New Standards Defining the Basics of Manual Workstations

The number of manually controlled machinery workstations has decreased considerably since the early 2000s. Automatization and robot applications keep pushing people from the shop floors around the world.

Automated parts production and assembly may fail, however, calling for manual "emergency operation strategies". Sometimes, production lots are simply not big enough to make fully automated production economical. And yet another factor bringing back manual control operations is the steady trend toward individualisation of products. Where the quantity of identical products is close to ONE, manual insertion and assembly of parts as well as manual start may return to the workplace. Three of the most important basic safety standards needed in this field have been revised recently:

- **EN ISO 13851 Safety of machinery -** Two-hand control devices - Principles for design and selection 04.2019
- **EN ISO 13854 Safety of machinery –** Minimum gaps to avoid crushing of parts of the human body 09.2019
- **EN ISO 13857 Safety of machinery –** Safety distances to prevent hazard zones being reached by upper and lower limbs 10.2019

The changes in the three standards are everything but revolutionary.
They may be summarised under the heading "modernisation". But the publication of the new versions is a good opportunity to remind technicians and engineers of a few of the most pertinent aspects of machine safety, and alert them to an important standardisation trend.

What is the point of two-hand control?

Often two-hand control is primarily understood as a means of starting a hazardous process, ensuring that the operator cannot reach into the hazard zone with either hand. But that is only one half of the story. Looking at the definition in EN ISO 13851 you will find two additional points worth considering:

"[Two-hand control is a] device which requires simultaneous actuation by the use of both hands in order to initiate and to maintain hazardous machine functions, thus providing a protective measure only for the person who actuates it".

The buttons do not just start the hazardous function, but must be held down, until the hazard is gone. In a long-stroke application this would mean that the operator must hold both buttons down until the stroke is finished. And this also means, that the movement must stop as quickly as possible, if the operator lets go of one of the buttons. Two-hand control thus is a control function forcing the operator to stay in a defined location outside the hazard zone as long as the hazard is present.
But it protects only one operator. Others are not protected. Therefore, other safety measures may have to be taken to protect others around the machine.

1.
Typical two-hand control panel (can also be supplied on a post, Siemens)

2.
Individual two-hand control button for integration into a control panel (two + controller needed, BANNER)

3.
Innovative two-hand control panel (ABB)

TABLE OF CHANGES

New Standard	Previous	Pertinent changes
EN ISO 13851	EN 574:2010	The new version is an international standard. The standard differentiates three types of two-hand control systems with differing scope of functions and allocated performance levels. PL = c to EN ISO 13849-1 is required as minimum con-trol system reliability. Type 3 controls require PL = d. A verification and a validation procedure are required and outlined. The minimum contents of information for use to be supplied by the supplier of a two-hand control device and by the machine designer integrating it are defined.
EN ISO 13854	EN 349:2008	The new version is an international standard. The content has not changed.
EN ISO 13587	EN ISO 13857:2008	The revised Figure 2 shows that arm reach above a bar-rier (e. g. guard fencing) must be considered.

This requires at least the following (compare EN ISO 12100 section 6.2.11.8):

- The entire accessible hazard-zone must be visible from the operator's workstation. Otherwise he might inadvertently endanger a person entering the hazard zone.

- The access opening(s) to the hazard zone should be as small as possible, so nobody can intentionally reach into the hazard zone or accidentally stumble and fall in. Ideally, the access opening would be just large enough to perform the operation, such as inserting and removing parts. To reduce the access opening one may have to install stationary and/or movable guards.

Functional requirements for two-hand control

EN ISO 13851 also outlines some functional requirements for two-hand control:

- The buttons must be pressed simultaneously (max. delay 0.5 seconds), and it must not be possible to restart the function, unless the operator lets go off both buttons (type 3 two-hand-control).

- Because two-hand-control is a safety-related function, it must work reliably. In technical terms that is determined by the "performance level" to EN ISO 13849-1. The required minimum level is PL = c, for type 3 controls (the most used type) it is PL = d.

- It must not be possible to press either of the control buttons unintentionally.

- In case the operator lets go of one (or both) of the buttons, the hazardous movement must stop early enough to prevent him from reaching moving parts and getting hurt. To achieve that the control panel must be located at sufficient distance from the hazard zone. This needs to be calculated based on EN ISO 13855 and verified by testing.

A standardization trend: requirements for verification, validation, and information for use

EN ISO 13851 is a new case in point exemplifying a trend that has been showing in new type-B2 standards since 2012. B2 standards describe safeguards such as guards, interlocking devices, emergency stop, pressure sensitive and optoelectronic devices, two-hand control, and the likes. Previously, such standards only set forth requirements, but since 2012 a growing number of them also requires a verification and validation process. This is to ensure that

- the requirements of the standard have been applied correctly and are fulfilled (verification),

- the safeguard employed or safety measure taken is effective (validation).

