Summary

1. OBJECTIVE

Support suppliers of Machinery and Equipment to interpret and apply, with the necessary precision, the essential Safety, Health and Environment demands determined by applicable norms, and exemplify the Best practices of safety in machinery, as well as aid in changes promoted at the company's internal processes (layouts, kaizens, etc.).

This Technical Standard does not approach "risk assessment", but only their controls in machinery and equipments, whether supplied or used at the company's premises.

It does not exempt the need for observance of ISO, EN local regulations and other applicable norms from the country.

2. COMPLEMENTARY DOCUMENTS

These standards are common to all countries and are developed and produced by the ISO - International Organization for Standardization and IEC - International Electrotechnical Commission. ISO and IEC consensus on ISO and IEC standards reflects agreement across a range of stakeholders at the standard drafting level, and it reflects a consensus across national standards bodies at the approval level. Their use is voluntary but designing and manufacturing equipment to them is the most direct way of demonstrating compliance with the EHSRs (Essential Health and Safety Requirements).

- EN ISO 12100 - Safety of machinery. Basic concepts, general principles for design. Parts 1 & 2.
- ISO 14121 (EN 1050) Principles for risk assessment.
- ISO 11161 (will also be EN 11161) - Safety of Integrated Manufacturing Systems - Basic Requirements.
- ISO 13849 (EN 954) - Safety related parts of control systems - Part 1: General principles for design. Part 2: Validation.
- ISO/EN 13850 - Emergency Stop devices, functional aspects - Principles for design.
- ISO 13851 (EN 574) - Two-hand control devices - Functional aspects - Principles for Design.
- ISO 13852 (EN 294) - Safety distances to prevent danger zones being reached by the upper limbs.
- ISO 13853 (EN 811) - Safety distances to prevent danger zones being reached by the lower limbs.
- ISO 13854 (EN 349) - Minimum distances to avoid crushing parts of the human body.
- ISO 13855 (EN 999) - The positioning of protective equipment in respect to approach speeds of parts of the human body.
- ISO 14118 (EN 1037) - Isolation and energy dissipation - Prevention of unexpected start-up.
- ISO 14119 (EN 1088) - Interlocking devices associated with guards - Principles for design and selection.

- ISO 14120 (EN 953) - General Requirements for the Design and Construction of Guards.
- ISO 10218-1 - Robots and robotic devices - Safety requirements for industrial robots - Part 1: Robots.
- ISO 10218-2 - Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration.
- IEC/EN 60204-1 - Electrical equipment of machines - Part 1 General requirements.
- IEC/EN 61508 - Functional safety of electrical, electronic and programmable electronic safety-related systems.
- IEC/EN 62061 - Functional safety of safety related electrical, electronic and programmable electronic control systems.
- DIN 2403 - Identification of pipelines according to the fluid conveyed.
- ISO 3864-1 - Graphical symbols - Safety colors and safety signs - Part 1: Design principles for safety signs and safety markings.
- ISO 16528 - Boilers and pressure vessels; or local similar.
- ISO 13857 – Safety of Machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs.

ISO is a non-governmental organization comprised of the national standards bodies of most of the countries of the world (157 countries at the time of this printing). A Central Secretariat, located in Geneva, Switzerland, coordinates the system. ISO generates standards for designing, manufacturing and using machinery more efficiently, safely, and cleanly. The standards also make trade between countries easier. ISO standards can be identified by the three letters ISO. The ISO machine standards are organized in the same fashion as the EN standards, three levels: Type A, B and C.

3. SAFETY AND PROTECTION OF THE ENVIRONMENT

3.1. PRINCIPLES FOR RISK ASSESSMENT

The estimation of risks shall be considered according to ISO 14121 (EN 1050) - Principles for risk assessment, in the project stage, execution of all functioning modes and exploration of the machine and especially its tuning (set up), the learning, the change or correction of the process, cleaning, research of defects or maintenance throughout the machine's lifecycle.

It is important to consider situations in which it is necessary to neutralize the safety functions (for instance, at times of repair / preparation) to have access to risk zones. The manufacturer needs to ensure that his machine is capable of being used safely.

The risk assessment should start at the machine design phase and it should consider all the foreseeable tasks that will be performed on the machine (see Figure 1). This task based approach at the early iterations of the risk assessment is very important. For example, there may be a regular need for adjustment of moving parts at the machine, at the design phase it should be possible to identify/design the measures that will allow this process to be carried out safely. If it is missed at the early stage it may be difficult or impossible to implement at later stage. The result could be that the adjustment of moving parts still has to be performed but must be done in a manner

that is either unsafe or inefficient (or both). A machine on which all tasks have been taken account of during the risk assessment will be a safer machine and a more efficient machine.

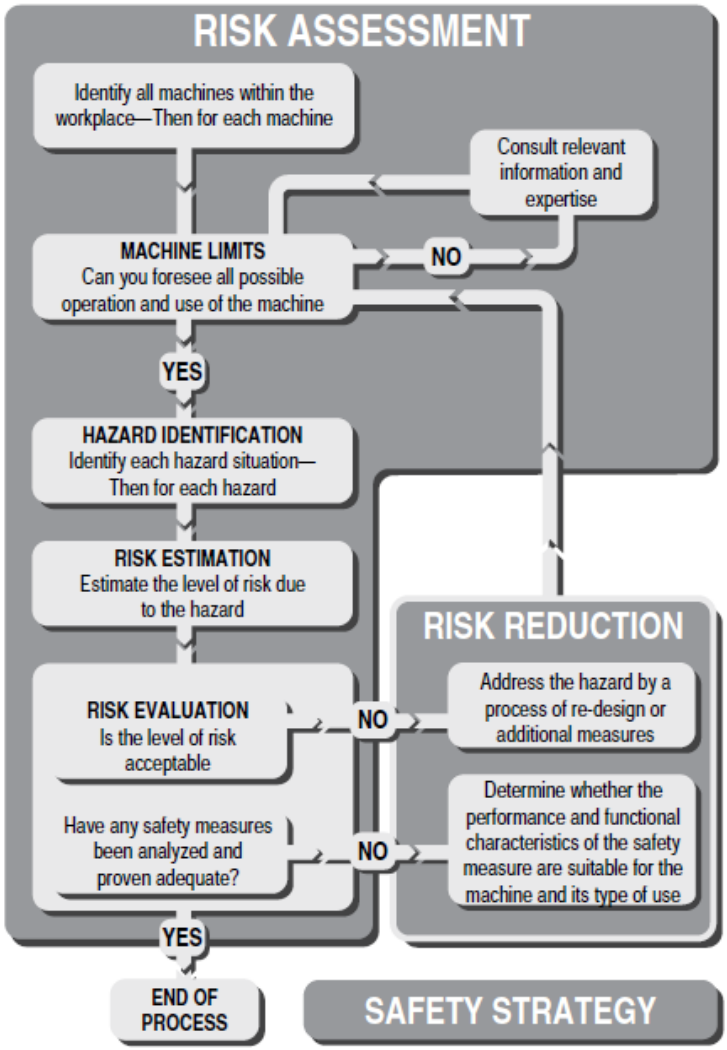


Figure 1 – Risk Assessment

All equipment that is acquired or undergoes renovation / retrofitting shall be evaluated by an EHS risk assessment within the parameters established by applicable Local/National Standards and Regulations and / or in the absence of such standards, current international standards, such as ISO 14121 Safety of machinery - Risk assessment, for defining the safety system's performance and safety requirements together with production and maintenance personnel.

3.2. HANDLING OF RISKS

Therefore, risks shall be handled as follows, in order of priority:

✓ **A – Elimination of Risk:**
Eliminate or reduce risks as far as possible (inherently safe machinery design and construction).

✓ **B – Risk Suppression:**
Suppress in concept the risks of binding, replacement of a chemical product by a less aggressive one, reduction of the electrical voltage, etc.

✓ **C – Protection against the risk:**
Installation of safeguards, installation of safeguarding devices, etc.

Install the necessary protective systems and measures (e.g. interlocked guards, light curtains, etc.) in relation to risks that cannot be eliminated by design.

✓ **D – Measures of organization in the work:**
The low efficiency of the provisions based only in organizational measures is to be noted.

Inform users of the residual risks due to any shortcomings of the protection measures adopted, indicate whether any particular training is required and specify any need to provide personal protection equipment.

3.3. SAFETY CATEGORIES – ISO 13849 (EN 954-1) - Safety related parts of control systems - Part 1

The table 1 illustrates the categories of safety, according to ISO 13849. To pick the category applicable to the equipment, the risk assessment must be made to establish the category. The risk assessment is a responsibility of the supplier of the equipment or machinery, subject to EHS's approval.

Summary of Requirements	System Behavior	Functioning Principles
CATEGORY B (see Note 1) Safety related parts of machine control systems and/or their protective equipment, as well as their components, shall be designed, constructed, selected, assembled and combined in accordance with relevant standards so that they can withstand the expected influence. Basic safety principles shall be applied.	When a fault occurs, it can lead to a loss of the safety function.	
CATEGORY 1 The requirements of category B apply together with the use of well tried safety components and safety principles.	As described for category B but with higher safety related reliability of the safety related function. (The higher the reliability, the less the likelihood of a fault.)	

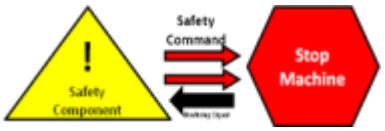
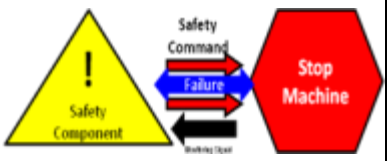
CATEGORY 2 The requirements of category B and the use of well tried safety principles apply. The safety function(s) shall be checked at machine start-up and periodically by the machine control system. If a fault is detected a safe state shall be initiated or if this is not possible a warning shall be given.	The loss of safety function is detected by the check. The occurrence of a fault can lead to the loss of safety function between the checking intervals.	
CATEGORY 3 (see Notes 2 & 3) The requirements of category B and the use of well tried safety principles apply. The system shall be designed so that a single fault in any of its parts does not lead to the loss of safety function. Where practicable, a single fault shall be detected.	When the single fault occurs the safety function is always performed. Some but not all faults will be detected. An accumulation of undetected faults can lead to the loss of safety function.	
CATEGORY 4 (see Notes 2 & 3) The requirements of category B and the use of well tried safety principles apply. The system shall be designed so that a single fault in any of its parts does not lead to the loss of safety function. The single fault is detected at or before the next demand on the safety function. If this detection is not possible, then an accumulation of faults shall not lead to a loss of safety function.	When the faults occur, the safety function is always performed. The faults will be detected in time to prevent the loss of safety functions.	

Table 1 - Categories of Safety

Note 1: *Category B in itself has no special measures for safety, but it forms the base for the other categories.*

Note 2: *Multiple faults caused by a common cause or as inevitable consequences of the first fault, shall be counted as a single fault.*

Note 3: *The fault review may be limited to two faults in combination if it can be justified, but complex circuits (e.g. microprocessor circuits) may require consideration of more faults in combination*

See the example in Figure 2:

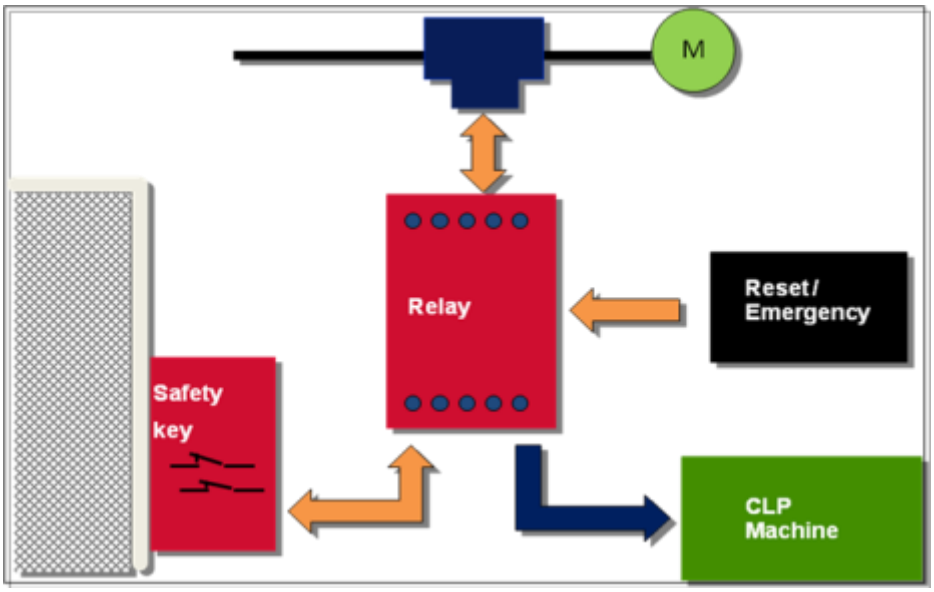


Figure 2 - Example of Safety

For all new and retrofitted machines, the safety circuit cannot be modified or supplemented by components/devices that do not have the minimum applicable safety function/performance and safety certification - such as interlocks, relays, fuses, safety PLC. Such machines may receive safety critical signals sent by safety components/devices, but will not function in a reliable manner to respond appropriately in an emergency. Safety components/devices must be properly identified.

3.4. SAFEGUARDING DEVICES

The mobile elements shall be conceived, built and distributed to prevent risks. When the risks remain, mobile elements shall be fitted with safeguards or safeguarding devices so as to prevent any contact risk that may result in accidents.

3.4.1. Choice between different types of safeguards and safeguarding devices

Safeguards or safeguarding devices must be chosen based on the existing risk and in the following preferred order:

a) Fixed safeguards
b) Mobile (moveable) safeguards if frequent interventions are anticipated
c) Safety Devices such as:
- Presence sensing devices (e.g. Light Curtain, safety floor mats);
- Safety devices that maintain a minimum safe distance (e.g.: two-hand controls);

d) Adjustable safeguards when certain mobile (moveable) elements that contribute to the execution of the work are required to become accessible because of the operator's necessary interventions.

3.4.2. Specific demands for safeguarding devices

These devices shall be designed and installed in a control system so that:

- The start of mobile elements (moving parts) is not possible while the operator is capable of reaching them;
- The person exposed cannot reach the moving mobile elements (moving parts);
- Its adjustments require a voluntary action, for instance, the use of a tool or a key;
- The absence or the fault of one of its components will preclude the start or will cause the stop of the mobile elements (moving parts).

3.5. GUARDS

Guards rank third in the risk reduction hierarchy, after inherently safe design and risk reduction (after **Risk Elimination** and **Risk Suppression**). Guards must therefore be chosen only if the first two measures cannot reasonably be applied. A guard must not create additional hazards (cutting, trapping, crushing, etc.) or cause the machine's users to remove, bypass or defeat the guard.

The movable components of a guard must be designed so that their dimensions and their weight facilitate their manipulation. A guard must be designed by taking into account all the environmental constraints or those operating constraints (possibilities of projectiles of solid or liquid matter) to which the guard is subjected during the machine's entire service life.

The guard must also be designed by taking into consideration, insofar as possible, all the intended uses and reasonably foreseeable incorrect uses of the machine and all the involuntary movements of the workers. A guard must be designed and built in such as way as to offer good visibility of the process and the machine. This type of design limits the dismantling of the guard, while allowing the machine to be checked for proper operation or a malfunction to be detected as soon as it occurs. The guard can be made of a transparent, perforated or meshed material (see the permissible dimensions below). It is suggested that the frame of the guard be painted a bright color, and the perforated or meshed part a color darker than the zone to be observed (flat black or charcoal grey).

There are two types of guards:

- Fixed guards: fixed enclosing guard;
  fixed distance guard;
  fixed nip guard.

- Movable guards: interlocking guard;
  interlocking guard with guard locking;
  power-operated;
  automatic closing.

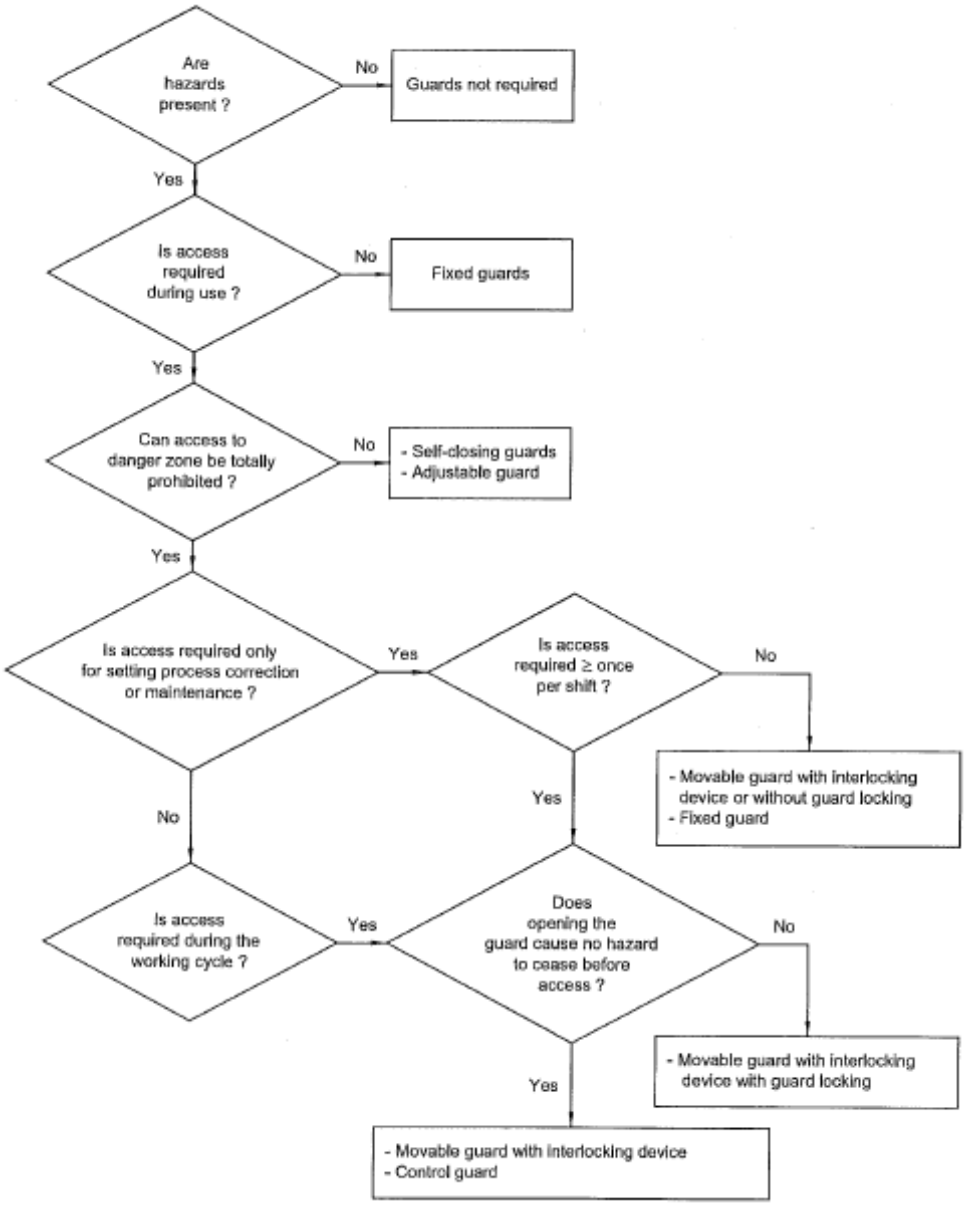


Figure 3 – Guidelines to assist in the selection of guards against hazards generated by moving parts (Source: ISO 14120)

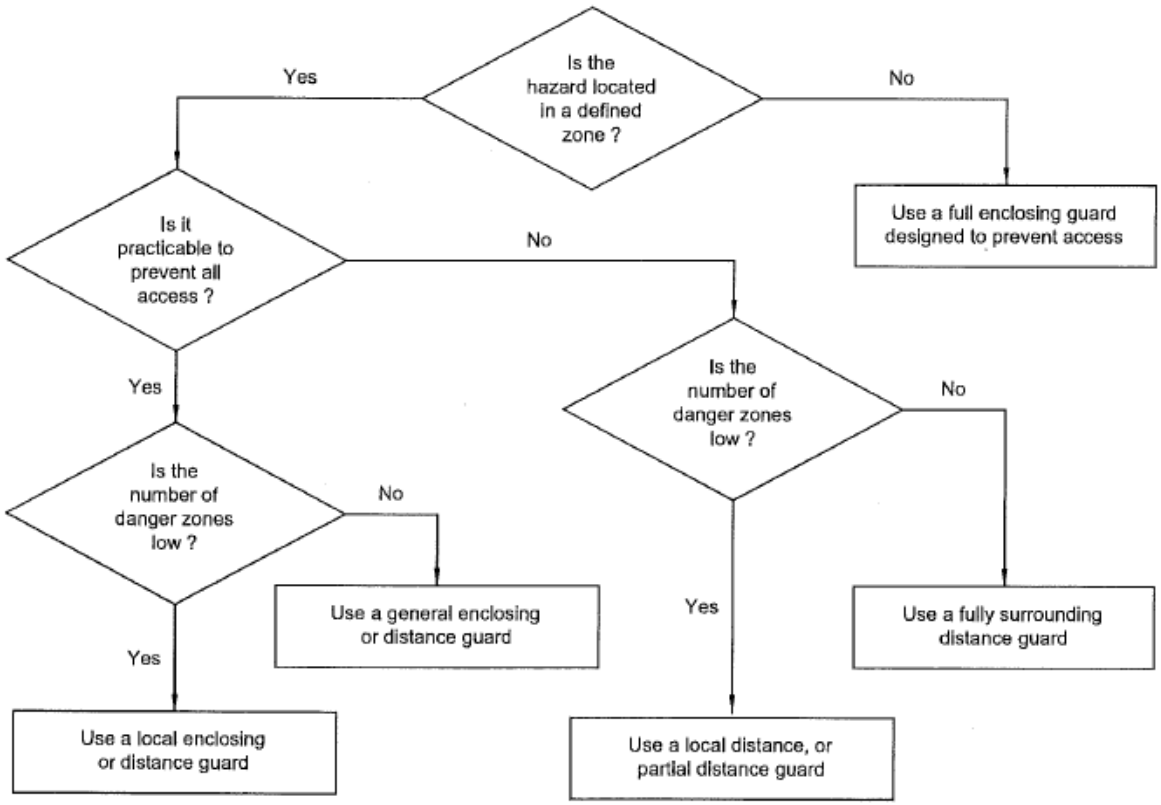


Figure 4 – Guidelines for the selection of guards according to the number and location of hazards (Source: ISO 14120)

3.5.1. Fixed guards

A fixed guard (permanent safeguard) is a guard that can only be removed with the assistance of a tool or that is set in place permanently, for instance by being welded. See examples in Figures 5, 6 and 7.

