



## Machinery Safety

Don Teng  
Safety Product Specialist

realizing

**OMRON – Your Safety partner**

**OMRON-STI provide total safety solution!**

**Latest information of safety standard**

- Safety standard guide
- Hold various safety seminar

**Control technique & Product line-up**

- Safety solution center
- Safety components series catalog

**Occupational safety Know-how**

- OHSAS18001/JACO Management system
- Factory tour

**Machine safety Achievement**

- Technical conference
- Global support Europe/ America/ Asia/ China

**SafetyControl**

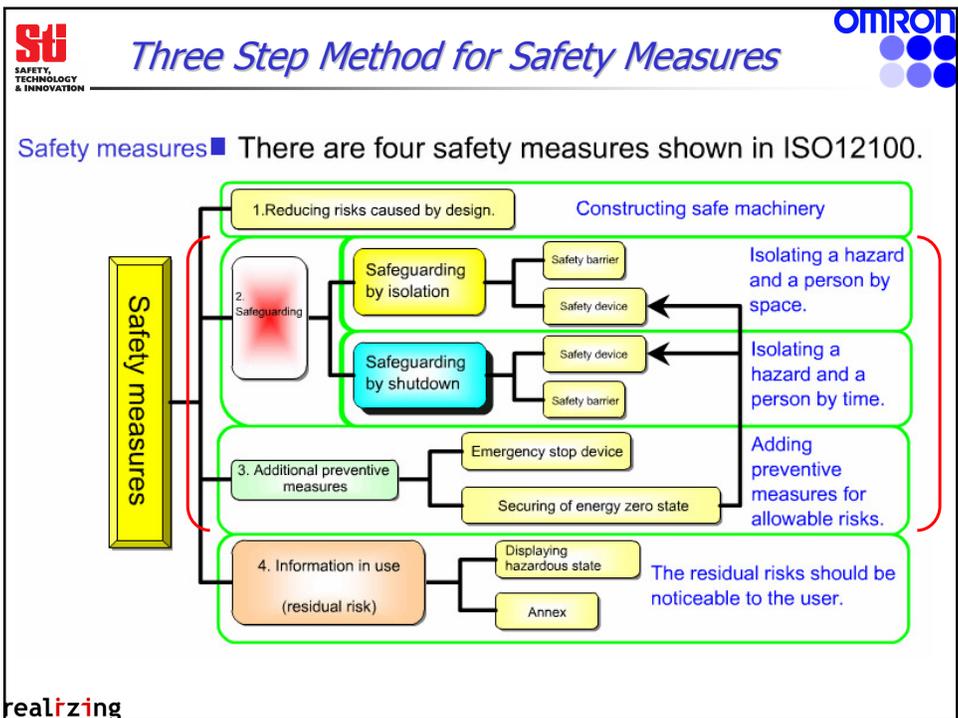
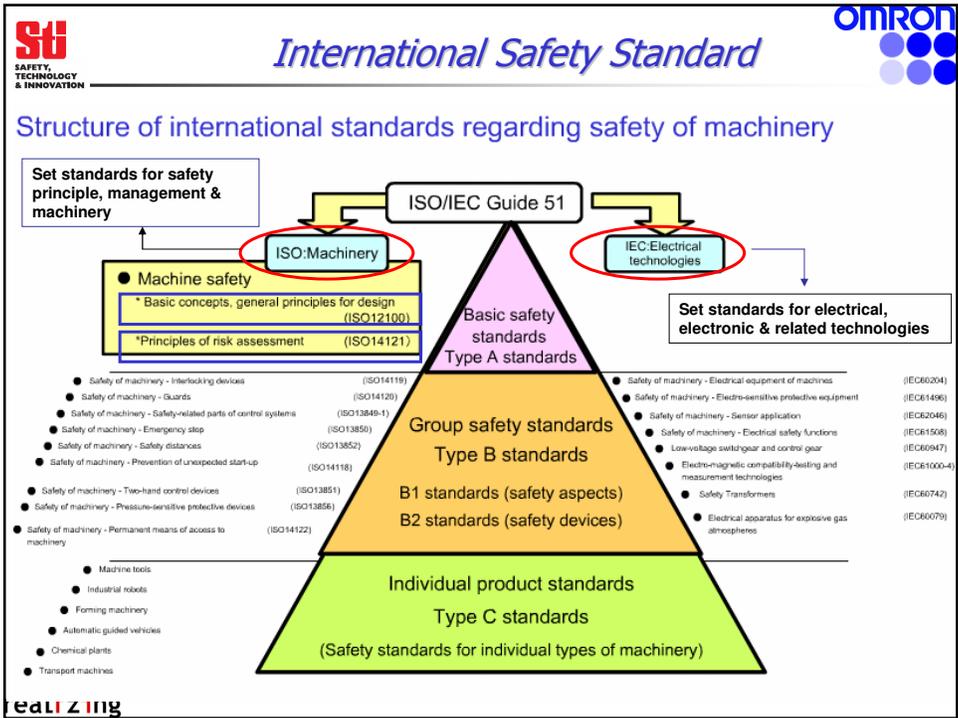
Sensor, Switch, Relay, Control

