BASIC OF LASER SAFETY

Work Instruction: '000-1-WI-011	Version: 01	Page: 1/8	Effective date: 7-Jul-2008

1. PURPOSE.

In order to provide knowledge for employee to ensure safety when employee worked with Laser machine

- Identifying underlying causes and potential hazard.
- Review existing controls, measures and procedures to ensure adequacy of systems which protect health and safety in the workplace.
- Recommend prevented action which can improve efficiency.

2. APPLICATION.

This Work Instruction applies to all sections.

3. TERMS AND DEFINITION.

Laser: Light **A**plification By **S**timulated **E**mission of **R**adiation

4. REFERENCE.

KEYENCE: Safety Precaution of 3-Axis CO_2 Laser Marker

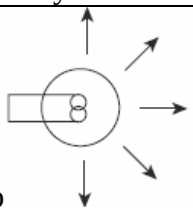
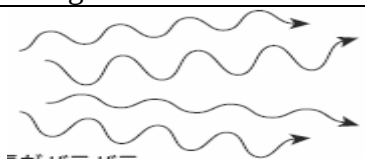
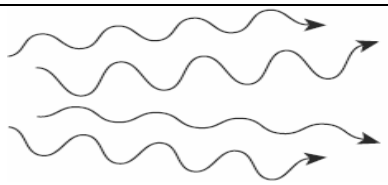
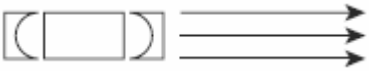
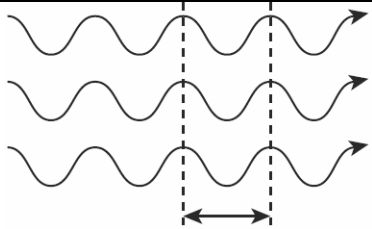
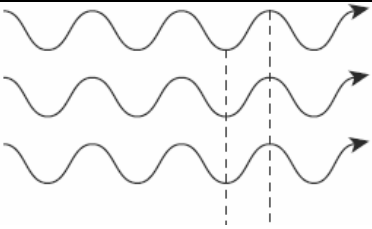
5. CONTENT.

5.1PRINCIPLE OF LASER OSCILLATION

5.1.1 MERIT OF LASER

❖ The difference between LASER and normal light:

- Advance in directivity:Light beam from LASER is almost transmit straightly without spread. In case of normal lamp, it transmites every directions
- Advance in single colour: LASER is only colour (wavelength and harmonic wave). In case of normal lamp, it transmites by mixed combined various colours
- Advance in coherence: due to laser light is evened mountain and valley shapes, the amplitude can obtain a big wave (big output) based on this wave synthensis

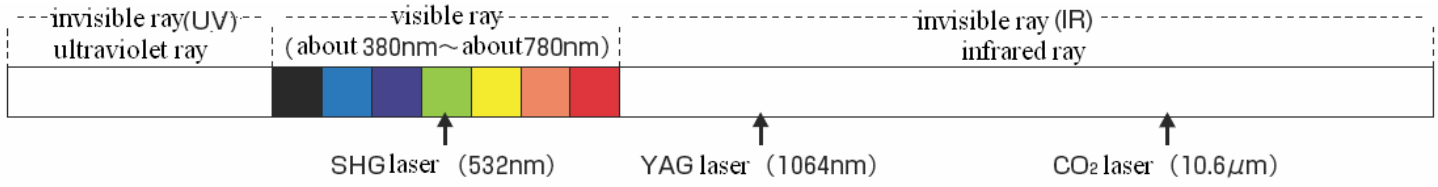
	Directivity	Straight line advancement	Coherence
Normal light	 Lamp	 Various wavelengths	
Laser light	 Laser	 Uniform wavelength	 Evened mountain and valley shapes

Checked by: Mr. Matsunaga Date: 7/ Jul/ 2008	Approved by: Mr. Dep Date: 7/ Jul/ 2008
Prepared by: Nguyen Quoc Tuan	Date: 6/ Jul/ 2008

Wavelength of LASER: Laser marker for production

There are 2 kinds of Laser marker: YAG (YVO_4) laser marker and CO_2 laser marker. The difference between these 2 laser markers is wavelength:

