# TVL Series

Industrial Robot

**Robot controller TSL3100**
**Robot controller TSL3100E**
**Robot controller TS3100**

# INSTRUCTION MANUAL

## SAFETY MANUAL

**Notice**

1. Make sure that this instruction manual is delivered to the final user of Toshiba Machine's industrial robot.
2. Before operating the industrial robot, read through and completely understand this manual.
3. After reading through this manual, keep it nearby for future reference.

June 2014

**TOSHIBA MACHINE CO., LTD.**

This manual is applicable to the following robots.

TVL Series: TVL500, TVL700



The information contained in this manual is subject to change without prior notice to effect improvements.

# Preface

This manual describes the safety measures for the system robot TVL series built by Toshiba Machine. You are requested to read through this manual and handle the robot, strictly observing the instructions given throughout the manual, so that you can completely understand the performance of the robot and use its functions safely over the long years to come.

This manual consists of the following sections.

Section 1 Cautions on Safety
This section deals with the important information on using the robot safely and properly.

Section 2 Locations of Warning Labels
This section describes the locations of warning labels affixed to the robot and controller.

Section 3 Safety Measures
This section describes the safety functions of the robot and controller, and safety cautions on installing and operating the robot.

Section 4 Compliant Standards and Safety Performance
This section describes the compliant standards and safety performance of the robot.

**Cautions on Safety**

This manual contains the important information on the robot and controller to prevent injury to the operators and persons nearby, to prevent damage to assets and to ensure correct use.
Make sure that the following details (indications and symbols) are well understood before reading this manual. Always observe the information that is noted.

[Explanation of indications]

| Indication | Meaning of indication |
|---|---|
|  **DANGER** | This means that "incorrect handling will lead to fatalities or serious injuries." |
|  **WARNING** | This means that "incorrect handling will lead to fatalities or serious injuries." |
|  **CAUTION** | This means that "incorrect handling may lead to personal injuries *1) or physical damage *2)." |

*1) Injuries refer to injuries, burns and electric shocks, etc., which do not require hospitalization or long-term medical treatment.

*2) Physical damage refers to damages due to destruction of assets or resources.

[Explanation of symbols]

| Symbol | Meaning of symbol |
|---|---|
|  | This means that the action is prohibited (must not be done).<br>The details of the actions actually prohibited are indicated with pictures or words in or near the symbol. |
|  | This means that the action is mandatory (must be done).<br>The details of the actions that must be done are indicated with pictures or words in or near the symbol. |
|  | This means danger and caution.<br>The details of the actual caution are indicated with pictures or words in or near the symbol. |

[Operation]

| ! DANGER | |
|---|---|
|  Prohibited | • During operation, NEVER enter the dangerous area of the robot. Otherwise, you will be injured seriously. (The dangerous area means the robot working area where a hazardous situation may occur if a person gets in.)<br>• DO NOT leave in the working range any machinery or materials which will hinder the operation. If the equipment went wrong, a person nearby will be injured or involved in an accident.<br>• Anyone other than the operator MUST NOT approach the equipment. Should he negligently touch a dangerous part of the equipment, he will get injured or involved in a serious accident.<br>• NEVER perform an inappropriate operation which is not described in the instruction manual. Otherwise, the equipment will start by mistake, resulting in personal injury or serious accident. |
|  Mandatory | • If you feel even a little that you are exposed to danger or the equipment works abnormally, press the EMERGENCY stop pushbutton switch to stop the equipment. If the equipment is used as it is, you will be injured or involved in a serious accident. When this happens, ask our after-sale service agent for repair.<br>• During operation, be sure to close the equipment cover. Should the cover be opened during operation, you will be struck by an electric shock or get injured.<br>• Only a well-trained and qualified person is allowed to perform the operation. Should the equipment be operated improperly, it will start by mistake, causing a personal injury or serious accident.<br>• If the equipment has malfunctioned, turn the power off, identify and remove the cause of the abnormality, maintain the peripheral equipment and completely restore the malfunctioned equipment. Then start the equipment at a low speed. If the equipment starts, leaving the abnormality, you will be involved in a serious accident. |

| ! WARNING | |
|---|---|
|  Prohibited | • Do not enter the movable range of the robot. Otherwise, you may be seriously injured.<br>• Do not put your hands near the moving parts of the robot. Otherwise, you may be injured with your hands caught in the robot. |

| ! CAUTION | |
|---|---|
| Prohibited | • DO NOT change the data of the system parameter file (ROBOT.PAR, SERVO.PAR). Otherwise, the robot will operate abnormally, resulting in damage or an accident. |
| Mandatory | • In principle, teaching operation should be performed outside the dangerous area of the robot.<br>(The dangerous area means the robot working area where a hazardous situation may occur if a person gets in.)<br>If it should be performed inevitably within the dangerous area, strictly observe the following matters.<br>(1) The teaching operation should be always performed by two (2) persons. One person performs the job and the other person watches outside the dangerous area. Also, both persons should try to prevent mis-operation with each other.<br>(2) When performing the teaching operation in the dangerous area, the operator must carry the controller's master key switch and the teaching pendant in order to prevent a third person from operating the machine.<br>(3) The operator should do the job in an attitude ready to press the EMERGENCY stop pushbutton switch at any time. Also, he should perform the job at a position from which he can evacuate immediately at the time of an emergency after confirming the robot working range and shields nearby.<br>(4) The supervisor should keep watch on the job at a position where he can see the entire robot system and operate the EMERGENCY stop pushbutton switch at the time of an emergency. Also, he should keep anyone from entering the dangerous area.<br>• If an abnormality has generated or the POWER LED lamp on the control panel remains off after the main power switch of the equipment was turned on, turn off the main power immediately and confirm the wiring. Otherwise, you will be struck by an electric shock or a fire will break out.<br>• Unless the robot operates toward a designated direction at manual guide, turn off the servo power. Otherwise, the robot will be damaged or you will be involved in an accident. When this happens, call us at the after-sale service agent.<br>• Pushbutton operations of the control panel and teach pendant should be confirmed visually. Otherwise, you will be involved in an accident due to mis-operation. |

| CAUTION | |
|---|---|
|  Mandatory | • Before operating the equipment, perform the following inspection.<br>(1) Make sure that visual appearance of the robot, controller, peripheral equipment and cables is in good condition.<br>(2) Make sure that no obstacle stands in or near the operating range of the robot and peripheral equipment.<br>(3) Make sure that the emergency stop and other safety devices operate properly.<br>(4) Make sure that no abnormal noise or vibration is involved in the robot operation.<br>If the above prior inspection is skipped, the equipment will be damaged or you will be involved in an accident. |
|  Caution | • The speed of test operation is initially set at 20 % of the maximum robot speed, and is also limited to 250 mm/sec.<br>• The speed of automatic operation is initially set at 100 % of the maximum robot speed. |

[Installation and transportation]

Strictly observe the following items to use the robot safely.

