause 7.3.4.

7.3.4 *Fire involving acetylene cylinder*

Any fire involving acetylene cylinder always poses a risk of cylinder explosion, and should be dealt with by the Fire Services Department. However, under safe circumstances, the following initial measures may be suitably adopted:

- (a) cool the cylinder by spraying with water only if it is safe to do so;

- (b) close the cylinder valve to control the fire only if it is safe to do so; and
- (c) evacuate the building by activating the fire alarm or by any other means.

Never attempt to remove an acetylene cylinder that has been involved in a fire, or move one which has been affected by heat from a nearby fire even if it appears to have been cooled down. Moving the cylinder may lead to explosion!

8 Information, Instruction and Training

8.1 Overview

8.1.1 The proprietor should ensure that the training and experience of the staff undertaking the gas welding or flame cutting operation are commensurate with the assigned task. The training and experience should cover the welding and cutting technique, selection and use of equipment as well as the safety and health aspects of the operation.

8.1.2 Notwithstanding that the workers have been trained on the general safety and health aspects of gas welding and flame cutting (refer to Section 8.2), the proprietor should provide appropriate information, instruction and training to the workers on the safety and health aspects specific to the assigned task. The information, instruction and training should appropriately cover:

- (a) safety rules established in the industrial undertaking;
- (b) safe working procedures for the assigned task;
- (c) emergency procedures and evacuation plan; and
- (d) specific safety and health considerations, such as working at height, operation in a confined space, operation on workpieces with flammable or combustible residue, handling of large workpieces.

8.2 General safety and health training

8.2.1 All persons involved in gas welding or flame cutting should be fully trained in the safety and health aspects of the work

under normal operation as well as in emergencies. The general safety and health training should cover:

- (a) hazards in gas welding and flame cutting;
- (b) relevant legislation and responsibilities of the persons concerned;
- (c) equipment and safety devices for gas welding and flame cutting, including their uses and limitations;
- (d) safety measures, including selection and use of ventilation system and personal protective equipment, and their limitations;
- (e) fire prevention and protection measures;
- (f) general safe practices in gas welding and flame cutting;
- (g) emergency response and procedures; and
- (h) general examination and maintenance of equipment, and pre-use equipment checks.

Appendix I

Unsafe acts

Many serious accidents have occurred in the industry due to misuse of oxygen, recharging of gas cylinders and warming up gas cylinders. These are unsafe acts.

1 Misuse of oxygen

When oxygen gas contacts combustible materials, it promotes combustion. Explosion may occur. Never use oxygen to:

- provide a source of pressure or a substitute for compressed air, such as to clear blockages in pipelines, to power air-driven tools;
- blow-down clothing, equipment or work areas to remove dust, etc.;
- ventilate a confined space instead of air; or
- sweeten the air of any work area or space.

2 Recharging of gas cylinders

Recharging gas cylinders by connecting them to other cylinders or a gas supply is extremely dangerous. Explosion may occur if:

- the gas line or its connections or the gas cylinders cannot withstand the high pressure during recharging;
- the recharging involves mixing of incompatible gases, such as charging oxygen into an acetylene cylinder.

3 Warming up gas cylinders

Warming up gas cylinders by any means in order to increase

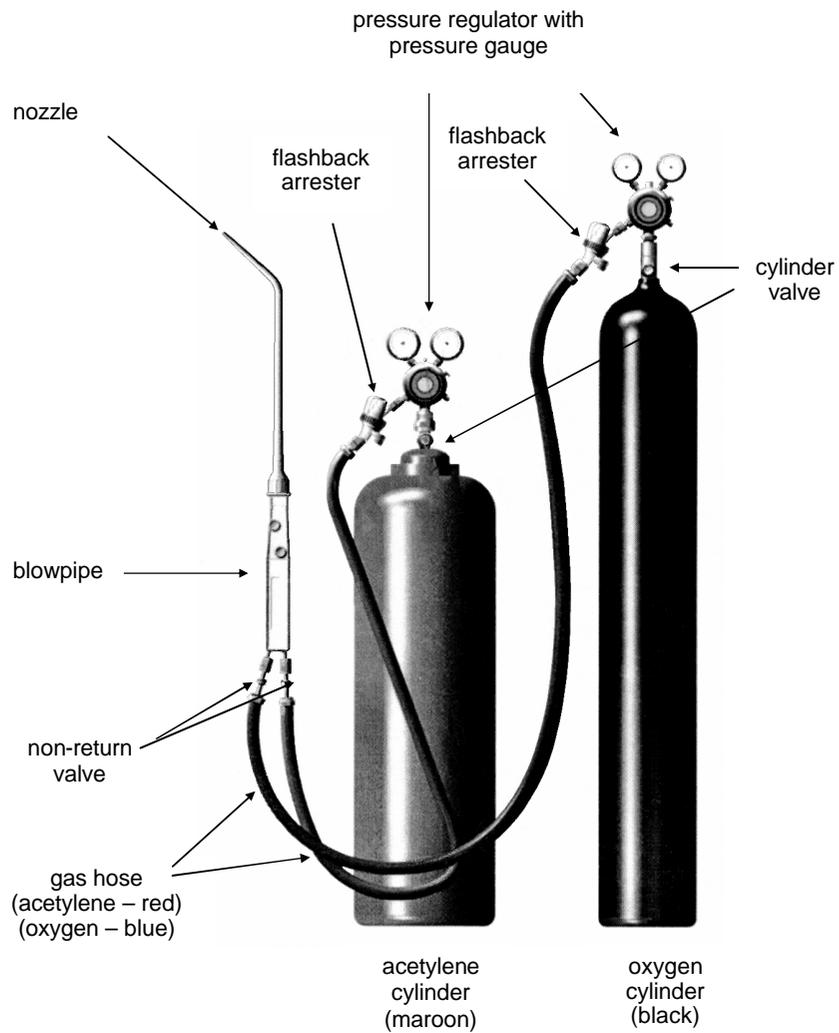
gas flow or to extract the last bit of gas stored in the cylinder for use is extremely dangerous. Fire and explosion may occur due to:

