

Laser Cutting Machine Safety Guide

(For employers and employees)



This safety guide is an English translation of Japanese safety guide based on Japanese laws and regulations.
Please comply with your country's laws and regulations if you are outside of Japan.



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Preface

This safety guide provides employers and employees with important general safety information they should know when they use laser cutting machines. Safety information for using laser cutting machines is also available in the operator's manuals of laser cutting machines and the warning labels affixed to laser cutting machines. Before you use your laser cutting machine, fully understand all of these pieces of safety information.

When your laser cutting machine is combined with a CNC turret punch press, also see the CNC Turret Punch Press Safety Guide. The CNC turret punch press belongs to the category of power presses (automatic presses) in the Industrial Safety and Health Act.

The safety guide describes residual risks of laser cutting machines. Fully recognize risks associated with machine installation, worksheet setup, machine operation, inspection, cleaning and maintenance, and other associated tasks. Implement risk reduction initiatives to suit the environment of your shop and the methods of using your machine, and conduct safety education for your workers at your responsibility as employer. The Industrial Safety and Health Act states that employers must take machine safeguarding measures. (See "Responsibilities of employer" on the next page.)

For risk reduction procedures by the employer, refer to the "Guidelines for the Comprehensive Safety Standards of Machinery" published by the Ministry of Health, Labour and Welfare (LSB Notification No. 0731001, revised on July 31, 2008). To see the guidelines, go to the website of the Japan Industrial Safety and Health Association (<http://www.jaish.gr.jp>), click the "Laws, Regulations and Notifications" button, enter "No. 07310001", and find the LSB Notification No. 0731001.

When a safeguarding device is retrofitted to your already installed machine, modification of the machine and its control may be required. When you study what safeguarding devices to adopt, please contact AMADA.

(1) Responsibilities of employer

The Industrial Safety and Health Act, Ordinance on Industrial Safety and Health and Radio Act impose certain obligations on the employer who uses the laser cutting machine. To protect from laser hazards those employees who are constantly engaged in jobs that involve the use of laser equipment or exposure to laser beams, the Summary of Measures for Preventing Laser Beam Hazards was formulated under the LSB Notification No. 39 of the Director-General of the Labour Standards Bureau of the then Ministry of Labour on January 27, 1986 and revised by the LSB Notification No. 0325002 on March 25, 2005. The summary provides detailed instructions for the protection of employees from laser hazards.

(1) Appointing laser safety officer

Establish an occupational health management system under the Industrial Safety and Health Act. Also appoint a laser safety officer from among employees with sufficient knowledge and experience about the operation of laser cutting machines and about the prevention of laser beam hazards. The duties of the laser safety officer are specified in the notification "Summary of Measures for Preventing Laser Beam Hazards" by the Director-General of the Labour Standards Bureau, Ministry of Health, Labour and Welfare.

(2) Duties of laser safety officer

- Preparation and implementation of plans for measures for protecting employees from laser beam hazards.
- Set and control the laser controlled area (area where operators are likely to be exposed to laser beams from the laser cutting machine).
- Control keys and other devices for operating the laser cutting machine.
- Inspect and maintain the laser cutting machine, and keep the inspection and maintenance records.
- Inspect and maintain personal protective equipment, and monitor the usage conditions of personal protective equipment.
- Conduct occupational safety and health education and keep the education records.
- Take measures for preventing laser beam hazards.

When you must appoint a health and safety officer at the workplace, you must have the duties of the above-mentioned laser safety officer performed under the supervision of the health and safety officer.

(3) Implementation of safety and health education

Provide education under Paragraph 1 or 2 of Article 59 of the Industrial Safety and Health Act and Article 35 of the Ordinance on Industrial Safety and Health when you employ operators for laser operations, change the job content of operators and engage them in laser operations, or change the laser cutting machine to use. The safety and health education must cover the following:

- Nature, hazardousness and harmfulness of laser light
- Principle and construction of laser cutting machine
- Operating methods of laser cutting machine
- Performance and operating methods of safeguarding devices and personal protective equipment
- Emergency measures and evacuation

(4) Appointing laser operators

- Appoint laser operators from among operators given safety and health education described in (3) above.
- Prohibit the operation of keys on control panels by other than the appointed laser operators and laser safety officer. This also applies to the setup and maintenance of the laser cutting machine.
- Operate the laser cutting machine by following the precautions and procedures described in the operator's manual supplied with the laser cutting machine.
- Installation and repair tasks not described in the operator's manual are potentially hazardous. Do not allow such tasks to be performed by unqualified operators. Report these tasks to the laser safety officer, have them performed by expert operators who have received special education and training, or ask the AMADA service engineer to perform them.