| ! DANGER | |
|---|---|
|  Prohibited | • DO NOT install or operate the robot if any part is damaged or missing. Otherwise, electric shocks, fires or faults will be caused.<br>• DO NOT install the robot at a place where it is exposed to splash of water or other fluids. Otherwise, electric shocks, fires or faults will be caused.<br>• DO NOT place the robot near a combustible material. If it ignites due to a fault, etc., a fire will break out. |
|  Mandatory | • Always secure the robot with attached clamps before carrying it. Otherwise, you will be injured if the arm moves when the robot is lifted.<br>• Wire the robot after installation. Otherwise, electric shocks or injuries will be caused.<br>• Always use the line voltage and power capacity designated by Toshiba Machine. Otherwise, the equipment will be damaged or a fire will break out.<br>• Always use the designated power cables.<br>(For details, see the "Transportation and Installation Manual.")<br>If a cable other than the designated is used, fires or faults will be caused.<br>• Install the controller outside the dangerous area where the operator can always watch the robot movements. Otherwise, it is very dangerous should the robot start during the controller operation. |
|  Always ground | • Completely connect the grounding cable. Otherwise, electric shocks or fires will be caused if a fault or fault current occurs. Also, it could cause mis-operation by noise. |

| CAUTION | |
|---|---|
|  Prohibited | • NEVER lift the robot by the arm 1 duct cover or arm 2. Otherwise, an excessive force will be exerted on the robot mechanism, resulting in damage of the robot.<br>• For the controller, secure an ample space for ventilation. (For details, see the "Transportation and Installation Manual.") Otherwise, the controller will heat and go wrong. |
|  Mandatory | • When lifting the robot, lift it up slowly as the robot will tilt slightly. If it is lifted up suddenly, it will cause a very hazardous situation.<br>• When storing the robot, secure it to the base completely. If the robot is just placed on the floor, it becomes unstable and will fall down. |
|  Caution | • When operating the robot after long-hour stop at a low temperature (10°C or less), be sure to perform a continuous operation at a low speed (approximately 20 % of the maximum speed) for a few minutes. Otherwise, a motor overload error may occur due to solidified grease. |

[Maintenance and inspection]

Strictly observe the following items to use the robot safely.

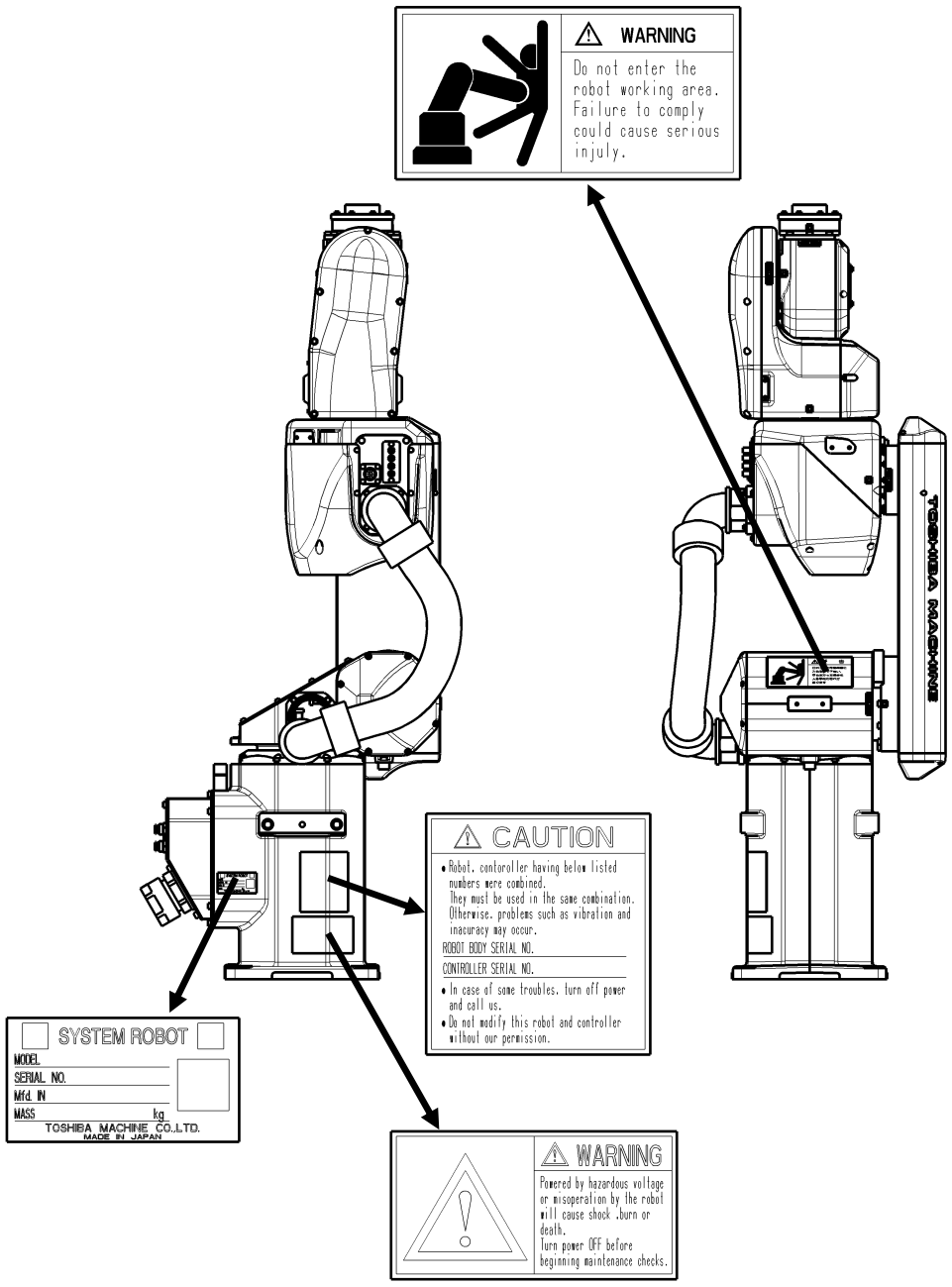
|  **DANGER** | |
|---|---|
|  Prohibited | • DO NOT incinerate, disassemble or charge the battery. Otherwise, it will rupture. |
|  Mandatory | • Be sure to turn off the main power of the controller before starting inspection or maintenance.<br>• When disposing of the battery, follow the user's provided regulations. |

|  **CAUTION** | |
|---|---|
|  Prohibited | • The user NEVER replace or modify parts other than those described in the instruction manual. Otherwise, the robot performance will deteriorate, or faults or accidents will be caused. |
|  Mandatory | • Always use the Toshiba Machine designated spare parts when replacing the parts.<br>• Perform maintenance and inspection regularly. Otherwise, the equipment will go wrong or you will be involved in an accident. |
|  Caution | • Each axis motor of the TVL series is equipped with a brake. Robot arm falls under its own weight when the brake is released. Be careful not to get your hand or leg caught in the robot. |