**Safety Solution**

realizing

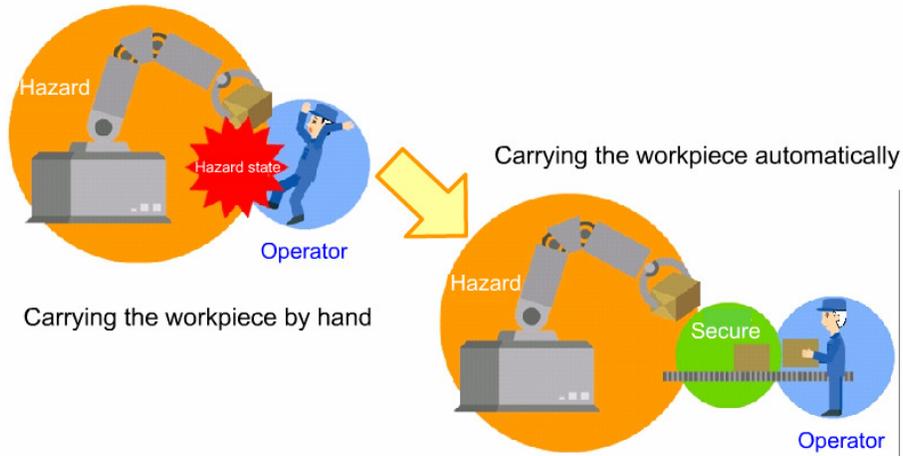
There is a lack of common understanding in the industries of applying proper Safety technologies for machines dangerous to hands. Improper use of Programmable Controllers or switches to bypass safeguards is often applied even though this is prohibited by consensus standards universally.

A **Standard Code of Practices** harmonized with International Safety Standard will serve as a good guideline to the Industries in designing or retrofitting safety control measures for machines thereby, achieving an optimal balance between safety & productivity.



### I: Risk reduction by inherently safe design

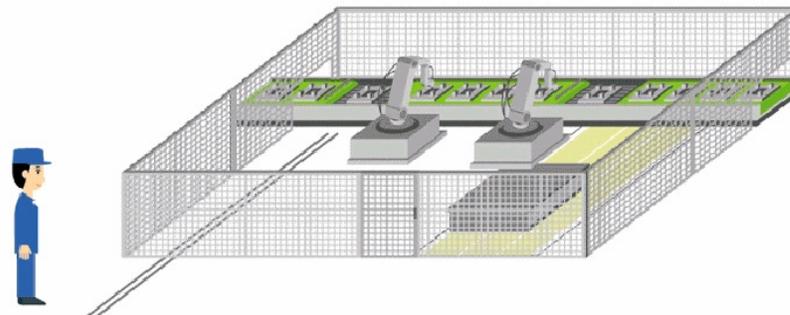
Design in which an operator and a hazard do not exist in the same area or time.