- YAG(YVO_4) laser marker' wave length →1,064nm (standard wavelength)/ 532nm (SHG)
- CO_2 laser marker's wavelength→10.6μm



Due to the YAG(YVO_4) laser marker' wavelength is shorter than the CO_2 laser marker's, its reflection ratio to metal surface is lower, it become easier to operate on metal surface. On the other side, due to the CO_2 laser marker' wavelength is longer, it easy be absorbed by transparent things such as glass, so it is used for letter printing of transparent things

5.1.2 KINDS OF LASER

Laser is divided 3 states as:

Vapor	Solid	Liquid
CO_2 He-Ne (Helium neon) Ar (Argon)	YAG YVO_4 LD (semi-conduction)	Dye

A. CO_2 Laser:

CO_2 Laser is mainly used in processing machine and Laser marking

Laser wavelength is 10.6μm with invisible infrared rays. Beside CO_2 is in the oscillation tube, N_2 (Nitrogen) is fix quantity combined with He (helium) and enclosed tightly

N_2 helps CO_2 increase energy, conversely He helps it decrease to the status be stable

B. YAG laser (Nd:YAG)

C. YVO_4 laser (Nd:YVO_4)

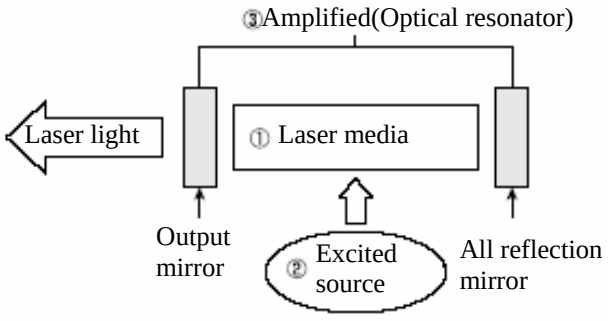
Structure of Oscillation tube: 3 elements of Laser

Whole tube is composed from 3 elements as below:

①. Laser media

②. Excited source

③. Amplified



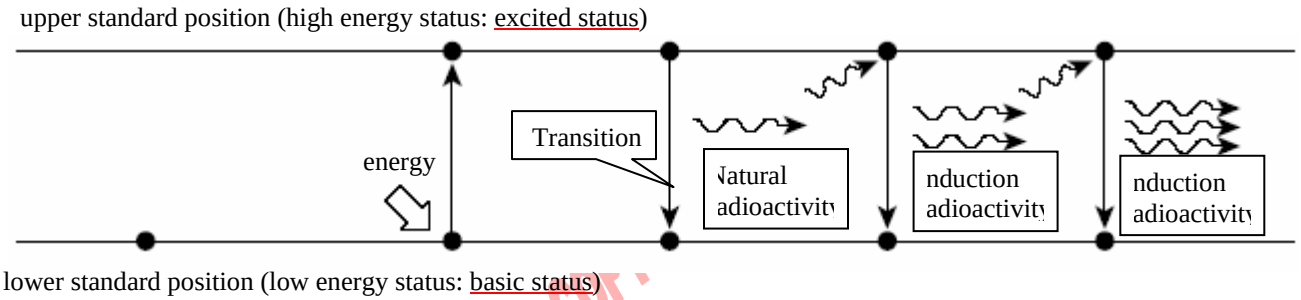
3 elements of laser marker:

	ML-G9300/ ML-Z9500 Serial	MD-H9800 Serial	MD-V9600A/MD-V9900/ MD-S9900 Serial
Laser media	CO_2 (vapor state)	YAG (Solid state)	YVO4 (solid state)
Excited source	Electric discharge	Light (LD)	
Amplified	Optical resonator		

5.1.3 PRINCIPLE OF LASER OSCILLATION

1. When atom (molecule) absorbs energy from outside, it will move from the lower energy standard position (basic status) to . This status is called “excited status”
2. This excited status is unstable, therefore it will return to the lower energy standard position immediately. This is call transition
3. At the moment, due to the difference of energy equivalent light is discharged. This is called natural radioactivity radio
4. The radioactive light activates to be the same the other atoms which exist in excited status to induce similar transition