(5) Application for permission to use high-frequency utilization equipment

- Apply to the Regional Bureau of Telecommunications for permission to use the oscillator as high-frequency utilization equipment. (Article 100-2 of Radio Act)

(6) Investigation of hazardousness, harmfulness, etc.

- Investigate the hazardousness and harmfulness of tasks and duties (or assess the risks of tasks and duties). Take necessary measures to prevent hazards to workers or prevent the health disorders of workers. (Article 28-2 of Industrial Safety and Health Act)
- For data concerning residual risks peculiar to specific machines and required to perform risk assessment, contact AMADA.

(7) Implementation of safeguarding measures at your responsibility as employer

- Take necessary measures to prevent the following hazards (Article 20 of Industrial Safety and Health Act):

1. Hazards due to machines, devices and other equipment (hereinafter referred to as machines, etc.)
2. Hazards due to explosive materials, ignitable materials, flammable materials, etc.
3. Hazards due to electricity, heat and other energy sources

- Take necessary measures to prevent the following health disorders (Article 22 of Industrial Safety and Health Act):

1. Health disorders due to raw materials, gases, fume, dust, oxygen-deficient air, pathogens, etc.
2. Health disorders due to radiation, high temperature, low temperature, ultrasonics, noise, vibration, abnormal air pressure, etc.
3. Health disorders due to instrument monitoring, precision machining, etc.
4. Health disorders due to exhaust gases, waste solutions or waste residues

- When the stroke ends (travel ends) of the machine are liable to cause hazards to operators, take necessary measures to prevent the hazards. (Article 108-2 of Ordinance on Industrial Safety and Health, enforced on July 1, 2011)

(2) Principle of laser cutting

Mechanism of laser cutting (oxygen cutting)

Iron is an easy-to-burn material. Once it starts to burn, it generates a large amount of the heat of reaction and continues to burn unless extinguished manually. This phenomenon is utilized by gas cutting.

Laser cutting is a machining process that forcibly removes the material by using the reaction of oxidation with a laser heat source and by using an assist gas.

With the laser cutting of mild steel, a laser beam is delivered by mirrors and a fiber to the cutting spot, and focused and irradiated by a lens on the worksheet. The worksheet surface is rapidly heated to a temperature well above the ignition point. A molten puddle is formed as a result. Injection of the assist gas (oxygen gas) into the molten puddle forms a hole there by the oxidation reaction. As the laser beam is moved, the kinetic energy of the injected assist gas and the oxidation reaction with the oxygen gas forcibly remove the material successively in the depth direction and form a continuous cut groove. Laser cutting makes use of this principle.

Roles of assist gas

The assist gas has the roles of generating the heat of oxidation reaction and removing the molten metal from the cut groove (kerf). It also prevents the contamination of the cutting lens and cools the cutting lens.

If spatter (metal particles scattered at high speed from the molten puddle) and fume (metal vapor) build up on the cutting lens, the laser beam is absorbed by the contaminated area as it passes through that area. The consequent temperature rise of the cutting lens changes its refractive index and laser focusing capability. This is called the thermal lens effect and is one of the main causes of cutting defects. Further contamination quickly raises the temperature of the lens, pushes up the laser absorption coefficient of the lens, and further increases the laser absorption. Eventually, the lens is damaged or broken by the thermal stress. This is called the thermal runaway.

Keeping the lens clean is most important to arrest the thermal runaway. How to cool the lens is also important. The most effective cooling method is to cool the lens with water. Water cooling is possible around the lens, but not at the center of the lens where the laser light passes. The lens is instead cooled with the assist gas.

(3) Types and hazards of lasers

Types of lasers

- Carbon dioxide (CO₂) laser

A discharge tube is formed between two opposed mirrors that comprise a resonator. A gas mixture laser medium of CO₂, N₂ and He is injected into the discharge tube. The gas molecules are excited by the discharge. The laser light resonates between the mirrors and is amplified. The amplified light is removed from a partially transmitting mirror designed to transmit some of the light.

