

SAFETY GUIDELINES FOR IRON & STEEL SECTOR		
MINISTRY OF STEEL, GOVT. OF INDIA	ARC WELDING & ARC CUTTING	Doc. No: SG/08
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1. Objective

The objective of this safety guideline is to provide safe working procedure while carrying out electrical arc welding & cutting jobs in iron & steel industry and prevent from major hazards like electrocution, fire, explosion and metal fumes.

2. Scope

2.1 The scope covers safety aspects during arc welding and arc cutting operations while taking up fabrication, maintenance and manufacturing jobs etc. in iron & steel industry.

2.2 The scope does not cover gas welding and gas cutting or heating through gas.

3. Procedure

3.1 General Requirements

- i. The procedure has to be implemented by all departmental Heads with the help of their authorized representative at work place and is also applicable to Contractor's employees.
- ii. Work permit shall be issued to working agency before start of arc welding/ arc cutting by the authorized person of the department
- iii. If the cutting/welding job is to be carried out at height (more than 2 meters) from ground level/in confined space/gaseous hazardous area/ near electrical installation, separate entry permit/work permit should be obtained from authorized agency. Electrical cables/ wires if any below the cutting area shall be properly guarded/ protected from falling spatters.

Falling of spatters from height must be prevented. For this a metal trough should be used and spatters should be collected in a trough at the point of generation. Moist ceramic cloth may also be used wherever required. In case of problem in preventing of all the spatters falling down at the area below the site of hot work the area has to be barricaded. No cylinders should be kept in the barricaded area. Proper covering of the knob, valves etc of the cylinders adjacent to the barricading must be ensured.

- iv. After completion of the job, the cables, spatters, etc. are to be properly removed and kept at designated place. Area to be cleaned and waste matter removed.
- v. After completion of the job, the work permit shall be returned by working agency and the receiving authority of owner department shall enter the form in the original along with the white copy.

- vi. Test the area for flammables before welding and cutting when the atmosphere is vulnerable to such hazards.
- vii. Workers must leave their personal mobile phones prior to proceeding to the work site(s) to avoid getting distracted to respond to phone calls which may lead to accidents.

3.1.1 **Fire Prevention and Protection**

- i. Relevant clauses covered in SG-16: 'Safety guideline for Fire Safety' shall be followed.
- ii. It should be ensured that before starting the job surrounding area of the work side should be made free of fire hazard.
- iii. Employees engaged on welding and cutting jobs should be trained and capable to use fire equipments in case of any fire emergency.
- iv. Adequate fire fighting provision to be made available close to each area of welding, cutting and other hot job.
- v. Emergency telephone number should be made available and displayed at work site by concerning agencies.
- vi. When practical, objects to be welded or cut shall be moved to a designated safe location or, if the objects to be welded or cut cannot be readily moved, all movable fire hazards in the vicinity shall be taken to a safe place, or otherwise protected.
- vii. If the object to be welded or cut cannot be moved and if all the fire hazards cannot be removed, positive means shall be taken to confine the heat, sparks, and slag, and to protect the immovable fire hazards from them.
- viii. No welding or cutting shall be done where the application of flammable paints or the presence of other flammable compounds, or heavy dust concentrations creates a hazard.
- ix. Suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained in a state of readiness for instant use.
- x. When the welding or cutting operation is such that normal fire prevention precautions are not sufficient, additional personnel shall be assigned to guard against fire while the actual welding or cutting operation is being performed, and for a sufficient period of time after completion of the work to ensure that no possibility of fire exists. Such personnel shall be instructed as to the specific anticipated fire hazards and how the firefighting equipment provided is to be used.
- xi. When welding or cutting is performed on walls, floors, and ceilings, since direct penetration of sparks or heat transfer may introduce a fire hazard to an adjacent area, the same precautions shall be taken on the opposite side as are taken on the side on which the welding is being performed.
- xii. Except when the contents are being removed or transferred, drums, pails, and other containers, which contain or have contained flammable liquids, shall be kept closed. Empty containers shall be removed to a safe area apart from hot work operations.

