HAZARD CONTROL

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Using Machine Safety Risk Assessment for Alternative Methods to LOCKOUT/TAGOUT

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IN THE *FEDERAL REGISTER* dated May 20, 2019, OSHA made a request for information (RFI) regarding two areas (control circuit type devices and robotics) where modernizing the lockout/tagout standard (29 CFR 1910.147) might better promote worker safety.

History of the Lockout Standard

The current lockout/tagout standard came into being in 1989 and was based on ANSI Z244.1-1982, American National Standard for Personal Protection—Lockout/Tagout of Energy Sources—Minimum Safety Requirements. As stated in the RFI, OSHA (2019) now recognizes that:

> Technological advances since the standard was issued in 1989 suggest that, at least in some circumstances, control circuit type devices may be at least as safe as [energy isolating devices]. OSHA requests information, data and comments that would assist the agency in determining under what conditions control circuit type devices could safely be used for the control of hazardous energy. OSHA may also consider changes to the lockout/tagout standard that address hazardous energy control for new robotics technologies.

The latest version of the ANSI standard is ANSI/ASSP Z244.1-2016, The Control of Hazardous Energy—Lockout, Tagout and Alternative Methods, and it provides guidance for when alternative methods may be used in lieu of lockout. Alternative methods are defined in ANSI/ASSP Z244.1-2016 as "A means of controlling hazardous energy (other than energy isolation) to reduce risk to an acceptable level." ANSI/ASSP Z244.1-2016 lists the following examples of tasks that could be accomplished using alternative methods:

- die changing
- cleaning
- jam clearing
- adjustments
- make-ready
- set-up
- lubrication
- inspection
- tool changes
- taking measurements
- roll polishing
- taking samples

It would appear that OSHA's RFI related to control circuit type devices and robotics means that OSHA may be willing to consider the use of what ANSI/ASSP defines as alternative methods.

Benefits of Updating OSHA's Lockout/Tagout Standard

If the lockout/tagout standard is updated to allow for the use of alternative methods, it offers the possibility of at least two benefits: improved safety and cost reduction.

KEY TAKEAWAYS

- **This article discusses OSHA's recent request for information related to updating the lockout/tagout standard, specifically regarding two areas of the standard: control circuit type devices and robotics. In both areas, the issue is whether technology has reached a point where alternative methods to lockout can be used without diminishing the level of safety required for the worker.**
- **The article describes a risk assessment methodology that can be used in situations where alternative methods to lockout are used to protect workers from hazardous energy.**

Improved Safety

Lockout is an administrative control; that is, it requires affirmative actions by people to be effective. For that reason, lockout is subject to human error. Consider, for example, a complex machine that requires seven points of lockout. Despite proper training and the use of machine-specific procedures, the fact remains that a person may inadvertently fail to lockout one of the points, thus presenting a risk of injury. Now consider the following scenario:

A machine is being designed with a hinged access door. In the event of a jam, the door would need to be opened to access and clear the jam. The designer considers two options:

1. Keep the door locked during normal operation. If a jam occurs, require that the machine operator use lockout/tagout before unlocking the door.

2. Control access to the machine via a door interlock system, so that in the event of a jam, as soon as the machine operator opens the door, all hazardous motion stops and all hazardous energy is relieved. Design the interlock system in accordance with ISO 13849-1:2015, Safety of Machinery—Safety-Related Parts of Control Systems—Part 1: General Principles for Design. Once the jam is cleared, the door would need to be closed and the machine reset before normal operation could commence.

In the first option, the safety of the machine operator depends upon the worker's consistent and proper implementation of lockout/tagout. Suppose the machine jams once per day, 5 days per week, 50 weeks per year, for 10 years. This would require that the machine operator lock the machine out (correctly) no fewer than 2,500 times.

In the second option, the interlock system would be designed to be control reliable. This would mean that, at a minimum (according to ISO 13849-1:2015), the safety function must meet Performance Level d, Category 3, which requires an average probability of dangerous failure per hour (PFH_d) of $\geq 10^{-7}$ to $< 10^{-6}$; that is, the interlock can fail dangerously no more than once every 114 years.

Cost Reduction

As long as the alternative method is at least as effective as lockout, it may provide a faster way to accomplish the task (e.g., die changing, cleaning, jam clearing, adjustments), thus reducing, for example, machine downtime. While safety is necessarily the first and most important consideration, OSHA requests comments related to cost in the RFI.