In most cases a table of items to be verified and/or validated is provided. Verification and validation procedures are specified. These include visual inspection, measurement, and testing. Where appropriate, fault situations also must be simulated, and the reaction of the safeguard be validated. For two-hand control, for instance, this includes checking the simultaneousness of actuation of the control buttons and letting go of either of the buttons, plus a check of the reset/restart behaviour. The trend toward verification and validation will likely continue and burden machine manufacturers with additional testing and corresponding documentation. However, much of this extra effort certainly is justified. The availability, reliability, and effectiveness of a safety function must be ensured to reach safety on the shop floor, not just in a risk assessment report or on a drawing.
Another trend observed in new type-B2 standards is the addition of a section on "information for use". Almost always this section references chapter 6.4 of EN ISO 12100, while adding specific content requirements. These mainly revolve around installation and maintenance information. The maintenance information to be supplied primarily serves the purpose of ensuring continuous reliability of safety features and functions. Component manufacturers, e. g. those offering two-hand control panels, will have to include such information in their manuals. Machinery manufacturers integrating such components will have to select which of the information needs to be passed on in their own operating instructions to ensure continued safety of their end products.*

*You will find Axelents instruction handbook for our machine guard X-Guard on our website

4. Use

4.1 Opening and closing doors

Doors shall be opened and closed using the handles provided. These may be part of an accessory supplied by Axelent or part of a safety switch, lock or other control added to the Axelent product.

Do not slam doors as this may cause personal injury and damage to
- parts of the locks and switches
- parts of the guide and locating mechanisms of the door
- the door itself

4.2 Sidestepping or climbing across guard fencing

It is **forbidden to sidestep or climb across guard fencing during any of the operating phases** of machinery or systems enclosed by it. This may cause hazard to yourself and others, because a danger area becomes accessible thereby.
Falling off a guard fence may cause serious or even fatal injury.

4.3 Removal of guard fencing

Guard fencing is meant to keep persons out of hazard areas and therefore **must not be removed or side-stepped during any of the operating phases** of machinery or systems enclosed by it.

Where removal of guard fencing or individual parts of it appears to be necessary, observe the following general safety information. For details concerning regulations and standards refer to the Annex of these operating instructions.

4.3.1 Roles concerning safety fences

Axelent is the manufacturer of the elements that form guard fencing around machinery. However, we are not designing the machinery or plant system itself nor its safety concept. In virtually all cases Axelent is not responsible for determining the correct height, position and safety distance of the guard fencing to the machinery, for instance. Therefore, Axelent cannot provide a universally applicable guideline for the removal of mesh panels from guard fencing, as this is the responsibility of the machinery designer and/or the company operating the machinery or plant system.

The machinery designer will have to determine all the above details concerning guard fencing in course of his design process. The same is true concerning safe shutdown of the machinery or plant system. Under European law and standards, stationary guards such as guard fencing must not be removed or side-stepped **during any of the operating phases** of the machinery (normal operation in any operating mode, setting, remedy of frequent faults/malfunctions, maintenance procedures that require the machine to be powered etc.). The machinery designer will therefore need to assess the risks that could be incurred when a person enters the area enclosed by guard fencing. He also needs to develop suitable shutdown procedures for the machinery or plant system (a so called "lock-out/tag-out" strategy).

The company operating the machinery or plant system will have to adapt the "lock-out/tag-out" strategy for the machinery or plant system based on the local needs as part of a workplace-related hazard analysis. Thereafter the company operating the machinery or plant system will need to enforce the strategy as well as authorize and instruct their personnel.

4.3.2 Template for instructions that may be given to operators

The following template is a suggestion/recommendation that will have to be checked, altered, reduced or extended by the machinery manufacturer and/or the company operating the machinery/plant system based on a risk assessment or hazard analysis.

Removal of mesh panels in guard fencing:

- Stop all machinery behind the safety fencing and disconnect it from all sources of energy supply, before removing any element(s) of the fence (electric, pneumatic, other energy sources).
- Lock all separating devices using padlocks, for instance (main switch(es), shut-off cock(s) for compressed-air supply, and where needed other switches and valves for other energy sources). The machinery manufacturer or company operating may wish to add other specific requirements such as for depressurising of pressure vessels, locking/blocking of axes subjected to gravity, dissipation of other residual or stored energy, removal or extraction of harmful substances etc.
- Fence elements must be removed exclusively by personnel that have been expressly authorised to do so by the employer/company operating the machinery/system.
- Keep the X-key in a safe place. It should not remain at the workplace near the machinery, where it would be available to any operator.
- Before restarting the machinery/system all fence elements must be reinstalled and the entire fencing and other safety devices must be inspected by a trained safety specialist.

