PMMI
The Association for Packaging and Processing Technologies

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Lisa Long
OSHA Directorate of Standards and Guidance
Occupational Safety and Health Administration
U.S. Department of Labor
200 Constitution Avenue, NW
Washington, DC 20210

RE: OSHA Docket Office, Docket No. OSHA-2016-0013 Technical Data Center, Room N3653

Dear Ms. Long:

PMMI, *The Association for Packaging and Processing Technologies*, is a leading global resource for the packaging and processing industry. Our core purpose is to unite the industry across the manufacturing supply chain. We connect people, knowledge and ideas to enable the supply chain to succeed in the global marketplace and navigate the future. PMMI membership consists of 900+ North American manufacturers and suppliers of equipment, components and materials as well as providers of related equipment and services to the packaging and processing industry. PMMI members promote business growth in a variety of industries by developing innovative manufacturing solutions to meet evolving consumer demands, today and in the future.

PMMI has been an Accredited Standards Developing Organization (SDO) by the American National Standards Institute (ANSI) since 1972. Since 2006, the ANSI/PMMI B155.1 Safety Requirements for Packaging and Processing Machinery has required suppliers to use the iterative process of risk assessment to build machinery to an acceptable level of risk.

The OpX Leadership Network (OpX) is a community of consumer packaged goods manufacturing, engineering and operations professionals and executives dedicated to operational excellence. OpX provides a forum where leading CPG manufacturers and OEMs come together to address common operational challenges, and apply best practices and innovative solutions to the real-world context of manufacturing. PMMI, as part of its response, actively solicited input from OpX member companies.

PMMI is pleased to respond to the Occupational Safety & Health Administration's Request for Information (RFI) concerning the "Control of Hazardous Energy (Lockout/Tagout)."

The request focuses on two areas, namely *control circuit devices* and *robotics.*
We understand the specificity of your inquiry; in our opinion, the subject matter deserves a comprehensive response.

Introduction

PMMI feels this RFI is an opportunity to make a significant impact in improving worker safety. More than thirty years have passed since 29 CFR 1910.147 was written. We anticipate that many more years will come and go before it is revised again. We believe that OSHA needs to write a rule that will *stand the test of time*. We also believe that OSHA and industry need to work together on this opportunity; not in adversarial roles, but cooperatively as there are many common goals and interests including:

- Protecting workers from hazardous energy
- Providing a safer workplace
- Making use of technological advances
- Making machinery and equipment safer, easier to use and more productive

PMMI feels this opportunity offers us all a unique opportunity for government and industry cooperation to achieve a mutually satisfactory outcome for the betterment of all involved.

Economic Impacts of Packaging

The packaging industry has a very significant impact to the U.S. economy. Packaging occurs in some form in nearly every production or processing system, but in particular food and beverage, pharmaceutical, medical devices, and consumer goods. The industry involves 750,000 workers, making an economic impact on the order of $300B. As a result, seemingly small productivity improvements, or limitations on improvements, have significant impacts to the economy, safety and productivity.

Packaging equipment is often involved at the end of a production line. Upsets, jams and downtime quickly start impacting upstream operations at the plant, and with it the economy.

Alternative Methods in the Packaging Industry

Packaging and processing operations commonly operate at 20 – 2,000 units per minute. These operations involve frequent access to the machinery. For example, there is considerable variability of the materials used (e.g., paperboard, corrugated, films, etc.), the conditions of use (moisture), and other factors. The variability and high rate of operations leads to jams occurring, which is one type of downtime.

Downtime requires an operator to interface with the equipment and exposes them to potential hazards. End users require machinery manufacturers to build machinery that allows quick and safe access to return to operation. This often means using Alternative Methods.

These safe approaches are already being used at varying levels by a majority of all machinery OEMs and end users in the packaging industry. They would make greater use of Alternative Methods if the regulations clearly enabled such use - or did not clearly prohibit such use.

Companies in the packaging industry, and likely many other industries, struggle with how to comply with outdated OSHA standards, yet by necessity make use of Alternative Methods. Updated regulatory requirements that allow the use of Alternative Methods are sorely needed.

Experiences in the packaging industry have shown that Alternative Methods are a very effective means to prevent injury because they do not rely on employee actions. LOTO is an Administrative Control that requires the employee make a choice to perform. In practice, Alternative Methods usually remove the choice by requiring the use of engineering controls to access the equipment. Removing the choice causes workers to use the safer solutions. Alternative Methods provide a safer solution when appropriately designed and maintained.

The regulatory requirements for Alternative Methods must be application specific. OSHA should not issue a blanket requirement that Alternative Methods must be Cat 3, control reliable, PLd, or similar, unless deviations are permitted from the requirements based on a documented risk assessment. A conveyor does not need a Cat 3 control system.

Small companies, or large companies with limited engineering staffs, may not be capable of doing the homework to make full use of Alternative Methods. These companies should continue to use LOTO to control hazardous energy. Similarly, there may not be value in conducting the analysis or retrofitting some existing equipment to use an Alternative Method. In these instances, the fall back position is LOTO.

Examples

Alternative Methods are currently being used in the packaging and processing industries. Annex A to this response includes a few real-world examples that describe some of these applications.

About the Response

PMMI is a member of the Z244.1 committee and participated in drafting the Z244 response to the RFI. This PMMI response to the RFI is based in part on the work of the ANSI Z244 Committee, but adapted to address the specific circumstances of the packaging and processing industries.

Summary of Key Points

In response to this RFI, PMMI recommends the following:

- Team OSHA. OSHA is not alone in this effort. Workers, industry and the Agency all can assist in developing solutions. OSHA should *not* try to "do it all."
- Alternative Methods to LOTO should be allowed for machinery, equipment or processes where the hazards have been identified, and the risks reduced to an acceptable level as documented in a risk assessment.
- Fundamentally, when considering Alternative Methods in lieu of LOTO, OSHA should realize that the *system* is the key, not just the components or devices in isolation.
- According to the generally accepted Hazard Control Hierarchy, lockout is an Administrative Control that relies on human behavior, whereas Alternative Methods usually involve Engineering Controls and control systems which are more preferred than Administrative Controls. Worker safety would be better served if appropriately designed and implemented Alternative Methods according to Z244.1 were allowed and encouraged consistent with the Hazard Control Hierarchy.
- OSHA should focus on the *what* not the *how* of energy control. OSHA's future Rule must *stand the test of time*. Strict and prescriptive rules on *how* to control hazardous energy will fail to keep up to date, and will become quickly outdated/obsolete. The means of *how* to control hazardous energy will change greatly in the coming years and should be left to industry standards that are required to keep current.
- In 5-10 years, vertical integration will occur where employers/end users will require machinery, equipment and processes to have compliant Alternative Methods built in upon delivery. Machine and equipment builders have qualified controls engineers on staff who create these systems in accordance with industry standards. OSHA has an exciting and unique opportunity with this revision to make a huge potential impact on workplace safety through this vertical integration.
- The Agency should reconsider its current position on servicing and maintenance. By placing requirements based on the characterization of a task, the discussion quickly turns to the nuances characterizing a task, rather than enabling the work to be done safely through the control of hazardous energy. By following the ANSI Z244.1 The Control of Hazardous Energy Lockout, Tagout and alternative Methods, OSHA could and should focus on the control of hazardous energy and not on labels or characterizations attached to a particular task.
- A revised Rule needs to better address energy control in processing industries. The current rule has a machinery bias that is a very poor fit for processing applications.
- Employers are currently and increasingly using control circuit devices in systems that are commensurate with the risks and meet the requirements of ANSI Z244.1.

- OSHA should not be overly concerned about training costs to employers or others.
- Alternative Methods, which has been referred to using a variety of terms, has been increasingly prevalent as a resolution to many employer citations at Informal Conferences, at the administrative court level, and at the OSHRC.
- Alternative Methods are commonly used today in industry, in developed countries internationally, and even in consumer products.
- Not all energies are hazardous. As the Agency evaluates new requirements, PMMI encourage OSHA to distinguish between hazardous energy that needs to be isolated or controlled, and other forms of energy that do not. PMMI recommend that OSHA consider adopting, accepting or incorporating the methodologies in the ANSI Z244.1 standard, and would welcome the opportunity to meet with the Agency to discuss these matters further.

Team OSHA

PMMI would like to emphasize that OSHA is not alone in this effort. OSHA has a role to play. Industry has a role to play. Each has different strengths, weaknesses, and expertise. The Agency should use these as best it is able. More specifically, OSHA should *not* try to "do it all." For example:

- OSHA writes the rules and defines what is acceptable, but does not design Alternative Methods. OSHA also enforces the rules.
- Industry, through ANSI SDOs like PMMI have the technical expertise to write the methods/processes for *how* to control hazardous energy.
- Operators/maintenance personnel use Alternative Methods but do not design them. They help define the tasks and hazards associated with equipment and can offer valuable insight into feasible risk reduction measures
- Controls engineers design systems to meet the requirements. They design and build Alternative Methods but do not use them.
- Each of these 'team members' brings valuable insights regarding how to control hazardous energy most effectively in ways that will not be defeated and therefore will reduce harm to workers.

LOTO and Alternative Methods

PMMI recognizes that LOTO works in many applications, but not all. This was a key premise in revising the American National Standard in 2016. LOTO relies on human procedures, which are not always reliable even when well-intended. LOTO is an administrative control.

Alternative Methods using current technological advances are very reliable when properly designed and implemented. Alternative methods can be “as safe or safer than LOTO” when properly integrated. The key element is that Alternative Methods must be appropriate for the application in order to protect workers from harm. OSHA should encourage the use of effective Alternative Methods in lieu of LOTO where the methods are applicable and properly designed and implemented.

As described in ANSI Z244.1, Alternative Methods are only allowed on systems under very specific conditions, including where a documented risk assessment has been performed. Risk assessment serves as the underpinning of machinery safety around the world, and the basis for many modern safety standards. Z244.1 presents an abbreviated description of the risk assessment process, and refers readers to ANSI ANSI/PMMI B155.1-2016 safety requirement for packaging and processing machinery for more detailed information. The significant point is that Alternative Methods are only allowed for machinery, equipment or processes where the hazards have been identified, and the risks reduced to an acceptable level as documented in the risk assessment.