Note *- Depending on its shape, the guard can be a housing, cover, door, screen or cabinet*.

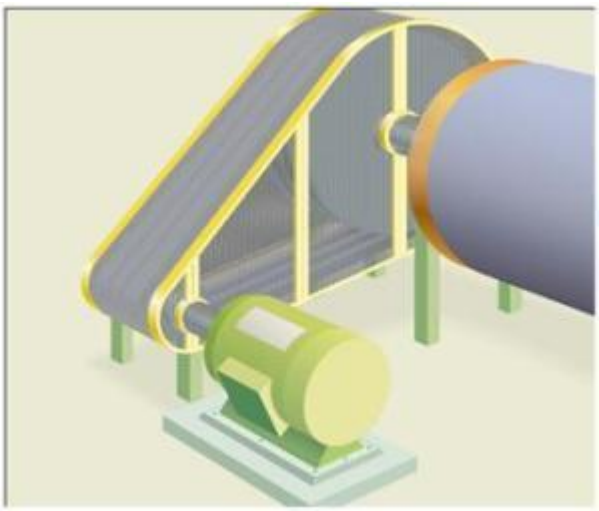


Figure 5 – Fixed enclosing guard - Fixed guard that prevents access to the danger zone from all directions (also known as "zero access")

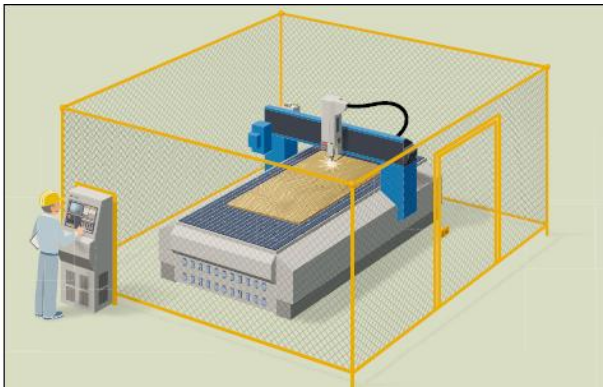


Figure 6 – Fixed distance guard - Fixed guard that does not completely enclose a danger zone, but that prevents or reduces access to it due to its dimensions and its distance from this zone. Example: a peripheral enclosure (perimeter fence).

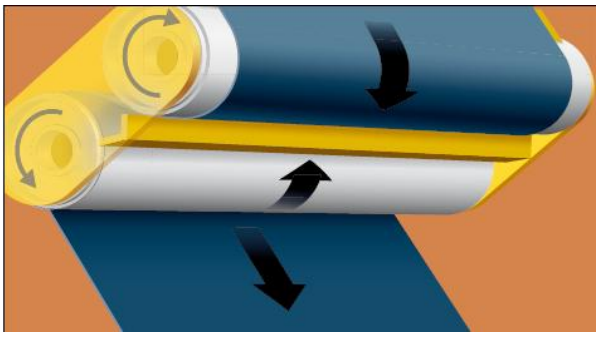


Figure 7 – Fixed nip guard - Fixed guard placed near an in-running nip to prevent access to the in-running nip, which creates the danger zone.

3.5.2. Safeguarding By Distance

Safeguarding by distance involves the use of a fixed or movable guard. Several situations are possible (see Figure 8).

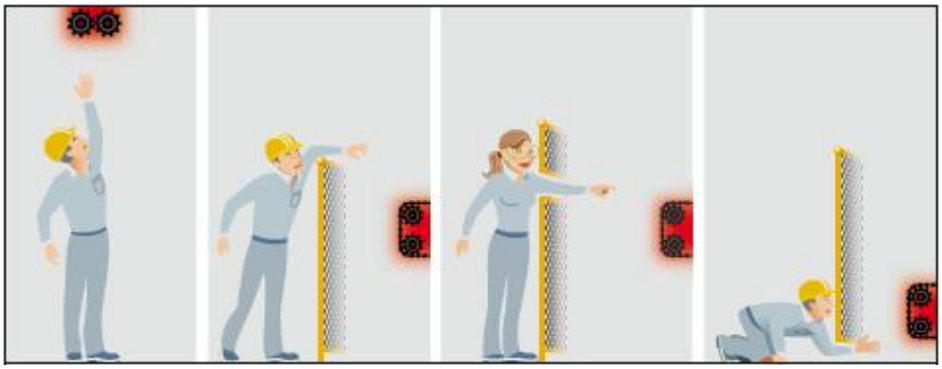


Figure 8 - Possible location of the danger zone

Note : *In all of the following cases, the established safety distance takes into account the fact that no voluntary movement will be made to reach the danger zone and that no accessory (tool, glove, pole, etc.) or object serving as a step (stepladder, chair, etc.) will be used to reach the danger zone.*

3.5.3. Access by reaching upwards

The safety distance determined between the ground, the catwalk or the permanent working platform and the bottom of the danger zone is a function of the height of the danger zone (see Figure 9) and its expected accessibility.

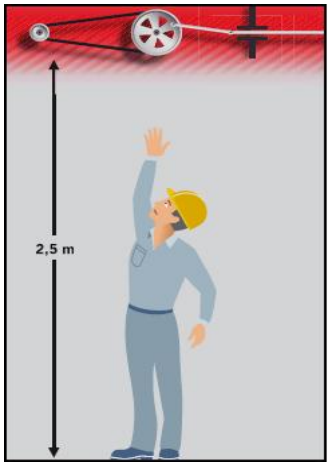


Figure 9 - Access by reaching upwards

Any danger zone located less than 2.5 m from the ground, catwalk or permanent working platform must be made inaccessible by a guard or by a safeguard or safeguarding device.

Any danger zone located more than 2.5 m from the ground, catwalk or permanent working platform must be made inaccessible by a guard or by a safeguard or safeguarding device if its access can be foreseen (for example, a worker doing regular preventive maintenance by using an elevating platform in or near the danger zone).

As needed, a complete risk assessment should be performed to define the appropriate means of protection.

3.5.4. Access by reaching over a fixed distance guard

The following letters (a, b, c) are used to designate the critical dimensions relating to access from above the guard (see Figure 10):

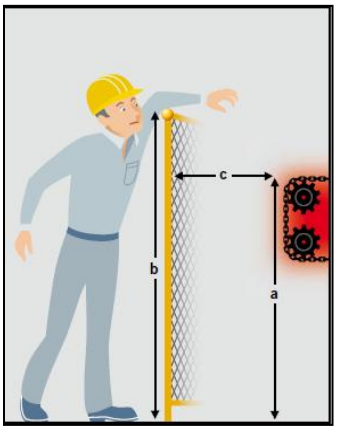


Figure 10 – Access by reaching over guard

a) is the height of the danger zone in relation to the ground or working surface (such as a platform, lift);
b) is the height of the guard;
c) is the horizontal distance between the guard and the danger zone.

As a general rule, a distance guard that protects a danger zone must be a minimum of 1800 mm high, and the values "a" and "c" in bold in Table (below) must be used. However, once a risk analysis has been done, all of the values in Table 2 can be used as minimum values when the risk is high, or those in Table 3 when the risk is low.

No interpolation must be done from the values indicated in these tables. If data "a", "b" or "c" are between two values, those that provide the greatest safety must be chosen in all cases.

Height of danger zone "a" (mm)	Height of the guard "b"* (mm)							
	1400	1600	1800	2000	2200	2400	2500	2700
	Horizontal safety distance to danger zone "c"** (mm)							
2700	0	0	0	0	0	0	0	0
2600	700	600	600	500	400	300	100	sd
2400	900	800	700	600	400	300	100	sd
2200	1000	900	800	600	400	300	sd	sd
2000	1100	900	800	600	400	sd	sd	sd
1800	1100	900	800	600	sd	sd	sd	sd
1600	1100	900	800	500	sd	sd	sd	sd
1400	1100	900	800	sd	sd	sd	sd	sd
1200	1100	900	700	sd	sd	sd	sd	sd
1000	1000	800	sd	sd	sd	sd	sd	sd
800	900	600	sd	sd	sd	sd	sd	sd
600	800	sd	sd	sd	sd	sd	sd	sd
400	400	sd	sd	sd	sd	sd	sd	sd
200	sd	sd	sd	sd	sd	sd	sd	sd
0	sd	sd	sd	sd	sd	sd	sd	sd

Table 2 - High risk - reaching over a guard

Height of danger zone "a" (mm)	Height of the guard "b"* (mm)						
	1400	1600	1800	2000	2200	2400	2500
	Horizontal safety distance to danger zone "c"** (mm)						
2500	0	0	0	0	0	0	0
2400	100	100	100	100	100	100	sd
2200	500	500	400	350	250	sd	sd
2000	700	600	500	350	sd	sd	sd
1800	900	900	600	sd	sd	sd	sd
1600	900	900	500	sd	sd	sd	sd
1400	900	800	100	sd	sd	sd	sd
1200	900	500	sd	sd	sd	sd	sd
1000	900	300	sd	sd	sd	sd	sd
800	600	sd	sd	sd	sd	sd	sd
600	sd	sd	sd	sd	sd	sd	sd
400	sd	sd	sd	sd	sd	sd	sd
200	sd	sd	sd	sd	sd	sd	sd
0	sd	sd	sd	sd	sd	sd	sd

Table 3 - Low risk - reaching over a guard

Notes:
**Distance guards less than 1400 mm in height mentioned in ISO 13857:2008 are not taken into consideration because they do not sufficiently limit movement.*
*** The abbreviation "sd" means safety distance.*

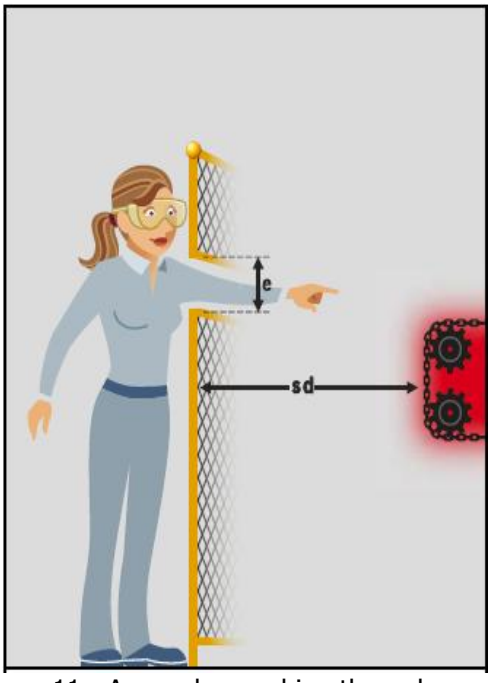
**** According to ISO/DIS 13857, section 4.1.2, note 1, "Low risks arise from hazards such as friction or abrasion where long term or irreversible damage to the body is not foreseeable."*

3.5.5. Access by reaching through an opening in a guard

The safety distance determined between the danger zone and the guard in the case of access through the guard (see Figure 11) is a function of the dimension and shape of the opening.

The following symbols are used: "sd" is the safety distance, namely the distance between the guard and the danger zone; "e" is the smallest dimension of the opening.

The safety distance determined between the danger zone and the guard in the case of access through the guard (see Figures 12) is a function of the dimension and shape of the opening.



Figures 11 - Access by reaching through a guard

3.5.5.1. Openings in the guard

The guards may include regular-shaped openings (square, round, slot or groove shaped) or irregular shaped openings for feeding the machine or for viewing the danger zone or the process.

Dimension "e" corresponds to the smallest dimension of a rectangular (slot-shaped) opening, to one side of a square-shaped opening, and to the diameter of a circular-shaped opening (see Figure 12).

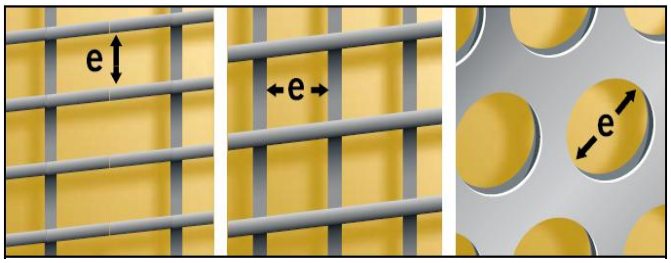


Figure 12: Shape of openings in guards (slot, square, or circle)

In the case of an irregular-shaped opening (see Figure 13), the safety distance "sd" to be retained is the shortest of the three distances determined from the "e" dimensions deduced from the diameter of the smallest circular opening, one side of the smallest square-shaped opening, and the narrowest width of the slot in which the irregular-shaped opening can be completely inscribed.

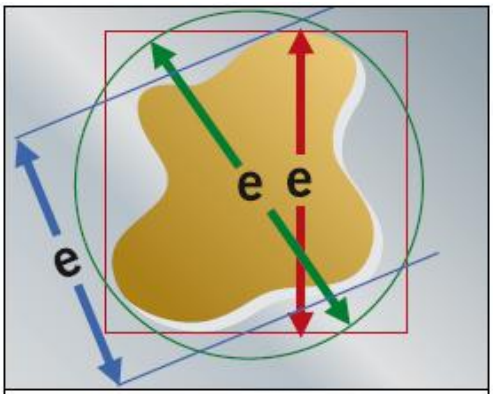


Figure 13 - Irregular-shaped opening

Table 4 is used to determine: the maximum acceptable opening (shape and dimensions) in relation to the chosen safety distance "sd"; the safety distance "sd" as a function of the existing opening (shape and dimensions).

SQUARE OPENING

Safety distance "sd" (mm)	Maximum opening (mm)	Opening (mm)	Minimum safety distance "sd" (mm)
Less than 13	S. O.*	From 0 to 6	≥ 13
From 13 to 47,9	6	From 6,1 to 11	≥ 48
From 48 to 65,9	11	From 11,1 to 16	≥ 66
From 66 to 165,9	16	From 16,1 to 32	≥ 166
From 166 to 444,9	32	From 32,1 to 49	≥ 445
From 445 to 914,9	49	From 49,1 to 132**	≥ 915
≥ 915	132**		

ROUND OPENING

Safety distance "sd" (mm)	Maximum opening (mm)	Opening (mm)	Minimum safety distance "sd" (mm)
Less than 2	0	0 - 4	≥ 2
From 2 to 4,9	4	4,1 < e ≤ 8	≥ 5
From 5 to 19,9	8	8,1 < e ≤ 10	≥ 20
From 20 to 79,9	10	10,1 < e ≤ 12	≥ 80
From 80 to 119,9	12	12,1 < e ≤ 40	≥ 120
From 120 to 849,9	40	40,1 < e ≤ 120***	≥ 850
≥ 850	120***		

Table 4 - Safety Distance: Dimensions of Square and Round openings

Notes:
**Guards shall not be located less than 13 mm from the hazard.*
***The maximum size of a slot- or square-shaped opening is 132 mm.*
****The maximum size of a circular or irregular-shaped opening is 120 mm.*

3.5.6. Tunnel guards

A guard in the form of a tunnel allows the material or the worked part to pass through while preventing the worker from accessing the danger zone (see Figure 14). In this case, the safety distance "sd" is the distance of the tunnel from the danger zone "sd1" plus the length of the tunnel "sd2".

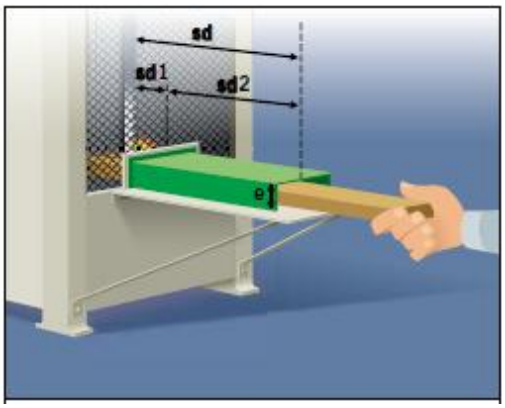


Figure 14 - Tunnel guard

The safety distance "sd" therefore depends on the tunnel's shape and "e" dimensions. It is appropriate to use the data in Table 4 to determine "e" in relation to "sd", or "sd" in relation to "e".

If openings are made in the guard, the guard must also be located far from the danger zone (see the data in Table 4 above).

3.5.7. Lower and upper limbs

If the risk assessment determines that there is a risk of access to the danger zone by reaching under the guard for the lower and upper limbs, the minimum safety distance "sd" for an opening of given dimensions must be the longest safety distance appearing in Table 4 (above) or Table 5.

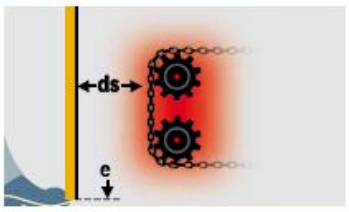
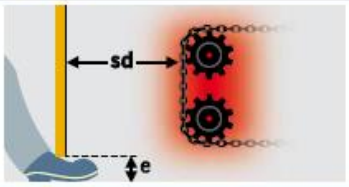
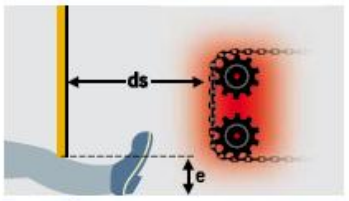
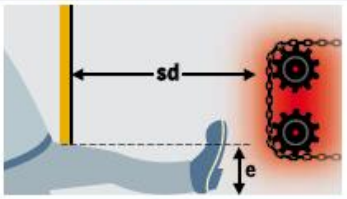
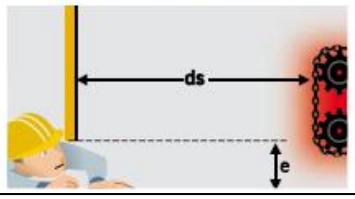
Part of lower limb	Illustration	Opening (mm)	Safety distance «sd» (mm) Slot	Square or round
Toe tip		e ≤ 5	0	0
Toe		5 < e ≤ 15	≥ 10	0
		15 < e ≤ 35	≥ 80*	≥ 25
Foot		35 < e ≤ 60	≥ 180	≥ 80
		60 < e ≤ 80	≥ 650	≥ 180
Leg (toe tip to knee)		80 < e ≤ 95	≥ 1100	≥ 650
Leg (toe tip to crotch)		95 < e ≤ 180	≥ 1100	≥ 1100
		180 < e ≤ 240	not admissible	≥ 1100
Whole body		**Attention: Slot openings with "e" > 180 mm or square or round openings with "e" > 240 mm allow access for the whole body. These dimensions are not permitted.**		

Table 5 - Reaching under a guard (lower limbs only)

*If the length of the slot opening is ≤ 75mm, the distance can be reduced to ≥ 50mm.

If the risk assessment determines that a hazard exists only for the lower limbs, the minimum safety distance "sd" must be taken from Table 5.

3.5.8. Limiting movement

Lower and upper limb movement can also be limited. However, the differences in lower and upper limb geometry must be taken into account when movement restrictors are being designed.

Free movement of the upper limbs (arms, hands, fingers) can also be limited in space by placing additional elements (support, diversion, deflector, plate, etc.) between the fixed guard and the danger zone (see Figure 15).

Figure 15 – Machine equipped with chicanes

3.6. ISOLATION OF THE ENERGY SOURCES

Every machine shall be designed and constructed with devices that allow isolation of each energy source. (See Figure 16) Such devices must be:

- clearly identified (see Table 6);
- possible to be locked if its reconnection presents the risk of creating a hazard, or if the operator cannot – from positions he must occupy – check the continuity of energy isolation.

The residual or stored energy which may result after energy isolation of the machine shall be dissipated with no danger. Certain circuits may not be separated from their energy source in order to allow, for instance, the part's maintenance, the protection of information, the lighting of internal parts, etc. In such cases, specific provisions shall be made in order to assure the safety of personnel (operators, maintenance, …).
In the case of electrical panels, whenever possible, power shall be separated from control, to facilitate planned maintenance. The control circuit shall be 24V, to comply with applicable safety requirements of the project contained under IEC/EN 60204-1 or local equivalent, for instance NR 10 in Brazil.

The powered points such as buses and electrical contacts must have individual protection, fully guarded, that prevents accidental contact (also known as "finger safe").

The power disconnect/circuit breaker shall have its handle outside the panel, at its side. The power disconnect inside the panel, with handle at the door, operated through

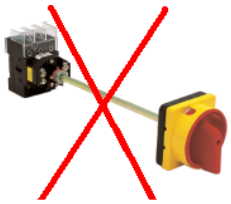
a shaft is not recommended, as it makes the blocking and identification lockout tagout (LOTO) procedure difficult for Embraco's power sources (LOTO SOP), (See Figure 16).