The radioactive light which be induced is called induction radioactivity



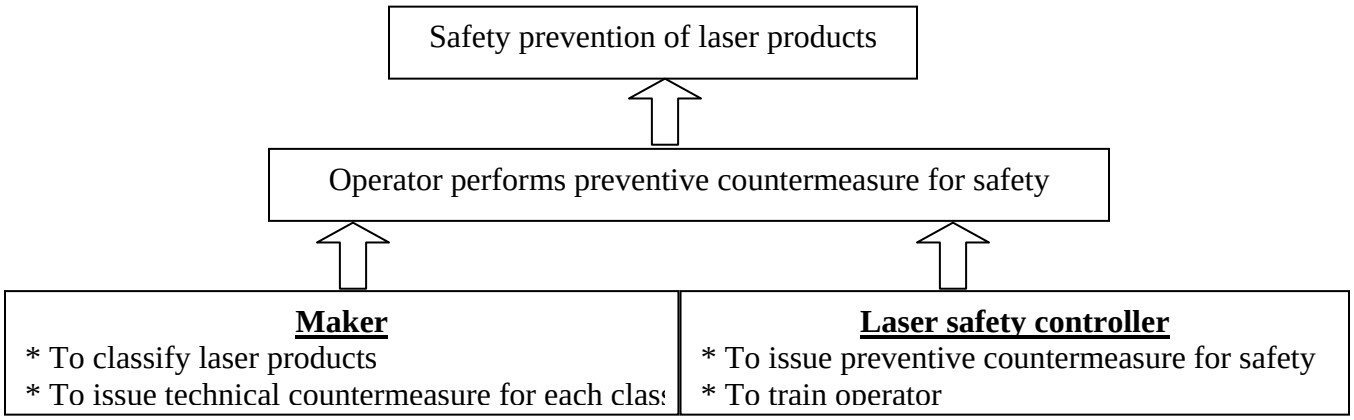
5.2 SUMMARY OF LASER SAFETY COUNTERMEASURES

5.2.1 How to think of Laser safety

Purpose: the JIS C6802 purposes to prevent in advance harmful to user based on laser products
Safety protection for laser is a thing to make the user recognizes exactly latent dangers of laser products, applies functions of safety countermeasure and realizes decided procedure exactly

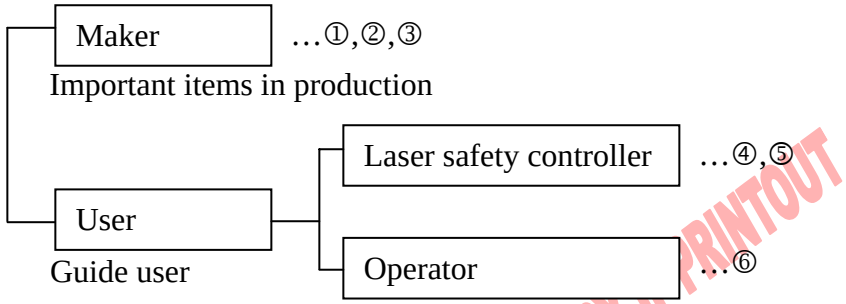
5.2.2 About prevention of laser safety

Preventive ation for safety countermeasure:
The partipators in laser products are marker and user, but the user must be divided 2 sides: safety controller and operator
The summary to should be done for laser safety as follows:



- Preventive countermeasure for safety of the marker
  - Classify laser products
  - To issue technical countermeasure for each class
  - To offer necessary information

- Preventive countermeasure for safety of the user (To guide the user)
  - To issue preventive countermeasure for safety
  - To train operator
  - To perform preventive countermeasure for safety



Classification of laser products

- IEC 60825-1

IEC 60825-1 is specification to stipulate for safety of laser products. Classification standard and Classification jugdement standard were revised by EIC commission in 2001. Based on these revisions, class 1M, class 2M and class 3R were established and added.