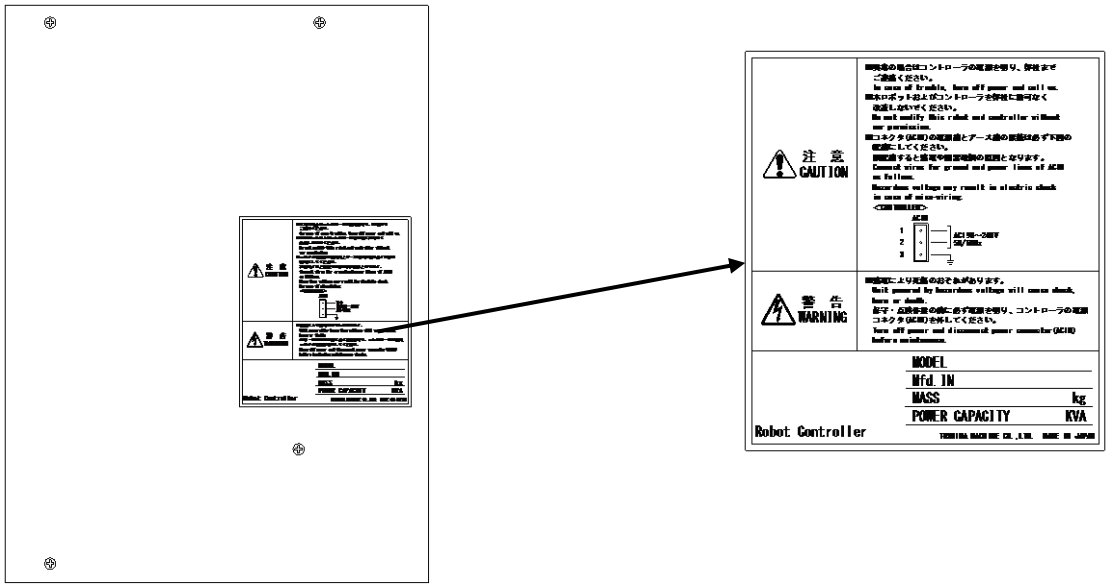
## Locations of Warning Labels

(1) Locations of robot warning labels

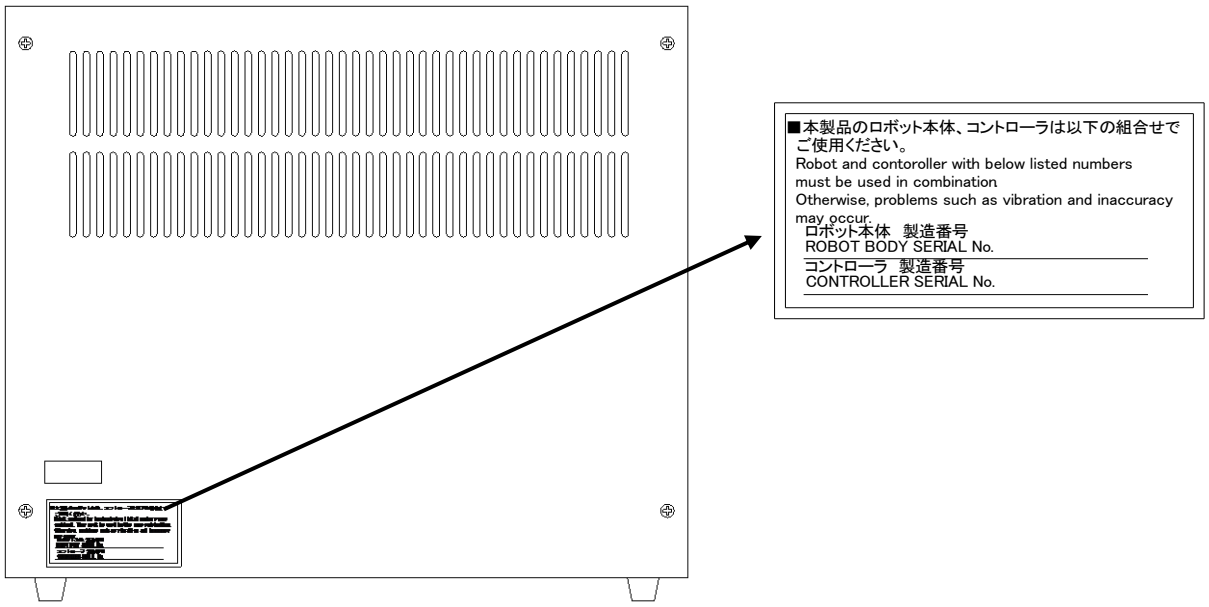
- TVL Series (The figure below shows the TVL500.)



(2) Locations of controller warning labels (for the TSL3100)