The System Approach

The RFI will provide very useful information, but PMMI encourage OSHA to expand the focus of its inquiry to look at the broader system in which energy exists. All energy sources are not necessarily hazardous and may even be beneficial during some tasks. Alternative methods leverage controlling various energies within a system as opposed to solely relying on isolation.

Contrary to some thinking “control circuit type devices” are not a discrete element like a disconnect switch, but rather work within a system, the ‘safety-related parts of a control system (SRP/CS)’ as described in ISO 13849-1. A control

system is a group of components that act together to achieve an end effect. The system is an array of interrelated components such as sensors, manual input and mode selection elements, interlocked decision-making circuitry and logic control elements, and output elements to the machine actuators, operating devices and mechanisms. High quality, well-tried, NRTL certified control circuit devices can be poorly integrated into a system, resulting in a potentially hazardous situation. It is not sufficient to focus solely on the devices. OSHA needs to raise its focus to the system level, where the aforementioned standards provide guidance on proper implementation.

OSHA correctly notes that under the variance granted to NSCI, “OSHA granted the variance based on a safety evaluation of the complete system, not just its individual components.” This is an excellent observation and the way that systems should be evaluated.

Fundamentally, when considering Alternative Methods in lieu of LOTO, OSHA should realize that the *system* is the key, not just the components or devices in isolation.

The Hazard Control Hierarchy

The safety community has used the Hazard Control Hierarchy as a framework for reducing risk. There are several different presentations of the concepts, but all follow a generally accepted progression from most preferred methods to least preferred methods. One representation is shown below from ANSI/PMMI B155.1-2016:

Table 2 - The Hazard Control Hierarchy

	Risk reduction measure	Examples	Influence on Risk Factors	Classification
Most Preferred	Elimination or Substitution	• Eliminate pinch points (increase clearance) • Intrinsically safe (energy containment) • Automated material handling (robots, conveyors, etc.) • Redesign the process to eliminate or reduce human interaction • Reduced energy • Substitute less hazardous chemicals	• Impact on overall risk (elimination) by affecting severity and probability of harm • May affect severity of harm, frequency of exposure to the hazard under consideration, or the possibility of avoiding or limiting harm depending on which method of substitution is applied.	Design Out
	Guards and Safeguarding Devices	• Barriers • Interlocks • Presence sensing devices (light curtains, safety mats, area scanners, etc.) • Two hand control and two hand trip devices	• Greatest impact on the probability of harm (Occurrence of hazardous events under certain circumstance) • Minimal impact on severity of harm	Engineering Controls
Least Preferred	Awareness Devices	• Lights, beacons, and strobes • Computer warnings • Signs and labels • Beepers, horns, and sirens	• Potential impact on the probability of harm (avoidance) • No impact on severity of harm	
	Training and Procedures	• Safe work procedures • Safety equipment inspections • Training • Lockout / Tagout / Tryout	• Potential impact on the probability of harm (avoidance or exposure) • No impact on severity of harm	
	Personal Protective Equipment (PPE)	• Safety glasses and face shields • Ear plugs • Gloves • Protective footwear • Respirators	• Potential impact on the probability of harm (avoidance) • Some impact on severity of harm	Administrative Controls

As the Table clearly shows, lockout is an Administrative Control that relies on human behavior to correctly follow the necessary procedures each and every time that energy has to be controlled. Conversely, Alternative Methods usually involve Engineering Controls and control systems which can be reliable and more preferred than Administrative Controls. Several other industry standards, safety texts, and research papers present similar teachings.

OSHA's current position that control systems cannot be used to control hazardous energy because they are not energy isolating devices is inconsistent with the fundamental principles of the hierarchy. PMMI suggest that worker safety would be better served if appropriately designed and implemented Alternative Methods according to Z244.1 were allowed and encouraged, consistent with the Hazard Control Hierarchy.

OSHA should Focus on the *What* not the *How*

OSHA's future Rule must *stand the test of time*. Strict and prescriptive rules on *how* to control hazardous energy will fail to keep up to date, and will become quickly outdated/obsolete. The means of *how* to control hazardous energy will change greatly in the coming years. Manufacturing is going to change dramatically moving forward with advances in:

- machine learning,
- Artificial intelligence (AI),
- mobile platforms,
- robotics / automation,
- manufacturing / mass customization,
- Industry 4.0 / industrial internet of things, etc.

The *how* to control hazardous energy is far better suited to industry standards and the ANSI Z244.1 process. Industry has the technical knowledge to answer this question, and the ANSI consensus process is designed for updating and accommodating changes. The ANSI process requires that a standard be revised or reaffirmed every five years to ensure effectiveness and accounting of evolving best practices. In contrast, the OSHA process struggles greatly with updating due to the political and regulatory systems within which it must operate.

OSHA Should Take the Long View - Vertical integration

In 5-10 years, employers/end users of machinery and equipment will require machines and equipment to have compliant Alternative Methods built in upon delivery. This is vertical integration. OEMs will build in the capabilities because the end users will require them. Many suppliers already integrate Alternative

Methods, as this is the norm in the global marketplace. The lack of OSHA acceptance immediately sets the employer at odds between compliance and utilizing systems that are proven to keep workers safe in other regions of the world. Machine and equipment builders have qualified controls engineers on staff who create these systems in accordance with industry standards.

In due course, productivity gains will likely influence end users to improve existing/legacy machines and equipment, thus raising safety for workers. Some employers will be motivated to upgrade legacy equipment in order to use Alternative Methods in lieu of LOTO. Other employers will decide that the time/expense to upgrade is not economical, and will continue to use LOTO on their legacy equipment. Other employers will work with a mix of LOTO and Alternative Methods.

Fundamentally, OSHA has an exciting and unique opportunity with this revision to make a huge potential impact on workplace safety through this vertical integration. There may never have been before, or will be again, such a potential to impact worker safety and productivity at the broadest level.

GENERAL RESPONSES

Minor Servicing

The RFI states that:

"Based on preliminary research and alliance-partner feedback, OSHA believes the use of control circuit type devices is typically limited to the types of tasks that do not meet the minor serving exception in the LOTO standard but also do not require either extensive disassembly of the machine or worker entrance into hazardous areas that may be difficult to escape quickly."

PMMI agree that extensive disassembly should be done under LOTO.

We do wonder however, that this observation may be self-fulling. Tasks that might fall under the minor servicing exception may not be on the Agency's radar as there is less discussion or conflict as to how these tasks are performed. If Alternative Methods are allowed, then there could be more instances/applications than are currently envisioned under the minor servicing exception.

We can share that the minor servicing exception construct certainly does drive employer responses and requests. It is common for employers to go to great lengths to frame a task to fit the language of the minor servicing exception. This is unfortunate as it focuses the discussion on how to characterize the tasks, rather than how to perform the task safely and how to best control hazardous energy.

The "ability to escape quickly" is not a parameter used in the evaluation of Alternative Methods in Z244.1. The ability to escape, or more specifically the ability to avoid a hazardous situation, would commonly be part of a risk assessment, and as a factor in evaluating the effectiveness of a risk reduction measure (e.g., safe/reduced speed). However, it should probably not be applied as a black letter criterion. This idea seems a bit dubious as written.

More generally, the Agency should reconsider its current position on servicing and maintenance. With the 2016 edition, ANSI Z244.1 abandoned the service and maintenance construct, and with it the minor servicing exception.

The following explanation appears in the Introduction to the revised standard:

> **The Service and Maintenance Construct**
>
> With the 2016 revision, the committee has rejected the normal production operations versus service and maintenance construct as an artificial distinction without real world application. More specifically, the committee realized that work gets done based upon the tasks to be performed without regard to a characterization of whether the task is normal production operations, service or maintenance. Hazards associated with the unexpected release of hazardous energy need to be addressed – regardless of any labels or characterization attached to it.

By placing requirements based on the characterization of a task, the discussion quickly turns to the nuances characterizing a task, rather than enabling the work to be done safely through the control of hazardous energy. Many discussions occur in industry as to whether a task is or is not servicing, or if it can be characterized in a manner to fit under the minor servicing exception. These conversations are not worthwhile or productive in terms of protecting workers or controlling hazardous energy. OSHA could and should focus on the control of hazardous energy and not on labels or characterizations attached to a particular task.

Processing Industries

During the drafting of the original 1910.147 language, OSHA either by intent or inadvertently created a built in “bias” toward the universe of hazardous energy control. First, in the preamble OSHA eliminated the term “process” from the standard that was imbedded in the 1982 ANSI cardinal document. OSHA explained that the term “equipment” would be sufficient for the process world and was not needed. Second, OSHA attempted to address production support tasks by adding the reference to Subpart O (Machinery and Machine Guarding) and the criteria in 1910.147(a)(2)(ii)(A) and 1910.147(a)(2)(ii)(B). When read together guarding, point of operation and machine operating cycle completes the “bias” toward machinery at the expense of all else. The process universe is a poor fit for this type of exclusionary language. See below:

Normal production operations are not covered by this standard (See Subpart O of this Part). Servicing and/or maintenance which takes place during normal production operations is covered by this standard only if:

1910.147(a)(2)(ii)(A)
An employee is required to remove or bypass a guard or other safety device; or

1910.147(a)(2)(ii)(B)
An employee is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being processed (point of operation) or where an associated danger zone exists during a machine operating cycle.

Note: Exception to paragraph (a)(2)(ii): Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection (See Subpart O of this Part).

PMMI encourage OSHA to hold Stakeholders meetings to ascertain the broader view of hazardous energy control. This initiative could provide a revelation on energy control incident information, technological advancements; inhibiting regulatory requirements as written, interpreted, enforced and adjudicated; future directions; and other subject matter opportunities.

Use

The RFI states that:

"OSHA is requesting information about how employers have been using these devices, including information about the types of circuitry and safety procedures being used and the limitations of their use, to determine under what other conditions control circuit type devices could safely be used."

Employers are using control circuit devices in systems that are commensurate with the risks and meet the requirements of ANSI/PMMI B155.1-2016.

Economic

PMMI has requested individual companies to offer comments on economic impacts directly to OSHA. We recognize that sharing such information in the public record has limitations. Annex A, Example 1 includes some economic impact data.