Figure 16 - With LOTO Protection

3.6.1. Identification of energy sources

The equipment must identify all sources of energy (electrical, pneumatic, hydraulic, mechanical, thermal, chemical, dynamic, etc.) as well as their points of isolation. This identification shall follow the procedures of Embraco's energy isolation program, as shown in Table 6:

The electrical panels shall have locks with keys:	Power disconnect / circuit breaker with option to install lock to block the prevent automatic start/restart.



Not recommended

The electrical panel shall be provided with a permanent label, indicating all levels of voltage. Warnings according to shall conform with the examples below and ISO 3864-1: 2011 (establishes the safety identification colors and design principles for safety signs to be used in workplaces)

Electrical Panel Height	Warning Symbol Sign Dimensions	Danger Text Dimensions
Up to 300 mm	45 x 45 mm	45 x 30 mm
300 mm to 800 mm	85 x 85 mm	85 x 50 mm
More than 800 mm	170 x 170	170 x 100 mm

(YELLOW COLOR)
Size according to table

380 V

Voltage identification (YELLOW COLOR) Size 70 x 40mm

24 V

Voltage identification (YELLOW COLOR) Size 70 x 40mm

Dimensions shall comply with the adjacent table

Sizes according to table on the side

Table 6 - Energy Sources identification

3.6.1.1. Energy Sources

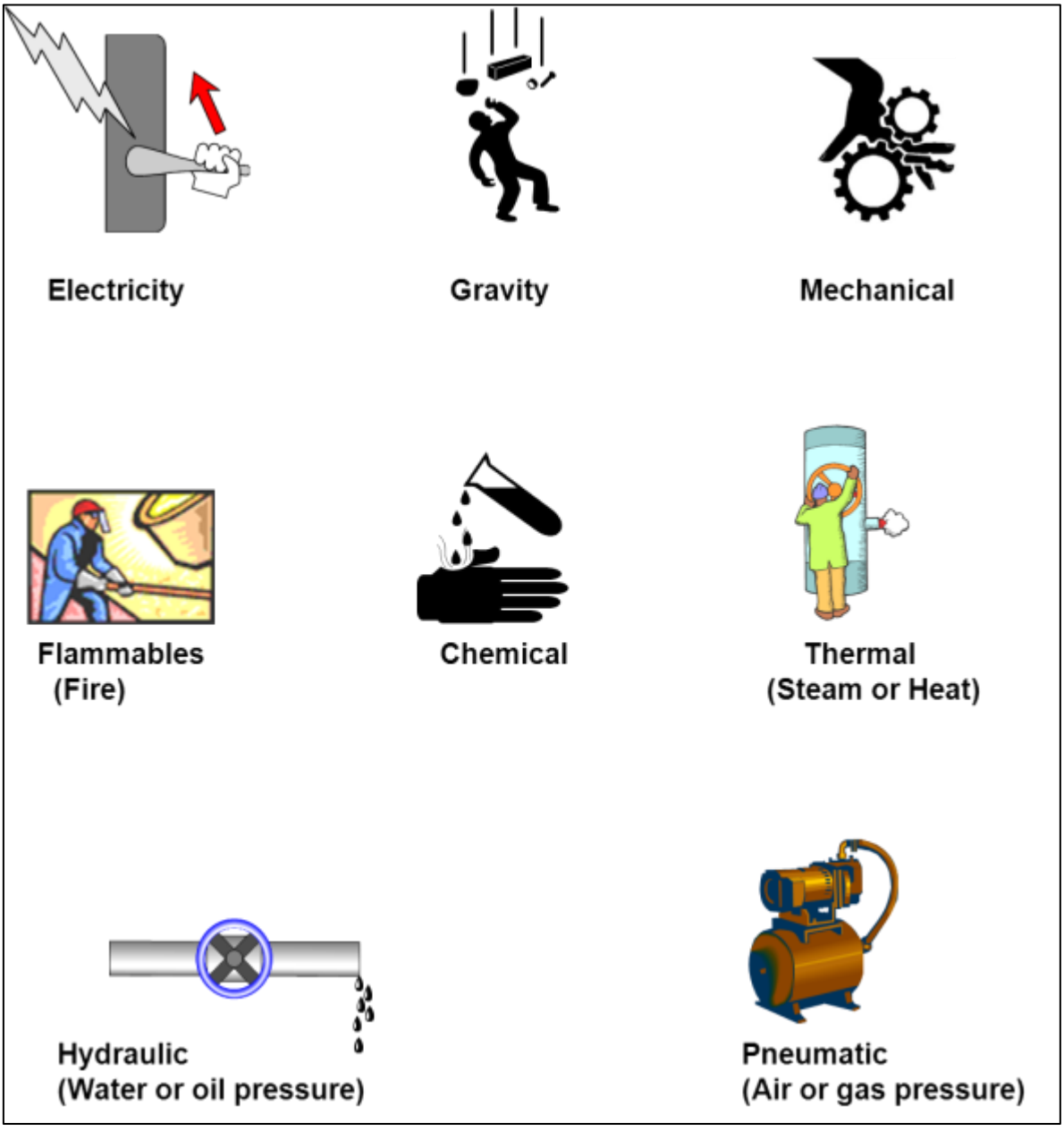


Figure 17 – Examples of Energy Sources

Note:
**Combustible is classified as Chemical Energy Source*

3.6.2. Lock Out / Tag Out (LOTO)

Prior to service or maintenance requiring energy isolation, equipment shall be de-energized in accordance with established LOTO procedure.

LOTO procedures shall be documented for each machine and each energy source (see Figure 20) and shall be posted on or near the equipment.

Personnel shall be:

- Trained to implement the LOTO procedures; and
- Provided with locking devices and tags in accordance with local and national machine and electrical safety regulations.

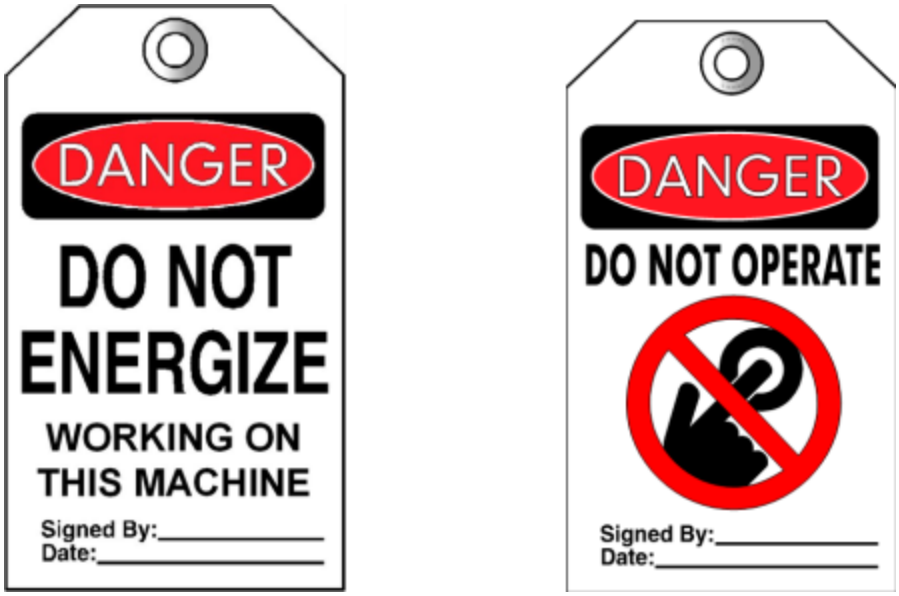


Figure 18 - Sample of LOTO Tags

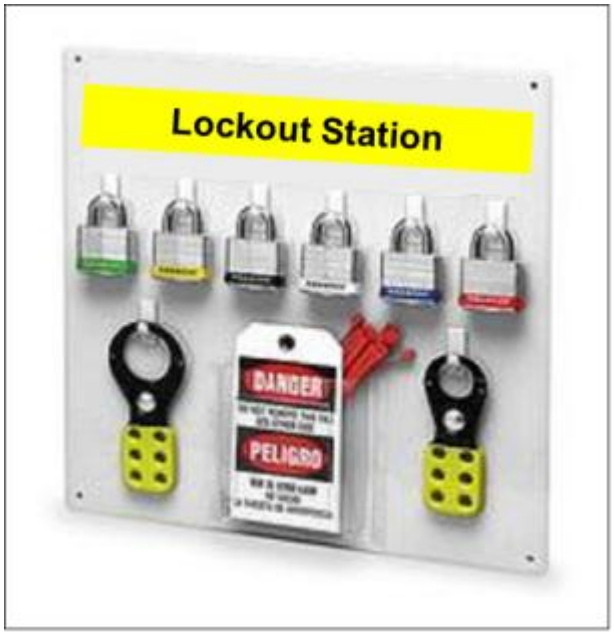


Figure 19 - Sample of LOTO Station

Equipment		SAP:		Issued date: **DD.MM.YYYY**
Location:	Description/Machine type			

Whirlpool embraco

LOCKOUT TAGOUT SEQUENCE

1. Conduct a brief discussion about the activity with the affected and authorized employee
2. Identify the types and magnitude of energy , the hazards involved and energy source controls
3. If the equipment is operating, shut it down using normal shutdown procedures .
4. Apply lockout devices, lock and tag an all energy sources described below.
5. Allow stored or residual energy to dissipate, be relieved, berestrained, or otherwise rendered safe
6. Try to start the equipment, triggering the start commands.
7. Replace the controls in neutral (off) position after verification (step 6).

EQUIPMENT IDENTIFICATION AND LOCKOUT TAGOUT SEQUENCE

LOTO SEQUENCE	Energy source and magnitude	Energy isolating device location	Procedure for Locking Out and/or Releasing Energy	LOTO devices and Hardware Required
A		Electrical		
B		Hydraulic		
C		Pneumatic		
D		H20		
E		Gas		
F		Steam		
G		Chemical		
H		Kinetic		
I		Thermal		

Each involved employee must put his own lock and tag in the LOTO Device

Specific LOTO location in the Equipment

PROCEDURE FOR RESTORING EQUIPMENT TO OPERATION

1. Ensure all nonessential items are removed, all components are operationally intact, and all protective features have been restored
2. Ensure all personnel are safely away from the equipment
3. Verify operational controls are in neutral (off) position
4. Remove lockout devices from energy isolating devices and reenergized the equipment
5. Inform an notify affected employees that maintenance is complete and equipment is ready for use and/or production

STD	Part	Revi	Confidentiality level	date	Creator	Approver	Resp Area

Figure 20 - LOTO Procedure Template (TEM 000198)

3.6.3. New Equipments

New equipment must be designed with Energy isolation devices (gas, electric, pneumatic, hydraulic, chemical, etc.) that allow use of Lockout/Tagout (LOTO). The equipment shall be supplied with the LOTO SOP - Energy Sources Analysis, completed and validated by an EHS team.

Note: *EHS Team, upon request, will provide the file (seen in Figure 20) per the example below to the supplier of electrical equipment (Figure 21).*

Equipment	**Injector Semeraro**		SAP:		Issued date: **DD.MM.YYYY**
Location		Description/Machine type	**Machine for Aluminium Injection**		
CTR Minis					

LOCKOUT TAGOUT SEQUENCE

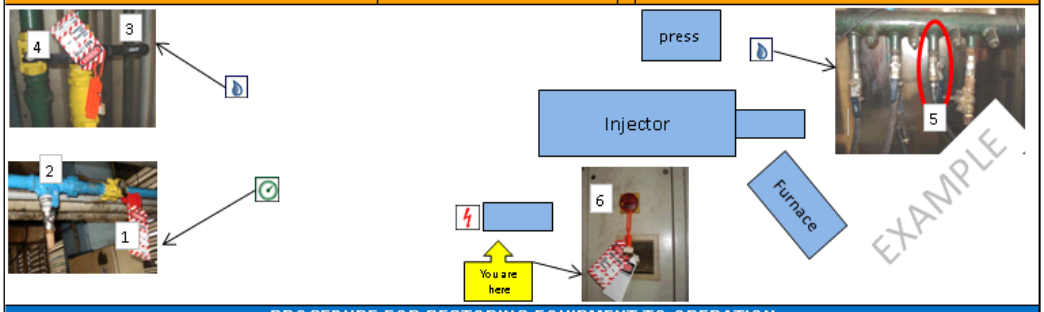
1. Conduct a brief discussion about the activity with the affected and authorized employee
2. Identify the types and magnitude of energy , the hazards involved and energy source controls
3. If the equipment is operating, shut it down using normal shutdown procedures .
4. Apply lockout devices, lock and tag an all energy sources described below.
5. Allow stored or residual energy to dissipate, be relieved, berestrained, or otherwise rendered safe
6. Try to start the equipment, triggering the start commands.
7. Replace the controls in neutral (off) position after verification (step 6).

EQUIPMENT IDENTIFICATION AND LOCKOUT TAGOUT SEQUENCE

LOTO SEQUENCE	Energy source and magnitude	Energy isolating device location	Procedure for Locking Out and/or Releasing Energy	LOTO devices and Hardware Required
A	6 Bar	Pneumatic	Switch off spherical input valve of compressed air (1); apply blocking device and then de-pressurized through the relief valve (2).	
B	70°C	H20	Switch off spherical input valve (3) and water output (4); apply blocking device and then de-pressurize thgrough the drainning valve (5).	
C	380 V	Electrical	Switch off the general switch of the electrical panel of the injector's intake and apply the blocking device (6).	
D	250 Bar	Hydraulic	After blocking electricity (step C), remove the residual hydraulic pressure of the multiplier at relief valve (7).	

Each involved employee must put his own lock and tag in the LOTO Device

Specific LOTO location in the Equipment



PROCEDURE FOR RESTORING EQUIPMENT TO OPERATION

1. Ensure all nonessential items are removed, all components are operationally intact, and all protective features have been restored
2. Ensure all personnel are safely away from the equipment
3. Verify operational controls are in neutral (off) position
4. Remove lockout devices from energy isolating devices and reenergized the equipment
5. Inform an notify affected employees that maintenance is complete and equipment is ready for use and/or production

Standard Type	Part	Revision	Confidentiality level	Date	Creator	Approver	Responsible Area
SOP 123456	**BRA**	***01**	**Public**	**dd/mm/yyyy**	**Name Surnar**	**Name Surname / Name S**	**Area name**

Figure 21 – LOTO Procedure Filled out

3.7. SAFETY INSTRUCTION MANUAL

Each machine shall have a Safety instructions manual providing at least the following in **LOCAL LANGUAGE**:

- Normal use conditions, as well as those that can reasonably occur;
- Instructions to start, use, transport (indicating the mass of the loads regularly transported), installation, assembly and dismantling, adjustment and maintenance (maintenance and repair) to be made free of risks;
- If necessary, programming instructions.

The Machine/Equipment manual must, if necessary, highlight the uses that are not recommended.

The instruction manual will include the plans (diagrams) and instructions necessary to commission, maintain, inspect, and check normal operation and, eventually, machine repairs, as well as all relevant information, especially regarding safety.

If the manufacturer foresees use of the machinery in an explosive atmosphere, the instruction manual must provide all required precautions.

3.7.1. Suppliers of Completed Equipment and Partially Completed Equipment

Suppliers of completed equipment and partially completed equipment shall provide documentation of compliance with applicable requirements of the CE "Machinery Directive" or applicable national / international safety norms.

The documentation may be in a "Declaration of Conformity" or a completed "Technical Construction File", or safety certification mark from a Nationally Recognized Test Laboratory or Certified Body (such as UL, CSA, NOM, TUV, IMQ, CCC, DEMKO, …).

See Annex VII of EN 42/2006 EC, "Technical File for Machinery", link:

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:157:0024:0086:en:PDF

A copy of the above referenced Annex VII of EN 42/2006 EC is shown below:

"A. Technical file for machinery

This part describes the procedure for compiling a technical file. The technical file must demonstrate that the machinery complies with the requirements of this Directive. It must cover the design, manufacture and operation of the machinery to the extent necessary for this assessment. The technical file must be compiled in one or more official Community languages, except for the instructions for the machinery, for which the special provisions of Annex I, section 1.7.4.1 apply.

1. The technical file shall comprise the following:
(a) a construction file including:

— a general description of the machinery,

— the overall drawing of the machinery and drawings of the control circuits, as well as the pertinent descriptions and explanations necessary for understanding the operation of the machinery,

— full detailed drawings, accompanied by any calculation notes, test results, certificates, etc., required to check the conformity of the machinery with the essential health and safety requirements,

— the documentation on risk assessment demonstrating the procedure followed, including:

(i) a list of the essential health and safety requirements which apply to the machinery,

(ii) the description of the protective measures implemented to eliminate identified hazards or to reduce risks and, when appropriate, the indication of the residual risks associated with the machinery,

— the standards and other technical specifications used, indicating the essential health and safety requirements covered by these standards,

— any technical report giving the results of the tests carried out either by the manufacturer or by a body chosen by the manufacturer or his authorized representative,

— a copy of the instructions for the machinery,

— where appropriate, the declaration of incorporation for included partly completed machinery and the relevant assembly instructions for such machinery,

— where appropriate, copies of the EC declaration of conformity of machinery or other products incorporated into the machinery,

— a copy of the EC declaration of conformity;

(b) for series manufacture, the internal measures that will be implemented to ensure that the machinery remains in conformity with the provisions of this Directive.

The manufacturer must carry out necessary research and tests on components, fittings or the completed machinery to determine whether by its design or construction it is capable of being assembled and put into service safely. The relevant reports and results shall be included in the technical file.

2. The technical file referred to in point 1 must be made available to the competent authorities of the Member States for at least 10 years following the date of manufacture of the machinery or, in the case of series manufacture, of the last unit produced.

The technical file does not have to be located in the territory of the Community, nor does it have to be permanently available in material form. However, it must be capable of being assembled and made available within a period of time commensurate with its complexity by the person designated in the EC declaration of conformity.

The technical file does not have to include detailed plans or any other specific information as regards the subassemblies used for the manufacture of the machinery unless a knowledge of them is essential for verification of conformity with the essential health and safety requirements.

3. Failure to present the technical file in response to a duly reasoned request by the competent national authorities may constitute sufficient grounds for doubting the conformity of the machinery in question with the essential health and safety requirements.

B. Relevant technical documentation for partly completed machinery

This part describes the procedure for compiling relevant technical documentation. The documentation must show which requirements of this Directive are applied and fulfilled. It must cover the design, manufacture and operation of the partly completed machinery to the extent necessary for the assessment of conformity with the essential
health and safety requirements applied. The documentation must be compiled in one or more official Community languages.

It shall comprise the following:

(a) a construction file including:

— the overall drawing of the partly completed machinery and drawings of the control circuits,

— full detailed drawings, accompanied by any calculation notes, test results, certificates, etc., required to check the conformity of the partly completed machinery with the applied essential health and safety requirements,

— the risk assessment documentation showing the procedure followed, including:

(i) a list of the essential health and safety requirements applied and fulfilled,

(ii) the description of the protective measures implemented to eliminate identified hazards or to reduce risks and, where appropriate, the indication of the residual risks,

(iii) the standards and other technical specifications used, indicating the essential health and safety requirements covered by these standards,

(iv) any technical report giving the results of the tests carried out either by the manufacturer or by a body chosen by the manufacturer or his authorized representative,

(v) a copy of the assembly instructions for the partly completed machinery;

(b) for series manufacture, the internal measures that will be implemented to ensure that the partly completed machinery remains in conformity with the essential health and safety requirements applied.

The manufacturer must carry out necessary research and tests on components, fittings or the partly completed machinery to determine whether by its design or construction it is capable of being assembled and used safely. The relevant reports and results shall be included in the technical file.

The relevant technical documentation must be available for at least 10 years following the date of manufacture of the partly completed machinery or, in the case of series manufacture, of the last unit produced, and on request presented to the competent authorities of the Member States. It does not have to be located in the territory of the Community, nor does it have to be permanently available in material form. It must be capable of being assembled and presented to the relevant authority by the person designated in the declaration for incorporation.

Failure to present the relevant technical documentation in response to a duly reasoned request by the competent national authorities may constitute sufficient grounds for doubting the conformity of the partly completed."

The technical documentation of equipment should be delivered, according to the classification in Figure 22:

Documentation	Equipment/Machines									
	Press & similars	Boilers, Pressure Vassels	Furnances	Cranes	Forklifts & Similars	Injector	Welding Machines	Washing Machine	Transfers and machining centers	Others
Certified Responsible Engineer	X	X	X	X	X	X	X	X	X	OPT
Safety Report whith: - Preparation and responsibilities - Identification of company (Contractor to carry out the retrofitting) - Information Equipment - Diagram the hierarchy of legislation - Principles for risk assessment (Methodology) - Calculation of the safety distance protections for two-hand controls and barriers (if used) - Overview of the equipment assessed (Photos of the equipment before and after safety devices)	X	OPT	OPT	OPT	OPT	X	X	OPT	OPT	X
Risk Assessment (RA) and Safety Measures to Implement (MSI)	X	X	OPT	OPT	OPT	X	X	OPT	X	OPT
Checklist after imlement de safety devices according with EHS Technical Manual	X	OPT	OPT	OPT	OPT	X	X	OPT	X	OPT
Certificates/Manuals of safety components and diagrams referring to part of Safety (Electric Scheme, hydraulic, pneumatic…) (in local language)	X	X	X	X	X	X	X	X	X	X
Noise Levels according with EHS Technical Manual	X	X	X	X	X	X	X	X	X	X
Operational Training (Practical and Theoretical)	X	X	X	X	X	X	X	X	X	X
Customer Responsibilities whit Frequency of Inspection and Maintenance of safety devices	X	X	X	X	X	X	X	X	X	X
Note: The EHS Dept can make changes as a result of the risks of equipment						**Legend**	X	Mandatory		
							OPT	Optional		

Figure 22

NOTE: *Figure 22 contains text: "Checklist after installation of safety devices …"*

3.8. CERTIFICATION OF THE SAFETY PRODUCTS

The EHS management, to ensure the reliability of safety products, requires safety certification as a minimum requirement. Application of the safety products shall not be in disagreement with the risks observed in risk assessment (see table 7).