- xiii. Drums, containers, or hollow structures which have contained toxic or flammable substances shall, before welding or cutting is undertaken on them, either be filled with water or thoroughly cleaned of such substances and ventilated and tested.
- xiv. Before heat is applied to a drum, container, or hollow structure, a vent or opening shall be provided for the release of any built-up pressure during the application of heat.

3.2 Arc Welding and Cutting

3.2.1 Manual Electrode Holders

- i. Only manual electrode holders which are specifically designed for arc welding and cutting, and are capable of safely handling the maximum rated current required by the electrodes, shall be used.
- ii. Any current-carrying parts passing through the portion of the holder which the arc welder or cutter grips in the hand, and the outer surfaces of the jaws of the holder, shall be fully insulated against the maximum voltage encountered to ground.

3.2.2 Welding Cables and Connectors

- i. All arc welding and cutting cables shall be of the completely insulated, flexible type, capable of handling the maximum current requirements of the work in progress, taking into account the duty cycle under which the arc welder or cutter is working.
- ii. Only cable free from repair or splices for a minimum distance of 3.0 m from the cable end to which the electrode holder is connected shall be used, except that cables with standard insulated connectors or with splices whose insulating quality is equal to that of the cable are permitted.
- iii. When it becomes necessary to connect or splice lengths of cable one to another, substantial insulated connectors of a capacity at least equivalent to that of the cable shall be used. If connections are effected by means of cable lugs, they shall be securely fastened together to give good electrical contact and the exposed metal parts of the lugs shall be completely insulated.
- iv. Cables in need of repair shall not be used and removed from site. When a cable, other than the cable lead, becomes worn to the extent of exposing bare conductors, the portion thus exposed shall be protected by means of rubber and friction tape or other equivalent insulation.

3.2.3 Ground Returns and Machine Grounding

- i. A ground return cable shall have a safe current carrying capacity equal to or exceeding the specified maximum output capacity of the arc welding or cutting unit which it services. When a single ground return cable services more than one unit, its safe current-carrying capacity shall equal or exceed the total specified maximum output capacities of all the units it serves.

- ii. Pipelines containing gases or flammable liquids, or conduits containing electrical circuits, shall not be used as a ground return.
- iii. Under any circumstances, no structure or pipeline shall be used as ground return.
- iv. The frames of all arc welding and cutting machines shall be grounded either through a third wire in the cable containing the circuit conductor or through a separate wire which is grounded at the source of the current. Grounding circuits, other than by means of the structure, shall be checked to ensure that the circuit between the ground and the grounded power conductor has resistance low enough to permit sufficient current to flow to cause the fuse or circuit breaker to interrupt the current
- v. All ground connections shall be inspected to ensure that they are mechanically strong and electrically adequate for the required current.

3.2.4 **Safety Devices**

- i. RCBO (Residual Current Breaker Overload)/ RCCB (Residual Current Circuit Breaker) shall be provided at the incoming side of welding machine.
- ii. VRD (Voltage reducing device) shall be provided at the outgoing / secondary side of welding machine in order to keep the open circuit voltage in safe range (between 8 to 10 V). These safety devices is to be used while doing the welding job in the following areas:
 - a) Confined spaces like inside vessels, storage tank, tunnels etc.
 - b) Wet or damp location
 - c) Hot and Humid conditions
 - d) Working at heights

The safety device may not be used for the general fabrication jobs done at the shop floor & the area which is not hazardous as mentioned above. This safety device reduces the hazard of high voltage present at the welding electrodes only and does not replace the existing safe working practices during electrical arc welding. The device shall be installed as per the guidelines given by the supplier.

3.2.5 **Operating Instructions**

Employers shall instruct employees about the safe means of arc welding and cutting as follows:

- i. When electrode holders are to be left unattended, the electrodes shall be removed and the holders shall be so placed or protected that they cannot make electrical contact with employees or conducting objects.
- ii. Hot electrode holders shall not be dipped in water; to do so may expose the arc welder or cutter to electric shock.
- iii. When the arc welder or cutter has occasion to leave work or to stop work for any appreciable length of time, or when the arc welding or cutting machine is to be moved, the power supply switch to the equipment shall be opened.