There are certainly compliance costs associated with the current 29 CFR 1910.147. The basic costs of training, annual re-training, and implementation will not change because LOTO remains a useful method to control hazardous energy, and Alternative Methods cannot be used for all tasks. The primary costs for compliance involve the downtime to operations, particularly where Alternative Methods provide an effective alternative in lieu of LOTO.

The compliance costs with the current requirements also include engaging legal counsel and outside experts to understand what is required, then provide a solution that meets the requirements. Employers may avoid these costs if a) they have sufficient in-house expertise, or b) they avoid a citation. In the event that neither is true, the outside compliance costs come into play. Those costs can be significant and considerably larger than the new citation penalty limits. If OSHA can clearly define what is required, the added external costs of compliance will be removed or diminished.

Compliance costs under new requirements for new equipment or machinery purchases are not expected to be significant. Once OSHA specifies the requirements, employers will acquire machinery and equipment that includes the necessary capabilities. This may not be a trivial expense, but it will be absorbed into new purchases.

Compliance costs under new requirements for existing/legacy equipment are more significant. With some systems, the costs will exceed the equipment value and no upgrades will be made. For these systems, LOTO will remain the method to control hazardous energy. With some systems, the upgrades will be made. These costs are likely to be significant as there will be engineering/design time to evaluate the system and determine necessary upgrades, and manufacturing time to implement them.

Consequences

OSHA also invites comment on any unintended consequences and consistencies or inconsistencies with other policies or regulatory programs that might result if OSHA revises the 29 CFR 19101.47 standard.

If, as recommended, OSHA ceases to use the (artificial) service and maintenance construct, a large body of case law, interpretations, citations, and training of both compliance officers and employer personnel will no longer be relevant. In most cases, this should be considered as a positive as there is the opportunity to wipe the slate clean and start anew with the focus where it should be - controlling hazardous energy. The Agency should expect some pushback from the legal community and some employers that are more comfortable in the familiar, if somewhat unclear and misguided, current system.

1. The training courses necessary;
2. The topics training would cover;
3. The types of employees who would need training and what percent (if any) of those employees currently receive the training;
4. The length and frequency of training;
5. Any retraining necessary; and
6. The training costs, whether conducted by a third-party vendor or by an in-house trainer.

Training

OSHA seeks to receive information on the following:

Presuming that the Agency will make changes to the 29 CFR 1910.147 requirements during the Rulemaking process, the new rules and requirements will require training for employers, employees and compliance officers.

Assuming that the Agency allows Alternative Methods to be used, there will be offsetting training costs. To use, and to be trained to use, an Alternative Method will require very limited training compared with LOTO. Alternative methods almost always make the operator's job much easier to perform. The training associated with maintaining Alternative Methods could be significant, particularly to maintenance personnel tasked with troubleshooting and maintaining the control systems.

The time to design and implement Alternative Methods should not be significantly different than what controls engineers currently do. For controls engineers familiar with Categories, Performance Levels from ISO 13849-1 or control reliability, they will simply need to meet the requirements. The requirements may be increased over what they currently provide, but the training and implementation is inconsequential. For employers that do not have control engineering personnel or expertise, the training and learning curve could be a significant challenge; however, many consultants are available in the marketplace to offload this burden.

After the rules are determined, there will be considerable in-person training offerings by consultants and others. As the new requirements become better understood, the training will move from third party offerings to in-person, in-house training. Subsequently, other forms of training will very quickly become available including online, web based, computer modules and other options. The initial training costs will likely be relatively high and in high demand. Subsequently, the costs should be expected to drop considerably as more is understood about the requirements and fewer questions arise.

As a result, OSHA should not be overly concerned about training costs to employers or others.

Precedent Decisions

The concept of Alternative Methods, which has been referred to using a variety of terms, has been increasingly prevalent as a resolution to many employer citations at Informal Conferences. Additional cases have been successfully resolved at the administrative court level and at the OSHRC by applying Alternative Methods. Alternative Methods address the real-world issues where traditional lockout/tagout is not feasible.

Monitored Power System (MPS) was a term used by General Motors as early as the 1990s. In the 1995 litigation *Secretary of Labor v General Motors Corporation*, an MPS was used to control energy to the machinery and prevent restart without workers completing a multi-step sequence of operations. Although the case involved extensive discussions as to whether there could be an unexpected restart of the machinery, the key point is that the machinery would not start because the MPS was an Alternative Method that provided effective protection.

Slide locks is another term used in the machine tool industry for presses. OSHA's slide lock CPL 02-01-043 allows control reliable circuitry to de-energize energy sources in lieu of other energy isolation devices to provide effective alternative employee protection.

More recently, decisions rendered in *Secretary of Labor v Matsu Ohio, Inc.* (2016) and *Secretary of Labor v Swiss Logistics and Walmart* (2018) have found that Alternative Methods prevented employees from being exposed to hazards.

OSHA should realize that Alternative Methods are being used, and will increase in usage in industry.

Experiences in Industry

The reality today is that many, many U.S. companies are already using various forms of Alternative Methods now to control hazardous energy. In some cases, the methods are carefully designed and implemented. Others are much less so, and may not provide an acceptable level of risk reduction. This is currently occurring without updated guidance or requirements from OSHA.

Internationally, Alternative Methods are safely and successfully used in the developed world as a preferred means rather than lockout/tagout. This difference negatively impacts U.S. competitiveness in the global marketplace, and may increase the incentive to intentionally bypass/defeat traditional lockout procedures.

Alternative Methods are commonly used today even in consumer products. In millions of homes, hands are placed in the hazard zone of kitchen food processors while relying on an interlock switch to prevent unexpected start, and not by unplugging and locking the plug.

Industry has progressed and developed new systems that did not exist in 1989. That progress will continue in the future as well. OSHA should provide some structure to U.S. employers that will help ensure that these methods provide an appropriate level of safety.

Energies

In its enforcement activities and various documents, OSHA seems to assume that all energy is hazardous and must be controlled. However, not all energy is hazardous. Some energy is actually beneficial to worker safety. For example, the hold down device on the unwinder for a coil of steel requires hydraulic energy to engage and hold the coil. Without the hold down device energized, the steel coil can unwind in a very hazardous manner when the securing bands are cut by the worker. Many injuries have occurred to workers when the hold down device is not used.

In addition, other energies that may be present during a task are not hazardous and need not be isolated or controlled. For example, low voltage power to sensors or power to a computer is often not hazardous and isolating these power sources creates unnecessary work with no impact to worker safety.

As the Agency evaluates new requirements, PMMI encourage OSHA to distinguish between hazardous energy that needs to be isolated or controlled, and other forms of energy that do not.

Additional Data and Comments

PMMI formed a task group to develop answers to questions under Item II.C in the OSHA RFI. The responses and some additional comments to the RFI from the task group are attached at Annex B.

ANSWERS TO SPECIFIC QUESTIONS:

PMMI are pleased to provide the following answers to OSHA's questions based on our understanding of what the Agency is asking. However, it is very important to reiterate that our responses consider "control circuit type devices" to be a part of an Alternative Method and that these elements <u>operate in a system</u> to provide a safety function. Thus, the responses are based on the details provided in Z244.1 Clause 8.1 that cover many aspects of system performance that go well beyond individual components.

1. In what work processes should OSHA consider allowing the use of control circuit type devices for hazardous energy control?

The answer is those circumstances that comply with the requirements of the revised ANSI Z244.1. The requirements were developed specifically to address this type of question.

We are sure you are aware of the Z244 committee's December 9, 2016 letter to then Assistant Secretary of Labor/OSHA, Dr. David Michaels announcing the newly revised ANSI/ASSE Z244.1-2016 Standard, *Control of Hazardous Energy – Lockout, Tagout and Alternative Methods*. In the revised standard, the thrust of your current information request is addressed in numerous clauses and annexes. We specifically call to your attention Clause 8.1 Alternative Methods where seven situations are identified:

> **Energy isolating device.** A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and, in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selector switches and other control circuit type devices are not energy isolating devices.

In these situations, Alternative Methods may be as safe or safer than conventional lockout, or conventional lockout may be inappropriate, not feasible or not practicable.

The situations mentioned in Clause 8.1 are commonly encountered in the current manufacturing and process universe.

Conversely, Alternative Methods should not be used for major repairs or disassembly where LOTO should be applied.

In 29 CFR 1910.147 the definition of energy isolating device (EID) reads:

NOTE: *Situations where alternative methods may apply include, but are not limited to:*

- *when hazardous energy is present because it is required to do the task;*
- *when lockout or tagout is not feasible or practicable (see Annex L for example practicability evaluation);*
- *when a documented risk assessment shows the task can be performed with acceptable risk;*
- *when inherent hazards (e.g., thermal, radiation) are unable to be controlled using lockout or tagout;*
- *when energy is required to maintain equipment in a safe state;*
- *when repetitive cycling of an energy isolation device compromises its safe function;*
- *when the operation of a standard energy isolation device creates an additional hazard.*

The last sentence has been historically problematic. Taken very broadly, the intent has been misused or misinterpreted to infer that it applies to any control system no matter how sophisticated and protective.

The definition of this term is nearly identical to the definition included in the original 1982 edition of the Z244.1 standard:

energy isolating device. **A physical device that prevents the transmission or release of energy, including, but not limited to, the following: a manually operated electrical circuit breaker, a disconnect switch, a manually operated switch, a slide gate, a slip blind, a line valve, blocks, and similar devices with a visible indication of the position of the device. (Push buttons, selector switches, and other control-circuit type devices are not energy isolating devices.)**

The series of device types addressed in that last sentence in the Z244.1 standard were aimed at a specific application of simple devices, with lower levels of reliability, used for isolation. The intent was never to limit technology nor exclude engineered solutions that offer effective protection. Properly designed

Alternative Methods are an effective means to control hazardous energy.

In the 1982 edition of the Z244.1 standard, Clause *6.8 Production Operations* contains important text that was omitted by OSHA in 29 CFR 1910.147. This clause supports the true intent of the phrase "other control circuit devices."

> ***6.8 Production Operations.*** **Personnel performing the activities listed in 3.1, other than normal operating activities, should do so under de-energized conditions in accordance with the lockout/tagout procedures required in this standard (see 5.2.1). In the case of required repetitive minor adjustments where this is not feasible, or in the case of normal production operations, these activities shall be accomplished under the protection of specially designed control circuits, control equipment, and operating procedures, that provide proven effective protection for the affected personnel.**

The 1982 standards committee realized that more robust "specially designed control circuits and equipment" existed, and future advances would be made, and therefore Clause 6.8 was an effort to differentiate simple circuit devices from the more effective systems.