- the gas supply system not capable of withstanding the resulted increase in gas pressure;
- evaporation of the solvent (acetone in general) for storing acetylene in the gas cylinder by the heat, causing damage to the gas hose and blowpipe and change in composition of the fuel/oxidant mixture for the flame.

Appendix II

Typical equipment for welding and cutting using oxy-acetylene flame

1 The equipment arrangement



2 Related standards

Blowpipe	ISO 5172:1995 <i>Manual blowpipes for welding, cutting and heating</i> $\frac{3}{4}$ <i>Specifications and tests</i> , International Standards Organisation; or equivalent.
Gas hose	ISO 3821:1998 <i>Gas welding equipment</i> $\frac{3}{4}$ <i>Rubber hoses for welding, cutting and allied processes</i> , International Standards Organisation; or equivalent.
Hose connection	ISO 3253:1998 <i>Gas welding equipment</i> $\frac{3}{4}$ <i>Hose connections for equipment for welding, cutting and allied processes</i> , International Standards Organisation; or equivalent.
Pressure regulator	ISO 2503:1998 <i>Pressure regulators for gas cylinders used in welding, cutting and allied processes up to 300 bar</i> , International Standards Organisation; or equivalent.
Other associated safety devices	ISO 5175:1987 <i>Equipment used in gas welding, cutting and allied processes</i> $\frac{3}{4}$ <i>Safety devices for fuel gases and oxygen or compressed air</i> $\frac{3}{4}$ <i>General specifications, requirements and tests</i> , International Standards Organisation; or equivalent.

Appendix III

Procedure for lighting up and shutting down the blowpipe

1 Lighting up procedure

- (a) Ensure that gas cylinder valves (or the outlet valves of the gas supplies), the adjustable outlet valves of the pressure regulators and the blowpipe valves are closed.
- (b) Slowly open the gas cylinder valves (or the outlet valves of the gas supplies) using the correct tools, and adjust the pressure regulators to the correct outlet pressure.
- (c) Open the oxygen valve at the blowpipe and allow the flow of oxygen to purge air out of the oxygen gas supply line and equipment.
- (d) Close the oxygen valve of the blowpipe.
- (e) Open the fuel gas valve at the blowpipe and allow the flow of fuel gas to purge air or oxygen out of the fuel gas supply line and equipment.
- (f) Immediately light the fuel gas, preferably with a spark lighter.
- (g) Open the oxygen valve at the blowpipe, and adjust the oxygen and fuel valves to provide the required flame setting.

2 Shutting down procedure

- (a) Close the fuel gas valve at the blowpipe.
- (b) Immediately close the oxygen valve at the blowpipe.
- (c) Close the cylinder valves or gas supply outlet valves for both oxygen and fuel gas.

- (d) Open both valves at the blowpipe to vent the pressure in the equipment.
- (e) Close the outlets of the adjustable pressure regulators for both oxygen and fuel gas.
- (f) Close both valves at the blowpipe.

Note:

- (i) Always light up and operate the flame in a well-ventilated area.
- (ii) Perform the purging in 1(c) and 1(e) for a few seconds to a minute depending on the length of the supply line and the gas flow rate.

Useful Information

If you wish to enquire about this guide or require advice on occupational safety and health, please contact the Occupational Safety and Health Branch of the Labour Department through:

Telephone : 2559 2297 (auto-recording after office hours)

Fax : 2915 1410

E-mail : laboureq@labour.gcn.gov.hk

Information on the services offered by the Labour Department and on major labour legislation can also be found by visiting our Home Page in the Internet. Address of our Home Page is <http://www.info.gov.hk/labour>.