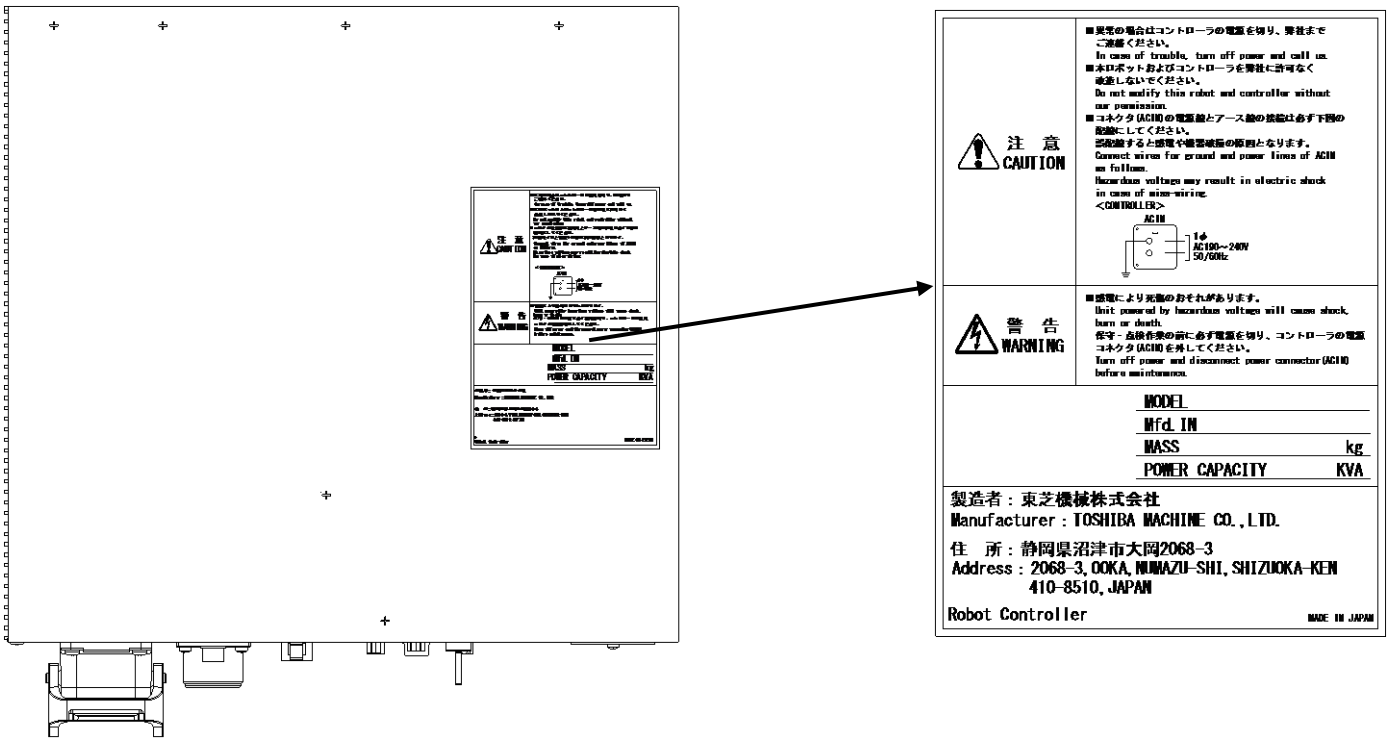



Controller top view

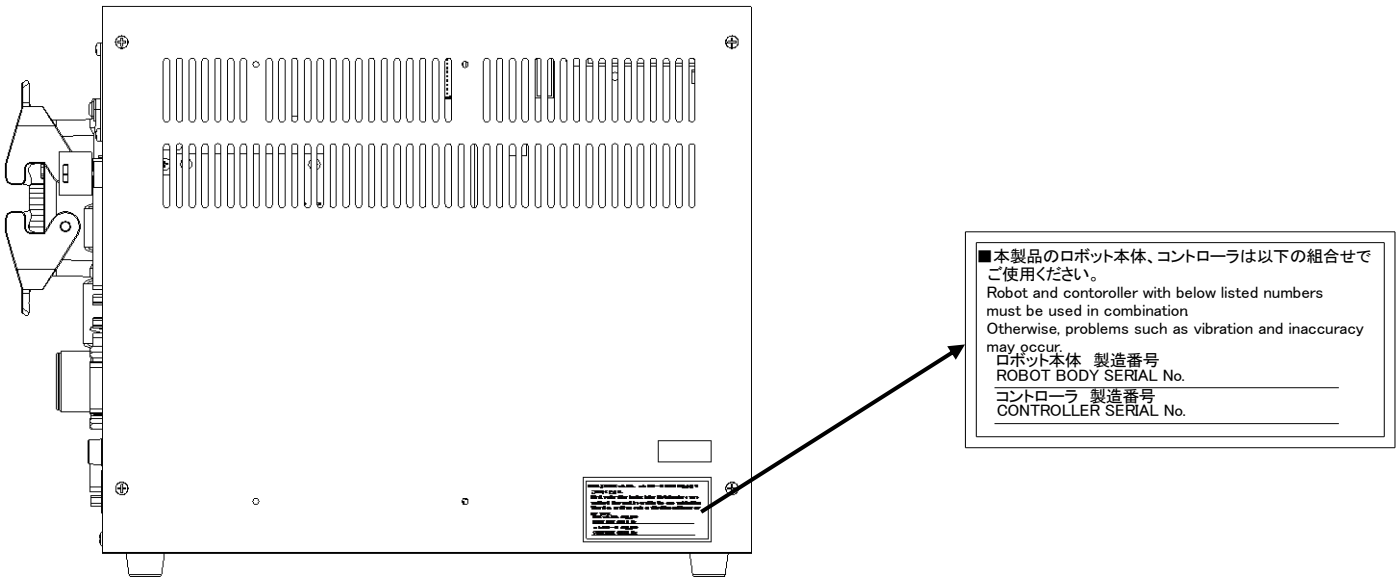



Controller side view

(3) Locations of controller warning labels (for the TSL3100E)

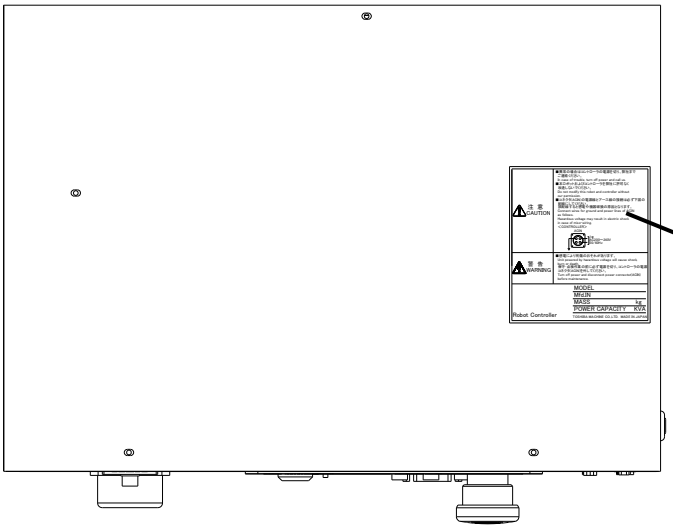


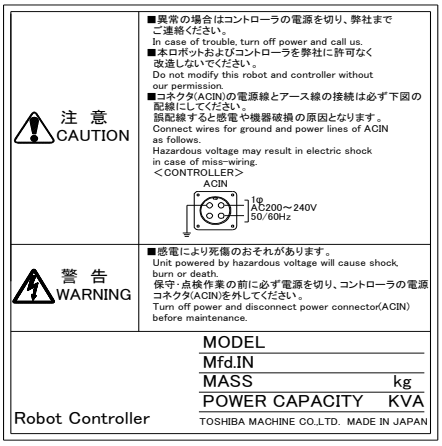

Controller top view



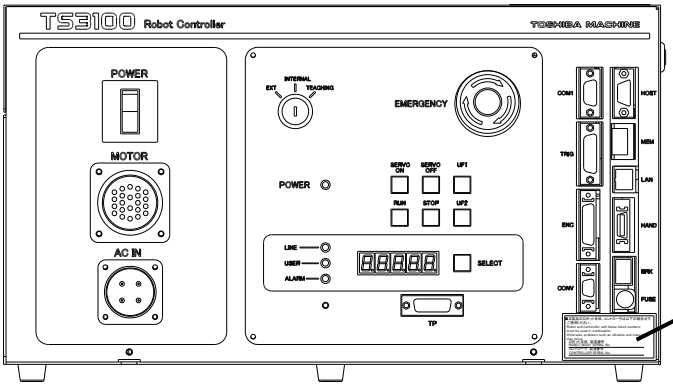

Controller side view

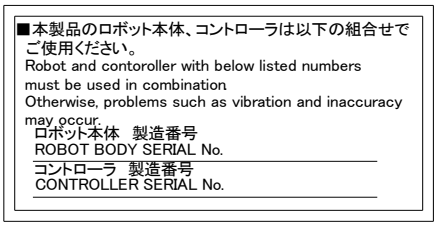
(4) Locations of controller warning labels (for the TS3100)






Controller top view




Controller

## Safety Measures

This section describes the necessity of safety measures, safety functions provided for the robot and robot controller, and general safety measures to be taken.