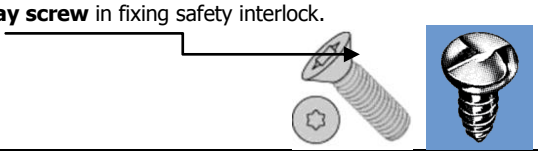
Equipment	EHS Description	Mandatory Safety Certificate
Light Curtain	24 Vcc/ca, Protection level IP65, Outputs with protection against short circuit, Operating mode with manual and automatic restart. *Resolution: 4mm – for fingers 30 mm – for hands 400 mm – for body *minimum light curtain resolution to be determined by category of Risk according to risk assessment.	TUV GmbH UL
Safety Interlock in thermo-plastic enclosure (with encoded latch) Refer to note	Construction in thermo-plastic material, 24 Vcc/Ca, Protection Level IP67, with at least 2 contacts (may be 2 closed contacts or 1 open and 1 closed depending on the application). Outputs with protection against short circuit. Resistant to drag of at least 10 N. Metallic actuator and encoded. Built according to norms IEC 947-5-1.	TUV GmbH UL
Safety Interlock with solenoid in thermo-plastic enclosure	Construction in thermo-plastic material, 24 Vcc/Ca, Protection Level IP66, with at least 2 contacts (may be 2 closed contacts or 1 open and 1 closed depending on the application). Outputs with protection against short circuit. Resistant to drag of at least 1200 N. Metallic actuator and encoded. Built according to norms IEC 947-5-1. Solenoid voltage 24 V.	TUV GmbH UL
Safety Interlock with metal solenoid	Construction in metal, 24 Vcc/Ca, Protection Level IP66, with at least 2 contacts (may be 2 closed contacts or 1 open and 1 closed depending on the application). Outputs with protection against short circuit. Resistant to drag of at least 2500 N. Metallic actuator. Built according to norms IEC 947-5-1. Solenoid voltage 24 V.	TUV GmbH UL
Hinged Door interlock - rotary type	Construction in thermo-plastic material, 24 Vcc/Ca, Protection Level IP67, with at least 2 contacts (may be 2 closed contacts or 1 open and 1 closed depending on the application). Outputs with protection against short circuit	TUV GmbH UL
Safety Relay for pushbuttons and emergency stop pushbuttons	Construction in thermo-plastic, feeding in 24 V, monitoring of the relays, option of automatic reset.	TUV GmbH UL
Enabling Control	These may only be used when "manual mode" (jog or teach) is allowed, to be determined by EHS. 3 position type (release OFF; compress to center position ON; compress beyond the center position OFF) is preferred.	TUV GmbH UL
Non-contact Interlock Refer to note	Magnetic Safety Key, without contact. Category 4 with connector (actuator and switched device), contact distance approximately 8 mm.	TUV GmbH UL
Two hand Control device	Shall be "anti-tie" down type, require synchronous operation, not to exceed 1/2 second for actuation of both controls.	TUV GmbH UL
Safety Valves	Safety valves 5/2 paths (pneumatic) Double channel with crossed flow (hydraulic)	Approval from EHS
Note 1: For equipment category 3, use valves of depressurization Sil 3 Note 2: Mandatory use of **one-way screw** in fixing safety interlock. 		
Notes: *1) Equipment and components not having safety certification require specific approval by EHS regarding the suitability and effectiveness for use in the safety application.* 2) *In applicable cases, the use of non-contact interlocks instead of interlocks with encoded latch is to be prioritized.*		

Table 7 - Minimum requirement

3.8.1. Safety Application Examples

The Figure 23 illustrate application examples of safety devices.

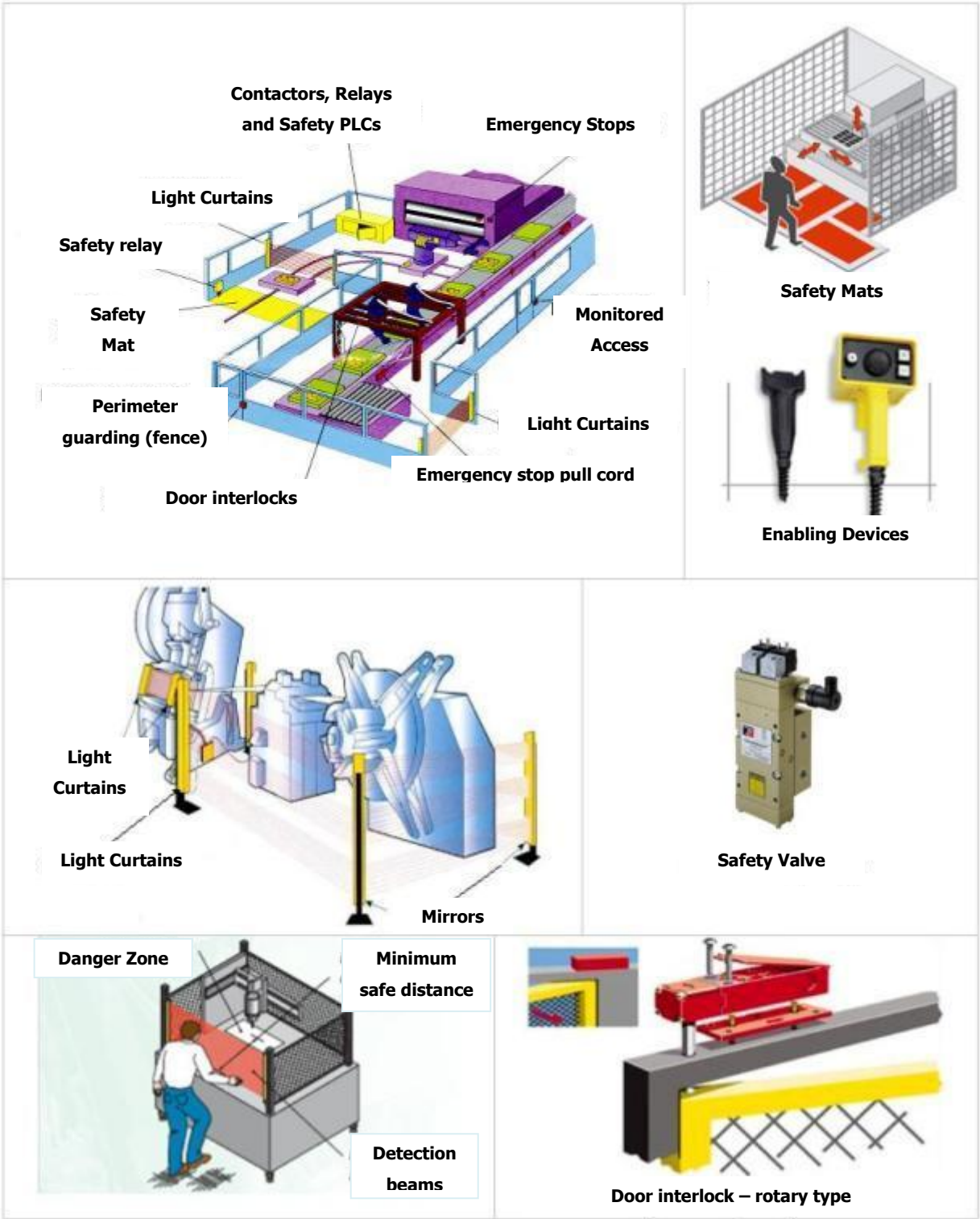


Figure 23 - Safety Application Examples

3.8.2. Application of fixed Safeguards - Examples

Figure 24 - Application of fixed safeguards - Examples

3.8.3. Application of adjustable Safeguards - Examples

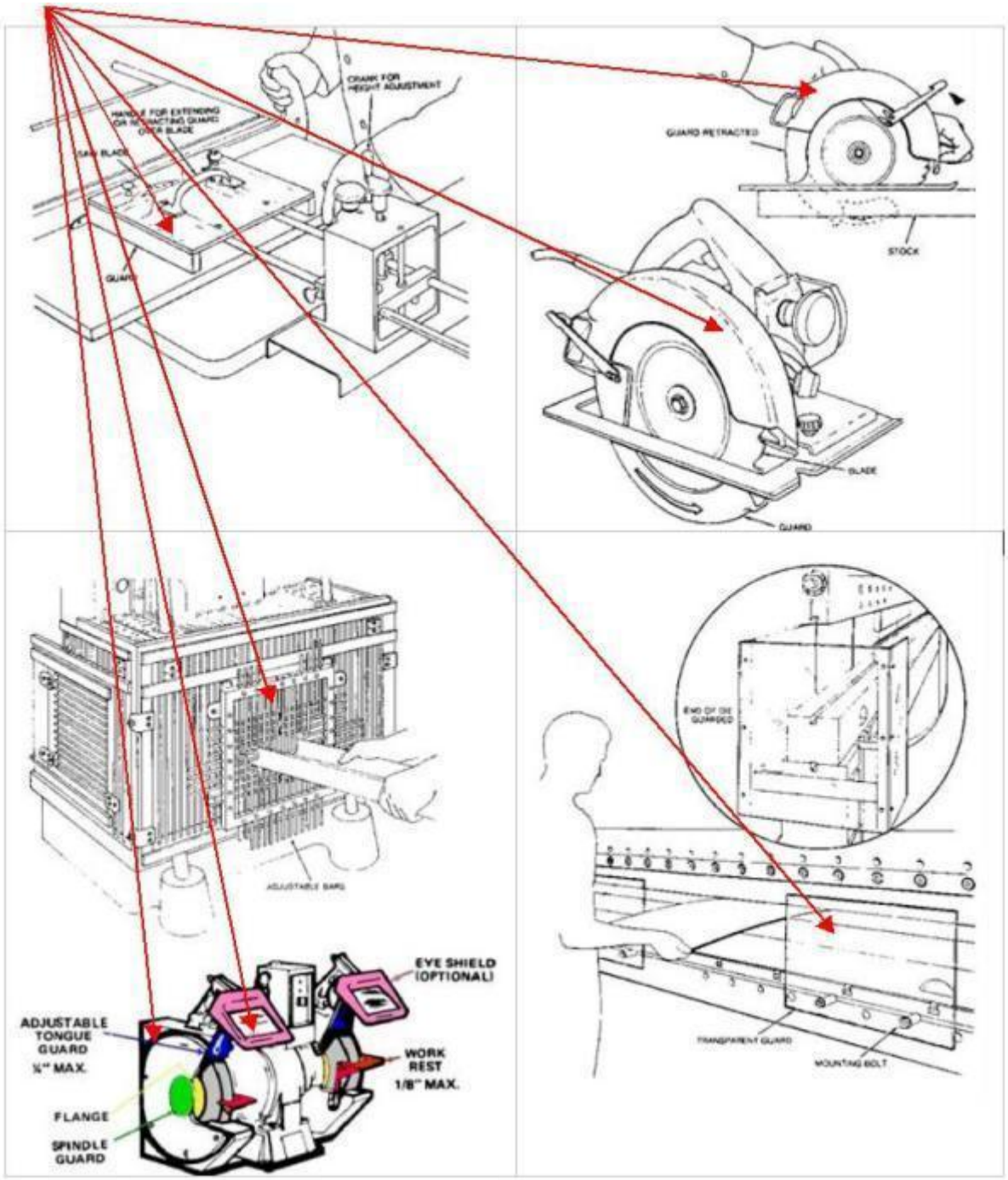


Figure 25 - Application of adjustable Safeguards - Examples

3.9. SAFETY

3.9.1. Technical Responsibility

In retrofitting equipment such as presses, injection molding, robotic work cells and other equipment after an initial risk assessment performed by the supplier together with Embraco - per ISO 13849 (EN 954-1) results in a classification of category 4, they must have an Expert report form (Technical Responsibility Note), signed by the responsible Certified engineer, attached in the documentation, with copies to the EHS Department. Specific documentation will be required, regardless of Safety category.

***Note**: The valve actuation of the brake clutch should be specific safety valve for the press.*

3.9.2. Emergency

Equipment that needs power (electric, pneumatic, steam, etc.) for its operation must have an Emergency stop button of 22.5 mm minimum diameter, with 2 NC contacts, self-monitoring, integrated with safety relay/ safety circuit monitoring.

The quantity and location of emergency stop devices (pushbuttons and/or pull cords) shall be in sufficient numbers, as defined by the EHS specification. If necessary, supplemental equipment emergency stop(s) may be added as implementation of risk assessment recommendations, conducted by EHS with Operators and Maintenance personnel.

The emergency stop device should function solely as emergency stop function must be initiated by a single human action. When executed, it will override all other functions and modes machine operation.

Release of the emergency stop device shall not by itself result in machine start or re-start, an additional human action shall be required for start and re-start. The emergency stop device shall be of the latched type (not a momentary type spring return) and require a manual release (pull out, or rotate to release).

The emergency stop devices shall be placed at (or readily accessible to) the operator control panel/station and other control locations where the emergency stop is required.

"The emergency stop devices shall implement the principle of positive mechanical action on its electrical contacts (positive break contacts), must have characteristic restraint (remain latched) after actuation and if the switch triggered by pull cord, a cut, under-tensioned (loose) or over-tensioned cable shall be automatically detected."

3.9.3. Wiring

Wiring used for safety devices and safety circuits must be standardized in orange for ease of viewing.

3.9.4. Controls

Operator controls shall be:

• Clearly visible and identifiable, and if possible be identified by graphical symbols;
• Positioned to allow a safe operation (operator must view the hazard area), without hesitation or loss of time and without equivocation;
• Arranged outside the danger zones;
• Located so that any operation can not give rise to additional hazards;
• designed or protected so that the desired effect, if it can cause a risk, can not occur without an intentional action.
• Devices for control of electrical circuits (control turns on or off) should be: Red "Off" - Off and Green "On" - Online.

When an operator control is designed to perform several different actions (keyboard, for example) the action must be entered uncoded and, if necessary, be subject to confirmation.

Figure 26

3.9.5. Machine with more the one Point of Control ("Single Point of Control")

If a machine has more than one point of control that if actuated can result in a hazard, then mutually complementary devices ("Single Point of Control" - the ability to operate the machine such that machine/hazard initiation from one source of control is only possible from that source and can not be overridden from another source.) shall be provided to exclude this risk.

3.9.6. Safeguarding of Moving Parts and Equipment Hazards - Emergency Stop "Span of Control"

All moving parts and equipment hazards must have adequate safeguarding so as to provide total safety to the operator and others.

In the case of machinery or parts of machinery designed to work in combination, the manufacturer shall design the machine so that devices can stop not only stop the machine and/or control the hazard(s), but also all other equipment (before and/or subsequent) if its continued operation constitutes a danger (also known as emergency stop "Span of Control" or "Zone Control").

3.9.7. Safety Mat/ Area Scanner

Safety Mat and / or Area Scanner (laser) Safety: If this solution is considered as a control measure, the device being used must have safety certification in accordance with section 3.3 of this standard. Installation of a safety device (mat or area scanner) shall comply with minimum safe distance requirements (EN 999), see item 3.9.13 below.

In accordance with Brazilian NR-12 and EN standards, a light curtain, safety mat, laser area scanner or other presence sensing device, shall not start a machine cycle (known as "PSDI" Presence Sensing Device Initiation).

Equipment that utilizes a light curtain as a safeguard must have at least one "Cycle Start" button, integrated with the safety control system, and only activated INTENTIONALLY by the operator (section 12.24, item (c) of NR-12).

Machine safeguarding devices with Presence Sensing Device Initiation ["PSDI"] - capability to control start/stop and/or machine hazards - must be designed, selected and installed such that:

a) personnel are detected in the hazard zone(s); and hazards are controlled before personnel can be exposed the hazard(s);

b) in an emergency the PSDI device can be de-activated or switched off by another person, other than the operator; and

c) unintentional start-up or shutdown by the operator, or by any other unintended means is prevented.

d) be provided with a means for secure attachment, and installed in a fixed location (not a moveable panel or station). Exception: The safeguarding device(s) can be mounted on mobile equipment, where the hazard zone(s) vary with machine operation - such as a laser area scanner on an automated guided vehicle (AGV).

3.9.8. Two Hand Control Device

Two hand control device (Bi-manual): The implementation must allow full visibility from the danger zone. They shall have the following characteristics:

- The individual operator's hand controls arranged by design, construction, or separation to require use of both hands within 0.5 seconds to initiate a cycle.
- Location and spacing between the two-hand control shall not allow unauthorized or unintended actuation (eg, a hand and arm, hand and elbow, etc.).
- Be designed to require release of all operator hand controls the re-activation of all operator hand controls before a cycle can be initiated (also known as "anti-tie down").
- A stop signal shall be issued if one or more hands are removed from the controls during the hazardous portion of a cycle.
- Be provided with a means for secure attachment, and installed in a fixed location (not a moveable panel or station).
- An emergency stop device (pushbutton or pull cord), according to item 3.9.2 of this standard, readily accessible to the two hand control.
- The number of two hand control stations shall not be less than the number of operators.
- Any device that can modify the number of two hand control stations shall not be easily accessible to operators.

This device can either:

- Be locked in a separate box with a special key held by supervisory personnel (eg team leader, , safety manager, skilled trade, …);
- Be deployed within an electrical cabinet;
- Be stopped by an authorized change in the operating system (eg microcomputer);
- Be controlled by a particular installation procedure.

3.9.9. Automated Transfer Capability Equipment

All equipment with automated transfer capability that is a risk to personnel shall not initiate a cycle through an optical two hand control device mechanical safety device (eg safety floor mat), or by Light Curtain controlled by PSDI (Presence Sensing Device Initiation).

Safety light curtains are most simply described as photoelectric presence sensors specifically designed to protect personnel from injuries related to hazardous machine motion. Light curtains offer optimal safety, yet they allow for greater productivity and are the more ergonomically sound solution when compared to mechanical guards. They are ideally suited for applications where personnel need frequent and easy access to a point of operation hazard. Light curtains shall be installed in accordance with safe distance requirements, as noted in Items 3.9.7 above and 3.9.13 below.

3.9.10. Access Doors, Moveable Guards, Covers and Panels

Access doors, moveable guards, covers and panels that prevent access to hazardous areas shall be equipped with safety devices to stop or control the hazard(s) immediately.

If the hazard(s) does not immediately stop or go to a safe state (controlled) after opening or moving the guard, a locking means shall prevent the guard from opening until the hazard(s) is stopped or in a safe state.

The safety device(s), shall be integrated in a safety circuit (eg monitored by a safety relay, safety module or safety PLC).

3.9.11. Energized Parts - Electrical Equipment

All electrically powered equipment and accessible conductive parts that may become energized in the event of an insulation breakdown, must be properly protected, enclosed, marked and have a grounding system, meeting the electrical safety requirements of IEC/EN 60204-1 or (NR-10 Brazil).

3.9.12. Machine Design - Egress

The machinery must be designed, constructed and equipped with a means to assure that an exposed person does not become trapped, or if not possible, provide a means to ask for help.

If perimeter guarding is provided and there is the possibility of full body access, the interlocking portion of an interlocked barrier (eg fence) shall be capable of being easily unlocked from inside the safeguarded space (also known as "egress"), without the use of a key, tool or power.

3.9.13. Light Curtains - Safety Distance

Light curtain detection capability (resolution) and category of safety to be used (category 2 or 4) must be determined through risk assessment, except equipment/ machines that have specific safety requirements (eg, presses and the like).

When installing safety light curtains, calculate the minimum safety distance to adequately position light curtain away from the hazard(s).

The distance between the hazard(s) and the light curtain must be such that the time the operator takes to reach the hazard(s) (in relation to the approaching speed of human body parts) is larger than the shut down time of the machine/hazard(s).

Safety Distance (ISO 13855 and EN 999)

S = (K x T) + C

S = Minimum safe distance between the light curtain and the hazard zone in mm

K = Approach speed in mm/s: constant, nominal value 1600 mm/s for hand/arm movement only; 2500 mm/s for nominal walking speed). Circumstances of the specific application need to be considered. As a general rule, the approach speed will vary from 1600 to 2500 mm/s. The total time in seconds after the intrusion occurs (eg light curtain beams are interrupted) before the hazard is stopped or controlled.

T = Delay time between light beam interruption and the machine/hazard is controlled (in a safe state) or stopped. This must include worst stopping time of the machine/hazard(s), worst stopping time of the control system, and response time of the safeguarding device including its interface.

C = Safety constant (additional clearance in mm)
The safety constant C = 8 x (d-14) is dependent on the particular resolution d (standard = 14 mm, 30 mm, 70 mm) of the light curtain. The actual resolution d must be re-calculated if the light beams are suppressed using the "blanking" function.

d = resolution of the screen (14 mm, 30 mm, 70 mm)
In addition to the safety function, light curtains may be used to initiate a machine cycle instead of two-hand control - **only if** either system application is approved by EHS.