2. What are the limitations to using control circuit type devices? Do they have specific weaknesses or failure points that make them unsuitable for hazardous energy control?

All devices have failure modes, including those listed in the 29 CFR 1910.147 definition for EID. Proper design and implementation of ANY solution includes evaluation of failure modes and reliability data. Control system solutions typically require more knowledge to apply and have more factors to consider. The ISO 13849-1 control system standard require formal evaluation of these limitations and failure modes as a part of the design process.

3. If OSHA were to allow the use of control circuit type devices or other methods to control hazardous energy, would your firm choose to use them? Why or why not? Do you anticipate that these devices would save your firm money? For example, would these devices simplify operations or maintenance? Are there fewer steps needed to implement the controls? How frequently do you employ some form of lockout/tagout system in your facility?

Yes. Reduced incentive to defeat or bypass safety systems and reduced downtime are two reasons many companies in industry are starting to use Alternative Methods that comply with the requirements in Z244.1. If OSHA were to formally allow the use of Alternative Methods, their use will increase significantly due to the safety and productivity improvements. This is a significant opportunity.

4. Are there any specific conditions under which the use of control circuit type devices would not be advisable?

The Z224.1 standard specifically addresses conditions where alternative means are not appropriate. An example would be new or unplanned tasks that are not specially identified to be completed under the Alternative Method. The standard requires a documented program to specify acceptable tasks.

5. When the Lockout/Tagout standard was originally drafted, OSHA rejected the use of control circuit type devices for hazardous energy control due to concerns that the safety functions of these devices could fail as a result of component failure, program errors, magnetic field interference, electrical surges, or improper use or maintenance. Have new technological advances to control circuit type devices resolved these concerns? How so?

Yes. Technology has greatly improved control circuit type devices and the systems in which they are used. The Z244.1 standard addresses these topics in the fault tolerance and tamper resistance subclauses of 8.2. These topics are also addressed in a consistent manner in ANSI/PMMI B155.1, ISO 13849-1 and B11.19.

6. Are there issues with physical feedback for control circuit type devices?

The meaning of this question in not clear and the answer depends on the meaning of 'physical feedback.'

7. What are the safety and health issues involving maintenance, installation, and use of control circuit type devices? Have you found that alternative safety measures themselves cause any new or unexpected hazards or safety problems? Please provide any examples if you have them.

One of the limitations of using Alternative Methods is the potential for 'copycat' or 'cheater' systems that have not been evaluated to meet the requirements of an Alternative Method. For example, an Alternative Method on a machine may include locking out using a group lockout hasp on a lockable E-stop device which has the appropriate structure, components, exclusivity of control and other applicable requirements of an Alternative Method under Z244.1. An employee might then decide that locking out any E-stop on any other machine is then acceptable, even on machinery or equipment for which it may not be appropriate.

Another limitation of Alternative Methods generally, which may include control circuit type devices, is the potential for tasks being performed that are not appropriate to be done using the Alternative Method (sometimes referred to as "task creep"). For example, clearing a jam may be an approved task using the Alternative Method, but changing a belt is not. Personnel should not perform tasks for which the Alternative Method is not intended as identified through a task-based risk assessment.

End users have expressed concerns about the training and implementation of Alternative Methods for equipment in a single facility (or organization) that has different capabilities for controlling hazardous energy. For example, Line 11 has Alternative Methods capability, but Line 10 does not. How are they to effectively communicate and train workers which tasks are permitted on Line 11 using the Alternative Method(s) but must be locked out for Line 10. This does not lend itself to a single session of training and "now go do it correctly."

8. Do control circuit type devices address over-voltage or under-voltage conditions that may signal power-off, power-on, or false negatives on error checking?

In general, yes. Technology has greatly improved control circuit type devices and the systems in which they are used. The Z244.1 standard addresses these topics in the fault tolerance subclauses of 8.2. These topics are also addressed in a consistent manner in ISO 13849-1, ANSI B11.19 and ANSI B11.26.

9. How do control circuit systems detect if a component of a control circuit device breaks, bends, or otherwise goes out of specification? How do the systems signal this to the exposed employee? Could these types of failures create a hazard while the system continues to signal that conditions are safe?

This question provides an excellent example of considering the device rather than the system. Individual devices are often too simple to provide diagnostic coverage taken on their own. As a part of a well-designed control system however, even a simple device can be monitored, cross checked and enhanced with diversity and redundancy to achieve high levels of reliability. Annunciation of fault conditions is most commonly considered secondary to achieving a safe state, but in its simplest form the signal to the employee is often the equipment being prevented from restarting.

This is further addressed in Z244.1 under monitoring and fault tolerance. These topics are also addressed in a consistent manner in ISO 13849-1 and ANSI B11.26 (2018).

10. What level of redundancy is necessary in determining whether a control circuit type device could be used instead of an EID?

Worldwide, the most common design tenet for safety control systems is that their level of reliability shall be commensurate with the risk. Z 244.1 also follows this requirement. As an example, many applications require Category 3, PL=d (ISO 13849-1), or control reliable architecture. Under this requirement no single failure will result in the loss of a safety function. The various systems for evaluating this situation are well documented in the standards and have achieved broad acceptance.

11. Lockout/tagout on EIDs ensures that machines will not restart while an employee is in a hazardous area. How do control circuit type devices similarly account for employees working in areas where they are exposed to hazardous machine energy?

The control circuit type devices do not. It is the system in which they are used. This issue is addressed by exclusivity of control in Z244.1. Additionally, ANSI B11.19 addresses a number of methodologies to reduce risk when an employee can enter into the hazardous area (safeguarded space), also known as "whole body access." LOTO is a primary approach, but other Alternative Methods, used either singularly or in combination with other elements, are also presented. The determination of which approach(es) to integrate are based upon a risk assessment.

12. How do control circuit type devices permit an employee to maintain control over his/her own safety?

Similar to #11 above, Z244.1 requires that Alternative Methods offer an appropriate level of exclusivity, such that workers are in control of the restoration of normal operation. This can range from simple proximity, to the application of physical locks to a device.

13. How do control circuit type devices permit employees to verify that energy has been controlled before beginning work in danger zones? How do the devices account for exposed employees before equipment is restarted?

There is a tremendous range of answers depending on the system, but often the same test methods used for LOTO can be applied. In other applications lights, sounds, or display screen can provide feedback. Restart also covers a huge range of applications, but typically effective protection is assured by exclusivity and procedures that are similar to LOTO.

This point is well considered and is part of the process in Z244.1.

14. Control circuit type devices have a number of claimed benefits compared to energy isolating devices, including workers' greater willingness to use such devices, better efficiency, less downtime, and the lack of a requirement to clear programming on computer-controlled devices. Are there any other benefits to *using control circuit type devices? Are there certain situations where these devices are especially advantageous? For example, where machine tasks require frequent repetitive access, is the process faster and/or less physically demanding than applying mechanical lock(s)?*

Certainly, the benefits listed above occur. As an engineering control solution, Alternative Methods are far more reliable than LOTO which is a lower order administrative control solution. Examples in Z244.1, Clause 8.2. *Evaluating Alternative Methods* and Annexes L through V provide insight concerning the use of alternative measures with relevance to safety-related control systems. Annex V *Control System Example Methodologies* reveals international criteria for assessing safety reliability and performance.

15. What other methods or devices, if any, are being used with control circuit type devices to control the release of hazardous energy, especially in cases where the control circuit devices are only used to prevent machine start-up? Are there control circuit type devices that require additional methods or devices to fully control the release of hazardous energy? What improvements to safety or health does the use of these devices or methods provide?

There is no one Alternative Method that suits all applications. Good controls engineering design and industry standards require a separate manual actuation to restart a machine.

16. What are the unit costs for installing and using control circuit type devices or other Alternative Methods of hazardous energy control? Are the costs of installing and using control circuit type devices or other Alternative Methods of controlling hazardous energy dependent on the capacity or efficiency of the devices? If so, please include details on the effects of capacity on these unit costs including the capacity of any equipment you use in your facility. Are these devices generally integrated into newly purchased machinery, or are they purchased and installed separately? What steps need to be taken, and how long do those steps take, for these systems to be engaged in a manner that fully protects workers from the release of hazardous energy?

It could be either built into machinery and equipment, or purchased and installed separately. Engineering controls will become part of new machinery purchase specifications in due time. In many cases, new machinery already includes Alternative Methods as current best practice. The only discrepancy in industry is *when* a specific task allows the use of Alternative Methods as opposed to the energy isolating device.

17. What additional actions is your firm taking to protect workers when they are servicing machinery with control circuit type devices in order to meet OSHA's Lockout/Tagout *standard requirements? For example, does your firm purchase and use physical devices that you feel do not enhance worker* *protections but nonetheless are required by the OSHA standard? What are these items and how much do they cost? Please explain why you feel these items do not enhance worker protections.*

PMMI is not aware of additional actions or equipment used specifically for servicing machinery as stated in this question. Employers rely on the Alternative Methods supplied or integrated with the packaging or processing machinery.

18. The American National Standards Institute (ANSI), the International Organization for Standardization (ISO), and the International Electrotechnical Commission (IEC) all have standards that may be applicable to control circuit type devices. Should OSHA consider adopting portions of any ANSI, ISO, or IEC standard that specifies requirements for control circuit devices as part of an updated OSHA standard? Are there recommendations in the consensus standards that you choose not to follow? If so, please explain why. Are there any requirements in these standards that would impose significant cost burdens if OSHA were to include those requirements in a revised Logout/Tagout standard? Are there provisions of one consensus standard when compared to the others that you perceive as having lower costs to implement and use on a day-to-day basis while providing protection to workers that is equal to or greater than that provided by the other standards? If so, please explain.

The information in both domestic and international consensus standards represents the best practices and knowledge for worker safety with machinery and equipment. Not all requirements in these standards apply to a given situation. So, in some circumstances, a requirement in the voluntary consensus standard is not followed because a documented risk assessment demonstrates that acceptable risk is achieved using another alternative risk reduction measure(s).