### 1 Cautions on Safety

The TVL series robot and robot controller are equipped with various safety functions. When actually operating the robot, however, the following dangers will be supposed.

a) Danger supposed in normal automatic operation
- Operator's mis-operation and mis-judgment, incomplete program.
- Unexpected robot movement, release or drop of workpiece due to fault of an electronic control device.

b) Danger supposed at teaching and inspection
- Danger of an operator entering the movable range of the robot.
- Operator's negligence from confusion or experience at generation of an unexpected abnormality, and operator's mis-operation due to shortage of behavior and knowledge.
- Approach of an operator to the robot due to unexpected complex movement of the robot.
- Abnormal movement, etc. caused by mis-wiring, contact failure, deterioration and noise.
- If the robot has axes with no motor brake, the axes may fall when the servo is turned off (ENABLE switch OFF).

c) Danger supposed in a related machine, etc.
- Sudden movement of the robot with a command from a related machine, etc.
- Sudden movement of a related machine after the robot movement.
- Danger of an operator being caught or entangled in the robot when teaching, inspecting or adjusting the robot while moving a related machine.

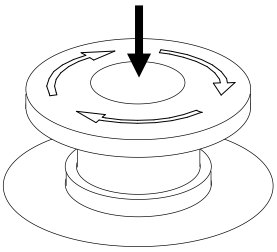
To use the robot safely, safety measures should be taken according to the operating conditions. Otherwise, an unexpected disaster may occur.
If there are safety rules and regulations, strictly observe them. Also, refer to all manuals relating to the robot and robot controller.

## 2 Safety Functions

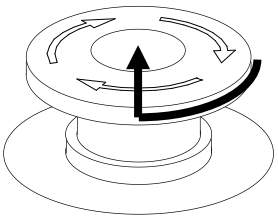
This robot and robot controller have various safety functions as shown below.

a) Emergency stop function

An emergency stop pushbutton switch is provided on the controller (TS3100), on the robot controller and on the teach pendant. This switch stops the robot immediately and shuts down the robot's power source when it is operated.
(Stop category 1)
The emergency stop function is always enabled irrespective of the operating condition of the robot.
Each emergency stop pushbutton switch is equipped with a lock mechanism. To reset the emergency stop state, pull up the upper part of the switch while turning it as shown in the following figure.
The robot controller has external emergency stop contacts (EMS1B-1C, EMS2B-2C), so an emergency stop switch can be added as needed. Select ISO13850-compliant emergency stop switches as the additional ones.



