COMPATIBILITY FACTOR

Interdependency of Design Safety & Ergonomics

By Doug Sten

Machine design safety should conform to good engineering practices, industry standards, national or international standards, and government codes and regulations that are applicable for that particular product (Bass, 1986).

When properly designed, a product should be fundamentally sound, have the proper safeguards, be operated and maintained with minimum risk to the user, and fail to a safe condition when a fault is detected in the safety control system (Sten, 2009).

The term "compatibility factor" refers to the state in which two conditions can exist or occur together, producing positive outcomes. So, where does ergonomics and the compatibility factor come into play? When designing to an operator's or technician's needs, the designer or engineer must take into account a person's physical and mental abilities (and limitations) in relation to the demands of the machine, job-related tasks (frequency and duration) and the work environment.

The design review process should include the following steps:

1. Define the production process, which includes materials (e.g., dimensions, weights, characteristics), operations (e.g., setup, workstation, manual loading and unloading, maintenance) and cycle time.

2. Determine the anthropometrics of the worker population, such as physical (e.g., stature, reach, strength, limitations) and mental abilities (e.g., education, training, perception).

The environment in which the product will be used may have a significant negative effect on one's physical state (stress) and well-being (decision-making process). These conditions can be influenced by temperature extremes, chemical exposures, flammable atmospheres, dust, water, inadequate illumination, and other physical and environmental conditions (McCormick & Sanders, 1982).

Furthermore, ergonomics or human factors engineering should analyze the design of the controls, types and location, human-machine interface (HMI) display units, visual and auditory, and other human factors such as anthropometrics to promote operator comfort and minimize physical stress and fatigue (ISO, 2016).

Following are a few less-than-desirable conditions the author has observed over the years with real proven solutions.

Problem: Many HMI screens installed with machines on shop floors are fixed in the vertical position. This does not allow for workers of various heights to properly view the screen, especially those wearing prescription safety glasses. This has resulted in noticeable visual challenges and muscular discomfort to workers' necks and shoulders. Providing a step stool only creates a major trip and fall hazard.

Solution: Design and install HMI screens that can be manually adjusted both vertically and horizontally to fit the user's needs.

Problem: Many two-hand palm button controls are designed and installed on top of the control box with protective rings to create an anti-tie-down condition. Now, instead of using one's palms as designed, the user is forced to actuate the controls with their fingers, generally applying 5 lb of pressure every 15 to 30 seconds.

Solution: Design and install the two-hand palm buttons on the sides (left and right) of the control box. No protective rings are required. The worker can use the palms rather than the fingers, eliminating ulnar flexion movement to actuate the controls. Alternatively, electronic swipe controls require no force at all to actuate and can be used with protective gloves if required.

Problem: Yellow-painted, expanded metal guards (fixed or moveable) are everywhere. Urban legend has it that general industry took this to be an OSHA compliance requirement. This is not so. To my knowledge, there are no global safety rules requiring guards to be painted yellow, red or orange. The critical issue is that yellow in particular presents a significant diffusion of visual acuity, meaning it can be difficult to see through it. This causes problems when trying to troubleshoot the machine when it is in operation, when performing inspections or when making adjustments during the production process. This has led users to remove these yellow expanded metal guards to perform

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TABLE 1
STANDING WORKSTATION DESIGN

Specifications that provide design criteria for workstations in which the operator is standing, useful for designing work surface locations and features applying ANSI B11 TR1 guidelines. Ergonomic assessment may need to be performed on a task-by-task basis.

Criteria	Dimension	Description
Work height		
Hands precision work	Adjustment: 37 to 50 in. (94 to 127 cm) Fixed: 44 in. (110 cm)	Distance from standing surface to hand work height for fine hand manipulations or visually intensive tasks
Light assembly	Adjustment: 33 to 42 in. (84 to 107 cm) Fixed: 38 in. (95 cm)	Distance from standing surface to hand work height for tasks requiring force exertion less than 10 lb (4.5 kg)
Heavy work	Adjustment: 28 to 39 in. (71 to 99 cm) Fixed: 34 in. (85 cm)	Distance from standing surface to hand work height for tasks requiring force exertion greater than 10 lb (4.5 kg)
Reach	19 in. (47.5 cm)	Maximum reach to grasp hand work
Display height	Preferred adjustment: 57 to 70 in. (145 to 178 cm) Fixed: 60 in. (160 cm)	Distance from standing surface to middle of viewable portion of display screen Rotate 45° up/down from vertical position is preferred with horizontal adjustment
Foot clearance depth	Minimum 6 in. (15 cm)	Depth from front of any obstruction

these tasks. Especially if the guards are of the fixed type and heavy, the tendency to not replace them is foreseeable.

Solution: Fixed and moveable expanded metal guards should be painted the same color as the machine to which it is affixed or the expanded metal guarding should be painted a flat black, especially if the machine is painted yellow, red or orange.

Table 1 offers some examples for guidance on workstation design. However, somewhere during the design review process, in many cases, these sound and well-founded ergonomic considerations (ANSI, 2016) are not applied or considered until after the machine is built, commissioned by the customer and ergonomic-related incidents begin to occur on the shop floor (Seiden, 1984).

The infusion of ergonomic applications in the design safety review process helps this interdependency and drives the compatibility factor. The benefits can be measured and realized, improving efficiency, productivity and safety. **PSJ**

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