realizing

### II: Risk reduction by safeguarding measures

Fixed guard: Principle of isolation



realizing

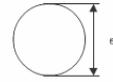
**Fixed Guard Installation Notes**

**Safety distance of upper limbs**

Unit: mm

Body part	Graphic display	Opening	Safety distance sr		
			Rectangular	Square	Circle
Fingertip		$e \leq 4$	$\geq 2$	$\geq 2$	$\geq 2$
		$4 < e \leq 6$	$\geq 10$	$\geq 5$	$\geq 5$
Finger up to finger joint or hand		$6 < e \leq 8$	$\geq 20$	$\geq 15$	$\geq 5$
		$8 < e \leq 10$	$\geq 80$	$\geq 25$	$\geq 20$
		$10 < e \leq 12$	$\geq 100$	$\geq 80$	$\geq 80$
		$12 < e \leq 20$	$\geq 120$	$\geq 120$	$\geq 120$
		$20 < e \leq 30$	$\geq 850$	$\geq 120$	$\geq 120$
Arm up to the base point of the shoulder		$30 < e \leq 40$	$\geq 850$	$\geq 200$	$\geq 120$
		$40 < e \leq 120$	$\geq 850$	$\geq 850$	$\geq 850$

e: Measurement of the opening



1) Since the thumb functions as a stopper if the length of the rectangular opening is 65mm or less, safety distance can be reduced up to 200mm.

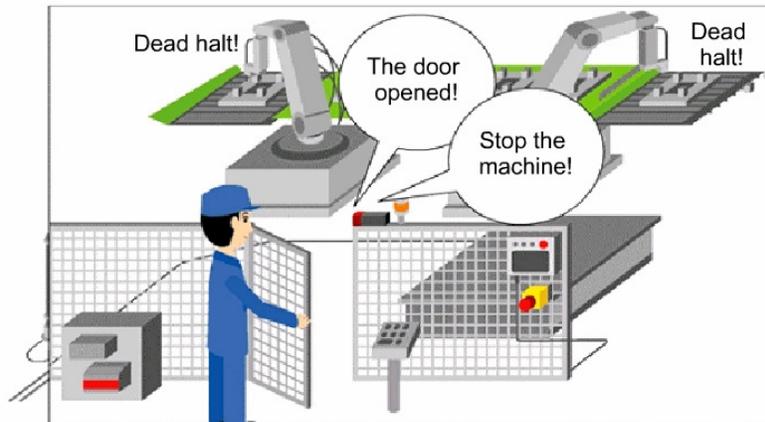
realizing

**II: Risk reduction by safeguarding measures**

**Movable guard: Principle of stop**

(Interlock Guarding)

--> Machine stops when the guard opens

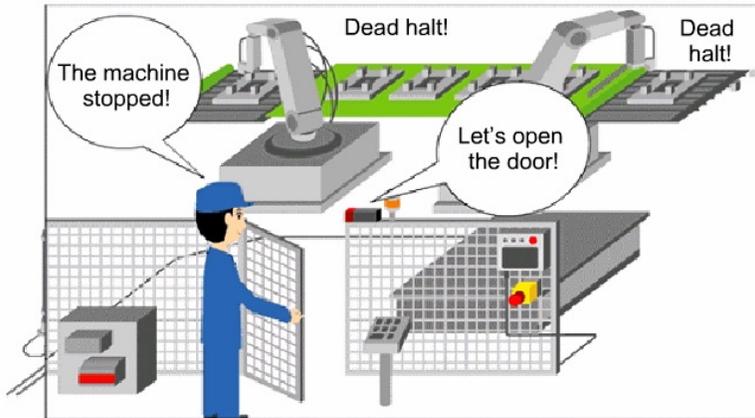


realizing

## II: Risk reduction by safeguarding measures

### Movable guard: Principle of stop

--> The guard does not open until the machine stops.



## III: Risk reduction by additional preventive measures

### Emergency stop devices

#### Emergency switch

- A165E (f16)
- A22E (f22)



#### Enabling switch

Used for emergency stop at teaching in a hazardous area.