- iv. Any faulty or defective equipment shall be reported to the supervisor.

3.2.6 **Shielding**

All arc welding and cutting operations shall be shielded by noncombustible or flameproof screens which will protect employees, helpers and other persons directly looking at the arc.

3.2.7 **Employee Protection**

Where welding or cutting operations are being performed in areas where it is possible for molten slag to come in contact with other employees, those employees shall be protected from being burned by providing overhead protection, by barricading the impact area, or other effective means.

3.3 **Protective clothing**

3.3.1 **General Requirements**

Employees exposed to the hazards created by welding, cutting, or brazing operations shall be protected by personal protective equipment in accordance with the requirements. Appropriate protective clothing required for any welding operation will vary with the size, nature and location of the work to be performed.

3.3.2 Specified protective clothing. Protective means which may be employed are as follows:

- i. Except when engaged in light work, all welders should wear flameproof gauntlet gloves. The welding gloves should be dry and free from holes and grease.
- ii. Flameproof aprons made of leather, or other suitable material may also be desirable as protection against radiated heat and sparks.
- iii. Cotton clothing should be used while performing any gas cutting/welding. Outer clothing such as jumpers or overalls should be reasonably free from oil or grease.
- iv. Sparks may lodge in rolled-up sleeves or pockets of clothing, or cuffs of overalls or trousers. It is therefore recommended that sleeves and collars be kept buttoned and pockets be eliminated from the front of overalls and aprons. Trousers or overalls should not be turned up on the outside.

Note: For heavy work, fire-resistant leggings, high boots, or other equivalent means should be used.

- v. In protection work a sheet metal screen in front of the worker's legs can provide further protection against sparks and molten metal in cutting operations.
- vi. Shoulder covers made of leather or other suitable materials should be worn during overhead welding or cutting operations. Leather skullcaps may be worn under helmets to prevent head burns.

3.4 **Ventilation and Protection in Welding and Cutting**

3.4.1 Mechanical ventilation. For purposes of this section, mechanical ventilation shall meet the following requirements:

- i. Mechanical ventilation shall consist of either general mechanical ventilation systems or local exhaust systems.
General mechanical ventilation shall be of sufficient capacity and so arranged as to produce the number of air changes necessary to maintain welding fumes and smoke within safe limits.
- ii. Local exhaust ventilation shall consist of freely movable hoods intended to be placed by the welder or burner as close as practicable to the work. This system shall be of sufficient capacity and so arranged as to remove fumes and smoke at the source and keep the concentration of them in the breathing zone within safe limits.
- iii. Contaminated air exhausted from a working space shall be discharged into the open air or otherwise clear of the source of intake air.
- iv. All air replacing that withdrawn shall be clean and respirable.
- v. Oxygen shall not be used for ventilation purposes, comfort cooling, blowing dust from clothing, or for cleaning the work area.

3.4.2 **Welding and Cutting in Confined Spaces**

- i. Relevant clauses of SG-03: 'Safety guideline for working in Confined space', shall be followed.
- ii. Either general mechanical or local exhaust ventilation meeting the requirements of clause 3.4.1 shall be provided whenever welding, cutting, or heating is performed in a confined space.
- iii. When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by air line respirators , and an employee on the outside of such a confined space shall be assigned to maintain communication with those working within it and to aid them in an emergency.

3.4.3 **Welding and Cutting of Metals of Toxic Significance**

- i. Welding or cutting in any enclosed spaces involving the metals specified in this subsection shall be performed with either general mechanical or local exhaust ventilation meeting the requirements of clause 3.4.1:
- ii. Zinc-bearing base or filler metals or metals coated with zinc-bearing materials.
- iii. Lead base metals
- iv. Cadmium-bearing filler materials
- v. Chromium-bearing metals or metals coated with chromium-bearing materials.
- vi. Welding or cutting in any enclosed spaces involving the metals specified in this subdivision shall be performed with local exhaust ventilation in accordance with the requirements of clause 3.4.1, or employees shall be protected by air line respirators.
 - a) Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;

- b) Cadmium-bearing or cadmium-coated base metals;
 - c) Metals coated with mercury-bearing metals;
 - d) Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.
- vii. Employees performing such operations in the open air shall be protected by filter-type respirators. Except that employees performing such operations on beryllium-containing base or filler metals shall be protected by air line respirators.
 - viii. Other employees exposed to the same atmosphere as the welders shall be protected in the same manner as the welder or burner.