Additionally, JIS C6802 concerning safety standard be also revised in Jan.2005

Therefore, laser class standard must be fixed with IEC specification
CO_2 laser marker (serial ML-G9300, serial ML-Z9500), YAG laser marker (serial MD-H9800) and YVO_4 laser marker (serial MD-V9600A/ MD-V9900/ MD-S9900) are classified in laser class 4

- Summary of requested items and classification based on IEC

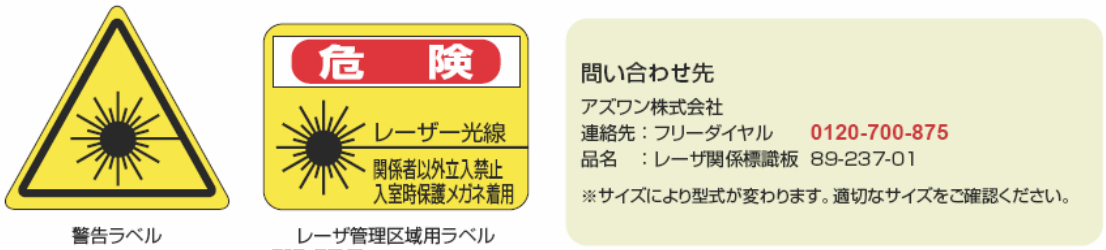
Laser class	Class positioning
Class 1	safety laser under normal operation condition (anticipatable operation condition)
Class 1M	latent dangers through using optical machine to view directly laser light with wavelength 302.5~4,000nm. Transmitted level of laser is class 1
Class 2	With wavelength 400~700nm, visible laser light can make eyes be reacted (wink)when watching directly, eyes protection is neccessary
Class 2M	With wavelength 400~~700nm, as same as class 2, but more considering to latent dangers when using optical machine to watch directly laser light
Class 3R	Latent dangers when watching directly beam, with laser light wavelength 302.5~106nm
Class 3B	Danger when watching directly laser light, but its reflection is safe
Class 4	It is danger to eyes and skin in case of watching not only optical beam directly but also its reflection light. It be considered as a cause of catching fire

5.2.3 Guiding the user:

- Preventive countermeasure for safety:
  Preventive countermeasure for safety be performed for laser production, but it can be applied to the user with its function when first period of using. Products that conformed with C6802 is not meaning “it is safe itself”, it only notes fuctions of preventive countermeasure for safety as stipulation

  The explaination for laser product user about standard of safety control and prevention is as below: (Please refer JIS C6802-safety standard of laser product- for more detail)

- Using remote interlock
  Please set inter lock in order to stop laser transmit when trouble
- Key control
  Safety controller keeps the key to avoid using without permission
- Setting control area and warning sign:
  Post warning sign at entrance door to pay attention to concerned person and outside person



警告ラベル　　レーザ管理区域用ラベル

Due to laser ray from laser product has heat- radiating and spread reflection, please terminate uneccessary part and do not use mirror

- Safety wearing:
  In order to avoid the laser reflection light touches to skin, or normal clothes, please wear fire proof clothes when operating
- Eye protection:
  Use protective eye-glasses when operating or performing maintenance
  Protective glasses: choose protective glasses with suitable wavelength of laser light (Serial MD-H9800/ MD-V9600A/ MD-V9900 are used for YAG laser (wavelength 1064nm), serial MD-S9900 is used for SHG laser (wavelength: 532nm), serial ML-G9300, ML-Z9500 are used for CO_2 laser (wavelength 10.6μm)
  Protective film:
  In case of YAG laser, laser window can terminate laser light by protective film

Protective glasses

Laser window

- Device of exhause:
  Set the system of exhause for poison gas occured by laser printing
- Asign person to control laser safety