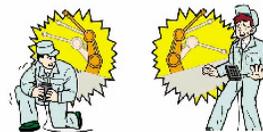
Enabling switch A4E  
Both horizontal and vertical mounting available



At normal status



In the event of emergency

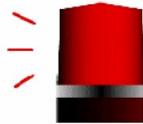


Lockout/tagout

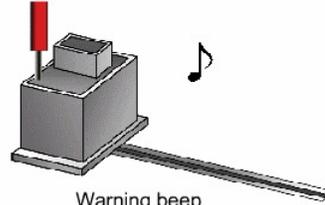


IV: Risk reduction by information in use

Warning (lamp, sound)



Indicator



Warning beep

Warning label

	Hazard identification Electric shock Electrical danger IEC 61310, ISO 3864		Mandatory symbol Wear eye protector IEC 61310
	Hazard identification Risk of caught-in IEC 61310		Prohibition symbol No smoking ANSI Z535.3

Safeguarding based on engineering controls is the most effective method.

	Protective Measure	Example
<p>Most Effective</p> <p>↓</p> <p>Least Effective</p>	Elimination or Substitution	<ul style="list-style-type: none"> <li>Eliminate human interaction in the process</li> <li>Eliminate pinch points (increase clearance)</li> <li>Automated material handling (robots, conveyors, etc)</li> </ul>
	Engineering Controls (Safeguarding Technology/ Protective Devices)	<ul style="list-style-type: none"> <li>Barriers</li> <li>Interlocks</li> <li>Presence sensing devices (light curtains, safety mats, area scanners, etc)</li> <li>Two hand control</li> </ul>
	Awareness Means	<ul style="list-style-type: none"> <li>Lights, beacons, and strobes</li> <li>Computer warnings</li> <li>Sign &amp; labels</li> <li>Beepers, horns and sirens</li> </ul>
	Training & Procedures (Administrative Controls)	<ul style="list-style-type: none"> <li>Safe Work procedures</li> <li>Safety equipment inspections</li> <li>Training</li> <li>Lockout/tagout</li> </ul>
	Personal Protective Equipment (PPE)	<ul style="list-style-type: none"> <li>Safety glasses</li> <li>Ear plugs</li> <li>Gloves</li> <li>Protective footwear</li> <li>respirators</li> </ul>

**sti** SAFETY, TECHNOLOGY & INNOVATION

**OMRON**

## Machines dangerous to Hand

**Hands and Fingers Amputations by Industry Breakdown**

(Source: Machinery Dangerous to Hands Dr...)

# Proper Safety Measure Required

High Risk Machine

**sti** SAFETY, TECHNOLOGY & INNOVATION

**OMRON**

## Machinery Safeguarding: How Risk is measured?

**Determine Risk level through Safety Categories**

**Risk Assessments**

```

graph TD
    Start((Start)) --> A[Determination of the limits of machinery]
    A --> B[Hazard Identification]
    B --> C[Risk Estimation]
    C --> D[Risk evaluation]
    D --> E{Is the machine Safe?}
    E --> End[End]
    E -->|Risk Reduction| A
    
```

Categories for safety measures	Requirement for safety measures (performance evaluation of functions for safety measures)
B	* Functions of safety-related parts of control systems must be fulfilled.
1	* Requirements of category B must be satisfied. * Carefully examined high-reliability components must be used and safety must be ensured based on safety principles.
2	* Requirements of category B must be satisfied. * Safety must be ensured based on safety principles. * Safety functions must be checked with appropriate intervals.
3	* Requirements of category B must be satisfied. * Safety must be ensured based on safety principles. * Design requirement: Safety function should not fail by a single failure. * A single failure should be detected as much as possible.
4	* Requirements of category B must be satisfied. * Safety must be ensured based on safety principles. * Design requirement: A single failure should be detected when implementing safety function or before the imp. When this requirement cannot be performed, safety function should not fail by accumulated failures.

ISO13849-1 Safety of Machinery

**realizing**

- Safety must be ensured base on Safety Principles

Examples of Safety Principles:-

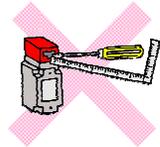
- Compliance of components with relevant standard
- Components are well-tried, reliable, suitable for safety-related applications and have their reliability validated.
- Decreasing the probability of failure occurrence.
- Early detection of failures.
- Defining the failure mode, such as opening the circuit and turning OFF the supply when failure occurs.
- If no failure is detected, operation is possible.

realizing

### Safety Interlock Switch



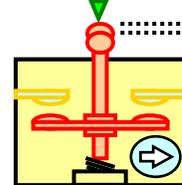
It disapproves by the implements such as screwdrivers and coins and so on.