Emergency stop switch ON



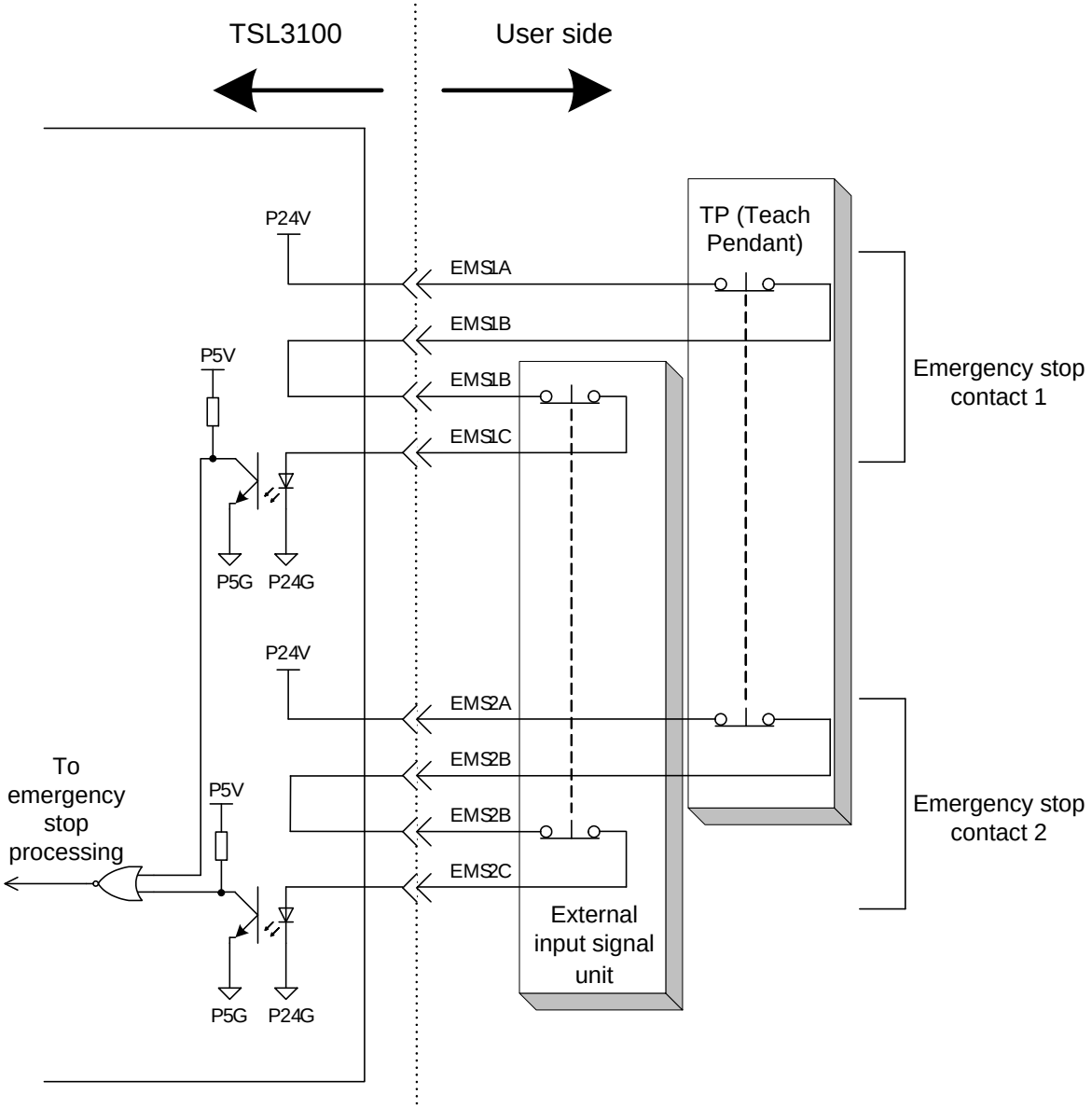
Emergency stop switch OFF

Notes on Emergency Stop Switch

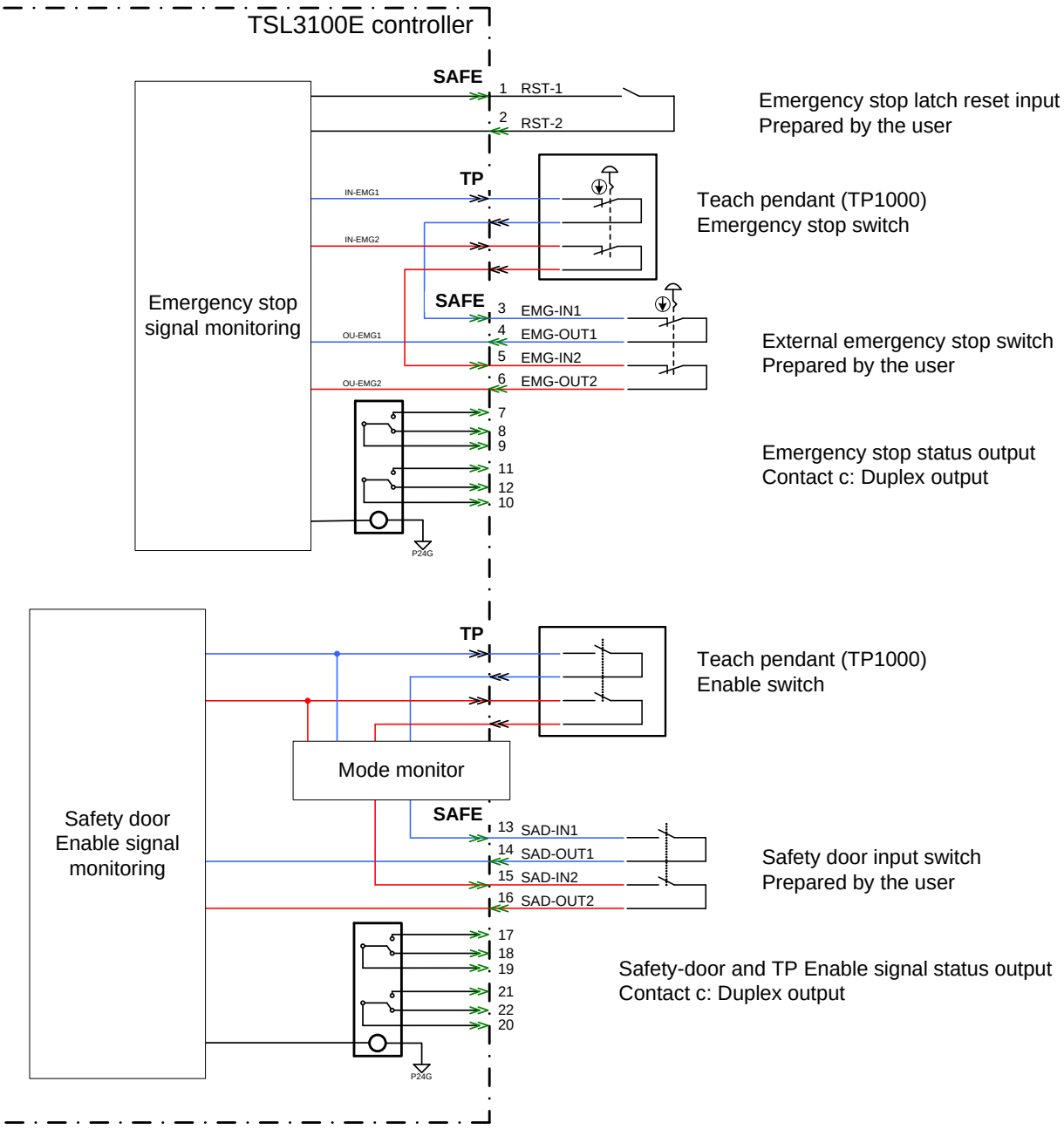
Select emergency stop switches, observing the following:

- Install each emergency stop device at a location where an emergency stop would be required and where they are easy to access when needed.
- Select emergency stop devices structured in a way that once they are activated, their circuits will only recover automatically after manual recovery, and their contacts cannot be restored before device recovery.
- Select emergency stop devices in any of the following shapes that are suited to the machine structure and are characterized to overcome dangerous situations:
  1) Mushroom-type pushbutton
  2) Rope-pull type, or bar type
  3) Belly or knee type
  4) Pedal switch without a protective cover
- The pushbutton type of emergency stop device shall have a red actuator on a yellow background.
- The rope-pull type of emergency stop device shall always maintain proper tension on the rope, and the rope shall be distinguishable via twisted red and yellow strands.

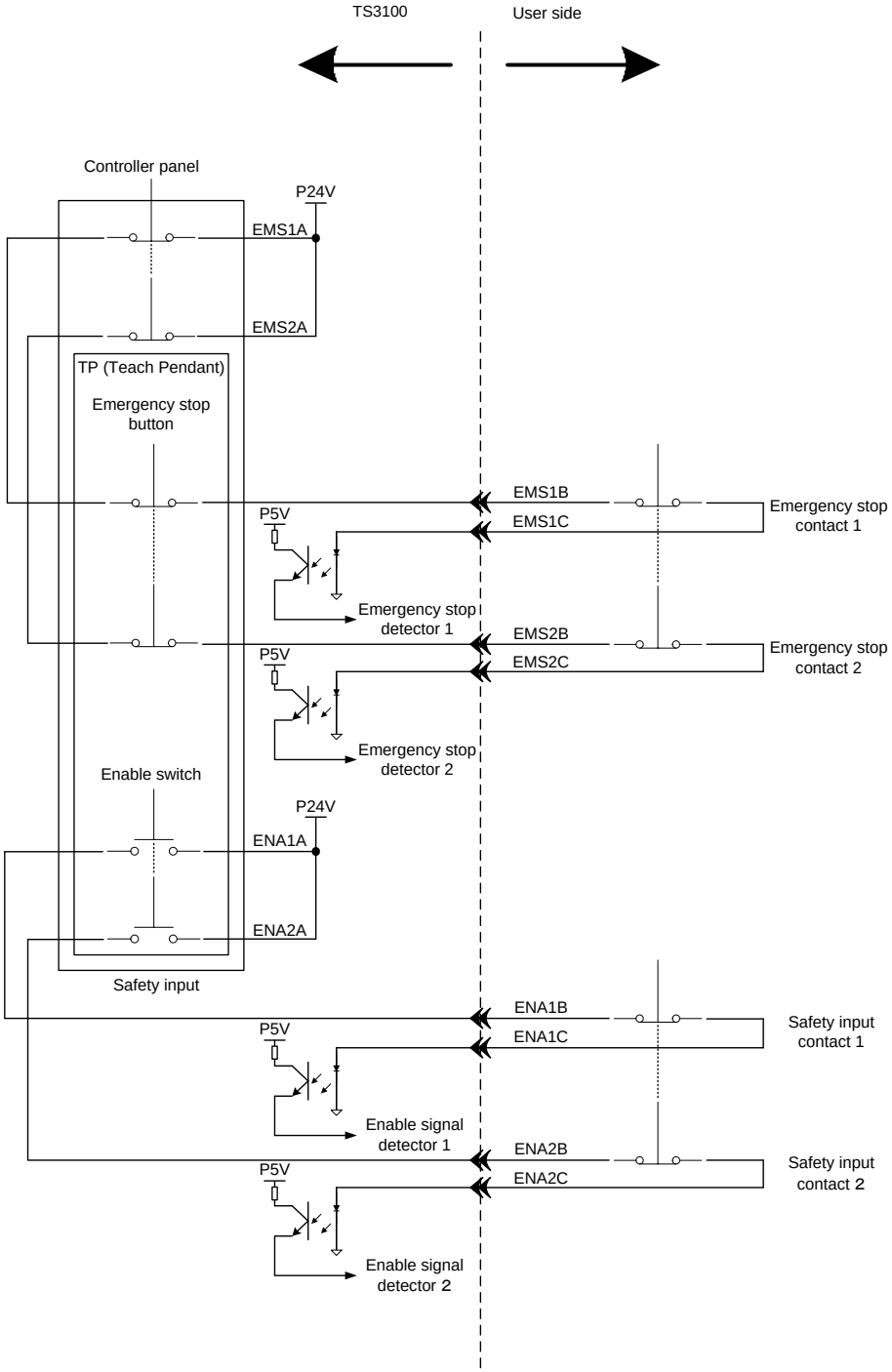
1) The external emergency stop contacts for the TSL3100 are shown in the following figure. Connect an emergency stop button to the INPUT connector pins 18-19 and 36-37 on the front of the TSL3100. Emergency stop buttons for the output common Type-N and Type-P should also be connected to the pins of the same numbers.