- Fiber laser

The fiber laser is a laser that uses a fiber (waveguide) as laser oscillator. Mirrors are not used. A diffraction grating, called the fiber Bragg grating (FBG), is formed. The FBG reflects particular wavelengths of light and serves as the resonator mirror. Usually, a semiconductor laser is used for excitation.

- Guide lasers (He-Ne laser and semiconductor laser)

A He-Ne laser is a gas laser that uses a He-Ne gas mixture as laser medium. Visible He-Ne lasers are available in green, yellow and orange colors, depending on their wavelengths. A red He-Ne laser is most popular.

A semiconductor laser consists of semiconductor PN junctions. When electric current is injected, positively charged holes and negatively charged electrons combine to produce a laser light. The laser light is passed back and forth in the resonator and amplified. Blue, blue violet and red visible laser lights are produced, depending on wavelengths.

Visible He-Ne and semiconductor lasers are used as guide lasers for checking the cutting position during setup, etc.

Hazards of lasers to human body

The carbon dioxide laser has a wavelength of 10.6 μm and is invisible to the human eye. The CO₂ laser light is absorbed well by water. When it enters the eye, it may burn the cornea. When direct or scattered CO₂ laser light shines on the skin, it may burn the skin.

Fiber lasers have a wavelength of 1.06 to 1.08 μm and are invisible to the human eye like CO₂ lasers. When the fiber laser light strikes the eye, it passes through the cornea and lens. When the light is focused on the retina by the lens action of the cornea and lens, it may do serious damage to the retina. When the skin is exposed to direct or scattered fiber laser light, it may be burned as done by the CO₂ laser light. The burn may penetrate deeper.

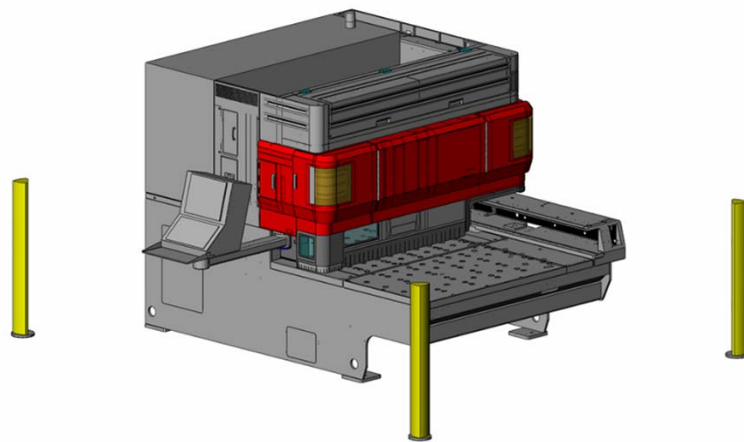
He-Ne lasers and semiconductor lasers have a wavelength of 0.6 to 0.7 μm and are visible to the eye. When these laser lights fall on the eye, they pass through the cornea and lens, and may damage the retina.

On laser cutting machines that use the lasers described above, operator safety is ensured by protective devices or shield devices composed of special windows to absorb specific laser light wavelengths, safeguarding devices to provide a safety distance, and protective goggles to protect the eyes. Every day, check all protective devices, safeguarding devices and personal protective equipment for holes, burn marks and other defects.

(4) Hazards of laser cutting machines

Hazards of toxic gases to human body

- When polyvinyl chloride is laser cut, it releases toxic hydrogen chloride gas. This toxic gas powerfully corrodes equipment. Do not laser cut polyvinyl chloride.
- The laser cutting of nylon and polyurethane generates toxic hydrogen cyanide gas. Do not laser cut them.
- When laser cut, plastics produce carbon monoxide and other toxic gases. When you laser cut materials whose safety is not verified, ask their manufacturers if they generate toxic gases and dust and if they present fire or explosion hazards. When you laser cut such materials, take necessary measures on your own responsibility.



Fire hazards

A fire occurs only when three conditions, a heat source, oxygen and a combustible material, are all combined. Of these conditions, the heat source is molten spatter from laser cutting or the laser light itself. Oxygen is used as assist gas. Effort must be made to eliminate the combustible material.