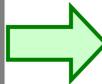
It approves by the dedicated actuators.



Forcibly making "OFF" when contacts remain welded. Keeping "OFF" when spring fails.



Ex.) If the general micro-switch is used for the detection of the door-opening, it is easily to be made Anti-tamper by the finger during door opening.



realizing

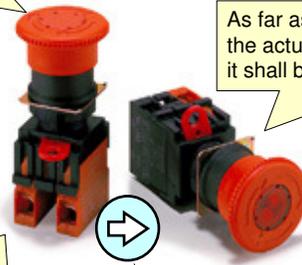


**Application** : It is used for the emergency stop of the machine.

**The demand** : The demand is based on the standard ISO13850.

the requirement for the actuator  
shape : mushroom-type push-buttons  
color : red

As far as a background exists behind  
the actuator and as far as is possible,  
it shall be colored yellow.



Ex. Type A22E

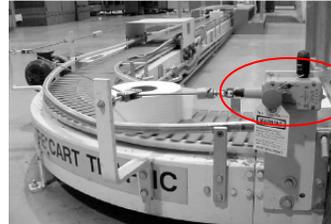
Contact-block must have the **direct opening mechanism**.  
(About the direct opening mechanism, reference Safety Switch.)

## Rope-Pull Emergency Stop Switch

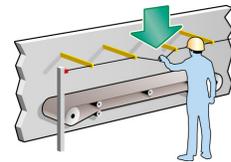


### Applications

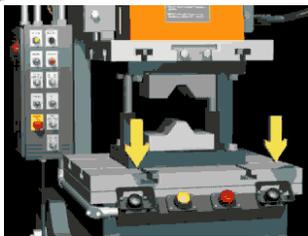
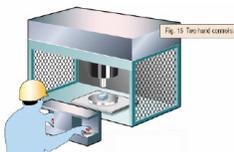
#### Material Handling & Conveyor Line



If there is a long conveyor line, it needs many emergency stop. In the situation, the rope switch is used. The rope switch is installed around the power of danger. And if the workers feel danger, they pull the rope and the machines are made "OFF".



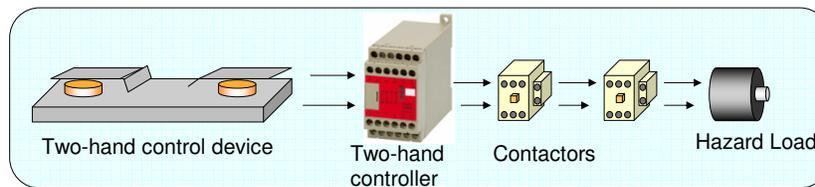
## Two Hand Control



(Source <http://www.osha.gov/SLTC/etools/machineguarding>)

Applications: To ensure both hands of the operator in safe position.

- Two start button must be operated at the same time (within 0.5s) to run machine.
- Must be monitored by a safety controller
- Machine should not go from one cycle to another without the releasing and pressing of both buttons. Prevents the possibility of both buttons being blocked, leaving the machine to run continuously.
- Releasing of either button must cause the machine to stop.

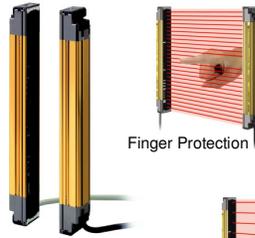


## Safety Light Curtain

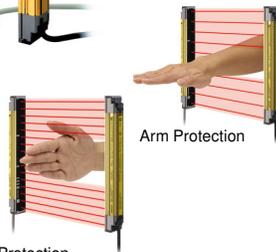
**Application** The detection of the intrusion of fingers, arms, or human bodies into hazardous areas.