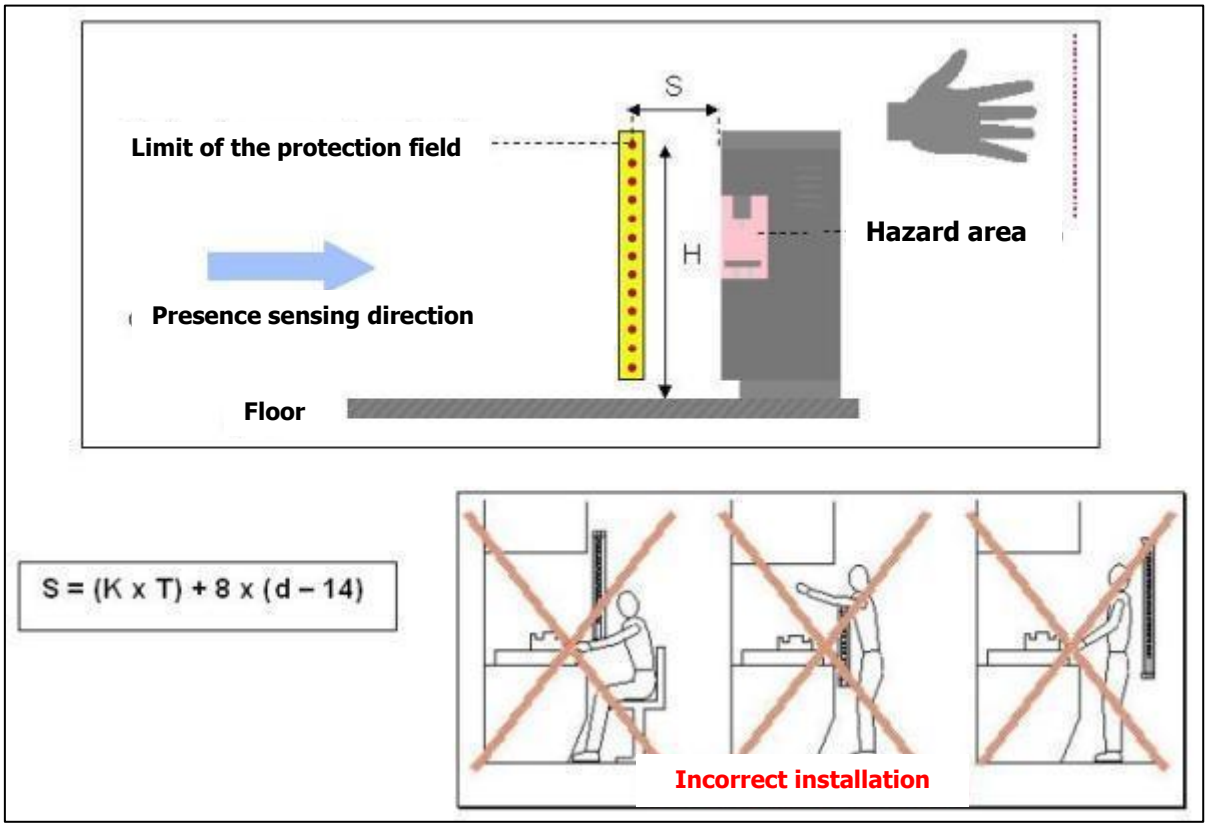


Figure 27

3.9.14. Furnaces

Furnaces that use fuel, gases or liquids must have explosion protection systems, reverse flame, and safety valve (shut off). The valves must be supplied with calibration certificate.

The network that feeds the equipment must have a readily accessible manual shut off valve for emergencies.

3.9.14.1. Furnace Safety Checks

The following is a guide. All checks shall be performed by qualified personnel in accordance with the furnace manufacturer's recommendations and applicable national and local safety codes.

A licensed plumber or heating contractor should perform these safety checks:

- Carbon monoxide safety test.
- Heat exchanger and fire box tests for leaks, cracks and other damage.
- Inspection of venting system to make sure the furnace is properly ventilated with no cracks or blockages.

- Chimney and flue checked for hazardous debris.
- Burners cleaned and set for proper combustion and ignition.
- Gas pilot safety system checked and cleaned.
- Proper flame characteristics evaluated. The flame should look sharp, stable and blue to indicate the gas is burning as purely as possible. A yellow flame indicates a poorly adjusted or dirty burner, which prevents it from mixing the gas and air properly.
- Fan, motor, bearings, belts and pumps checked, cleaned and lubricated, according to the furnace's specifications. Fan belt condition, tension and alignment checked and required adjustments made. Blower operation checked.
- Operation of thermostat and safety controls checked.

Figure 28

3.9.15. Boilers and Pressure Vessels

Boilers and pressure vessels must comply with ISO 16528:2007 - Boilers and pressure vessels; or local similar Regulation, for example NR13 in Brazil, and submit to approval by local authorities.

3.9.16. Special requirements for Robotic installations

Compliance with minimum clearance requirements (0,5 meter to prevent a trapping or crush condition) between the robot and a perimeter guard (eg fence) or other structures/equipment (see the following paragraph), often requires restricted movement of the robot. Clearance determination shall consider the robot arm, end-effector (such as gripper tool) and payload. See Figure 29.

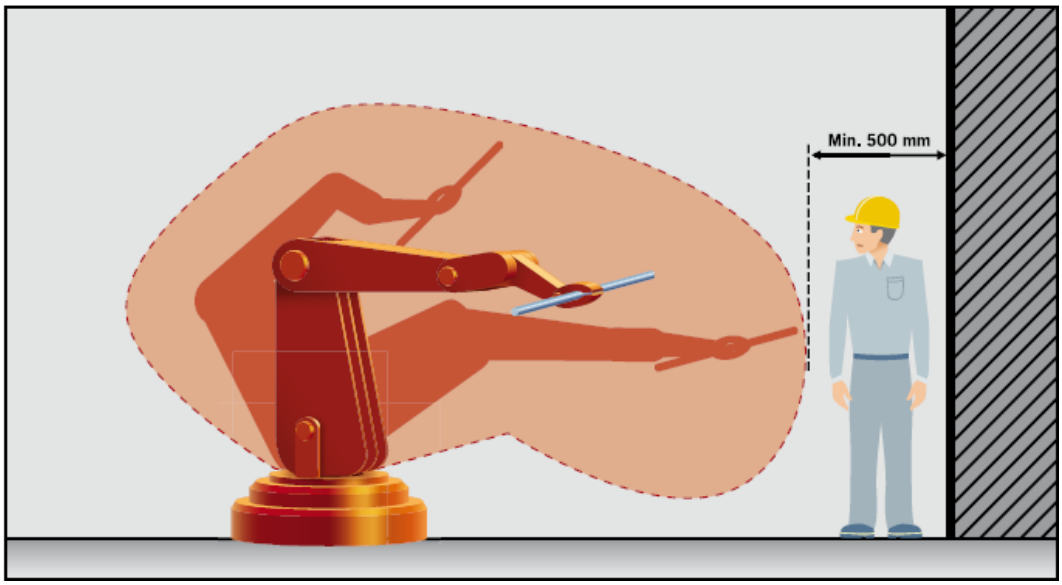


Figure 29: Minimum gap between the robot, end of arm tooling (such as end effector), payload and the guard (safety zone provided in the perimeter fence)

When personnel must enter the safeguarded space (robot work cell) to perform manual (slow speed) teach function, the robot system shall be installed to provide a minimum clearance from the operating space of 0,5 m from areas of building, structures, utilities, other machines and equipment not specifically supporting the robot function that may create trapping or a pinch point.

Where this minimum clearance is not provided, additional safeguarding devices to stop robot motion while personnel are within 0,5 meter of the trapping or pinch hazard shall be provided. This does not include those areas that are not readily accessible except by climbing over, around or under an obstruction unless access is required for the teaching function.

Restricted space is accomplished by adjusting the robot axis limits to restrict the maximum possible displacement of the robot on its axes.

Axis limiting adjustment considers the normal trajectories of programmed paths, as well as the positions of inclination (work envelope). Only after studying the options of installing axis limits the deployment of guards which are the peripheral enclosure is defined.

There are four types of devices which limit the displacement of a robot in its individual axis:

- Mechanical hard stops (fixed) defined by the robot design
- Adjustable mechanical (movable) hard stops
- Electro-mechanical
- Programmable logic/ software based.

Programmable logic (process path)/ software based limits are set to stop the robot before it reaches the other axis limiting means. Although process path software based axis limiting does not provide a level of safety consistent with the safety regulations, it may avoid certain faults that could cause a hazard.

Note: *Recently introduced technology, optional in some new robot systems, employs safety certified safe soft limit axis control. If such technology is integral to the robot system, the use of software based axis control may be considered. This technology can not be retrofitted to previous generations of robot systems.*

Axis 1 can be:

a) equipped with one or more adjustable mechanical hard stops; or
b) a means that does not depend on the use of a mechanical limit fixed by design and installed on an axis to limit its rotation in one direction. For example, a sensing device that is independent of the programmed path.

To avoid a dangerous "mechanical failure", two electro-mechanical limiting devices can be installed to cause the robot stop before it reaches the mechanical limits (hard stops). Such limiting devices shall be adjusted and installed properly.

Devices used as an axis limiting means shall be "safety rated" (tested, evaluated, and proven to operate in a reliable and acceptable manner when applied in a function critical to health and welfare of personnel), suitable for the application (eg environmental conditions - moisture, dust, chemicals, temperature, cleaning solutions, …) and integrated with the robot controller safety circuit.

Axis 2 can be equipped:

a) with one or more adjustable hard stops or
b) a means that does not depend on the use of a mechanical limit fixed by design and installed on axis 2 to limit its rotation in one direction.

Non-mechanical axis limits are deployed only if they complement or improve the performance / reliability that restricts the range of travel already obtained.

Electro-mechanical path limits can be deployed in this axis.

Axis 3 can be equipped:

a) with one or more adjustable hard stops; or in exceptional cases, can be equipped with electro-mechanical limit. The addition of electro-mechanical limiting devices should be done only after it has been compared with other safeguarding (cable stretched across the path of the robot, for example).

Note*: Section 3.9.16, Special Requirements for Robotic installations, does not represent all applicable robot safety requirements. Refer to the safety standards below for additional robot and robot system integration requirements:*

ISO 10218-1 - Robots and robotic devices - Safety requirements for industrial robots - Part 1: Robots.

ISO 10218-2 - Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration.

3.9.17. Forklift Safety kit

Forklifts must comply with the requirements and safety features below (see Figure 30), before being put into operation.

Figure 30: Forklift Safety

3.9.18. Color Codes

If colors identify safety related information, then identification shall comply with technical standards from Utilities area (Pte 00001) and DIN 2403 Identification of pipelines according to the fluid conveyed / ABNT NBR 6493-1994 Use of colors for pipeline identification.

As mentioned in this technical standard, the pipes shall be identified near the shut-off valves and painted, see Figure 31 for example:

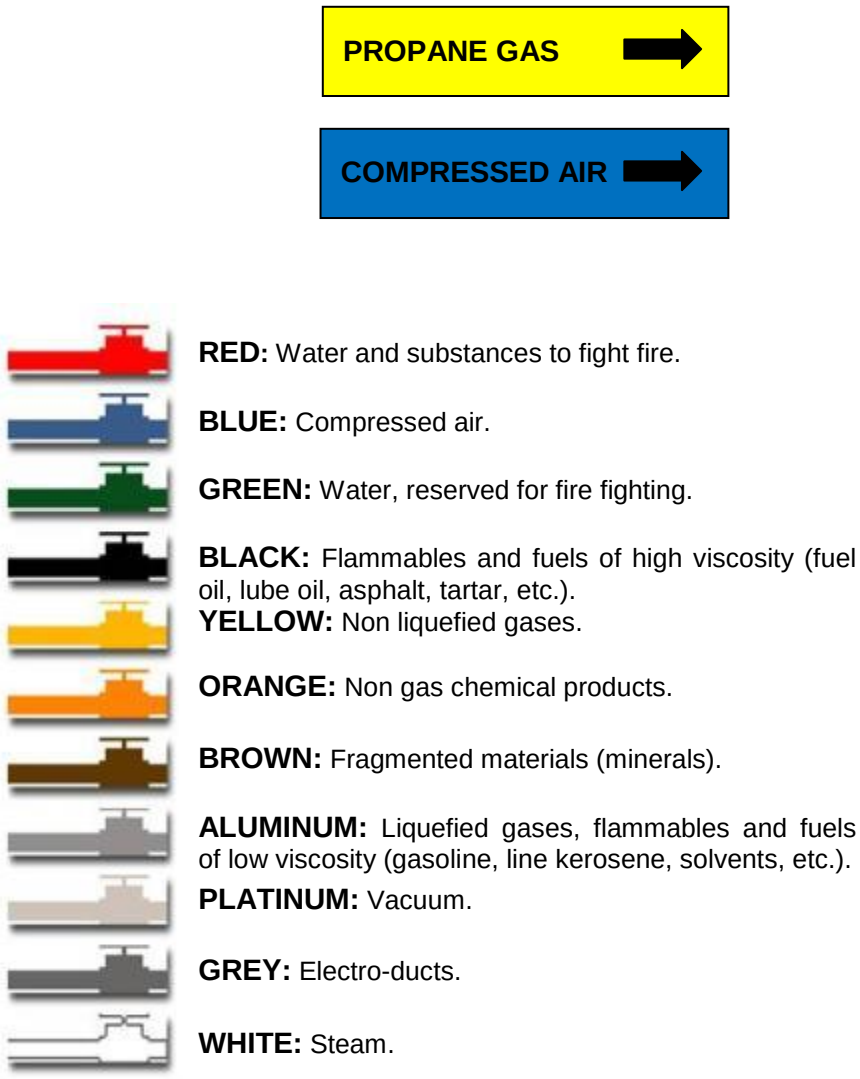


Figure 31

3.9.19. Safety Function Suspension (Bypass)

Manual suspension of safety functions can be performed in accordance with the provisions of ISO 13849-1 (EN-954-1). If it is necessary to suspend (bypass) manual safety functions (eg for configuration, adjustment, maintenance, repairs), a request shall be presented and discussed with EHS for solutions that take into consideration:

- Safe and effective means to prevent the manual suspension (bypass) mode of operation where this is not allowed;

- Restoration of safety function related parts to the safety control system, shall be completed before normal operation is restored;

- The part related to the safety control system responsible for manual suspension (bypass), shall be selected, to comply with the principles of ISO 14121. Manual suspension (bypass) shall only be permitted to be enabled when the machine is not in a dangerous cycle.

NOTE - *In some applications, an awareness means (such as a light or signal) to indicate the manual suspension (bypass) of the safety function may be necessary. EHS shall discuss with the machine builder, operator(s) and service personnel to determine the design requirements for implementation.*

3.9.20. Chemical Use

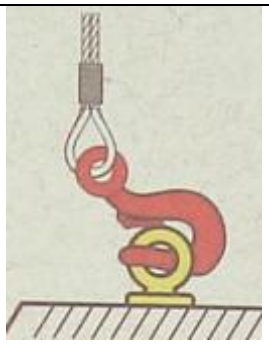
Chemical products used in equipment or processes must be first submitted for approval to Plant EHS department according internal procedures as well as labeled described in table 8:

	**O**	**Category:** Oxidizing
		Definition: Substances and mixtures which can contact other substances, particularly flammable substances exhibit highly exothermic reaction.
	**F**	**Category:** Flammable.
		Definition: Material which catches fire easily and burns rapidly; flashpoint below 37.8 °C.
	**C**	**Category:** Corrosive.
		Definition: Any solid, liquid or gas capable of irreparably harming living tissues or damaging material on contact.
	**T**	**Category:** Toxic.
		Definition: Substances and mixtures which if inhaled, swallowed or penetrate the skin, may involve serious risks, acute or chronic, and even death.
	**Ex**	**Category:** Explosion.
		Definition: Substance that can explode if it comes in contact with a flame or subjected to shock or friction.
	**Xn**	**Category:** Noxious.
		Definition: Substances or mixtures that can cause death or acute or chronic effects when inhaled, ingested or in skin contact.
	**Xi**	**Category:** Irritant.
		Definition: Substance that can cause irritation of the skin, eyes, or respiratory system. Effects may be acute from a single high level exposure, or chronic from repeated low-level exposures.

Table 8 - Chemical Label

3.9.21. Movement of Loads

Figure 32 - Use of Accessories – Recommendations and Precautions

 The second loop does not allow tension of the cable to equalize		In this situation, the force will be exerted at the weakest point of the hook, causing it to break.

Shackle/eyebolt

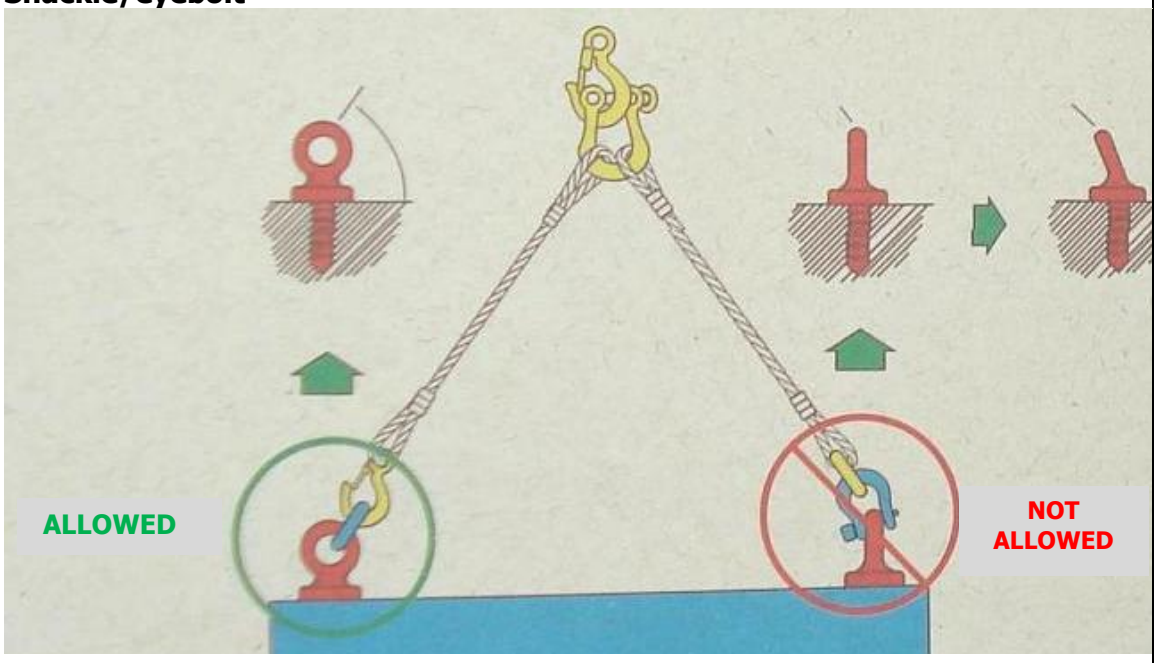


Figure 33

Securement of wire rope sling

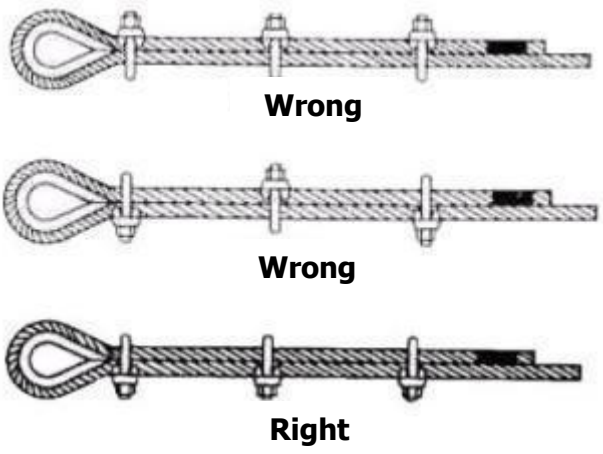


Figure 34

3.9.22. Inspection of the Slings (Polyester Belts) in Service

During the period of use, frequent checks shall be made to check for defects or damage, including damage concealed by splices, which may affect the safe use of the sling. Also check any connections or lifting accessories used with the sling. If there is any doubt as to suitability for use, or if any of the required markings have been lost or become illegible, the sling should be removed from service. Also see the instructions for use and maintenance.

Examples of Defects or Damage that may impact the slings *suitability for use:*

1. Any obvious damage on the cover indicates that there is potential damage to the core of the sling, endangering support of the load. Transverse and longitudinal cuts on the cover or any damage to the seam also compromise the integrity of the core. **REMOVE FROM SERVICE**.

2.Localized wear, which is different from general wear, may have been caused by sharp edges while the sling was under tension, may cause serious accidents. **REMOVE FROM SERVICE**.

3. In normal use there may be some chafing on the sling loop point (**is this the intent?**). Excessive wear can cause an accident. **REMOVE FROM SERVICE**.

4. A knot in the sling reduces the carrying capacity of 25-100%. Round slings should never be tied or twisted. **REMOVE FROM SERVICE.**

5. Transverse or longitudinal cuts on the cover and also damaged fibers of the internal loop sling may cause sling breakage. **REMOVE FROM SERVICE**.

6. Cross-sectional and longitudinal cuts, or cuts or damage to the edges of straps with eyelets. **REMOVE FROM SERVICE**.

7. Chemical exposure can result in weakening the material. This is indicated by scales on the surface of the cover or tape. Chemical exposure to the cover / tape can cause serious accidents. **REMOVE FROM SERVICE**.

8. Transverse and longitudinal cuts on the cover and also damaged fibers of the internal loop may cause sling breakage. **REMOVE FROM SERVICE**.

9. A sling that is not load rated and marked for its service should never be used. The label and rating information must be legible. **REMOVE FROM SERVICE**.

10. Payloads that are too big for the strap, resulting in a very large open angle, can destroy the belt. **REMOVE FROM SERVICE** and / or contact the vendor for guidance.