19. ISO categorizes "the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions" into one of five levels, called performance levels. These performance levels "are defined in terms of probability of dangerous failures per hour." Should OSHA consider requiring a specific performance level in determining whether a control circuit type device could be a safe alternative to an EID?

Functional Safety Standards.

The RFI inquires about certain consensus standards: "As part of this RFI, OSHA is also evaluating criteria used by consensus standards to determine the safety effectiveness of control circuits." In particular, OSHA asks about ISO 13849-1 and IEC 62061.

These two standards are tools that controls engineers use to address the functional safety or reliability of a SRP/CS. The Performance Levels and SILs are two distinct but similar evaluation methods. These methods are a newer/updated methodology of what was "control reliability," which OSHA has referenced in the past. A very common method that came from an earlier version of ISO 13849-1 uses Categories. Although some methods are newer/more refined than others, all of these methods remain valid as none has been shown to be invalid. That is, a machine designer can use any one of these methods (categories, performance levels, control reliability, safety integrity levels) to develop an appropriate control system for a given application based on a risk assessment.

These two consensus standards are written for machine designers, and more specifically for controls engineers. The skill level required to use these standards is not trivial, and usually beyond the capabilities of maintenance personnel in a typical employer's facility. Maintenance personnel can often maintain such systems, but designing a new machine, or evaluating existing equipment is typically beyond what OSHA should expect of employers.

Even with these limitations on the ability for some personnel to apply these standards, OSHA could reasonably set performance specifications per those standards. If OSHA set a requirement of "Category 3, PL=d or control reliable, with permitted deviations from the requirements based on a documented risk assessment," employers will find ways to meet these requirements if they see benefit in using Alternative Methods versus LOTO. OSHA should anticipate that industry would be very receptive to its setting such a specification.

Setting a specific Category/PL/SIL/control reliability requirement would simplify communications with employers, but could easily result in overspecification of a requirement. Not specifying a specific requirement would allow for employers to determine the appropriate level based on a documented risk assessment. Setting a specific level but allowing deviations based on a documented risk assessment may be the best answer.

20. Can System Isolation Equipment, as discussed in the UL consensus standard UL6420 Standard for Equipment Used for System Isolation and Rated as a Single Unit, provide protection equal to that obtained through lockout/tagout?

It depends on the system in which this equipment is used. Companies will, and are, developing such single purchase solutions. The use of such systems can achieve levels of risk reduction equivalent to LOTO with the added benefit that these systems tend to significantly reduce the probability of defeating/bypassing by employees.

21. The ANSI/ASSE Z244.1 consensus standard encourages the use of risk assessment and hazard control hierarchy as Alternative Methods of hazardous energy control. Should OSHA consider incorporating these methods in any new standard with respect to the use of control circuit type devices?

Look Very Closely at ANSI Z244.1

The ANSI Z244 Committee's approach to revising the Z244.1 standard used a systems approach. ASSE (now ASSP) gathered subject matter experts (SMEs) on control of hazardous energy from across industries and the country. Industries represented included:

- automotive
- consumer products manufacturing
- construction equipment
- general manufacturing
- government
- industrial machinery
- labor
- metals manufacturing
- plastics
- railway operations
- packaging machinery
- printing
- robotics
- semiconductors
- and others

This diverse committee revised the standard on how to best control hazardous energy. The committee used the ANSI consensus process to build on the best ideas. If OSHA were to start with a blank page and write a new standard for the control of hazardous energy, it would very likely want to follow this same approach. Therefore, the Agency should look closely at the resulting Z244.1 standard.

Z244.1 is both specific in its requirements and enforceable. An explicit intent of the Committee was that the standard be enforceable.

LOTO is part of the standard as an approach to control hazardous energy. Z244.1 includes requirements for LOTO because it is a very important method to control hazardous energy.

Z244.1 requires real homework by employers before an Alternative Method is allowed. If the homework is not done, then an Alternative Method is not allowed. In those cases, LOTO should be applied.

The requirements for Alternative Methods in Clause 8.2 represent far too much work for employers unwilling to do the homework. There are no shortcuts. Diligent employers willing to do the homework and work the process within Z244.1 will develop Alternative Methods that meet the standard and increase safety in the workplace.

In the RFI, OSHA describes the history of ANSI Z244.1 in relation to 29 CFR 1910.147. Z244.1 presents the most current knowledge and information on how to effectively control hazardous energy. The Agency should adopt or, incorporate the methodologies in the 2016 standard.

One deviation of Z244.1 is that it currently does not permit the use of Alternative Methods that provide solutions that are "as safe or safer than LOTO." Under the current Z244.1 standard, if LOTO is feasible, it is expected to be used because LOTO is considered the primary method to control hazardous energy. In the next revision of Z244.1 PMMI anticipate that this limitation will be removed and Alternative Methods will be on an equal footing as LOTO, thus giving employers the choice as to the best method to control hazardous energy based on the application.

Another limitation of Z244.1 is that the analysis required to use an Alternative Method is currently fairly complex. As companies become more familiar with the process, this is expected to get easier. Indeed tools, templates and checklists are currently being developed to assist companies in working through the Alternative Method process.

The elements of an Alternative Method as described in ANSI Z244.1 clause 8.2 need to be considered as the means to evaluate the systems to control hazardous energy, not just the control circuit type device. The potential parameters used in evaluating an Alternative Method include:

8.2 Evaluating Alternative Methods

In evaluating an alternative method to lockout or tagout, the risk reduction measures that will comprise the alternative method shall be identified. Based on current analyses and best practices, alternative methods shall consist of the following parameters as applicable:

- practicability/justification analysis (clause 8.2.1)
- risk assessment based on the tasks being performed (clause 8.2.2)
- industry best practices/methods (clause 8.2.3)
- architecture/structure (clause 8.2.4)
- using well-tried components (clause 8.2.5)
- using well-tried designs (clause 8.2.6)
- common cause failure (clause 8.2.7)
- fault tolerance (clause 8.2.8)
- exclusivity of control (clause 8.2.9)
- tamper resistance (clause 8.2.10)
- program to support (clause 8.2.11)
- procedures in place (clause 8.2.12)
- periodic checking and testing (clause 8.2.13)
- review by a qualified person (clause 8.2.14)

Each topic is addressed in greater detail as follows. Not all of the above parameters will necessarily apply to a specific situation.

NOTE: When considering alternative methods, it should be understood that conventional energy-isolating devices are also subject to failure and the user should exercise care when subjecting them to use beyond their inherent performance capability (disconnects can arc or experience mechanical fault, valves can leak, powered valves can experience upstream control failures, etc.).

These parameters were used to evaluate the Alternative Method used in the NSCI Variance that OSHA granted as described in the RFI. Thus, these parameters have been proven effective and approved by OSHA in at least one instance.

22. Do you currently utilize the services of a specialized safety engineer or employment safety administrator to test for competency and/or ensure that the hazardous energy control system is operational? If so, how many hours does this individual spend on these tasks? Do you anticipate you would need to make use of these services if OSHA revised the Lockout/Tagout requirements to align with the consensus standards? Based on data from the Bureau of Labor Statistics, OSHA estimates that an occupational health and safety specialist makes $33.14 an hour or $68,930 annually plus benefits. If you have used the services of such specialists, how does this compare with your experience?

There are very different skill sets between a safety administrator and a safety engineer. The rates above are very low for an engineer. To develop an Alternative Method requires special expertise as currently done. If OSHA simplified this process, such a need for external expertise would be reduced. However, fear of change should not be a deciding factor; any improvement can only be achieved by enhancements which differ from past methodologies.

23. How much training do you currently provide on Lockout/Tagout requirements? How long does training on this subject take and how often do employees receive training on the subject? If OSHA were to revise the Lockout/Tagout standard to permit use of control circuit type devices in some circumstances, would newly hired workers require more training or less than under the current standard? What format do you use to provide training on the Lockout/Tagout standard at your facility (i.e., small group classroom session, self-guided computer modules, etc.)? If you have used third-party training vendors to provide similar training, what are the costs? If training is provided in-house, what sort of employee provides the training (i.e., a first-line supervisor, a safety and health specialist, etc.)?

Applying Alternative Methods, based on risk assessment, are considered a higher order approach to reduce risk in the workplace according the hazard control hierarchy. Alternative Methods are an engineering control which reduce risk independent of human behavior.

LOTO, on the other hand, is entirely dependent on human behavior, thus putting a higher reliance on training and supervision, and therefore are included in the lowest order of measures to reduce risk. The hierarchy from ANSI/PMMI B155.1 2016 illustrates this concept as shown below:

Table 2 - The Hazard Control Hierarchy

	Risk reduction measure	Examples	Influence on Risk Factors	Classification
Most Preferred	Elimination or Substitution	• Eliminate pinch points (increase clearance) • Intrinsically safe (energy containment) • Automated material handling (robots, conveyors, etc.) • Redesign the process to eliminate or reduce human interaction • Reduced energy • Substitute less hazardous chemicals	• Impact on overall risk (elimination) by affecting severity and probability of harm • May affect severity of harm, frequency of exposure to the hazard under consideration, or the possibility of avoiding or limiting harm depending on which method of substitution is applied.	Design Out
	Guards and Safeguarding Devices	• Barriers • Interlocks • Presence sensing devices (light curtains, safety mats, area scanners, etc.) • Two hand control and two hand trip devices	• Greatest impact on the probability of harm (Occurrence of hazardous events under certain circumstance) • Minimal impact on severity of harm	Engineering Controls
Least Preferred	Awareness Devices	• Lights, beacons, and strobes • Computer warnings • Signs and labels • Beepers, horns, and sirens	• Potential impact on the probability of harm (avoidance) • No impact on severity of harm	
	Training and Procedures	• Safe work procedures • Safety equipment inspections • Training • Lockout / Tagout / Tryout	• Potential impact on the probability of harm (avoidance or exposure) • No impact on severity of harm	Administrative Controls
	Personal Protective Equipment (PPE)	• Safety glasses and face shields • Ear plugs • Gloves • Protective footwear • Respirators	• Potential impact on the probability of harm (avoidance) • Some impact on severity of harm	

24. Should OSHA consider making revisions to the Lockout/Tagout standard that address advances to robotics technology with respect to hazardous energy control? If so, what revisions should OSHA consider?