Safety Light Curtain unlike area sensor is safety rated and comply to relevant safety standard. These devices emit a "curtain" of harmless infrared light beams in front of the hazard area. When beams are blocked, the light curtain control circuit sends a stop signal to the guard machine.



Finger Protection



Arm Protection

Hand Protection



Guarding a Food Mixing Machine

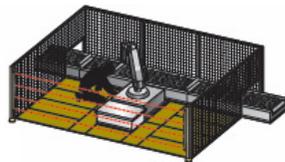


Applied in LCD Panel Assembly Process

## Safety Mat

**Application** Operator Presence Detection in work areas.

Safety Mats guard machine operators against some of the potential hazards and dangers of a modern manufacturing environment. Compared with other guarding methods, such as mechanical barriers, sliding gates, safety mats offer operators freedom movement flexibility that not only enhanced safety, but may also reduce the occurrence of cumulative trauma disorder.



Turret Punch Machine Guarding

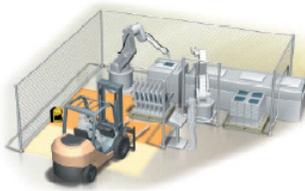


Welding Machine Guarding

**Application** Operator Presence Detection in work areas with complex shape



Safety laser Scanner uses a harmless laser light to sense an intrusion into a guarded area. It can be configured for multiple irregularly shaped Hazardous area, making it an excellent choice for Safeguarding work cells, transfer lines, robot stations, and automated guided vehicles

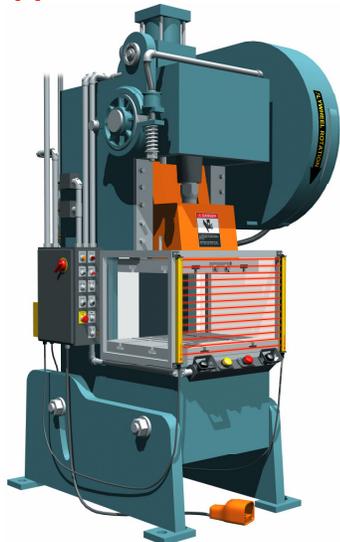


Guarding a Tumbler Machine

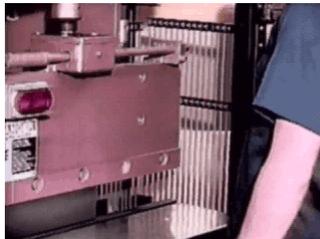
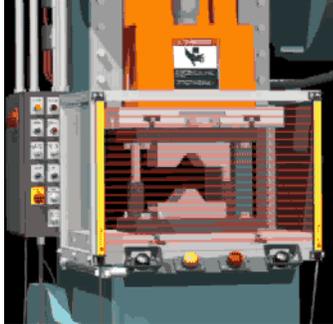


Human Presence Detection

### Applications #1: Mechanical Clutch Power Press



- Safe Guarding through a combinations of E-stop, Fixed Guarding, Safety Light Curtain, 2-Hand Control.
- Complimentary safe guarding technologies are also apply i.e. stop time monitoring, dual spool port valve & brake monitoring system.
- Safe Guarding systems has 2 functions:
  - 1) To proper safeguard operator from machines
  - 2) To monitor faults within the safety system to prevent loss of safety functions in the event of requesting.
- If some part of the beams of Safety Light Curtains are blocked, it will send a stop signal to the air clutch without stopping the power.



(Source <http://www.osha.gov/SLTC/etools/machineguarding/presses>)

### Check List:

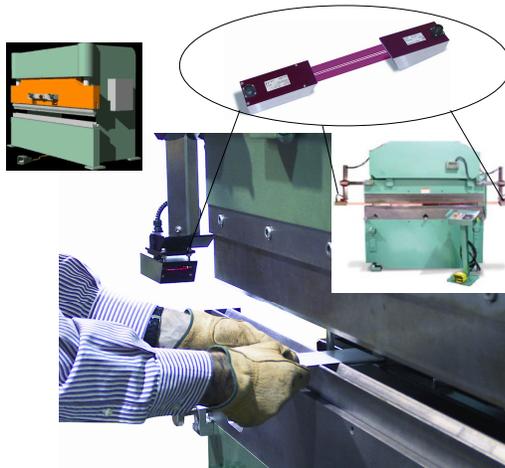
- Apply Correct Safety Distance
- No reach-over, reach under or reach behind
- No large gaps left open
- Must always active
- Not suitable to use in Full-revolution Press.
- No space to stand undetected between light curtain and machine