3.4.4 Inert Gas Metal Arc Welding

Since the inert-gas metal-arc welding process involves the production of ultra-violet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process until the following special precautions have been taken:

- i. The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.
- ii. Employees in the area not protected from the arc by screening shall be protected by filter lenses. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.
- iii. Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and free of highly reflective surfaces.
- iv. When inert-gas metal-arc welding is being performed on stainless steel, the requirements of clause 3.5.3 shall be met to protect against dangerous concentrations of nitrogen dioxide.

3.4.5 General Welding and Cutting

- i. Welding or cutting jobs not involving conditions or materials described in clauses 3.4.2, 3.4.3, and 3.4.4, may normally be done without mechanical ventilation or respiratory protective equipment, but where, because of unusual physical or atmospheric conditions, an unsafe accumulation of contaminants exists, suitable mechanical ventilation or respiratory protective equipment shall be provided.
- ii. Employees performing any type of welding or cutting shall be protected by suitable eye protective equipment.

3.5 Welding and Cutting in Way of Preservative Coatings

- 3.5.1 Before welding or cutting is commenced on any surface covered by a preservative coating whose flammability is not known, a test shall be made by a competent person to determine its flammability. Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity.
- 3.5.2 Precautions shall be taken to prevent ignition of highly flammable hardened preservative coatings. When coatings are determined to be highly flammable, they shall be stripped from the area to be heated to prevent ignition.
- 3.5.3 Protection against toxic preservative coatings:
 - i. In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators.
 - ii. In the open air, employees shall be protected by a respirator.
- 3.5.4 The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the un-stripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

3.6 Checking, Corrective & Preventive Action

Departmental HOD shall ensure implementation and regular compliance of above procedure through periodic interaction with manager/Operators/Contractors and review of work permits system records. In case of any deviation, corrective and preventive action shall be immediately undertaken.

3.7 RECORD

- i. Concerned Sectional In-charge shall maintain record of work permits for Hot Job for at least one year.
- ii. Record for Incident/Accident is to be maintained at the department and is also available at Safety Department for at least five years.
- iii. Ensure if all persons left the place. They are informed not to return / restart work without a fresh permit.