11. Fibers of the sling material, damaged by heat and friction take on a glazed appearance and, in extreme cases, there may be fusion of the fibers, indicating a weakening or breakdown of the internal core. **REMOVE FROM SERVICE.**

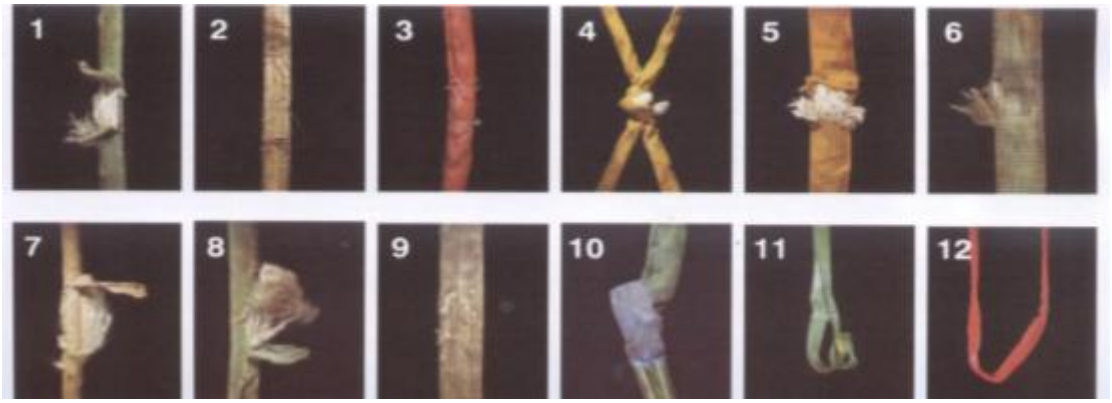


Figure 35

3.9.23. Service Stairs, Handrails and Fall Protection

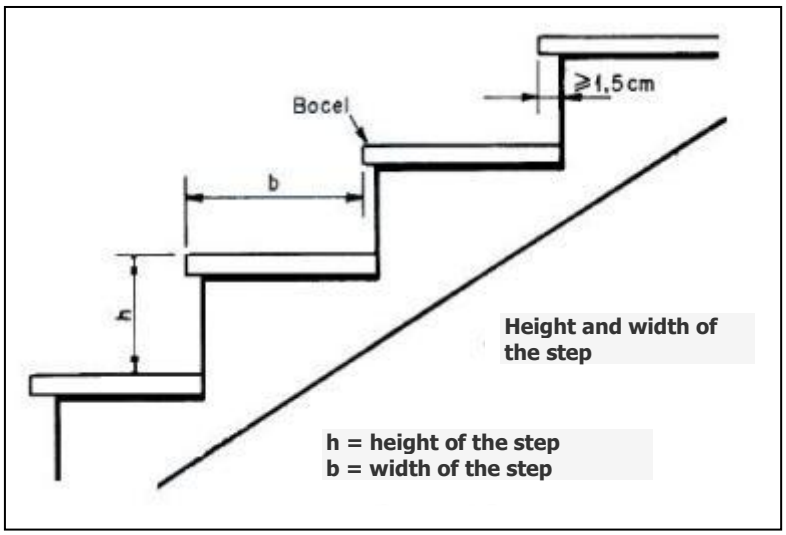


Figure 36

Dimensions of steps and staircase risers must be constant throughout the staircase. The floors and staircase riser can be hollow, if they do not cause additional risks. The step dimensions are: (see Figure 36 opposite)

a) Height "h" between 16.0 cm (6.3 inches) and 18.0 cm (7.1 inches), with tolerance of 0.05 cm (1.27 inches);

b) Width "b" per the Blondel formula: 2h + b = 63 cm to 64 cm (24.8 to 25.19 inches), example: h = 16, b = 23.5 cm / h = 18, b = 22.5 cm.

The width of stairways shall be determined according to the umber of people. The *recommended* minimum width or fixed stairs on accessible routes is 1.50 m (4 feet, 11 inches) and 1.20 m (3 feet, 11.24 inches) is the minimum acceptable width.

3.9.23.1. Fall Protection Sizing of steps and Levels

The staircases should have at least one landing every 3.20 m (9 feet, 0.84 inches) and whenever there is a change of direction. The Flights of stairs should be provided with minimum longitudinal dimension levels of 1.20 m (3 feet 11.24 inches). Landings located at changes of direction must have dimensions equal to the ladder width.

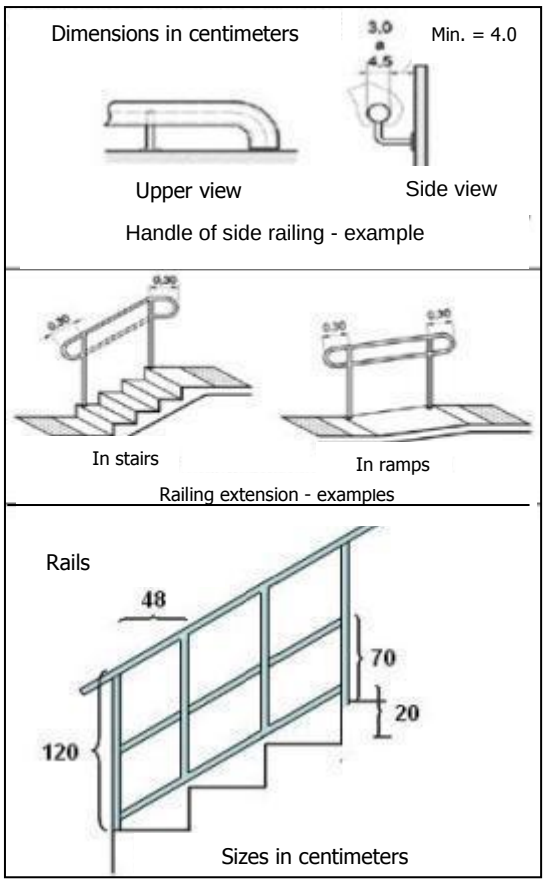


Figure 37

3.9.23.2. Portable ladders

Portable ladders should be restricted to service access and temporary use.

Portable ladders may be up to 7.00m (seven meters) (22 feet, 11.59 inches) long and the spacing between the rungs should be uniform, between 0.25m (twenty-five centimeters) (9.84 inches) to 0.30m (thirty centimeters) (11.81 inches).

3.9.23.3. Handrails

Handrails should be installed on both sides of isolated stairs, staircases and fixed ramps. Handrails shall have a width between 3.0 cm (1.18 inch) and 4.5 cm (1.77 inch), without sharp edges. Allow an open space of at least 4.0 inches between wall and handrail. Allow good grip and slide, being preferably circular section, as shown below (Figure 34).

The side rails shall extend at least 30 cm (11.81 inches) before and after the end of ramp or stairway, as shown below (Figure 38).

For isolated steps and stairs, the height of handrails shall be 0.92 m (3 feet) above the floor. For ramps and optional for stairs, the side railings shall be installed at two heights: 0.92 m (3 feet) and 0.70 m (2.29 feet) from the floor.

3.9.23.4. Guardrails

Fall protection, when shields are composed of a rigid system of guardrails and foot guards, must meet the following requirements:

a) be constructed with a height of 1.20 m (one meter and twenty centimeters) (3.93 feet) to the cross bar and 0.70 m (seventy centimeters) (2.29 feet) to indent the intermediary;
b) have foot guards with height of 0.20 m (twenty centimeters) (0.65 feet);
c) have openings between rails filled with screen or other device that ensures safety closure of the opening

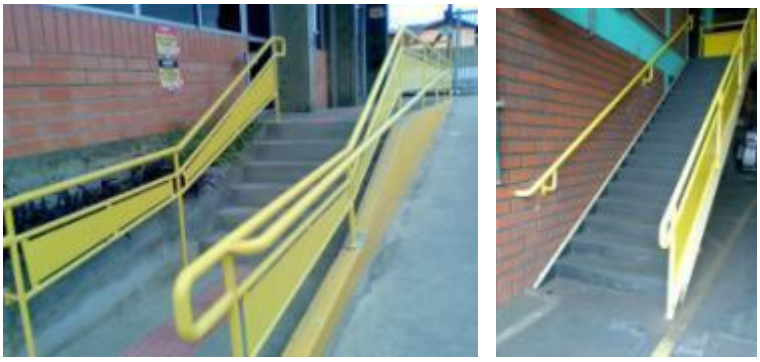


Figure 38 - Examples of stairs and ramps

3.10. PROTECTION TO THE ENVIRONMENT AND TO THE WORK ENVIRONMENT

3.10.1. Noise (Ambient Sound Level)

Noise that is continuous/ intermittent should be measured in decibels (dB), with instrument sound pressure level (decibel) operating in the range of "Scale A".

3.10.1.1. Noise Measurement Distance

All operating conditions should be measured at and not exceed **80 dB**, and the readings are as follows:

a) operator: at the ear;
b) machine: at a distance of 80 cm (31.49 inches) from the machine.

3.10.1.2. Noise Impact

The noise impact should not exceed 80 dB in the quick response "C scale".

3.10.1.3. Measurements on New Equipment

After equipment installation at the designated location, re-measure and evaluate the increase in noise that this equipment will bring to the environment taking into account the measurements, "a" and "b" of Item 3.10.1.1.

3.10.1.4. Acoustic Enclosure

Equipment with an acoustic enclosure must have devices that allow operation only with all the access doors closed.

All equipment that exceeds 85 dB, the readings made as described in Section 3.10.1, shall provide for the installation of acoustic enclosure to ensure that the equipment is below 80 dB (unless the technical characteristics of the process does not allow this level of sound pressure).

3.10.2. Air Emissions

Equipment that in its operating process emanates dust, gases and vapors, must have adequate exhaust system, and agents will be treated / filtered before being released to the outside environment, in accordance with environmental standards (ISO 14001) and Local Mandatory Requirements.

In this case, sampling points (collection nozzles) should be provided for atmospheric emissions in the chimneys, namely:

2 holes with sleeve (glove) of 4 inches placed 90º from each other;

The holes should be positioned in a straight piece of chimney pipe. In this part they should be positioned so that the tube length is at least 2D (where D is the pipe inner diameter), ideal for 8D before the holes and at least 0.5 D (the ideal being 2D) after the holes. The straight pipe is one that has no curves, reduced diameter of the chimney, change of flow direction and installed equipment (fans, exhaust fans, etc. ...) – see figure 39;

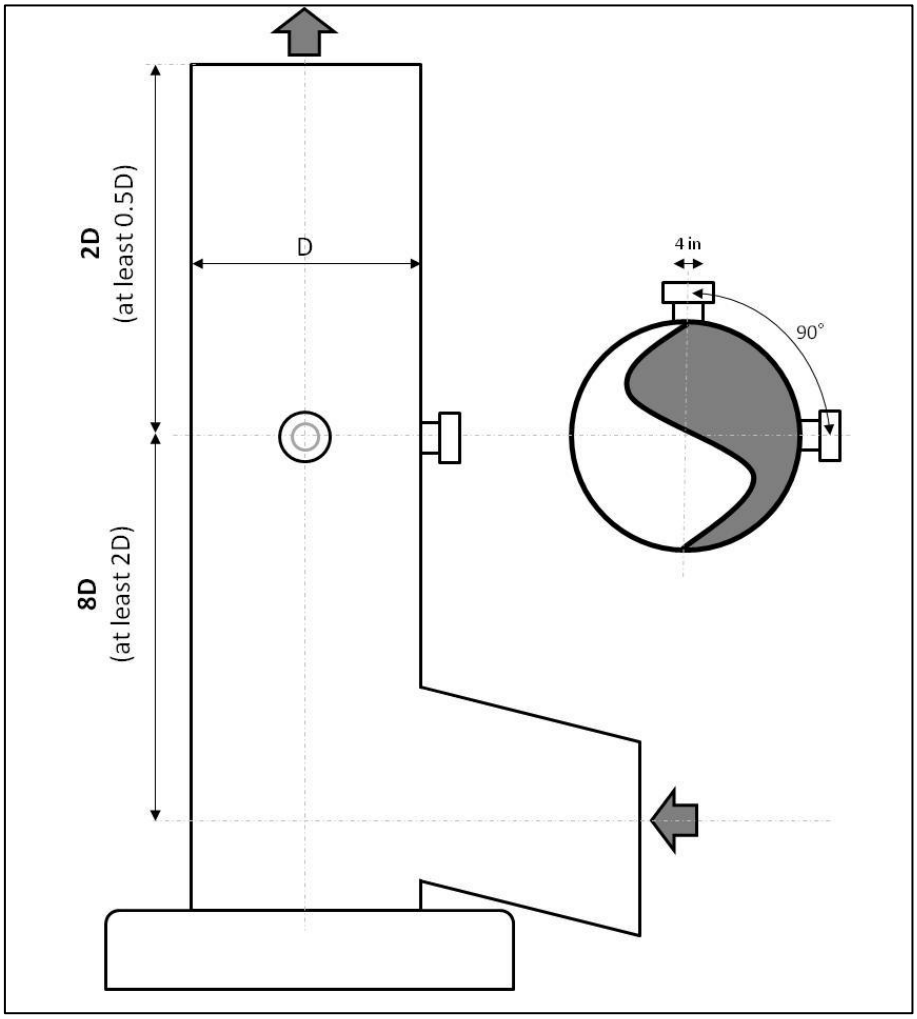


Figure 39 – Positioning of monitoring holes

If more than one part in a straight tube, which meets the criteria of the previous item, the holes should be made that they offer better physical conditions and safety for collection of atmospheric emissions;

System should be provided with capability to plug the holes (e.g., stopper type lid).

3.10.3. Radiation

Equipment that issue ionizing and non-ionizing radiations shall have protection, so as to prevent any type of contact with the operator and nearby areas.

3.10.4. Heat

Equipment must be technically isolated so that the contact temperature, in all of its surrounding, does not exceed 26º IBUTG Index (Global Thermometer Wet Bulb).

3.10.5. Lighting

Where possible make the most of natural lighting, which besides being free does not cause environmental problems. When it is necessary to resort to artificial lighting, be careful to adapt the lighting to the type of work.

Considering the scenario of Standards and regulations in all Countries where Embraco has plants, the summary of lighting recommendations is outlined below:

- Minimum values of illuminance in office workplaces, design and conference rooms vary from 200 to 500 lx, which leads to a discrepancy of lighting power of 1:2.5 if the uniformity of lighting delivered in the rooms is identical.
- Recommendations concern minimum horizontal and vertical illuminance values. The recommendations do not take into account illuminance of computer screens.
- Ratios of illuminance in the field of vision are rather consistent and similar to the CIE work recommendations.
- Glare ratings use either the Unified Glare Ratio (UGR) of the CIE or the Visual Comfort Probability (VCP) of the IESNA (Illuminating Engineering Society of North America). These specifications are rather consistent.
- Ceiling illuminance and shielding seem to be rather consistent. This is essential with the development of direct/ indirect luminaries. However, no specification takes into account the risk of overhead glare, which is an issue under discussion at the CIE.
- The general or supplemental lighting should be designed and installed to avoid glare.
- General lighting should be evenly distributed and diffused.

3.10.5.1. Recommended illuminance levels

Basically, the differences in recommended illuminance are not high since they tend to be related to the CIE recommendations. However, there are countries which recommend lower values of minimum illuminance.

The ISO standard ISO 8995-1:2002 (CIE 2001/ISO 2002) states that in the areas where continuous work is carried out, the maintained work plane illuminance should not be less than 200 lx. In all the reviewed recommendations, the minimum work plane illuminance in offices were higher. ISO 8995-1:2005 standard does not give any recommendation for uniformity of illuminance on the work plane, but suggests that the illuminance in the vicinity of the task should not be too low in comparison to the illuminance on task area. For example, the illuminance in the vicinity of task is 300 lx for a task with illuminance of 500 lx, 200 lx for a task with illuminance of 300 lx. However, the illuminance in the vicinity of task should be equal to the illuminance in the task area if the value for task illuminance is below 200 lx. In most countries which were reviewed, the minimum maintained illuminance on desks for regular office work is 500 lx, but lower values are recommended in India (300 lx), Denmark (300 lx), USA (depending on type of task) and Australia (320 lx). Minimum illuminance values for lounges, lobbies and corridors are specified within a range from 50 to 100 lx depending on country.

As a guide, select one of three illuminance values described in Table 9, and one should make use of the Table 10, balancing the respective weights as follows:

Table 9 – Lighting by class of visual task		
Class	Lighting (lux)	Type of activity
The lighting for areas used with interruptions or with simple visual tasks	20 - 30 - 50	Public areas with dark surroundings.
	50 - 75 - 100	Simple guidance for a short stay.
	100 - 150 - 200	Places not used for continuous work; warehouses.
	200 - 300 - 500	Tasks with requirements.
B - General lighting for working areas	500 - 750 - 1000	Tasks with normal visual requirements, medium work-with machinery, offices.
	1000 - 1500 - 2000	Tasks with special requirements, manual recording, inspection, garment industry.
C - Additional lighting for difficult visual tasks	2000 - 3000 - 5000	Visual tasks precise and prolonged, electronics in small size.
	5000 - 7500 - 10000	Very precise visual tasks, assembly in micro-electronics.
	10000 - 15000 - 20000	Very special tasks, surgery.

Table 10 – Determining factors for proper lighting			
Features of the task and the observer	Weight		
	-1	0	+1
Age	Less than 40 years old	40 to 55 years old	**Above 55 years**
Speed and	No relevance	Relevant	**Relevant**
Background reflectance task	Over 70%	30 to 70%	**30 to 70%**

1 look at each feature to determine its weight (-1, 0 or +1);

2 sum the three values found algebraically, considering the signal;

3 using the luminance bottom group, where the total is equal to -2 or -3; luminance higher when the sum is +2 or +3; and luminance average, in other cases.

* **Note 01**: The highest of the three luminance should be used when:
1 task is presented with very low reflectance and contrast;

2 errors are difficult to correct;

3 the visual work is critical;

4 high productivity and accuracy are of great importance;

5 the eyesight of the observer may be below average.

* **Note 02**: The lowest of the three

Note: *Waste of light should also be prevented, by maintaining a constant lighting and cleaning the light sources from one to four times a year (depending on their exposure to dust).*

3.10.6. Internal Components

If certain internal components should be inspected frequently, they must be equipped with appropriate lighting, the same should occur for the areas of adjustment and maintenance.

3.10.7. Refrigeration Equipment

The refrigeration equipment, chillers and fire extinguishing systems shall not use substances that degrade the ozone layer and should be designed to avoid the automatic purging of refrigerant materials.

3.10.8. Asbestos

It´s forbidden to use materials containing asbestos fibers (asbestos) in its composition in use in machinery and equipment (e.g. use in insulation of furnaces, pipes, etc. ...).

3.10.9. PCBs

It´s forbidden to use transformers and capacitors containing PCBs (ascarel oil). They shall contain a steel plate stating the type of oil they use. If possible, use dry transformers, oil-free.

3.11. ERGONOMICS

The ISO 11226 Ergonomics — Evaluation of Static Working Posture, ISO 11228 - Ergonomics – Manual Handling establishes parameters for the adjustment of working conditions to the psycho physiological characteristics of workers in order to provide optimal comfort, safety and efficient performance; it must be used in its entirety when designing an equipment/ machine/ job.

3.11.1. Equipment Trigger (Actuation)

The equipment should not have their operational processes triggered (actuated) by foot.

3.11.2. Equipment Heights

Panels and equipment must be designed to 150 cm (59.05 inches) from the floor to the point of greatest visual concentration.

The height of the assembly line/ equipment must be between 900 mm (35.43 inches) and 1100 mm, (43.3 inches) considering the height of the component and its weight.

For weights above 2 kg (4.4 lbs), where the arm movement is necessary, it is recommended that the work is done standing.

3.11.3. Horizontal and Vertical Movement

In the assembly lines, which use conveyors, distance to pick up a part shall not exceed 250 mm (9.84 inches) in the horizontal and vertical direction and its movement does not exceed 30 degrees.

3.11.4. Sitting work

For sitting work there must be an internal area of 700 mm (27.55 inches) width for legs. The depth should be at least 500 mm (19.68 inches) on top and 1000 mm (39.37 inches) at the bottom, near the feet.

Recommendations:

Thickness (rail) - 100 mm (3.93 inches)

Foot rest 100-300 mm (3.93 - 11.81 inches)

Note - From the foot rest to the height of the row space of less than 700 mm (27.55 inches)

Maximum height to work standing or sitting, a maximum of 1,100 mm (43.3 inches)

3.11.5. Two-hand Controls

The distance between the two hand controls can not be less than 600 mm (23.62 inches).

3.11.6. Forearm contact

All parts in contact with the forearm should have rounded corners with a radius of not less than 10 mm (0.39 inches).

3.11.7. Transport Equipment

The equipment for transport, handling systems and displacement of materials shall have the following characteristics:

a) the force applied must not exceed 20 kgf (44 lbf);
b) in motion longer than 1 minute, the force should not exceed 10 kgf (22 lbf);.

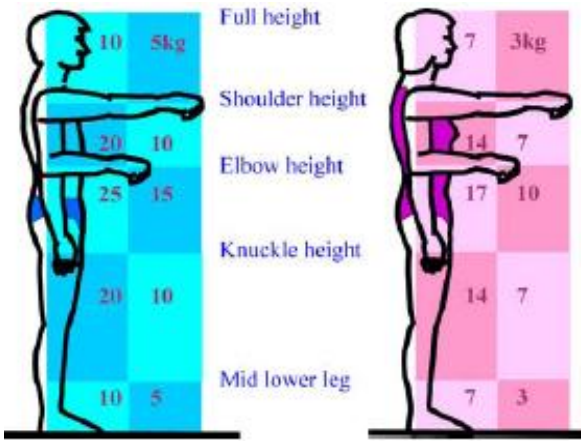


Figure 40

3.11.8. Handles

The handle of the hand carts must be 30 to 35 mm (1.18 - 1.37 inches) in diameter and a height of 900 mm (35.43 inches).

3.11.9. Steps

The steps are preferably a maximum height of 170 mm (6.69 inches) and a minimum depth of 290 mm (11.41 inches). The slope of an incline should not exceed 15 degrees (260 mm per meter [10.23 inches per 39.37 inches]) and its width is 1200 mm (47.24 inches) for frequent access.