### Additional Safety Feature of Safety Light Curtain



Fixed Blanking feature

### Applications #2: Press Brake Machine



- Safe Guarding press brake machine through adoption of Single laser beam safety sensor, Lazer Safe.
- Allow operator to work closely at high speed.
- Continuously monitor the speed and stopping distance of the movable ram of the machine.
- Reduction in productivity cycle.

**Applications #3: CNC Machining Centre**

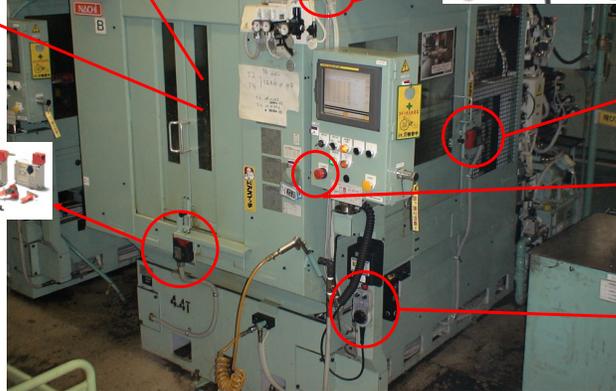
- 1) Spindle at High Speed when operating.
- 2) Spindle will not stop immediately due to high inertia.
- 3) Movable Slide