Robots are manufacturing systems in some instances, such as in a robotic welding cell. As a manufacturing system, these are deserving of systematic attention for the control of hazardous energy.

In other systems, robots are merely components of manufacturing systems, such as a pick and place or product transfer robot in a packaging machine. In these instances, robots are not deserving of any special attention at all – they are just components, no different than motors, brakes, belts, switches, control circuit devices, etc. In these instances, robots should be treated just like any other component.

As with control circuit type devices, the focus needs to be on the *system* that the robot or device operates within, not the robot or the device individually.

The RFI seeks information on the control of hazardous energy related to the increased interactions of employees with robots. As described previously, robots can be a integrated machinery system, or simply a component within a machinery system. With advancing technology, these differences can be expected to blur. It would be a mistake for the Agency to single out robots for special handling under the control of hazardous energy. Such an approach would take the Agency into the details of *how* to control hazardous energy for a particular industry sector for which it is expected that the methods will rapidly change.

Robots are an excellent example where industry applications will be advancing with little limitation to their application. Collaborative robots, mobile robots, service robots, medical robots, and others will continue to quickly evolve and enter the workplace. Hazards will be introduced with new situations/applications. The appropriate risk reduction measures will depend on the specific situations. By developing a ruling that will *stand the test of time*, The Agency can trust that employers following the risk assessment process and applying engineering hierarchy of controls will control hazardous energy for evolving applications and technology.

25. What are the aspects of design and build, the features, or the specifications of modern robots that are relevant to an evaluation of whether a robot has the potential to release hazardous energy while in the presence of employees? How do you use robotics? Are robotics isolated from nearby employees? Near employees? Directly employed or worn by employees?

…

26. Are you aware of any instances where workers have been injured or killed by the release of hazardous energy when working with robotic technologies? Please provide examples if you have them.

None with situations that have been designed to industry standards including ANSI Z244.1 and ANSI/RIA R15.06. There have been serious injuries and fatalities with robotic systems that have not met the requirements of these industry best practices.

27. Robots operate using software. What processes or tools exist to ensure that this software is safely operating (including protection from malware, tampering, and other threats) or displaying signs that a robot could malfunction and lead to a release of hazardous energy while in the presence of employees? Should OSHA consider making revisions to the Lockout/Tagout standard with respect to the safe functioning of robotics software? If so, what revisions should OSHA consider? To the extent that there are such revisions, how much would they increase the costs of or development hours for the software?

No. Malware or tampering is well beyond the scope or needs of this project. These are very real issues that are being addressed by industry in other committees. This is a very dynamic and changing situation (daily). OSHA is not well suited to this issue within the scope of the control of hazardous energy.

28. Are you currently using some form of lockout/tagout to control hazardous energy in robots? What steps do you take? How long do those steps take? Do you use any specially purchased equipment or materials for this process? How frequently do you take steps to control hazardous energy releases in your industrial robots? How does the process compare to the steps undertaken to comply with OSHA's Lockout/Tagout standard? How many labor hours do these additional steps require? Do these steps require any additional equipment? If so, what does this equipment cost?

In the packaging and processing industries, robots are usually treated the same as any other component or machine. For example, clearing a jam on a robotic palletizer requires the same or similar controls as clearing a jam on an automated but non-robotic palletizer.

29. Should OSHA consider adopting portions of the ANSI/RIA R15.06-2012 standard on Industrial Robots and Robot Systems, which outlines the safety requirements for risk assessments of robotic system installations? Are there any requirements in the ANSI/RIA standard that would be prohibitively expensive for your company to implement? Are there any requirements that do not provide sufficient protections for workers?

Adopting a current industry standard in lieu of writing a separate OSHA standard is always a better solution. However, R15.06 does not explicitly address the control of hazardous energy. A new robot standard is under revision and anticipated to be published in 2021 or 2022, based upon an international standard.

30. Is there another standard, besides ANSI/RIA R15.06-2012 Industrial Robots and Robot Systems - Safety Requirements, that OSHA should consider in developing requirements for the control of hazardous energy involving robotics?

Stay with a larger view. Focusing on robots is too narrow. Robots are sometimes a system, sometimes a component. A new robot standard is under revision and anticipated to be published in 2021 or 2022, based upon an international standard.

Specific Questions Regarding Economic Impacts.

31. Please describe in detail how a standard for the control of hazardous energy that incorporates the use of control circuit type devices or new robotic technology could create more jobs; eliminate outdated, unnecessary, or ineffective requirements; or produce other economic benefits. Please provide information supporting your view, including data, studies and articles.

As noted previously, packaging and processing operations commonly operate at speeds of 20 - 2,000 units per minute. The economic impacts of efficiency improvements of seconds or partial seconds quickly become significant. See Annex A, Example 1 for one application.

32. The Regulatory Flexibility Act (5 U.S.C. § 601, as amended) requires OSHA to assess the impact of proposed and final rules on small entities. OSHA requests comments, information, and data on how many and what kinds of small businesses, or other small entities, in general industry employment could be affected if OSHA decides to revise provisions in 29 CFR 1910.147. Describe any such effects. Where possible, please provide detailed descriptions of the size and scope of operation for affected small entities and the likely technical, economic, and safety impacts for those entities.

…

33. In addition, are there any reasons that the benefits of reducing exposure to hazardous energy might be different in small firms than in larger firms? Are there any reasons why the costs for controlling hazardous energy would be higher for small employers than they would be for larger employers? Are there provisions that would be especially costly to small employers? Please describe any specific concerns related to potential impacts on small entities that you believe warrant special attention from OSHA. Please describe alternatives that might serve to minimize those impacts while meeting the requirements of the Occupational Safety and Health Act of 1970, 29 U.S.C. 651 et seq.

…

Closure

It is now almost 40 years since the original language was crafted and 30 years of compliance application by OSHA. PMMI endorse the current re-evaluation of the current Agency view on “control circuit type devices” and the use of advanced control system technology to contemporize our human protective approach. The current regulatory interpretation has created significant compliance defense costs, impeded the use of advanced technologies and best practices, and inadvertently affected industry competitiveness in a negative manner.

Jim Pittas
President and CEO, PMMI

Annex A:

Real-World Examples of Alternative Methods in the Packaging and Processing Industries

1. Filling Cans in Food Manufacturing Facility

A food manufacturer operates a filler of cans. The operators must clean, check levels and clear jams on this filler. The checks usually take less than one minute and occur every hour. The cleaning happens every eight hours and takes less than ten minutes. Clearing jams take less than a minute that happen throughout the shift. A full LO/TO event takes 30-45 minutes or more.

The company developed Alternative Methods in accordance with the requirements of ANSI Z244.1. This included primarily:

- Appropriately designed and implemented control circuitry to achieve Category 3 functional safety. No single fault could result in the loss of the safety function.
- Documented safe work procedures
- Authorized employees and training

The Alternative Methods allow the jam clearing, checks and cleaning tasks to be completed in less than a minute to 5 minutes.

This machine runs 1,000 cans per minute. The company is currently using the Alternative Methods 50-100 times per shift with great success.

The company did a cost analysis and determined that the cost for downtime is $135/minute.

For a single instance, the differentials between LOTO and the Alternative Method is

	Lost time	**Lost production**	**Cost**
Best case	30 – 5 = 25 minutes	25,000 cans	$3,375
Worst case	45 – 1 = 44 minutes	44,000 cans	$5,940

For the current usage rage of 50-100 times per shift:

	Lost time	**Lost production**	**Cost**
Best case	1,250 minutes	125,000 cans	$168,750
Worst case	4,400 minutes	440,000 cans	$594,000

For the company to use LOTO instead of Alternative Methods, it would incur a cost *per shift* of $168k - $594k due to the downtime.

The Alternative Method was demonstrated to show that it provided effective protection for workers performing the necessary cleaning tasks, checks and clearing jam, yet provided an efficient and effective solution to minimize downtime for production.

Note that there remain several tasks that are required to be performed under full LOTO. Example tasks include; motor replacement, conveyor servicing/maintenance and others. Alternative Methods are not used for those tasks.

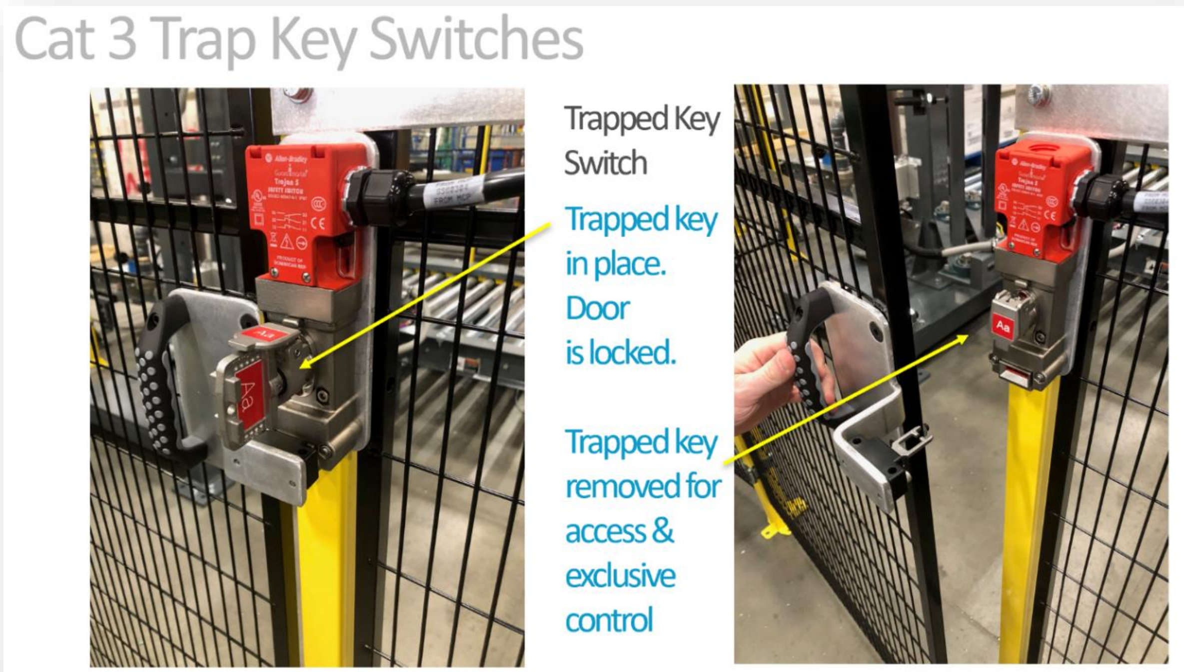
2. Bottling Line

On high speed bottled water fillers, you're looking at speeds of up to 1,800 bottles/min. with PET plastic bottles. At these speeds we're prone to jams between the air conveyor and infeed starwheel. The machine detects these jams through a clutch monitoring system and stops the machine. To clear the jam, the operator must access that area by opening the interlocked guard door and jog the machine at a safe limited speed. Once the jam location is advance, the jam is cleared and the machine reset. This method takes less than 5 minutes to accomplish.