Requirements for Using Alternative Methods

If OSHA updates the lockout/tagout standard to allow for alternative methods, the following (as stated in ANSI/ASSP Z244.1-2016, clause 6.1) will likely be required to justify such methods:

> Before alternative methods are used, the following shall be completed:
> - a practicability/justification analysis as per clause 8.2.1
> - a risk assessment as per clause 8.2.2
> - other applicable evaluations as described in clauses 8.2.3-8.2.12

While this article focuses on the risk assessment requirement, it is important to note the requirements for a practicability/justification analysis (clause 8.2.1) and other applicable evaluations (clauses 8.2.3 to 8.2.12), as no proper attempt at using alternative measures can be made unless the following requirements are also addressed:

A documented practicability/justification analysis requires the user to evaluate the following:

•impacts of conventional lockout/tagout

•options for avoiding using power or minimizing the use of energy

•obstacles which prevent using the lockout

•potential methods which may be suitable to the situation

Other applicable evaluations include evaluations of:

•industry best practices and methods

•architecture/structure (this is related to reliability of the alternative method)

•safety-related parts of the control system (well-tried components, well-tried designs, common cause failure and fault tolerance)

•exclusivity/individual control

•tamper resistance

•a program to support the alternative method

•the procedures in place for the alternative method

In addition, whenever using alternative methods, a written work permit is required, as stated in ANSI/ASSP Z244.1-2016, clause 6.3:

> Where the user has a task which is qualified by a risk assessment and lockout is not practicable, either tagout or an alternative method which permits de-energization, energization or partial energization shall be permitted and documented on the machine, equipment or process specific procedure.

Risk Assessment

Robotic Industries Association (RIA) publication TR R15.306-2016, Technical Report for Industrial Robots and Robot Systems—Safety Requirements—Task-based Risk Assessment Methodology, is a document written (as explained in the document's foreword):

> . . . with the objective of enhancing the safety of personnel associated with industrial robot systems, including robots, robot end-effectors and ancillary equipment, by presenting a task-based risk assessment methodology that has been demonstrated to provide risk reduction guidance for hazards presented by industrial robot system applications.

Despite having been written specifically for industrial robot systems, RIA TR R15.306-2016 can also be used for essentially any machine safety risk assessment. Using the methodology of RIA TR R15.306-2016, the user:

a. determines the initial risk of injury due to a potential hazard,

b. selects risk reduction measures, and

c. determines the residual risk (risk remaining after risk reduction measures are taken).

The methodology requires that appropriate risk reduction measures be used to reduce the residual risk to an acceptable level.

Risk is the combination of the probability of occurrence of harm and the severity of that harm. In RIA TR R15.306-2016, risk is determined by three criteria:

1. Injury severity, which is a function of the degree of estimated harm due to each hazard while a person is performing a task. Severity has three ratings, which (for the sake of brevity) are summarized as follows:

•S3 (serious), such as a nonreversible (i.e., permanent) injury

•S2 (moderate), such as a reversible (i.e., recoverable) injury

•S1 (minor), such as an injury requiring first aid only

2. Exposure, which is a function of the estimated incidence of exposure (either frequency or duration) to the hazard. Exposure has three ratings, which (for the sake of brevity) are summarized as follows:

•E2 (high), such as a daily activity

•E1 (low), such as a weekly activity

•E0 (prevented), meaning that there is no exposure (e.g., an exposed sprocket may be located so high above the floor that the machine operator is effectively not exposed to the hazard)

3. Avoidance, which is an assessment of a person's ability to sense and elude a hazardous situation. Avoidance has three ratings, which (for the sake of brevity) are summarized as follows:

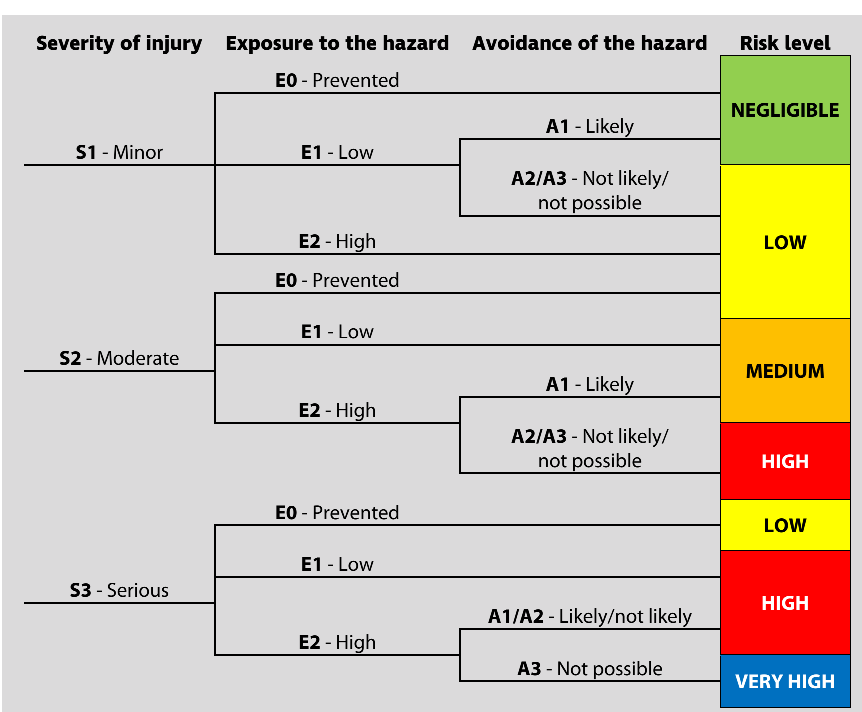
•A3 (not possible)

•A2 (not likely)

•A1 (likely)

The combination of severity, exposure and avoidance, determined prior to the implementation of any risk reduction measures (i.e., determined before any safety features are considered), yields the initial risk level (Figure 1). The resulting initial

FIGURE 1
RISK LEVEL DECISION MATRIX



Note. Adapted from Table 2 of "Technical Report for Industrial Robots and Robot Systems—Safety Requirements—Task-Based Risk Assessment Methodology (RIA TR R15.306-2016)," by Robotic Industries Association, 2016.

risk is either negligible, low, medium, high or very high. Negligible risk, being the lowest level, is acceptable risk; however, low risk may also be considered acceptable, depending upon circumstances (in fact, in the case of industrial robot systems, RIA TR R15.306-2016 states that "a risk level of low or negligible can be considered sufficient to achieve acceptable risk"). Medium, high and very high risk levels are considered unacceptable and must be reduced.

Once the initial risk is determined, the user selects one or more risk reduction measures. As shown in RIA TR R15.306-2016, Table 3, the hierarchy of risk reduction measures, from most preferred to least preferred, is:

•Elimination: Eliminate the hazard.

•Substitution: Substitute the hazard with a less severe hazard.

•Limit interaction: Reduce or eliminate interaction between the hazard and the person.

•Safeguarding: Use guards and/or safety-related parts of the control system (SRP/CS) to protect people.

•Complementary protective measures: Although not explicitly defined in RIA TR R15.306-2016, these are measures that: a) assist in avoiding contact with the hazard (e.g., an enabling device); or b) assist in avoiding further injury from the hazard (e.g., an emergency stop).

•Information for use: Warnings and awareness means (e.g., signs or alarms), administrative controls (e.g., training) and/or PPE.

Note that according to RIA TR R15.306-2016, neither complementary protective measures nor information for use may be used until or unless the risk level is or has been reduced to low or negligible, which are considered acceptable risk levels.

While each initial risk must be evaluated by reviewing the severity, exposure and avoidance, one of the benefits of the RIA TR R15.306-2016 methodology is that (although not explicitly shown in the document) the residual risks are essentially fixed by the combination of initial risks and the risk reduction measures chosen:

•If elimination is used, then, no matter what the initial risk, all values for severity, exposure and avoidance are reduced to their lowest rating levels, S1 and E0 (note that once exposure is eliminated, avoidance is no longer applicable).

•If substitution is used, then severity is reduced, but exposure and avoidance remain unchanged (note that the 2014 version of TR R15.306 stated the following: "Exposure to a hazard or avoidance of a hazard does not impact the severity of a potential injury."). The level of severity reduction depends on the substitution, and the substitution must meet the criteria for substitution shown in TR R15.306. For example, suppose you substitute a concentrated acid (with an initial severity rating of S3) with a weaker acid. The user need only determine the resulting severity rating (S2 or S1) of the weaker acid.