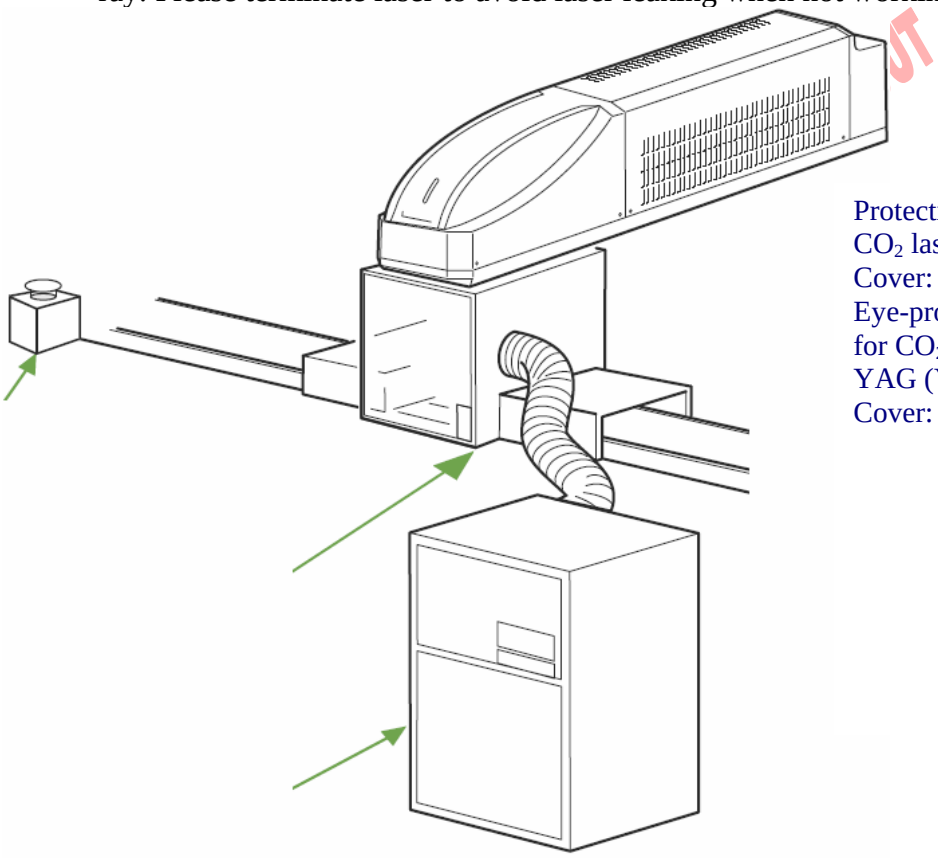
The person be asigned to control laser safety must have experience and knowledge in harmful by transmited laser .

Main responsibility of safety controller

1. To perform preventive countermeasure of laser transmit
2. To set area where affected with transmited laser
3. To control switch key
4. To confirm the maintenance and usage status of protective equipments
5. To train operator

Example for setting laser marker

The hoover should be set to collect dust and smoke from laser printing operation. Besides, in order to collect dust well and prevent laser reflection, please use non-transmission material to cover the laser ray. Please terminate laser to avoid laser leaking when not working



Protectivecover, eye-protection
CO_2 laser marker
Cover: acrylic sheet(thickness 5mm up)
Eye-protection: laser protective glasses for CO_2
YAG (YVO_4) laser marker
Cover: metal

❖ **Warning**

Please keep the rules as below to prevent causes of accident and harmful

1. Do not watch directly to laser light and dispesive reflection light
   (If watching laser light directly, it causes blear)
2. Do not touch directly to laser light, mirror reflection light, dispersive reflection light
3. During operating, operator must wear protective glasses.
   (Do not watch directly laser light and reflection light even wore protective glasses)
4. Do not take apart this product
   (If taking apart, it causes harmful to eye and skin by laser leaking and electric shock. Besides, the maker will refuse warranty or repair

5. Block the laser ray and reflection range
   Do not expose the laser light during laser printing. Please cover working area to avoid operator get in touch with laser light. Do not set the operation height as same as eyesight level
6. Please turn off the laser light when cleaning lens surface or performing maintenance, and remember wearing protective glasses
7. Do not implement any operation out of this instruction book

Harmful action:
When the laser ray illuminates human body, it causes protein denaturation, tissue of optical reaction and sonic boom (plasma stream and its pressure wave). Laser light, output wave shape (continuous wave and pulse wave) can make organism anomaly. And the harmful to eye is more serious than to skin. Beside harmful direct to organism, laser light is secondary bad effected to equipments and organisms around it