The edges of steps and stairs should be non-slip.

3.11.10. Posture

To improve posture, as tilted systems, aid to the operator, lifting brackets, should be installed. If inclined motors are installed, the following specifics apply:

3.11.11. Manual transport of loads

The manual transport of loads is one of the oldest forms of work and common, accounting for a large number of injuries and accidents. These lesions mostly affect the spine but can also cause other diseases such as, scrotal hernia.

The correct technique for lifting loads (box, bar, bag, etc.). The knee should be advanced at an angle of 90 degrees. Arms stretched between the legs. Back erect. Chin not downward. Legs spaced laterally. Load close to the vertical axis of the body. Minimal trunk bending.

The manual handling is expensive, inefficient (the yield useful for lifting operations is around 80-10%), distressing (causes intense fatigue) and cause numerous accidents. So whenever possible, should be avoided or minimized. The maximum load is 20 kg (44 lbs) in good condition at most once per hour.

3.11.12. General recommendations for manual transport of loads:

- Avoid handling loads not appropriate for body type, shape, size and position;
- Use appropriate technique depending on the type of cargo;
- Do not bend, the column should serve as support;
- When you are carrying a load avoid laughing, sneezing or coughing;
- Avoid twisting motions around the body;
- Keep the load at the position closest to the vertical axis of the body;
- Symmetrically distribute the load;
- Carry the load in the upright position;
- Move loads by rolling, wherever possible;
- Place the arms beside the body;
- Always use your body weight in order to facilitate the handling of cargo;

The mechanization of activities can be done with the use of: pulleys, belt conveyors, hoists forklifts, carts to transport, lifts, cranes, bridges, walkways, etc.

3.11.13. General Tips

3.11.13.1. Keeping an Eye on Visual Comfort

To ensure visual comfort, keep your monitor between 45 and 70 cm (17.71 - 27.55 inches) distance and adjust its height at most, to your line of vision. This can be done through a monitor stand, or by use of dynamic tables. Whenever possible, try to "rest" the view, looking at objects (tables, plants, aquariums, etc., ...) and landscapes to more than 6 meters (19 feet, 8 inches).

3.11.13.2. Neutral Grip is key

Just as the height of the monitor, the keyboard should also be adjustable. Adjust it until it is at the level of the height of your elbows. During typing it is important that the cuff is neutral (straight) as shown above. Keep the keyboard always in the lowest position and type with your arms hanging or use a wrist support!

3.11.13.3. Feet well supported

It is important that people can work with their feet on the ground. Chairs should therefore have adjustments consistent with the population in question. For Brazil, the ideal would be chairs with adjustable height from 36 cm (14.17 inches). When the

chair does not allow the person foot support on the ground, the solution is to use a footrest, which serves to relax muscles and improve blood circulation in lower limbs.

3.11.13.4. Give it a rest for the back

Except for some activities, the chairs must have backs (back) of medium size. Greater support surface ensures a better distribution of body weight, and better muscle relaxation. We recommend also that the chairs have no arms (the support must be on the tables, to ensure a correct support) and the lining should be soft and rugged fabric.

3.11.13.5. Lighting

To avoid reflections, work surfaces, walls and floors should be opaque and the monitor must have an anti-reflective screen. Avoid placing the computer near a window and use light fixtures with adequate protection.

3.11.13.6. Colors

Balance the luminance using soft colors in matte shades. The reflection coefficients of the areas of environment, should be around: 80% for ceiling, 15-20% for the floor, 60% for the wall (upper), 40% for the divisions to the wall (lower part) and for furniture.

3.11.13.7. Temperature

As a general rule, comfortable temperatures for computing work areas, are between 20 and 22 degrees centigrade (71 Fahrenheit) in winter, and between 25 and 26 degrees centigrade (77 and 79 Fahrenheit) in summer (with humidity levels between 40-60%).

3.11.13.8. Acoustics

Acoustic levels should be suitable for work environments where there is constant attention and intellectual application, with sound pressure levels below 65 dB (A). For this reason we recommend appropriate treatment of the ceiling and walls, through acoustical materials and adoption of special divisions.

3.11.13.9. Humanization of the environment

Wherever possible, humanize the environment (plants, paintings and when possible, sound). Encourage social interaction among employees. Many companies are adopting policies to this effect have been achieving a significant increase in productivity. Remember that the process of socialization is very important for mental health.

Recommended Workstation Measurements (inches)

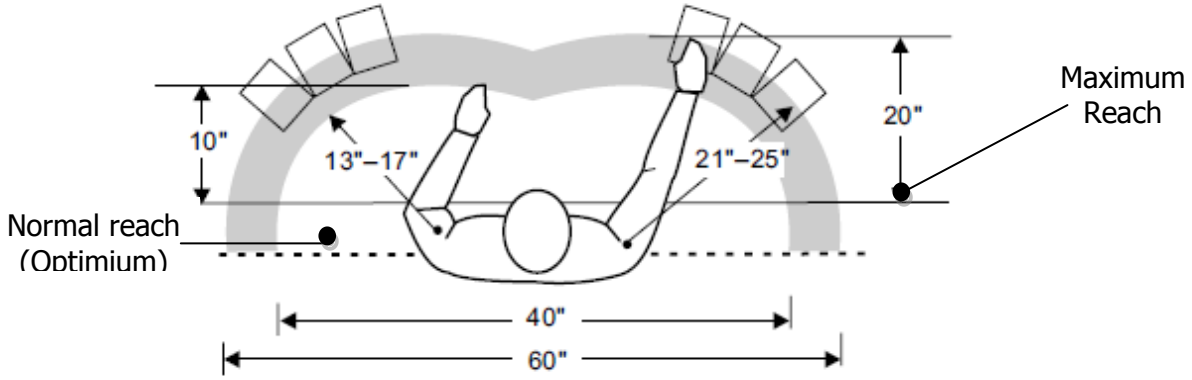


Figure 41

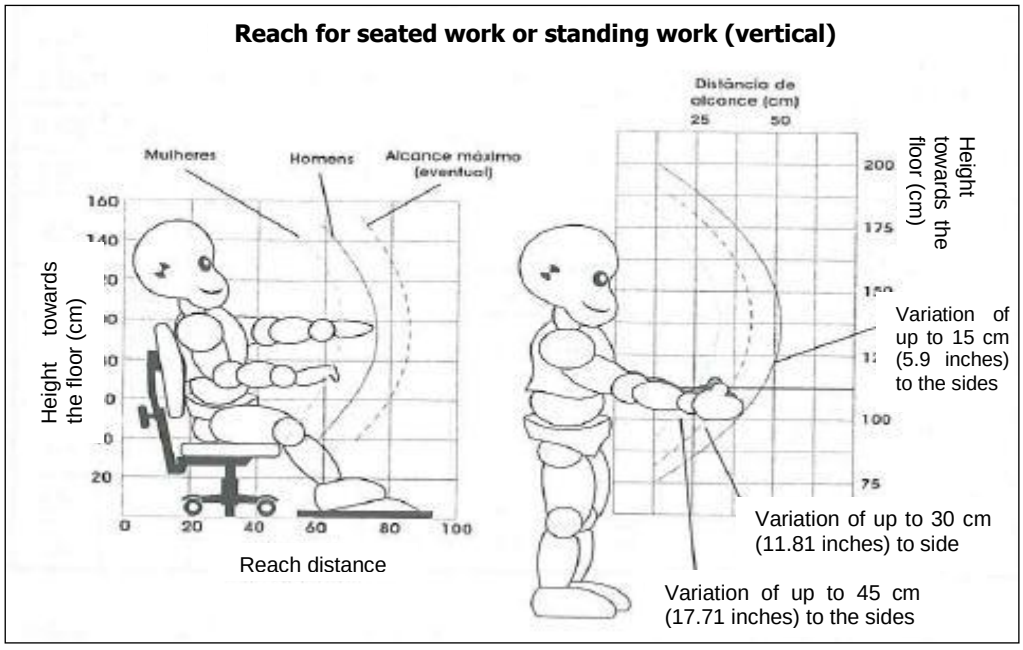


Figure 42

3.11.14. Chairs and Backrests

The chair must give the body a number of support points, so:

- The support surface of the seat should be large;
- Seat height should be adjustable;
- The seat should be tender but not soft;
- The front edge of the seat should be rounded;
- The level of the seat should be adjustable according to the level of the table;

- The curvature of the backrest should adjust to the back;
- The edges of the backrest should be inclined;
- The rod of the backrest should be semi-flexible;
- Backrest should be able to rotate horizontally;
- Chair legs should occupy little space.

The footrest shall:

- Be stable, have large bearing surface and allow multiple positions;
- Have adjustable height;
- Have the height adjusted according to the chair;
- Make a right angle, approximately, with the leg.

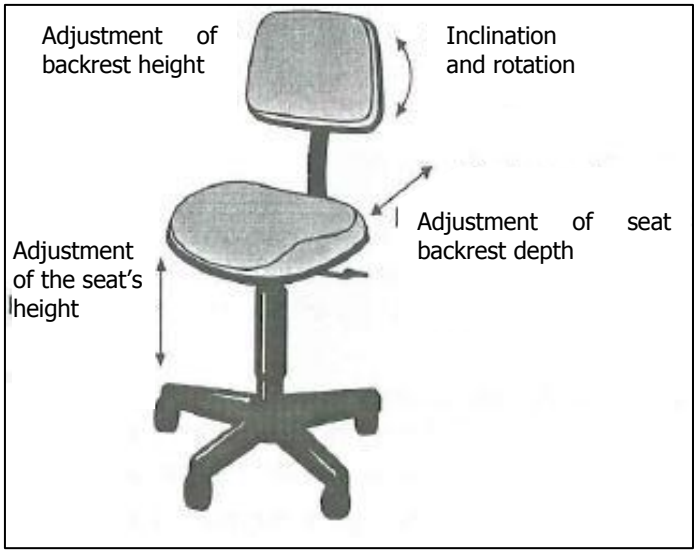


Figure 43 - Some adjustable parameters needed on chairs

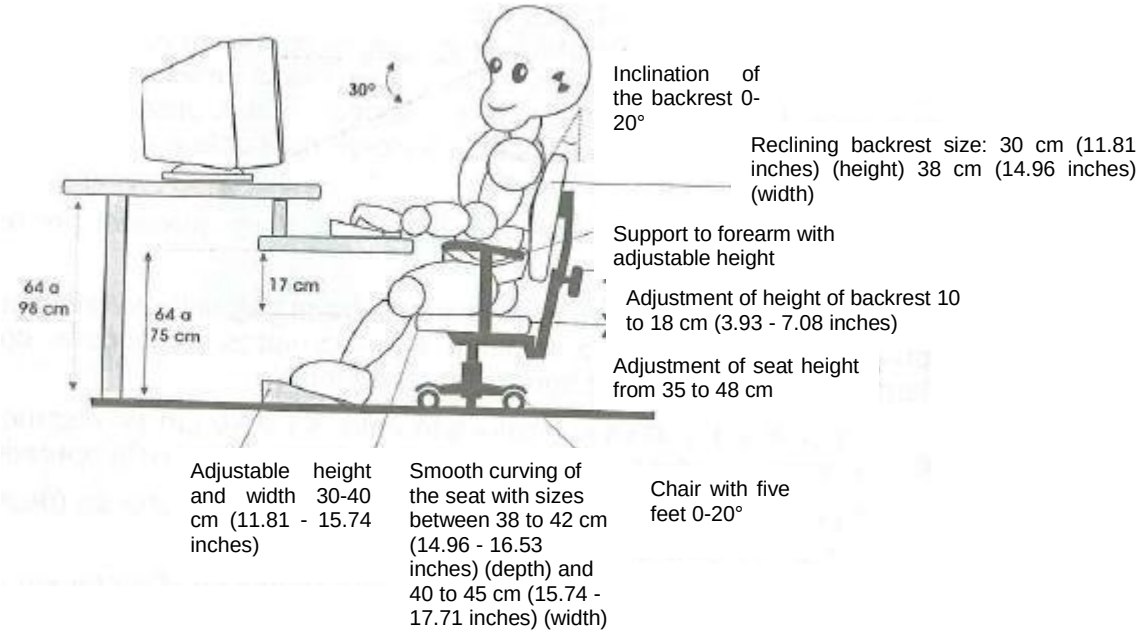


Figure 44

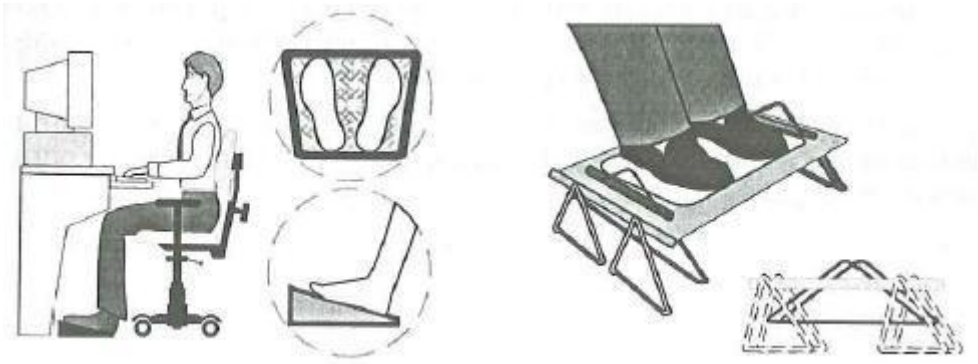


Figure 45 - Foot support

3.11.15. Standing Work

Workbench heights should be:

- Above elbow height for ***precision work***
- Just below elbow height for ***light work***
- 4-6 inches below elbow height for ***heavy work***

Shelf heights which a freestanding person can reach and place a hand flat on a shelf should not exceed 60 inches.

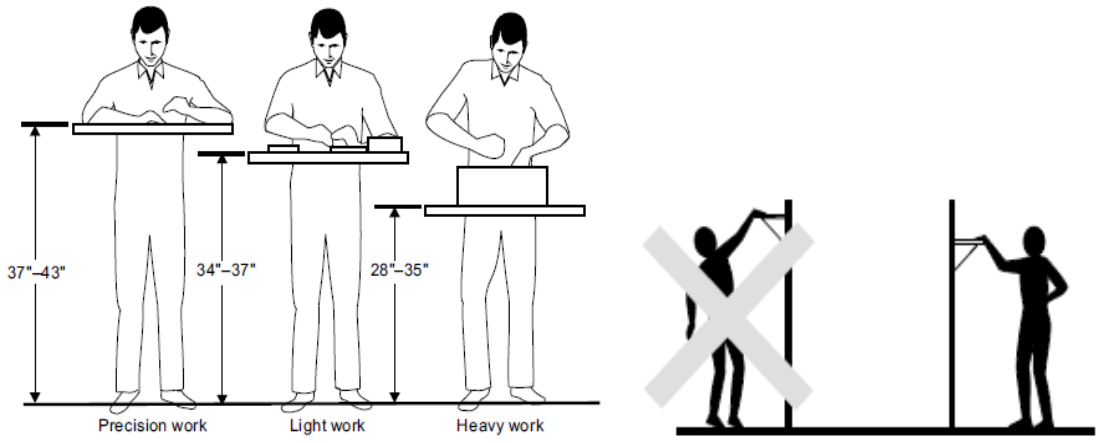


Figure 46

3.11.16. Tables and Desks

The tops of tables and desks should not be too big to be areas that a person sitting in a chair, hardly reaches, or so small they do not permit a person to work at ease. The recommended maximum dimensions are approximately 75-80 x 190-195 cm (29.52-

39.41 x 74.8-77.77 inches). These dimensions allow anyone to work comfortably on a format A4 document anywhere on the table.

The minimum should not be less than 60 x 75 cm (23.62 x 29.52 inches). These dimensions allow any person to work comfortably on an A4 size document.

3.11.17. Energy efficient Guidelines for Electrical Products

3.11.17.1. Motors

All motor installed in new machines or replaced during retrofitting must be premium-efficiency models.

Think systematically. The full potential of an efficient motor can best be captured if it is integrated into an optimized drivepower system. This may be difficult to do in retrofit applications, but it is very important when designing new systems, for which all components can be right-sized from the start. Properly optimized motor systems often use less than half the energy of systems designed according to standard rules of thumb. To create an efficient drivepower system, select efficient, properly sized models of the equipment that the motor will drive, such as pumps and fans. (The DOE also offers a free Pump System Assessment Tool that can help industrial users assess the efficiency of their pumping system operations.)

For more information on sizing fans, see the Purchasing Advisor **HVAC** (Heating, Ventilating, and Air Conditioning): **Fans.**

Buy the right size of motor. Motors operate at their highest efficiency between about 60 percent and 100 percent of their full-rated load, dropping off sharply in efficiency below 50 percent loading. About one-third of motors in the field are so oversized that they operate below 50 percent of rated load most of the time. Motors only operate at their peak efficiency if they are sized correctly for the load they drive. In addition to operating inefficiently, oversized motors carry a higher first cost than right-sized units. They can also contribute to reduced power factor, which increases load on the building's electrical system and can result in utility fees for low power factor.

Account for the motor's impact on power factor. Power factor is an indicator of how much of a power system's capacity is available for productive work. Low power factor is undesirable because it increases the load on a building's electrical system, and utilities sometimes charge customers a penalty for facilities with low power factor. Because power factor is lower when a motor is lightly loaded, be sure to choose the right-sized motor. You can also specify a motor with a high power factor, but such models sometimes have lower efficiency. The ultimate selection depends in part on whether a facility is subject to power factor penalty charges. A facility with a significant number of induction motors and a low power factor can solve the problem with premium-efficiency motors that are properly sized.

3.11.17.2. HVAC (Heating, Ventilating, and Air Conditioning) - Fans

According to a recent study, more than 25 percent of the energy consumed in commercial buildings is used for heating and air-conditioning. Of that, a good portion (anywhere from 20 to 60 percent) is consumed by the fans and pumps that transfer heated or cooled air or water from central heating and cooling plants to conditioned spaces. Supply and exhaust fans are the major players, primarily because most fans operate continuously while the building is occupied. There is a wide variation in efficiency between different fan designs (from as low as 40 to as high as 80 percent). In light of their long operating hours and wide-ranging efficiencies, HVAC fans are often good candidates for energy-efficiency retrofits.

In addition to the efficiency of the fan itself, the low cost and wide availability of variable-frequency drives in all horsepower ranges make this technology an important part of most energy-efficiency upgrade strategies.

Axial-flow fans. Axial-flow fans are the familiar propeller-type fan (similar in many ways to residential fans that get plugged into the wall for space cooling); the air is passed straight through. Axial fans are often directly connected to their motors, avoiding losses associated with a drive belt. They also have a central hub that allows the motor to fit neatly behind the fan with little penalty in efficiency. The weight distribution of their blades allows for low starting torque.

Axial fans can be subdivided into three categories (see Figure 47): propeller fans (used to move high air volume against low or no static pressure), tube-axial fans (fans that encase the propeller in a duct section), and vane-axial fans (fans that use straightening fins to convert circular, twisting air motion into longitudinal, straight air motion). Vane-axial fans tend to be the most efficient fans available for HVAC air-handling units - with efficiencies in the high 80s - largely because the direction of the airflow is little changed as it passes through the fan.

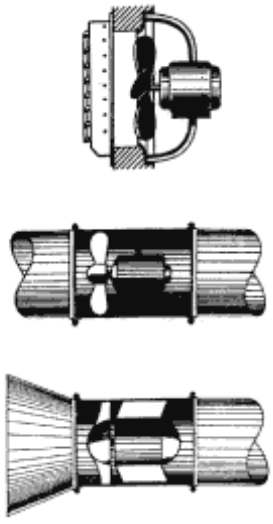


Figure 47

The pitch of axial fan blades can be fixed, adjustable, or "variable pitch in flight," meaning that the blade angle can be varied as the fan rotates. Fixed-pitch blades are the norm for low-efficiency propeller fans and for constant-volume fans. Adjustable-pitch fans allow the user to manually adjust blade pitch to tune the flow - a useful feature for commissioning or for building in a safety factor without penalizing efficiency. Variable-pitch blades can be adjusted "in flight" by pneumatic or electric actuators; they provide efficient volume control without changing the speed of the fan. The mechanism that enables blade pitch to be varied in flight must be diligently maintained in order to ensure proper operation over time.

Centrifugal fans. Centrifugal fans, also known as "squirrel cage" or "utility" fans, have an entirely different design (see Figure 48). Instead of passing straight through, the air makes a 90-degree-angle turn as it travels from the inlet to the outlet and is "thrown" from the blade tips. Centrifugal fans have more mass farther from the axle, which requires more starting torque, but they're generally quieter than axial fans.

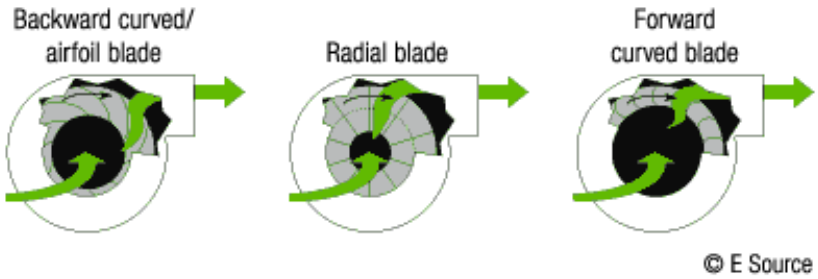


Figure 48: Centrifugal fan impeller blades
Backward-curved airfoil impellers provide the highest efficiencies for centrifugal fans

Despite their lower efficiencies, centrifugal fans greatly outnumber axial fans - anecdotal estimates indicate that centrifugals make up 80 to 90 percent of the HVAC supply fans currently used in the U.S. and nearly 100 percent of fans in smaller packaged air handlers.