This task would not be possible with lockout tagout without disassembling and reassembling the whole infeed system of the machine (air conveyor guides, infeed starwheel). The time between solving the jam and restarting would take up to 45 minutes.

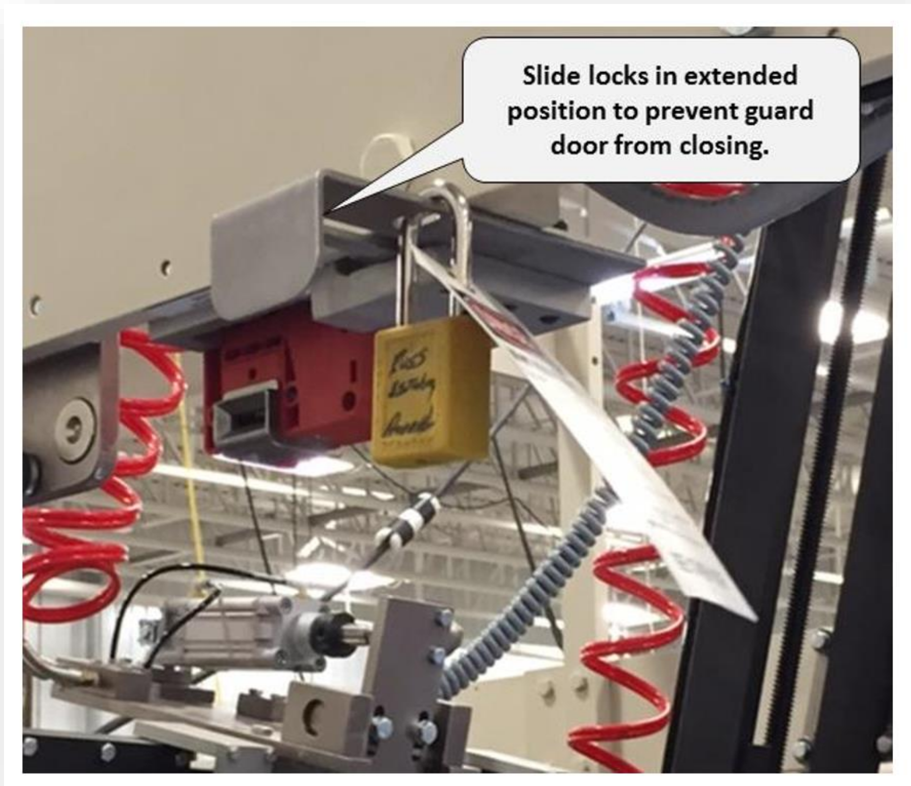
3. Trapped Key Gate Access

Trapped key systems are one example of Alternative Methods used in the packaging industry with considerable success. These systems remove the decision-making process from the employee. Workers cannot get to the machine without powering down the machine. These systems do add cost, but have proven very effective. One large end user in the food industry with multiple facilities throughout the US has had zero injuries with trapped key solutions. An international OEM finds trapped key an excellent solution which customers prefer. These Alternative Methods are not electronic, thus they can be used in the food industry and survive washdown environments. An example of a trapped key gate access is shown below:



4. Slide Locks to Prevent Restart

in one packaging industry application, slide locks are used as part of an Alternative Method. The interlocks as part of the control system prevent the unexpected restart of the machine. To prevent the access door from being closed behind the worker, slide locks are used to provide exclusive control to the employee.



Being able to open the access panel and hang a lock on the slide gate enables the approved tasks to be performed without having to follow full LOTO procedures.

5. Automated Robotic Case Packer

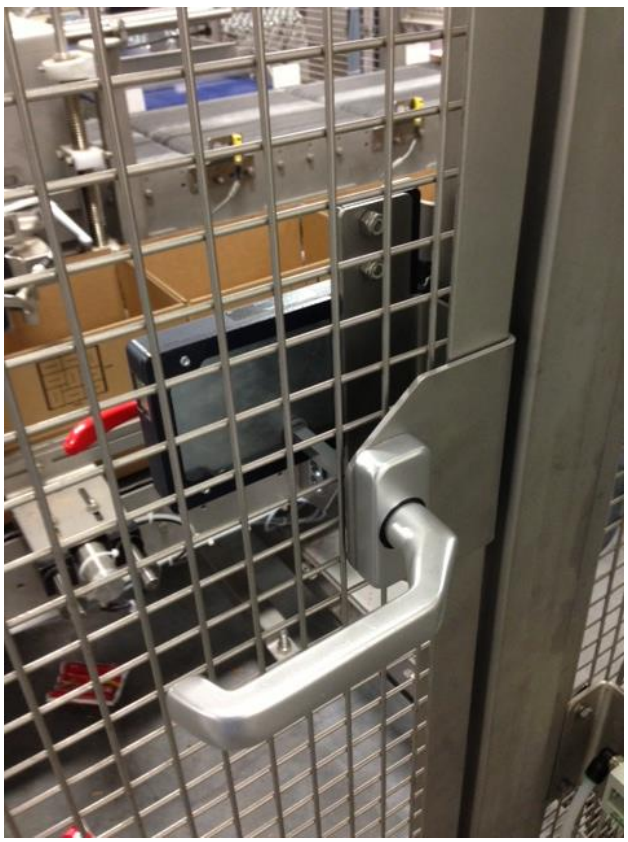
A highly automated robotic case packer requires access to the machinery after a box jam. Using a traditional EID and locking out the machine created problems in use. The end user company was concerned about the potential failure of the mechanical disconnect mechanism from repeated cycling that could result in one electrical phase remaining energized. In addition, abrupt on/off cycling of the disconnect could damage the electronics in the newer machinery.

The end user developed an Alternative Method using the Allen Bradley Dual Safe Off system. The system uses two independent and redundant safety circuits for each variable frequency drive. Either circuit will arrest the motor movement in the event of a fault. Both circuits are monitored to ensure they are working each time the system is started. The door mechanism provides a lockout point for employees to hang a lock enabling exclusive control during access and preserves the standard practice of locking a machine before entering.

The end user described the advantages of the new system as follows:

- **Enhanced Safety -** the statistical chances of the dual safety failing are considerably lower than a mechanical disconnect
- **Operational Speed** – Although speed should never be a consideration when it comes to safety, a positive outcome of using the more inherently safe Allen Bradley dual safe off system is speed to clearing jams and making minor adjustments
- **Longer Equipment Life** – If opening the main disconnect were required for clearing jams and minor adjustments, the excessive "on-off" that comes from completely de-energizing would shorten the life of all the electrical components

The end user described the system as being "vastly more reliable than a mechanical disconnect."



Annex B:

PMMI COMMENTS ON OSHA RFI ITEM II.C

OSHA's Request:
For discussion of equipment-related costs, OSHA is interested in all relevant factors including:

1. *The prevalence of current use of the equipment;*
2. *The purchase price;*
3. *Cost of installation and training;*
4. *Cost of equipment maintenance and operation and upgrades; and*
5. *Expected life of the equipment.*

The agency also invites comment on the time and level of expertise required if OSHA were to implement potential changes this RFI discusses, even if dollar-cost estimates are not available.

In response to this request, PMMI formed a Task Group of packaging and processing machinery builders and end users. The responses are collated below.

PMMI Answers:

OSHA Factor #1: The prevalence of current use of the equipment

- #1 (End User) Most automated machinery in our facilities are equipped with control reliable safety systems. In many instances fixed guarding is not practical because easy access to machine components is required for cleaning, changeovers, or clearing jams.

- #2 (OEM) Our experience is that users first began requesting enhanced safety circuits ca. 2011, with the advent of ISO 13849-1, -2. Multinational users were earliest to adopt. Our response was to offer these as options when the systems had functional requirements less than Cat 3. Our position on Safety Circuits:
    - Majority of systems are well-satisfied with a Cat 1 circuit, with a PLb or below.
    - There are certain options within our systems that have PLc or above, and those hazard areas, when they can be segregated, are zoned as Cat 3, while the balance of the machine is Cat 1.
    - If a user makes a Cat 3 requirement, the entire system is done as Cat 3, regardless how low the PL value.

- #3 (OEM) I'm not sure either, but I am going to approach the question/answer another way. If the current machine does not implement any safety systems, the use of the machine may be decreased because of the lack thereof.

- #4 (OEM) This kind of machines (Higher Speed Blow Molders) are installed in facilities where there is 24/7/365 production schedule with usually 4 hours of weekly downtime for weekly Preventive Maintenance.

- #5 (OEM) Answer: Palletizers have frequent problems with bad product and pallets that require the operators to enter the machine to clear or rearrange bad product or pallets. It is not uncommon for this to occur once an hour or more, but it is highly dependent on a customer's product quality and operating conditions.

- #6 (End User) Current prevalence is low. While End User #6 owns and operates many highly integrated PLC controlled machines, some with engineered safety systems in place, the vast majority are CAT-2 or less in safety architecture. One machine out of all of our equipment is Cat-3. We are currently in the process of upgrading high risk systems to Cat-3. End User #6 does accept less than Cat-3 for "Alternative Means of Protection" under the "Minor Servicing" exception when risk assessments of qualified task are completed and the leadership team agrees to an acceptable level of risk.

The purchase price

- #1 (End User) Control reliable safety systems do add cost. However, in the food industry, it is unlikely that rule changes that make alternative means more common will result in higher machine costs. Use of control reliable components (guard switches, logic devices, energy delivery components) are required for efficient operation of the machine in the first place. Making alternative means more common will increase productivity by reducing the time necessary to access guarded areas and return the machine to normal operation.