Detect position of door



Maintaining Safe Work access with door lock



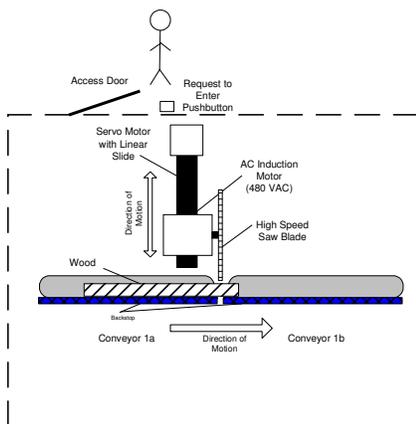
Safety Interlock Door Switch



Stopping Equipment in an emergency



**Applications #4: Wood Cutting Machine**



•Cut wood to specified length for assembly of furniture

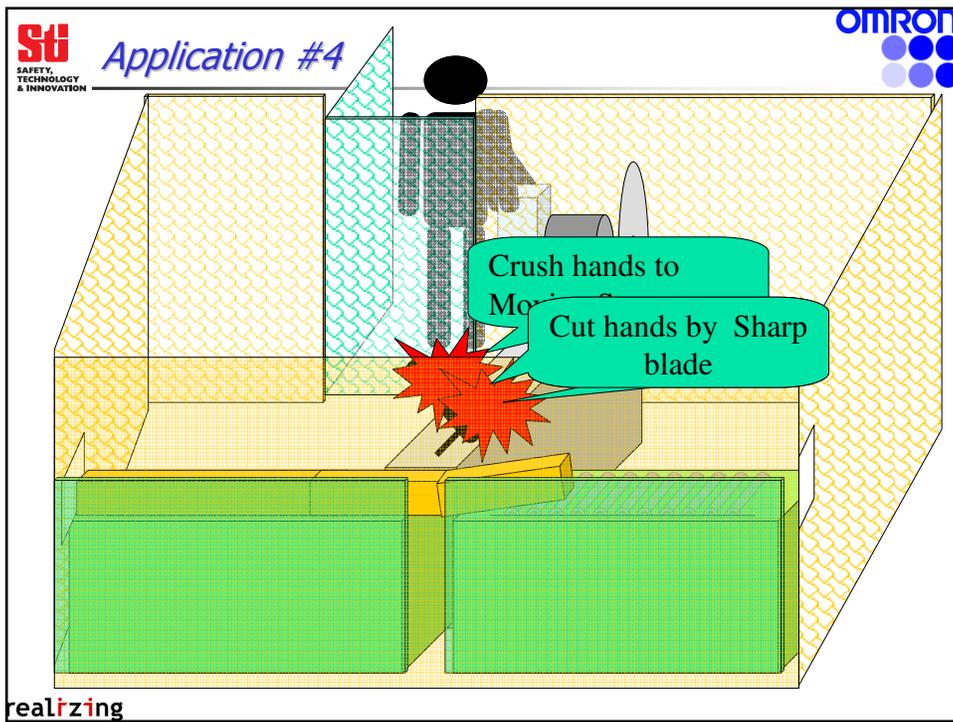
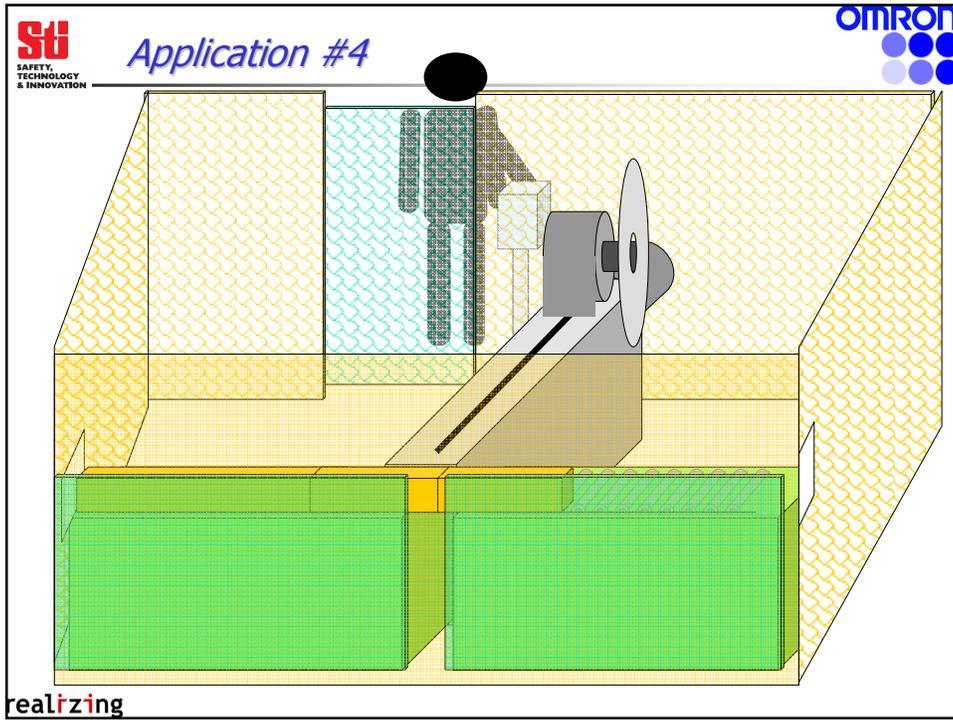
**•Structure of the machine**

This work cell consists of a conveying system to transport the wood to the cutter. The cutter is a saw blade mounted to a Motor, the motor is mounted onto a linear slide

**Process of application**

•The lumber enters through an aperture from an adjacent work cell, the conveyor carries the wood to the saw blade, when the wood has passed the saw blade by a predetermined length the servo moves the induction motor (spinning saw blade) and cuts the wood.

•The operator only needs to enter the cell for maintenance or clearing a jam at which time the servo goes to a home position. Before the operator is allowed to enter the work cell, they must press a "Request to Enter" button located near the door..





- sti** SAFETY, TECHNOLOGY & INNOVATION
- Conclusions**
- OMRON**
1. Machinery Safeguarding is a form of engineering control and **most effective**.
  2. As long as Safety is a concern, **Safety rated components** should be reasonably applied.
  3. Safety Components are well tried, field proven, **fault tolerant** and **comply** to relevant safety standards.
  4. **Due diligence** of machine manufacturers and user in the process of safeguarding that Safety solutions can be applied practicably and reasonably.
- realizing