How to Make the Best Choice

Pick a size that's just right. There is broad anecdotal evidence that many fans and motors are larger than necessary for their intended use. One investigator concluded after making field measurements on about 1,000 motors that about half operated at less than 60 percent of their rated load and a third operated at less than half their rated load. Probably the fans whose motors were attached were similarly oversized. That's bad news for those who pay the energy bills, because fans operate at their highest efficiency within a relatively small range. Outside of that range, efficiency drops off dramatically.

To pick the appropriate size, use a fan chart such as that shown in Figure 43. For new construction, carefully calculate the airflow and pressure drop and then add a safety factor. In a retrofit case, use the chart with data from actual measurements of flow

and pressure to determine the optimum size, rather than looking for a like replacement.

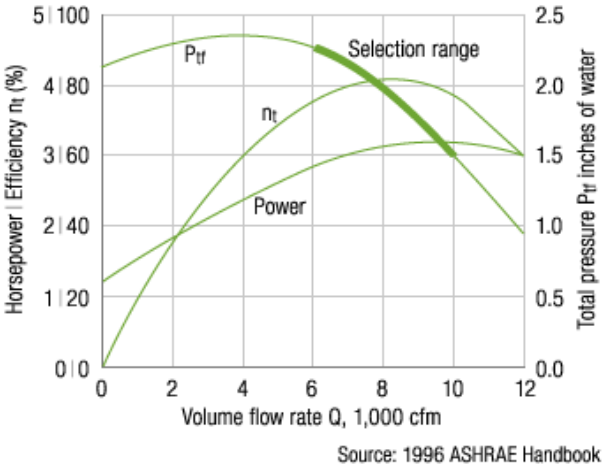


Figure 49

Fan curves show the relation between the quantity of air that a fan will deliver and the pressure against which it can discharge the air. The curves also indicate the horsepower required from the drive motor for the corresponding airflow, and the fan efficiency. For a given application, pick a fan that operates most of the time at the highest part of the efficiency curve. As shown, choosing a fan too far to the right will ensure plenty of airflow, but at a penalty in efficiency.

If HVAC fans are oversized, replacing them with ones that are correctly sized - "rightsizing" them - can be cost-effective. A rightsized system saves energy costs, but there are other advantages as well:

- Lower first costs. Because the capacity required from the fan system is reduced, the system can be more accurately tailored to the new airflow requirements. By installing smaller, more energy-efficient equipment that meets these requirements, first costs are also reduced.

- Comfort. If the fan system supplies too much air to occupants, energy is wasted and comfort can be compromised. Too much air can result in disturbing drafts, increased humidity, and noise.

- Equipment life. Prolonged operation at very low speed of an oversized motor with a variable speed drive can reduce the useful life of the motor and associated equipment. Properly sized equipment will be more suited to operation at reduced capacities.

As a first step, the opportunity for rightsizing an air distribution system can usually be determined by building maintenance staff. Once an opportunity has been identified, however, it is usually necessary to hire an HVAC engineer to verify it, to conduct a more detailed analysis, and to make recommendations for optimizing the system.

If you've got a variable air volume HVAC system, the first step in rightsizing the system is to reduce the static pressure setpoint to the minimum setting at which occupant

comfort is maintained on hot, humid days. This step in itself can save a lot of energy. Once the lowest acceptable static pressure setpoint has been determined, measure the fan-motor power draw using a true RMS (root-mean-square) power meter under peak load conditions (that is, on a hot, humid day). If the measured power is less than 75 percent of the motor's nameplate rating, there's a good chance that the motor is oversized.

For constant air volume systems, you can determine whether the fan is oversized by comparing the system's actual static pressure to design pressure. Measure the main supply fan system static pressure on a hot, humid day. Make sure that all fan vanes and dampers are fully open. If the measured static pressure is greater than the design pressure (found in building mechanical drawings), the fan is supplying too much air and is probably a good candidate for rightsizing.

Characteristic	Centrifugal fan, forward-curved	Axial fan with vanes
Fan efficiency, full load (%)	63	78
Power requirement, full load (kW)	15.9	12.8
Fan efficiency, part load (%)	47	63
Power requirement, part load (kW)	10.	6 7.9
Annual fan energy use (kWh)	58,300	46,300
Annual cooling energy required (kWh)	17,147	13,618
Annual energy use (kWh)	75,447	59,918
Annual energy cost ($)	6,036	4,793
Annual energy savings ($)	NA	1,242
Incremental fan cost ($)	NA	600
Simple payback period (years)	NA	0.5

Notes: NA = not applicable; kW = kilowatts; kWh = kilowatt-hours © E Source

Figure 50

Check the cost-effectiveness of high-efficiency options. Axial fans are the most efficient, but consider backward-curved fans where centrifugal design must be used. To evaluate the cost-effectiveness of high-efficiency fans, estimate the time spent in full- and part-load operation and calculate the potential savings as shown in (Figure 44).

In addition, consider how variable-frequency drives (VFDs) might figure into the equation, especially if there are a significant number of operating hours spent at part load.

A VFD provides significant benefit during part-load operation for airfoil and fixed-pitch axial fans, but less benefit when applied to a forward-curved fan (horsepower requirements for forward-curved fans drop off more steeply with reduced airflow than for other fan designs, so the VFD provides less of an efficiency improvement).

A VFD should not be employed on a variable- or adjustable-pitch axial fan. Such fans are designed to operate at a constant speed, and varying fan speed can cause it to operate at a resonant frequency, causing excessive vibration that can actually make

the fan blades break free from the hub (potentially causing substantial damage to surrounding equipment).

This table (Figure 44) illustrates the calculations required to evaluate the cost-effectiveness of a high-efficiency fan. The calculations assume a full load of 10 kilowatts and a part load of 5 kilowatts, operating time of 3,000 hours per year at full load and 1,000 hours per year at part load, and an electricity cost of $0.08 per kilowatt-hour. Use a fan curve (see Figure 43) to find the efficiency at the desired operating conditions. Note that the heat generated by the fan adds to the cooling load - the energy required to remove that heat is calculated assuming a cooling coefficient of performance of 3.4.

Pay attention to entrance and exit conditions. The conditions at the entrance and exit to a fan greatly influence fan system efficiency. Following these guidelines can help you get the most out of your fan system:

- Use long, straight duct runs upstream and downstream of the fan.
- Use gradual slopes when ducts expand or contract. A slope of 1:7 usually works well.
- For single-inlet centrifugal fans, place the drive system opposite the inlet to keep the inlet clear of obstructions.
- Avoid spinning the air into the impeller of centrifugal fans. Bringing the air in axially produces the best efficiency unless the impeller is specifically designed for either pre-rotation or counter-rotation. For example, inlet guide vanes, sometimes also called pre-rotation vanes, are used to vary the air delivery of centrifugal fans.
- If duct elbows must be used near a fan inlet or outlet, install turning vanes. If an elbow is installed near the outlet of a centrifugal fan, have it turn in the same direction as the fan impeller. Doing the opposite - turning the air in the opposite direction from the impeller - is colloquially known as "breaking the back of the velocity profile" and leads to substantial pressure drop.
- If a centrifugal fan with inlet guide vanes is to be retrofitted with a VFD, remove the inlet vane assembly from the fan inlet and replace it with a smooth bell mouth in order to improve efficiency.
- For axial fans, use bell mouths, spinner cones, and tapered outlet sections for maximum efficiency.

Consider VFDs for variable flows. Variable-frequency drives - also known as variable-speed drives or variable-frequency inverters - use electrical waveform modification to vary the voltage and frequency of the alternating current that drives the motors. By controlling motor speed so that it closely corresponds to varying load requirements, VFDs can reduce energy consumption (in some cases, energy savings can exceed 50 percent), improve power factor, and provide other performance benefits such as soft-starting and overspeed capability. They also can eliminate the need for expensive and energy-wasting capacity control mechanisms such as outlet dampers or inlet guide vanes. VFDs require a small amount of power to operate, and so fans with a VFD consume more power at full load than single-speed fans - typically 2 to 3 percent more - but it takes very little time operating at part load to make up the power draw of the VFD. VFDs can be cost-effective in cases with average loads as high as 90 percent, but an analysis should be performed for each individual case based on the time spent

at part-load conditions and the efficiency of the fan with and without the VFD. The price of VFDs has continued to decrease, while performance and reliability have increased. As a result, energy codes in some states now require VFDs on almost all fans employed in HVAC systems. (For more information about VFDs, see "Motors: Adjustable Speed Drives.").

4. SAFETY WARNING MARKINGS AND GRAPHICAL SYMBOLS

4.1. MANDATORY ACTION

Samples of Mandatory Action warning markings and graphical symbols are shown in Figure 51 below. Explanatory English text may be modified according to the local language.

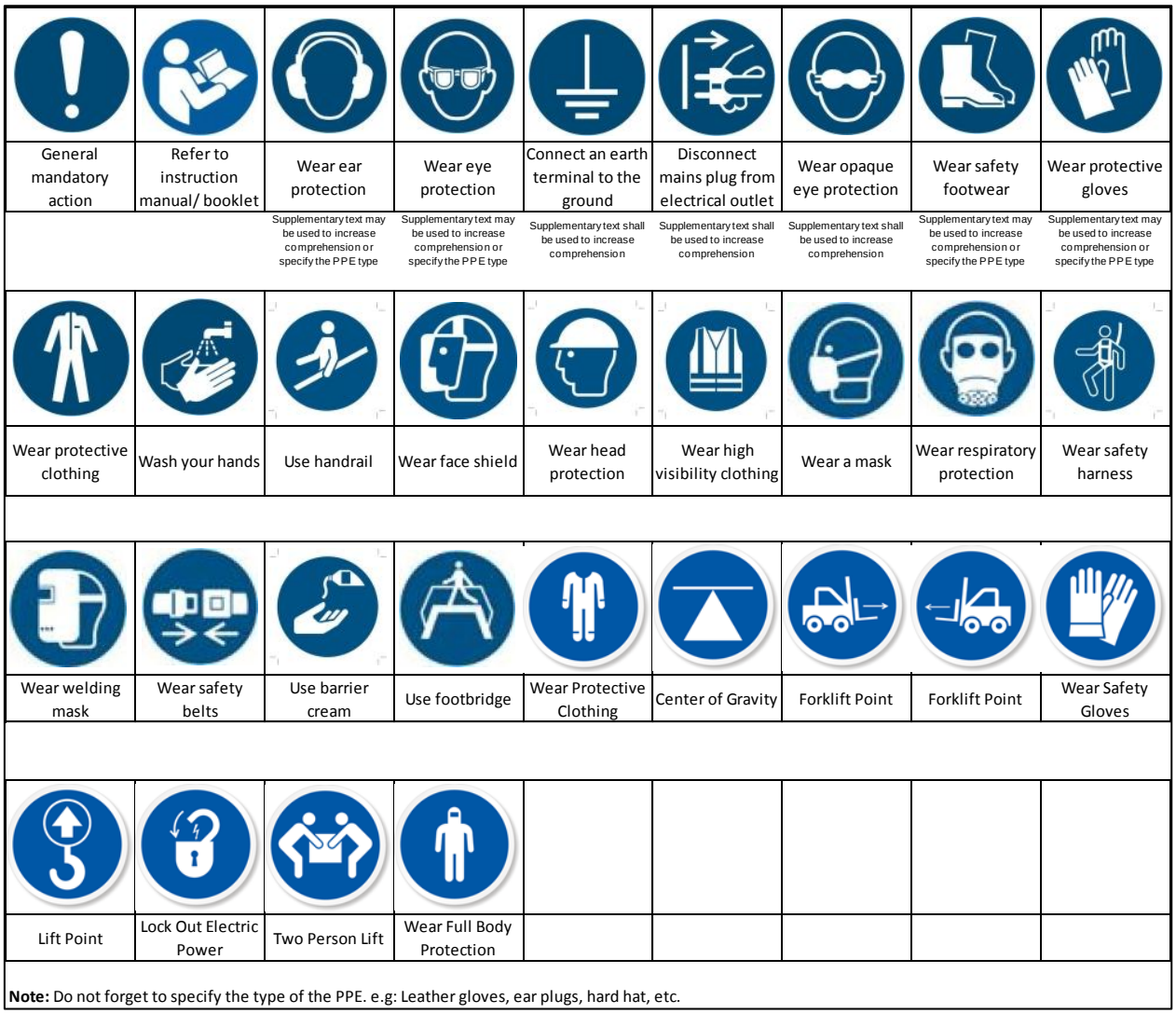


Figure 51 - Samples of Safety warning markings and graphical symbols

4.2. PROHIBITIONS

Samples of Prohibition warning markings and graphical symbols are shown in Figure 52 below.

Explanatory English text may be modified according to the local language.

Figure 52 - Samples of Prohibition safety warning markings and graphical symbols

4.3. WARNING

Samples of Warning markings and graphical symbols are shown in Figure 53 below.

Explanatory English text may be modified according to the local language.

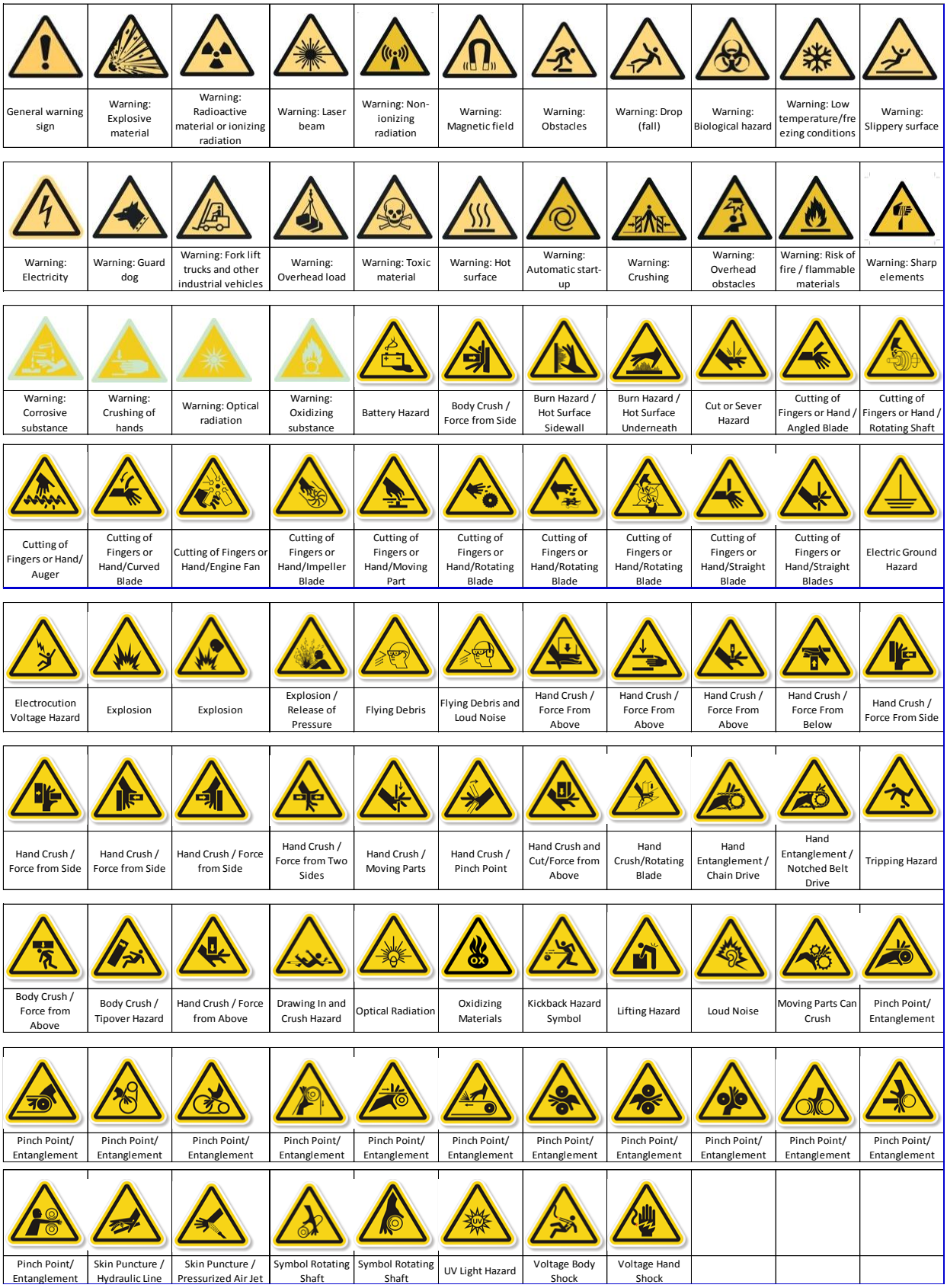


Figure 53 - Samples of Warning markings and graphical symbols

4.4. CHEMICALS (SUBSTANCES AND MIXTURES)

Samples of Chemicals (substances and mixtures) markings and graphical symbols are shown in Figure 54 below.

Explanatory English text may be modified according to the local language.

	Exploding Bomb	Unstable explosives Explosives of Divisions 1.1, 1.2, 1.3, 1.4 Self reactive substances and mixtures, Types A, B Organic peroxides, Types A, B
	Flame	Flammable gases, category 1 Flammable aerosols, categories 1, 2 Flammable liquids, categories 1, 2, 3 Flammable solids, categories 1, 2 Self-reactive substances and mixtures, Types B, C, D, E, F Pyrophoric liquids, category 1 Pyrophoric solids, category 1 Self-heating substances and mixtures, categories 1, 2 Substances and mixtures, which in contact with water, emit flammable gases, categories 1, 2, 3 Organic peroxides, Types B, C, D, E, F
	Flame Over Circle	Oxidizing gases, category 1 Oxidizing liquids, categories 1, 2, 3
	Gas Cylinder	Gases under pressure: - Compressed gases - Liquefied gases - Refrigerated liquefied gases - Dissolved gases
	Corrosion	Corrosive to metals, category 1 Skin corrosion, categories 1A, 1B, 1C Serious eye damage, category 1
	Skull and Crossbones	Acute toxicity (oral, dermal, inhalation), categories 1, 2, 3
	Health Hazard	Respiratory sensitization, category 1 Germ cell mutagenicity, categories 1A, 1B, 2 Carcinogenicity, categories 1A, 1B, 2 Reproductive toxicity, categories 1A, 1B, 2 Specific Target Organ Toxicity - Single exposure, categories 1, 2 Specific Target Organ Toxicity - Repeated exposure, categories 1, 2 Aspiration Hazard, category 1
	Environment	Hazardous to the aquatic environment - Acute hazard, category1 - Chronic hazard, categories 1,2
	Exclamation Mark	Acute toxicity (oral, dermal, inhalation), category 4 Skin irritation, category 2 Eye irritation, category 2 Skin sensitisation, category 1 Specific Target Organ Toxicity – Single exposure, category 3
SOURCE: http://www.unece.org/trans/danger/publi/ghs/pictograms.html		

Figure 54 - Samples of Chemicals (substances and mixtures) markings and graphical symbols

5. GLOSSARY

°C	Degrees Centigrade
ABNT NBR	Brazilian Association of Technical Standards. - Brazilian Standart
CIE	International Commission on Illumination
cm	centimeter
dB	Decibel; a measure of sound level
DIN	Deutsche Industrial Norm (German Industrial Standard)
DIS	Draft International Standard
DOE	Department of Energy; a Cabinet-level department of the United States government concerned with US policies regarding energy and safety in handling nuclear material.
e.g.	for example
EHS	Environment, Health and Safety
EHSRs	Essential Health and Safety Requirements
EN	European Norm
HVAC	Heating, Ventilation and Air Conditioning
IBUTG	Index Global Thermometer Wet Bulb
IEC	International Electrotechnical Commission
IP	Ingress Protection; rating of an enclosure with certification to protect against contamination, such as dust, water (drip, spray, jet, immersion)
ISO	International Standards Organization
kg	kilogram; equal to 2.2046 avoirdupois pounds
kgf	kilogram force; gravitational metric unit of force, equal to the magnitude of the force exerted by one kilogram of mass
lb	pound; equal to 0.4536 kilogram
lbf	pound force; equal to the gravitational force exerted on a mass of one avoirdupois pound
LOTO	lockout/ tagout; isolation of sources of machine energy (examples: electrical, pneumatic, hydraulic, potential, steam, stored, …) and identification of the individual(s) who has locked out the energy source
Lb or lbs	pound(s); a unit of measuring weight
Lx	lux; SI unit of illuminance and luminous emission, measuring luminous flux per unit area.
m or M	Meter
mm	Millimeter

NEMA	National Electrical Manufacturers Association; enclosure ratings define ingress protection (such as dust, water, …) performance of electrical enclosures.
NR 10	National law for Electrical safety in Brazil.
NR 12	National law for Machine safety in Brazil.
NR13	National law for Boilers and pressure vessels in Brazil.
OPT	Optional
OSHA	Occupational Safety and Health Administration - part of the Federal government in USA, in the Department of Labor, that oversees safety in the workplace (www.osha.gov).
PCBs	polychlorinated biphenyl (ascarel oil)
PLC	Programmable Logic Controller
PSDI	Presence Sensing Device Initiation
Pte	Utilities area (Pte 00001)
sd	safety distance
Sil or SIL	Safety Integrity Level - a relative level of risk-reduction provided by a safety function, or a specified target level of risk reduction.
SOP	Standard Operating Procedure
TUV GmbH	One of multiple German certification companies, that issues safety and quality certificates.
UL	Underwriters Laboratories, an independent test and safety certification organization, recognized by OSHA (USA) as a Nationally Recognized Test Laboratory (www.ul.com).
VFDs	variable-frequency drives
zero access	Fixed guard that prevents access to the danger zone from all directions.

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