2) The external emergency stop contacts for the TSL3100E are shown in the following figure. Connect an emergency stop button to the SAFE connector pins 3-4 and 5-6 on the front of the TSL3100E, and a safety door or the like to the pins 13-14 and 15-16. Then, connect an interlock switch such as a limit switch or a foot switch that operates in conjunction with the door of the safety fence.

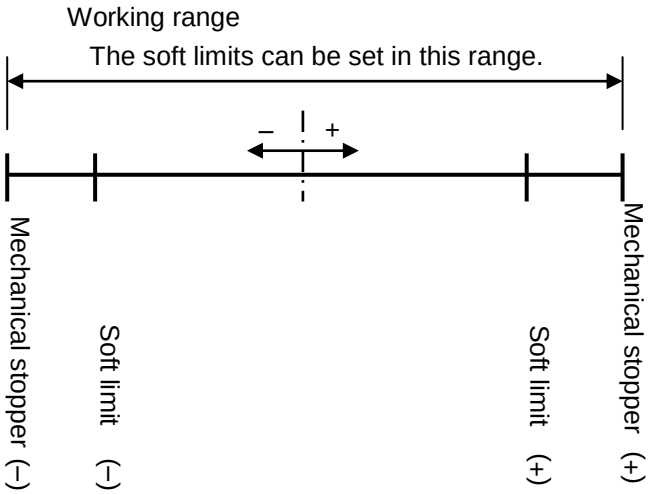


3) The external emergency stop contacts for the TS3100 are shown in the following figure. Connect an emergency stop button to the EMS connector pins 7-8 and 9-10 on the rear of the TS3100, and a safety door or the like to the pins 3-4 and 5-6. Then, connect an interlock switch such as a limit switch or a foot switch that operates in conjunction with the door of the safety fence.



b) Mechanical stopper

The robot is equipped with mechanical stoppers as overrun prevention functions.
The mechanical stoppers are provided to the axes 1, 2, 3, and 5 in order to prevent the robot's moving parts from overrunning.
The robot working range can be limited by changing the mechanical stopper positions, depending on the robot model.
For the change of the mechanical stopper positions, see the Transportation and Installation Manual.

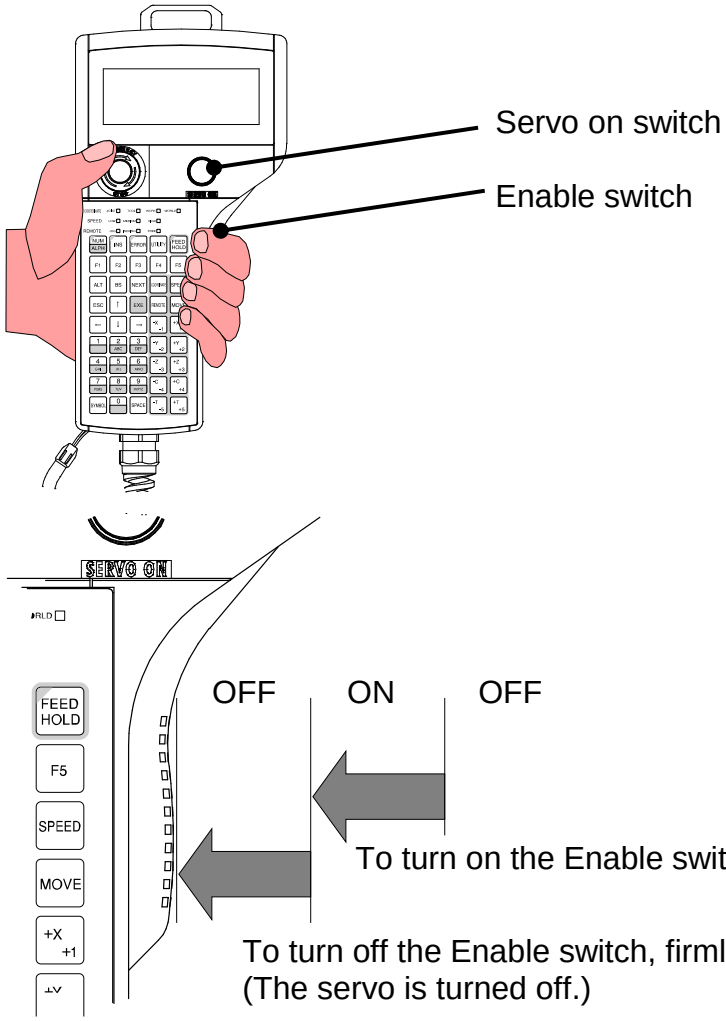



c) Working range limiting function

Soft limits can be set as the working range limit functions. The soft limits prevent collision with the mechanical stoppers due to a wrong operation or program error.
The soft limits should be set inside the robot working range as the auxiliary functions of mechanical stoppers.
For setting of soft limits, see the User Parameter Manual.

d) Operation switches on the teach pendant
An Enable switch is provided on the teach pendant in order to increase the safety level. When guiding the robot in manual mode, the operator holds the teach pendant and presses the Enable switch to turn on the servo.

The Enable switch is of the three-position type; the switch stops the robot immediately and turns off the robot's power source when it is "released" or "firmly pressed."