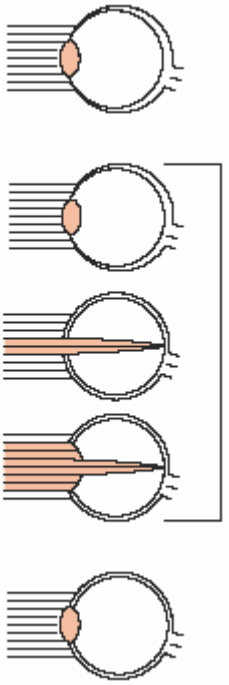
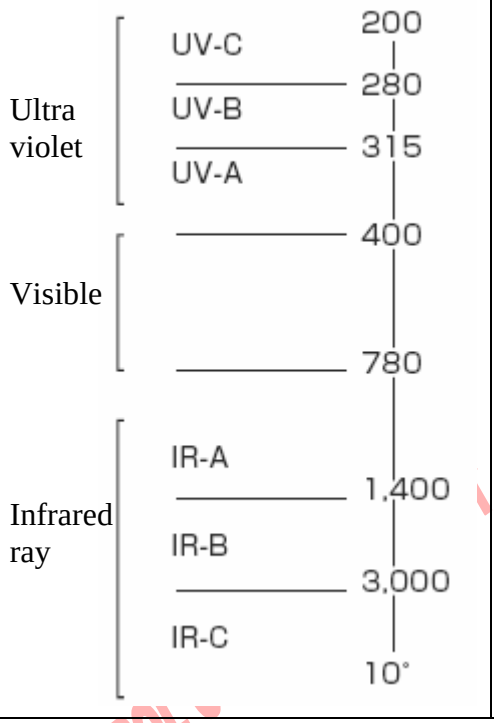
❖ **Eye harmful**

a. Argon laser, YAG laser, CO_2 laser, etc… transmite continuous wavelength and long pulse laser cause below harmful by heat radiating optical radiating

   - When the cornea, crytalline lens be absorbed laser light, which is outside of visible focus wavelength (ultra violet (200~400nm)and a part of infrared ray (1,400~1,600nm), it causes burn cornea, faculty of sight be reduced

   - When the cornea, crytalline lens be absorbed laser light, which is inside of visual focus wavelength (visible (400~780nm), a part of infrared ray (780~1,400nm)), light is condensed with density 105times on retina, it causes:
     + Burn retina (center or surround)by heat radiating due to absorbed continuous wave
     + Visual pigment of retina photoreceptor absorbed laser light, which visible wavelength about 430nm, it makes harmful to retina

b. YAG (Q-switch) laser, CO_2 laser transmite high peak power of short pulse can burn retina, bleeding eye, faculty of sight be seriuosly reduced by sonic boom

Eyeball absorbed	Wavelength area of CIE (nm)	Harmful/ effect to eye
 Area of visual focus		Cornea, conjunctiva be seriuos painful by optical radiating, heat radiating Crytalline lens be turbid by heat radiating Harmful to retina by visible optical radiating, or retina be damaged by heat radiating and sonic boom Burn cornea, cornea turbid by heat radiating

❖ **Skin harmful**

It causes feel off, erythema, foam, fever, carbonization

About the Acrylic sheet CO_2 transmission

Standard of material selection for covering laser machine

Based on AEL class 1 stipulated, dispersion and reflection laser light be safety if it meets below items.
In case of CO_2 laser (wavelength 10.6μm), AEL class 1 is $10^3 W/m^{-2}$

- Laser media…. CO_2 laser
- Wavelength…. 10.6 μm
- Maximum output…. 80W
- Spot diameter…. About ϕ60μm (ML-G9370)
- Spot area…. $2.82x10^{-9}m^2$ (calculated of ML-G9370 ϕ60μm)
- Ratio of Acrylic sheet CO_2 transmission… 60% (thickness 15μm)

REVISION HISTORY FORM

Date	Person in charge	Version	Revised contents	Reason	Requester
6 Jul 07	Nguyen Quoc Tuan	01	Established	New issue	Mr. Matsunaga