4.3.3 Availability of the X-Key

The X-Key allows removing wire mesh panels from an Axelent X-Guard fence from the inside of the fenced-in area. It is a special tool meant to be available to personnel authorized by the company operating the machinery or system enclosed by the guard fencing. When authorizing personnel, the company operating shall as a minimum:
- set up a safe system of work for its use
- set forth the rules of the system of work in writing
- document the authorization of persons in writing
- regularly instruct and train the authorized persons
- document the instruction and training in writing, recording the date of the instruction or training and the full names of the persons trained
- monitor access to the X-Key

A safe system of work is a formal procedure which results from systematic examination of a task in order to identify all the hazards. It defines safe methods to ensure that hazards are eliminated or risks minimised. A safe system of work is needed when hazards cannot be physically eliminated and some elements of risk remain. (quoted from UK Occupational Safety & Health Council Guidebook "Safe Systems of Work", January 2004)

4.3.4 Using the X-Key to remove panels

The illustration below shows how to use the X-key.

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Gaps preventing crushing of body parts – EN ISO 13854 replaces EN 349

EN 349 was one of the last few European Standards on machine safety that had not yet been fully harmonised with its ISO version (ISO 13854 has existed since 1996!). EN ISO 13854 does not contain technical changes. While that may be considered good news, saving us time rechecking our machinery designs, two ideas from the standard deserve consideration:

- The safety distances (gaps) to be left between a moving and a stationary part or between two moving parts, apply to crushing hazards only. When shearing or impact are concerned, additional aspects deserve attention, particularly, motion speed.

- If more than one part of the body can be endangered, the largest of these body parts determines the required safety distance. That is: The gap for the arm (120 mm) can only be used for moving parts inside a machine housing, if it is not possible to enter the housing and reach the hazard location with the entire body or leaning forward. If it is easy to climb into the machine's interior and operators are likely to try that, the gap for the full body would have to be considered (500 mm).

This shows that the decisions must be made based on careful risk assessment of the actual work situation and the tasks involved, not just based on dimensioned drawings.

Reaching across and through openings in guards and housings – EN ISO 13857 updated

The third of the updated standards (EN ISO 13857) is one of the most important safety standards for machinery designers, because it deals with two important issues they face almost daily:
- The possibility of people reaching across a guard (e. g. a fence), determining the required height based on the safety distance available (or vice versa)
- The possibility of sticking body parts (especially fingers and hands) through openings in guards and housings.

What is new in this relatively well-known standard? There are no changes in the safety distance values. However, there is a detail that deserves mention. Talking about reaching across a guard or housing into a hazard zone, we used to think of a person reaching down across the barrier (e. g. a fence).
But the person could also extend an arm upward to a hazard zone above the barrier. This must be considered, and the idea is shown in the revised figure 2 in the standard. *(see picture below.)*
This is not mere theory. Large robots are often capable of reaching much higher than standard fence heights of 2 to 2.5 m. If the robot can at the same time move close to the guard, it could collide or otherwise injure the extended arm of a person.

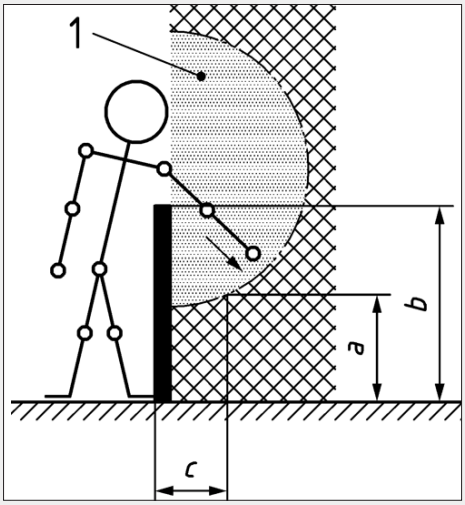
In such cases either the fence needs to be higher or the robot's motion range needs to be limited accordingly (2.5 m high fencing will generally quench any concern, provided the robot stays away the minimum distance of 120 mm from the fence).
When designing guards, carefully consider all work situations that may occur and, employing figure 2 and table 2 of the standard, ensure protection against deliberate or inadvertent contact with hazardous machine elements (moving, hot,…).

Summary

New safety standards, such as the three here discussed, are no longer changing in revolutionary ways. This shows we are nearing the equilibrium stage and may concentrate on perfecting both the requirements and the way we fulfil them. Now it is high time to include the contents into university and commercial education and to modernise the way standards are presented. In that field, sadly, the digital revolution has not yet begun.

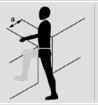
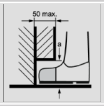
Picture 2 from the standard

Arms reach according to EN ISO 13857:2019, people may also reach upward!



1 – Arm reach
2 – Hazard zone

Table of safety distances from EN ISO 13854

BODYPART	MINIMUM DISTANCE	PICTURE
Body	500	
Head	300	
Leg	180	
Foot	120	
Toe	50	
Arm	120	
Hand, wrist, fist	100	
Finger	25