- Do not bring combustible materials around the laser cutting machine.
- Constantly watch for the occurrence of a fire during laser cutting. Install a fire extinguisher against fire emergency.
- Oil, dust and protective film powder built up on the brush table and conveyor may burn. Check and clean the brush table and conveyor every day.
- Failure to clean the dust collector filter or dust box may lead to a fire. Some dust collectors come with a fire extinguishing function. Contact AMADA for such a dust collector.
- Be sure to install your laser cutting machine in a fire-resistant shop building.
- If you continue to operate the laser cutting machine for many hours of marking or with cutting defects uncorrected, there may be a fire hazard due to reflected laser light. Pay attention to this possibility.
- Do not laser cut acrylics, plywood, and other combustible materials. Doing so always carries a risk of fire.
- Do not cut film-coating materials (including paper and resin) with oxygen assist gas since it might cause a fire accident.

Dust explosion hazards

Dust from laser cutting presents dust explosion hazards as well as fire hazards. Dust explosions occur the instant three conditions, oxygen, dust above the lower explosion concentration and minimum ignition energy, are all met. If dust is accumulated, the first dust explosion scatters the accumulated dust and may develop into a secondary explosion of greater scale.

- Clean scrap boxes, pre-boxes, and dust collector dust boxes every day.
- Dust from the laser cutting of magnesium and magnesium alloys has the highest risk of dust explosion. Do not laser cut magnesium and magnesium alloys.

Thermite reaction hazards

When a mixture of dust with aluminum and iron oxide or other oxide ignites from some cause, the aluminum generates high heat and explodes. This is called the thermite reaction and is a very dangerous chemical reaction.

- Dust from the laser cutting of titanium, aluminum, zinc and their alloys causes the dangerous thermite reaction when mixed with dust of oxidized iron or copper. Use dedicated machines for laser cutting specific materials, completely remove the dust before and after laser cutting other materials, and control so that dusts from laser cutting of different materials do not mix together. When these metal dusts react with water, they generate high heat and hydrogen gas and also present the risk of explosion. Never use water on metal fires. Be sure to install fire extinguishers for metal fires.

Hazards of machine's moving parts to human body

Enclosures, fences, light curtains and other safeguarding devices are required to prevent the moving parts of the laser cutting machine from impacting or crushing the operator's body parts while the laser cutting machine is operating. When worksheets overhang the table during repositioning, for example, it is necessary to install an auxiliary table. Optional safeguarding devices are available. Contact AMADA.

Request for provision of accident information

On April 15, 2014, the Labour Standards Bureau of the Ministry of Health, Labour and Welfare issued the LSB Notification No. 0415-1 "Procedure for Promoting Provision of Disaster Information, etc., from Machine Users to Machine Manufacturers, etc."

The notification obligates machine manufacturers to clearly state contact points, contact methods and accident information and other contact items in instruction manuals, etc., and machine users to furnish information to machine manufacturers and to take measures for preventing the recurrence of accidents, etc., in coordination with machine manufacturers.

Following the notification, AMADA intends to collect accident information from our customers and use it to prevent the recurrence of similar accidents with our machines and to promote greater safety in the design and manufacturing stages of our machines. We kindly ask for your cooperation.

(1) Contact point

Report accident information, etc., by telephone or otherwise to our sales office service center in your area.

(2) Information to be provided

Furnish to us accident information concerning the contact items described in the following accident report.

Accident report

Date reported:	● Overview of accident
Classification of accident: 1. Occurrence or likelihood of injury or fatal accident 2. Occurrence or likelihood of fire accident	Date and time of accident occurrence: [Injury or fatal accident]
● Customer	Victim: 1. Operator 2. Other than operator ()
Company name (department name):	Sex (age): 1. Male 2. Female () years old
Name (position):	Accident situation (body part and degree of injury):
Address:	[Fire accident] Ignition source and ignited material (if determinable): Burnt range:
Telephone number:	Work and process leading to accident:
Fax number:	
E-mail address:	Usage of protective equipment:
● Amada machine used (Information stamped on serial number plate)	
Model:	Comment from customer:
Manufacture number:	
Manufacture date:	



AMADA hopes that this safety guide book will help you to provide a safe workplace for your laser cutting machine operators. If you have something to know about the safeguarding of laser cutting machines or need other information or proposals, contact AMADA.

You can also see this safety guide on our website.

<http://www.amada.co.jp/>

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