* The servo cannot be turned on when the Enable switch is OFF.
  Keep the Enable switch ON when guiding the robot in manual mode.
* This figure in the case of TP1000. For the TP3000, see the " TP3000 OPERATOR'S MANUAL"

e) Master key switch in front of a controller (TS3100/TSL3100E)
The master key switch is provided to select the TEACHING or EXT mode of the control panel. When having to enter the dangerous area in order to do teaching operation or inspection, the operator must select the TEACHING mode and carry the master key switch with him during the operation. This procedure prevents another operator from changing the mode.

f) Control panel (TS3100) Master key switch

The master key switch is used to switch the TEACHING, INTERNAL and EXT modes on the control panel. When the operator must enter the danger area in a teaching or inspection operation, the operator switches the mode to TEACHING and performs necessary operation while keeping the key in his/her possession so that no other person can operate the robot.

g) CE-conformed safety function (TS3100E)

TS3100E denotes the TS3100 robot controller that conforms to CE Category III. For differences from the TS3100, please see the section on "Conforming Standards and Safety Performance."

The TS3100E robot controller is equipped with an input terminal for connecting a safety circuit.

To satisfy the safety performance conforming to CE (Category III, PL=d), please connect the TS3SFB unit (option). For more information about the TS3SFB unit, see the "Instruction Manual: TS3SFB Unit."

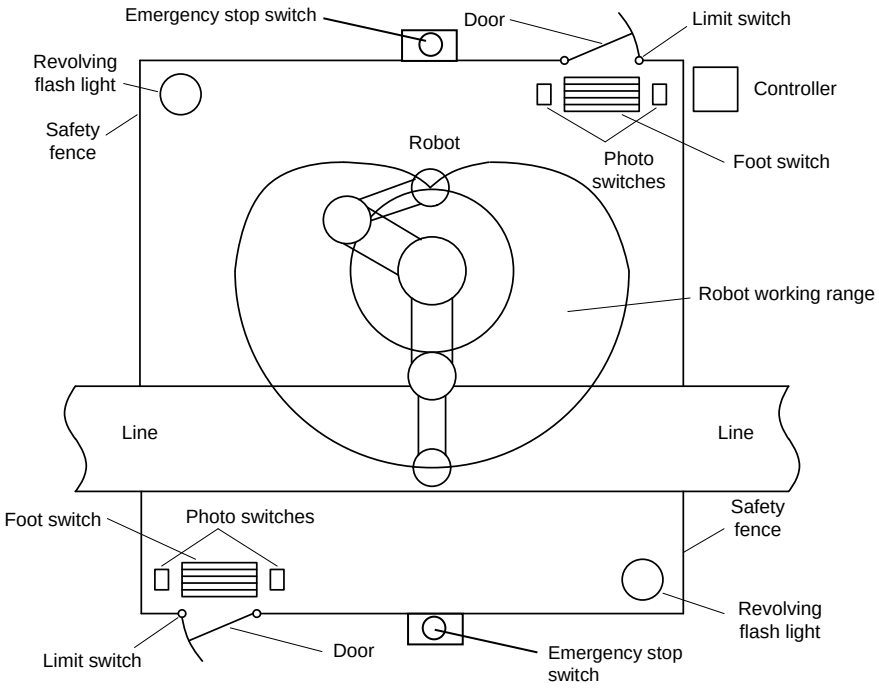
## 3. Safety Measures

Most of disasters caused by the robot originate from unsafe behavior of man.
When using the robot, he should foresee what will involve danger and try to prevent such a dangerous condition. Operation should be done only after all safety conditions are satisfied.
Main safety measures are as follows:

### a) General cautions on using the robot

1) When installing the robot, provide a space required for the job safely.

2) The dangerous area should be identified. For this purpose, necessary measures should be taken to prevent entry of any person, by installing safety fences, etc.
The dangerous area signifies an area near the robot, where, if a person has entered, he will jeopardize.




3) Install emergency stop switches outside the safety fence, and connect it to the external emergency stop contact (EMS1B-1C, MS2B-2C ).
An emergency stop switch must be installed at a location where it can be pressed immediately by an operator who has determined the occurrence of abnormality.
Be sure to connect an ISO13850-compliant emergency stop device.

4) Install the interlock switches such as, limit switch, photo switch, and foot switch to the entrance and exit doors of the safety fence so that the robot will stop if anyone enters the dangerous area. Again, the interlock switches should be electrically independent break-contact (normally-closed contact) switches.

5) Set the controller outside the dangerous area, in a location where the operator can observe the robot work.

6) Operation should be performed only by a well-trained and qualified operator. Anyone who does not understand and is not familiar with the movements of the robot and related equipment should not execute operation. Also, current condition of the robot should always be displayed to prevent an unrelated person from carelessly entering the working range or operating the robot.

7) Before day's operation, perform the following check. Pushbutton switches equipped on the control panel and teach pendant should always be operated while confirmed visually.

<Check before operation>

- Make sure that visual appearance of the robot, controller, peripheral equipment and cables are in good condition.
- Make sure that no obstacle stands in or near the working range of the robot and peripheral equipment.
- Make sure that the emergency stop and other safety devices operate properly.
- Make sure that no abnormal noise or vibration is involved in the robot operation.

b) Cautions on teaching operation

In principle, teaching operation should be performed outside the dangerous area of the robot. If it should be performed inevitably within the dangerous area, strictly observe the following cautions.

1) The teaching operation should always be performed by two (2) persons. One person performs the job and the other person watches outside the dangerous area. Also, both persons should try to prevent mis-operation with each other.

2) The operator should do the job in an attitude ready to press the EMERGENCY stop pushbutton switch at any time. Also, he should perform the job at a position from which he can evacuate immediately at the time of an emergency after confirming the robot operating zone and shields in the surroundings. Also, he should not turn his back to the robot.

3) The supervisor should keep watch on the job at a position where he can see the entire robot system and operate the EMERGENCY stop pushbutton switch at the time of an emergency. Also, he should keep anyone from entering the dangerous area.

c) Other cautions

1) The gripping unit of the robot should not stick out, except for the part required for operation. Also, even at a sudden stop due to power failure, malfunction or emergency stop during operation, the robot should hold a workpiece in a stable posture.

2) If the robot has malfunctioned, turn the power off, identify and remove the cause of the nonconformity, maintain the peripheral equipment and completely restore the malfunctioned robot. Then confirm its movements at a low speed.
Even if the robot has stopped, DO NOT approach the dangerous area immediately.

3) Before entering the dangerous area of the robot for inspection, maintenance or repair, be sure to turn the power off. Also, turn the power off when the robot is not in use.

Note) Because of space limitations, this document covers only important safety precautions for robot operation, but not all general safety information. Thus, it is recommended that the operators should read safety instructions issued by Safety Division of Ministry of Labor and Japan Industrial Safety & Health Association (JISHA) before attempting to operate the robot.