•If limit interaction is used, and human interaction is eliminated, or we automate the tasks, then exposure is reduced to E0

FIGURE 2

RISK REDUCTION USING ELIMINATION, SUBSTITUTION, LIMIT INTERACTION & SAFEGUARDING

Before any risk reduction measures				Elimination				Substitution (Severity reduced to minor)				Substitution (Severity reduced to moderate)				Limit Interaction (Interaction eliminated or tasks automated)				Limit Interaction (Exposure reduced to low)				Safeguarding			
INITIAL RISK				RESIDUAL RISK				RESIDUAL RISK				RESIDUAL RISK				RESIDUAL RISK				RESIDUAL RISK				RESIDUAL RISK			
S	E	A	Score	S	E	A	Score	S	E	A	Score	S	E	A	Score	S	E	A	Score	S	E	A	Score	S	E	A	Score
3	2	3	V. HIGH	1	0	–	NEGL.	1	2	3	LOW	2	2	3	HIGH	3	0	–	LOW	3	1	3	HIGH	3	0	–	LOW
3	2	2	HIGH	1	0	–	NEGL.	1	2	2	LOW	2	2	2	HIGH	3	0	–	LOW	3	1	2	HIGH	3	0	–	LOW
3	2	1	HIGH	1	0	–	NEGL.	1	2	1	LOW	2	2	1	MEDIUM	3	0	–	LOW	3	1	1	HIGH	3	0	–	LOW
3	1	3	HIGH	1	0	–	NEGL.	1	1	3	LOW	2	1	3	MEDIUM	3	0	–	LOW	3	1	3	HIGH	3	0	–	LOW
3	1	2	HIGH	1	0	–	NEGL.	1	1	2	LOW	2	1	2	MEDIUM	3	0	–	LOW	3	1	2	HIGH	3	0	–	LOW
3	1	1	HIGH	1	0	–	NEGL.	1	1	1	NEGL.	2	1	1	MEDIUM	3	0	–	LOW	3	1	1	HIGH	3	0	–	LOW
3	0	–	LOW	1	0	–	NEGL.	1	0	–	NEGL.	2	0	–	LOW	3	0	–	LOW	3	0	–	LOW	3	0	–	LOW
2	2	3	HIGH	1	0	–	NEGL.	1	2	3	LOW	2	2	3	HIGH	2	0	–	LOW	2	1	3	MEDIUM	2	0	–	LOW
2	2	2	HIGH	1	0	–	NEGL.	1	2	2	LOW	2	2	2	HIGH	2	0	–	LOW	2	1	2	MEDIUM	2	0	–	LOW
2	2	1	MEDIUM	1	0	–	NEGL.	1	2	1	LOW	2	2	1	MEDIUM	2	0	–	LOW	2	1	1	MEDIUM	2	0	–	LOW
2	1	3	MEDIUM	1	0	–	NEGL.	1	1	3	LOW	2	1	3	MEDIUM	2	0	–	LOW	2	1	3	MEDIUM	2	0	–	LOW
2	1	2	MEDIUM	1	0	–	NEGL.	1	1	2	LOW	2	1	2	MEDIUM	2	0	–	LOW	2	1	2	MEDIUM	2	0	–	LOW
2	1	1	MEDIUM	1	0	–	NEGL.	1	1	1	NEGL.	2	1	1	MEDIUM	2	0	–	LOW	2	1	1	MEDIUM	2	0	–	LOW
2	0	–	LOW	1	0	–	NEGL.	1	0	–	NEGL.	2	0	–	LOW	2	0	–	LOW	2	0	–	LOW	2	0	–	LOW
1	2	3	LOW	1	0	–	NEGL.	1	2	3	LOW	1	2	3	LOW	1	0	–	NEGL.	1	1	3	LOW	1	0	–	NEGL.
1	2	2	LOW	1	0	–	NEGL.	1	2	2	LOW	1	2	2	LOW	1	0	–	NEGL.	1	1	2	LOW	1	0	–	NEGL.
1	2	1	LOW	1	0	–	NEGL.	1	2	1	LOW	1	2	1	LOW	1	0	–	NEGL.	1	1	1	NEGL.	1	0	–	NEGL.
1	1	3	LOW	1	0	–	NEGL.	1	1	3	LOW	1	1	3	LOW	1	0	–	NEGL.	1	1	3	LOW	1	0	–	NEGL.
1	1	2	LOW	1	0	–	NEGL.	1	1	2	LOW	1	1	2	LOW	1	0	–	NEGL.	1	1	2	LOW	1	0	–	NEGL.
1	1	1	NEGL.	1	0	–	NEGL.	1	1	1	NEGL.	1	1	1	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.
1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.