- #2 (OEM) We generally see a Cat 3 upcharge of about $3k, when the system is normally Cat 1. A Cat 1 machine is usually designed to optimize back panel space and enclosure volume. Taking this to Cat 3 increases these items, along with the additional design, components, and validation steps.

- #3 (OEM) I get this concern all of the time especially try to satisfy a pneumatic safety requirement. Even if the requirement is to Release all energy, or some other Safety function, a pneumatic safety solution will require additional valve content. Not necessarily 50%, and that does not mean all of the pneumatics on the machine will need to be "safe". The machine may require "Zones" or sections of safety, and the cost will increase in these sections of the machine.

- #4 (OEM) $1.2M

- #5 (OEM) All of our palletizers have CAT3 safety circuits as standard, so the only additional cost for a "Minor Servicing Option" is for the addition of a trapped key system and a CAT3 auto-air dump valve. The cost varies with the complexity of the palletizer, but the addition of a "Minor Servicing Option" is usually about 1.5% to 2% of the cost of the equipment to a customer.

- #6 (End User) We are currently purchasing a new machine which included a $20K adder for CAT-3 controls. Total purchase price for machine was $300K. 7% upgrade.

How would the installation costs change? How about training costs?

- #1 (End User) It is not likely that installation costs will change significantly. Control reliable devices are already a necessity for safe machine operation. There is a potential for a few more control reliable devices to be added if rules change, but I wouldn't expect the number of devices to change drastically.

  Training costs may increase. If alternative means were more common, there will likely be added periodic checks required for the safety system. This procedure will not be entirely straightforward for many machines. It will require independent guard openings, light curtain breaches, and presses of e-stop buttons to ensure that each component is functional. This checkout task cannot be entrusted to an untrained person

- #2 (OEM) This is the trickiest part of the issue.
  - Our cost to raise the level of knowledge for our design personnel has been significant, and the initial push was several hundred thousand dollars – but seen as an investment, and a separator for our company and its products. Our ongoing cost is probably $100k p.a., but spread across thousands of machines. The standard hasn't changed, but we have personnel changes, product changes, and shifts in user requirements.
  - We do not integrate our safety circuit with the user's safety circuit, and teach our field personnel to manage these situations with identification of our safety circuit interfaces and extendibility. Identify how to connect (interface) to our safety circuits for safety actions within our machines, and use our safety circuit as an input to the user's safety circuit. Provide sufficient "overhead" (extendibility) in our safety circuit to allow the user to elect the inputs and outputs that will not de-rate our machine's safety circuit qualification. We intentionally do not advise users how to use these inputs or outputs as that places us in the role of the integrator.
  - There are few users with sufficient training on the integration of machine safety circuits into a system safety circuits.

- #3 (OEM) I would expect the cost of installation to increase slightly, depending on the safety requirement (e.g. electrical, pneumatic, hydraulic), see above. Training costs may increase as well. However, if training is done as normal practice, it should not increase that much just because safety systems are now implemented. I guess this may change based on the complexity of the safety systems.

- #4 (OEM) $181,000 installation and commissioning cost. Training by certified OEM #4 instructor is $80K for a full week, for up to 10 people.

- #5 (OEM) The installation cost is included in the number above and our training charge to the customer for a new machine installation is the same as a standard machine without a "Minor Servicing" option.

- #6 (End User) None

Cost of equipment maintenance and operation and upgrades

- #1 (End User) Maintenance - More prevalent use of control reliable devices will add to maintenance costs. These devices will eventually fail (safely), are relatively expensive, and require qualified personnel to service.

  Operation - Safe execution of alternative means requires rigorous, competent periodic (daily) testing. This will add cost.

  Upgrades – two situations

  Upgrade from LOTO to Control Reliable
  It is unlikely that machine builders and end users will want to switch from LOTO to alternative means unless they believe that increased productivity will more than make up for the cost of installing, operating, and maintaining a control reliable system.

  Original Control Reliable to more modern Control Reliable
  If a machine was originally equipped with a control reliable safety system and needed to be upgraded, the cost will be greater than if the machine originally relied primarily on LOTO.

- #2 (OEM) Safety circuit components have a finite life, defined by their manufacturers, and published as part of their safety qualification. (MTTFd).

  Monitoring use of the safety circuit components (primarily guard doors and e-stops) would enable the user to determine when the component is approaching its safety-life (not a real term – my term for this writing).

  One event of each component replacement, or modification of the circuit, ISO 13849-2 (validation) must be applied. This is commonly overlooked, but definition of these types of steps would increase confidence that the safety measure was effective over the life of the product.

  Tracking of e-stop events is already something part of PackML. A further segregation to discrete safety actions would be an enhancement to that standard. We are seeing major users make the requirement for segregation of e-stop events from open guard events.

- #3 (OEM) In my opinion, maintenance, operation and upgrades cost can be higher, and the level of safety (e.g. CAT / PL) required, will have an effect. Troubleshooting as an aspect of operation could be very costly, this depends on the amount and quality/depth of training.

- #4 (OEM) This varies depending on our customers organization and maintenance culture, but we could say an average $160k a year (minor PM, overhauls, retrofits, tech support and new product types additions included).

- #5 (OEM) We do not have that much insight into this cost to the customer, but feel that it is not a significant cost because our machines have CAT3 safety circuits as standard.

- #6 (End User) Upgrades should be categorized differently than regular maintenance and operation.

  Operation and maintenance:
    - Operators need to be trained on what CAT-3 controls actually do for them and what they don't. They don't automatically make a machine safe.
    - Maintenance personnel will need to be trained on how to maintain and troubleshoot CAT-3 controls and how to use specialized software like the AB Guardmaster products within RSLogix.

  Upgrades:

    - Upgrades to existing equipment to CAT-3 could result in significant cost impact. Engineering cost to specify and design the controls upgrade, significant hardware acquisition cost, specialized technical resources for installation, startup, and troubleshooting.

Expected life of the equipment

- #1 (End User) I would not expect additional control reliable components to reduce the life of the equipment.

- #2 (OEM) We generally state our expected life as ten years. Our safety circuit designs typically exceed that life expectancy, based on our frequency of use assumptions. The user needs to evaluate our assumptions against their expectations of use, and react accordingly.

- #3 (OEM) I agree with Bruce, the same components are used (Pneumatic solution), so the life expectancy should not be affected. Achievable mission time may require replacement prior to 20 years, but normal life expectancy should not change.

- #4 (OEM) If maintained and retrofitted properly, these machines could run up to 18 – 20 years efficiently.

- #5 (OEM) This is not a question we can answer, but we don't anticipate an unusually short life of the components used.

- #6 (End User) Possible avoidance of obsolesce in the future if OSHA requirements increase.

Additional Observations

During the review of the PMMI RFI Response, the following additional observations were made by members of the task group:

- Failure mode – with a safety circuit, for anything Cat 3 or above, a failure will not lead to the loss of the safety function. With an electrical disconnect, the failure mode may be the fusing of the electrical contacts in the energized position. When this occurs with the handle in the locked position, it presents the machine as safe, while it remains energized.

- Reliability – Safety circuits are more reliable. With safety circuits, all of the safety-critical parts in the circuit are required to have "life ratings", shown as MTTFd (Mean Time to Dangerous Failure). This value is the result of testing of the components to determine the average life of the components in "cycles of use". MTTFd is the number of cycles for in the testing when the first 10% of the parts fail. For perspective –
    - A disconnect switch has a published, typical average life of 30,000 cycles.
    - An interlock switch has a typical MTTFd of 1,000,000 cycles.

- Scope of control within a machine – A disconnect switch is usually applied for electrical energy control for a single machine, and a separate action is needed for LOTO of other energy forms (e.g., pneumatics). With a safety circuit, the safety action is usually designed to control the energy for the hazard zone where intervention is needed, and addresses all forms of hazardous energy simultaneously.

- Scope of control outside a single machine - Safety between individual machines is better managed with safety circuits, as the areas between machines can be addressed by designing the two safety circuits to work together.

- Qualification – Safety Circuits, as defined in ISO 13849-1, require both design to established criteria, and qualification. The qualification can be done with industry-standard software, using established benchmarking methods.

- Proofing – Safety Circuits, as defined in ISO 13849-2, require validation of the design prior to first use, on the modification of the circuit, or on the replacement of any component.
- Test and Check – Most users of safety circuits additionally apply verification of function of the safety circuit before machine use. That is, they test the safety circuits before operating the machine, sometimes as frequently as at the start of each shift.
- Monitoring - Safety circuits that are Category 3 or above, automatically check for faults between channels.

The Table below from ISO 13849-1 is how we explain the different categories to those new to the topic.

Cat.	Architecture	Failure Mode	Principles (Performance Levels Possible)	Component Life (MTTFd[1])	Diagnostic Coverage	CCF
B	Uses components and design practices that follow standards in place. Basic safety principles apply.	Failure of the safety circuit can lead to a loss of the safety function	Mostly component selection (a,b)	Low to medium	None	Not a factor
1	In addition to "B", the application of well-tried components, and well-tried principles.	Failure of the safety circuit can lead to a loss of the safety function, but probability is low.	Mostly component selection (b,c)	High	None	Not a factor
2	In addition to "1", a means to periodically check the safety function is part of the control system.	A fault can lead to a loss of safety function, but the loss is detected between checks	Mostly by structure of the circuit (a,b,c)	Low to high	Low to medium	Requires a score of ≥65 of 100 on segregation, diversity, knowledge and experience of the designers, immunity from environmental factors e.g., shock, vibration, elec-tromagnetic fields)
3	In addition to "1", a single fault does not cause the loss of the safety function (redundancy), and, whenever practicable, the occurrence of the single fault is detected	A single fault can occur, but the safety function performs. Some faults are detected. A combination of individual faults can lead to loss of the safety function	Mostly by structure of the circuit (a-d, b-e)	Low to high	Low to medium	
4	In addition to "1", a single fault in any of the parts does not lead to loss of the safety function, and is detected on or before the next use of the safety function. If that detection is not possible, combined faults do not lead to a loss of the safety function.	The safety function is always performed, even with a single fault. Detection reduces probability of safety function loss. Faults are detected in time to prevent loss of the safety function.	Both component selection and structure of the circuit (a-e)	High	High	