Monitoring & Reviewing

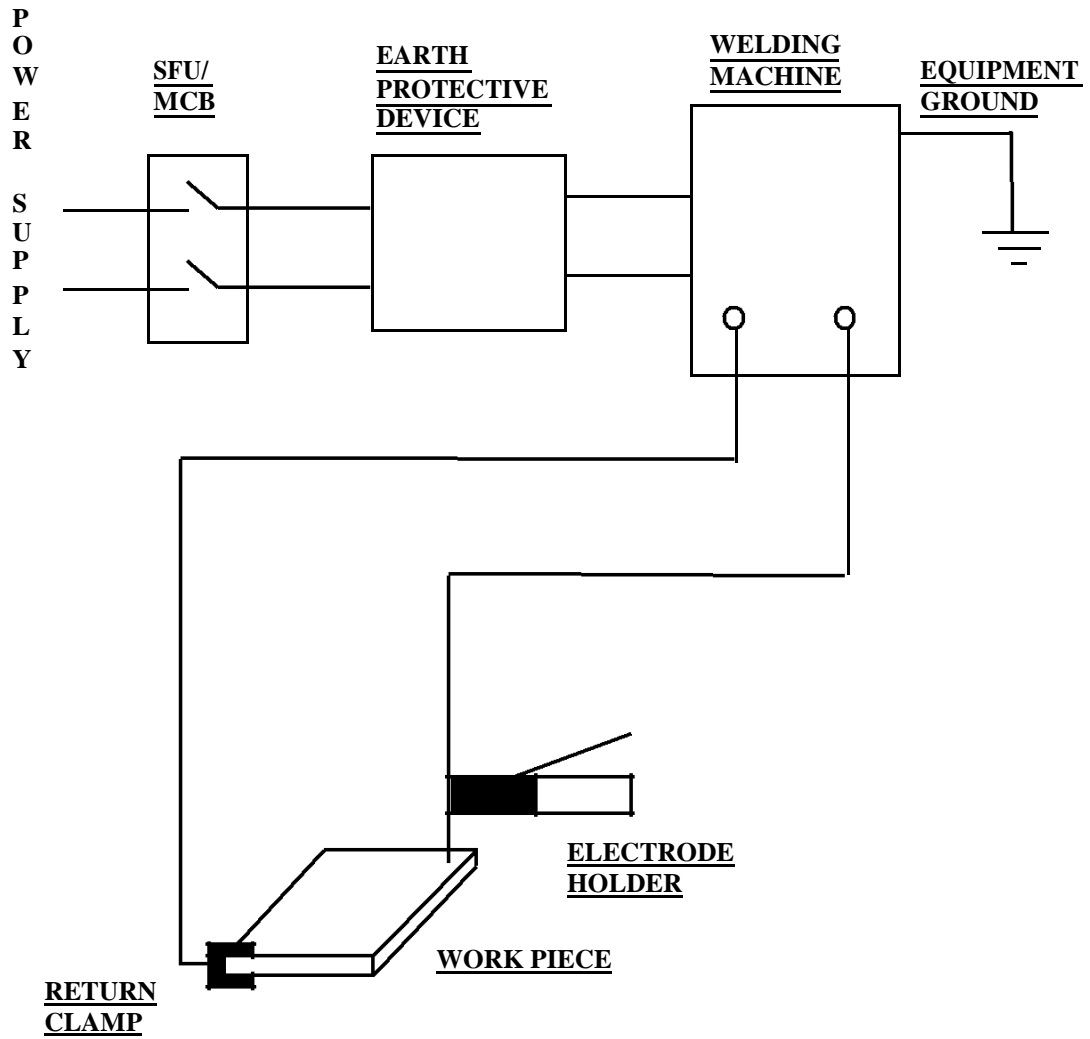
Frequency	Mechanism	Record	Responsibility
Daily	Inspection of work permit issue	Record of work Permit	All Contractors, Consultant Contractors

REFERENCE:

1. IPSS 1-11-020-15: Safety Procedure for Welding & Cutting
2. IPSS 1-11-017-12: Safety Procedure for Gas Cutting by Regular/ Contractor Workers

Electrical Circuit Diagram of Welding

NOTE- VRD Should be placed after the welding machine and before the electrode holder and return clamp



Checklist for Arc Welding and Cutting

Sl. No.	Points	Yes	No	NA
1.	Is work permit issued to working agency before start of the job?			
2.	Is the additional work permit issued to the agency if the job is to be carried out at height (more than 2 meter)/ confined space/ gaseous hazardous area/ near electrical installations?			
3.	Do all the manual transformer based welding machines contain manufacturer's name & detail technical specifications?			
4.	Are the falling of spatters from height prevented by proper barricading?			
5.	Are all welding & cutting cables completely insulated, flexible type and capable of handling the maximum current requirement of the work?			
6.	Are all the exposed portion of the cable protected by suitable rubber and friction tape or other equivalent insulation?			
7.	Are all frames of arc welding and cutting machines grounded properly?			
8.	Is the wesguard safety device put in place, where required?			
9.	Are the fire extinguishers available in the working area with readiness for use?			
10.	Is there proper ventilation system in place, when the welding & cutting job is performed in confined space?			
11.	Is the flammability test conducted if welding or cutting to be done on the surface covered by preserve coating?			
12.	Is the working area free from all inflammable materials?			
13.	Are all the work permits for hot job recorded?			
14.	Is there an arrangement for collecting spatters at the source?			
15.	Is IR (Insulation, Resistance) value of the welding machine > 2M-Ohm, measured with 500 Volt Megger?			
16.	Is the welding machine connected with separate circuit breaker or Switch Fuse Unit (SFU)?			
17.	Is the earth leakage protective device used?			