FIGURE 3
RISK REDUCTION USING COMPLEMENTARY PROTECTIVE MEASURES OR INFORMATION FOR USE

Results of using complementary protective measures or information for use once the initial risk has been reduced to low or negligible by elimination, substitution or limit interaction (known collectively in TR R15.306 as inherently safe design measures) or safeguarding.

After employing inherently safe design measures and/or safeguarding				Complementary protective measures				Information for use			
RISK				RESIDUAL RISK				RESIDUAL RISK			
S	E	A	Score	S	E	A	Score	S	E	A	Score
3	0	–	LOW	3	0	–	LOW	3	0	–	LOW
2	0	–	LOW	2	0	–	LOW	2	0	–	LOW
1	2	3	LOW	1	2	2	LOW	1	2	2	LOW
1	2	2	LOW	1	2	1	LOW	1	2	1	LOW
1	2	1	LOW	1	2	1	LOW	1	2	1	LOW
1	1	3	LOW	1	1	2	LOW	1	1	2	LOW
1	1	2	LOW	1	1	1	NEGL.	1	1	1	NEGL.
1	1	1	NEGL.	1	1	1	NEGL.	1	1	1	NEGL.
1	0	–	NEGL.	1	0	–	NEGL.	1	0	–	NEGL.

(and, therefore, avoidance is no longer applicable), but severity remains unchanged.

•If limit interaction is used, and human interaction is reduced, then exposure is reduced (as long as it meets the criteria for exposure), but severity and avoidance remain unchanged.

•If safeguarding is used, then exposure is reduced to E0 (and, therefore, avoidance is no longer applicable), but severity remains unchanged.

•If complementary protective measures or information for use is used, then avoidance is reduced (as long as it meets the criteria for avoidance), but severity and exposure remain unchanged.

Figure 2 (p. 27) illustrates the use of elimination, substitution, limit interaction and safeguarding to reduce risk.

Note that if the risk reduction measure chosen does not result in low or negligible residual risk, the process is repeated. For example, suppose substitution reduces a very high initial risk to a high risk. In the next iteration, limiting interaction might be used to reduce the high risk to low risk.

As stated, neither complementary protective measures nor information for use may be used until or unless the risk level is or has been reduced to low or negligible. Figure 3 illustrates the results of using complementary protective measures or information for use once the initial risk has been reduced to low or negligible by elimination, substitution or limit interaction (known collectively in TR R15.306 as inherently safe design measures) or safeguarding.

Note that while the use of complementary protective measures and information for use will certainly improve safety, unfortunately, in most instances, the resulting residual risk level will not change from low to negligible. For example, suppose, after employing safeguarding, the risk is S1, E2, A3 (which is low). You then employ information for use. The resulting risk is S1, E2, A2, which is still low.

Example

The following example may help to illustrate the risk assessment process:

An operator works an entire shift standing 5 ft (i.e., close enough to get splashed) from a 50-gallon open-surface tank of 55% sulfuric acid. The initial risk is:

•severity = serious
•exposure = high
•avoidance = not likely

Therefore, risk = high.

To reduce the risk, the process is redesigned to use 20% acetic acid. The residual risk is:

•severity = moderate
•exposure = high
•avoidance = not likely

Therefore, risk = high.

After switching to acetic acid, we then limit the operator's interaction by increasing the distance between the operator and the tank to 30 ft (where the worker cannot get splashed). The new residual risk is:

•severity = moderate
•exposure = prevented
•avoidance = no longer applicable

Therefore, risk = low.

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Conclusion

OSHA's RFI regarding revision of the lockout/tagout standard offers a long-overdue opportunity to bring the standard into the 21st century. Revision would provide the regulated community with the ability to achieve enhanced safety and (although far less important) reduced costs. If the lockout/tagout standard is revised, risk assessment will become a critical component of machine safety design, with the potential for improving safety beyond the concerns of lockout/tagout. Safety professionals should embrace this once-in-a-career chance to make a difference in worker safety by supporting revision of the OSHA lockout/tagout standard. **PSJ**

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