System Isolation Equipment vs. traditional manual supply disconnect isolating switches

White paper

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The Problem:

Traditional Manual Disconnect Devices not durable for frequent access needs

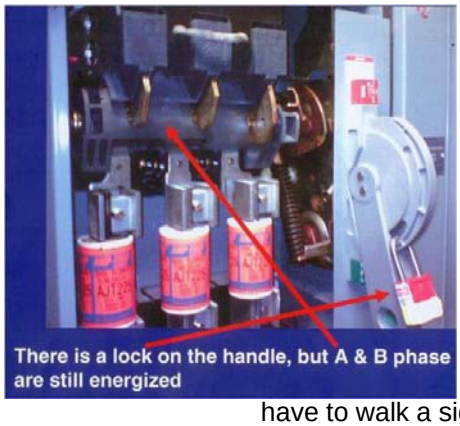
Typical existing equipment used to isolate motive power from industrial machines and processes are not designed to handle the frequency of access required for modern machinery. Historically, a manual disconnect device has been used to remove the hazards related to motive energy sources.

Manual operated isolation disconnect switches are typically designed for 8,000 operations. “Frequent Use” AC23a rating is available at lower amperages at 20,000 Operations. Read the fine print in the manuals, one operation is one throw of the switch.

A LOTO procedure cycle requires 2 operations, throw the switch OFF and then back ON. Over 20 year mission life modern Safety Systems are designed for, that means only 1.3 operations per day on average before the manufacturer states the switch will fail. Regardless if it fails safe or unsafe replacing the switch is an inherently dangerous job often needed once every 2-3 years for frequent use applications. Larger disconnects over 600 amps are rated only 2000 operations or less.

Newly realized arc flash hazards to the disconnect operator are also a concern. The 0perator is required to stand in front of the switch to operate it. Qualified Electricians are trained not to stand in front of the switch when actuating but machine operators are not. The problem is compounded in that most disconnects have the handle on the right and most operators are right handed, so uninformed operators tend to stand right in front of the switch to operate.

It is necessary when performing a lockout procedure to verify a zero energy state before performing a task. Pressing the start button after turning a disconnect switch off does not confirm power is guaranteed to stay off when a person applies a lock to a disconnect switch. Other devices may be temporarily preventing motion. For tasks requiring unexpected startup prevention a window can be installed in the disconnect housing to verify the disconnect blades are disconnected. This manual verification process has proven to be ineffective as studies have shown disconnects can fail unsafe and the operator becomes complacent in that they observe one blade out and do not notice the others. Below is an example of a failed switch.



For tasks that require servicing the hazardous energy directly it is required to verify zero energy by suiting up in proper PPE, measuring voltage present to verify the meter works and then turn off the switch and verify zero voltage. This puts the person in direct hazard of a short circuit arc flash which can be caused by the act of using the test meter if not properly performed. If a person leaves one probe on a test point and draws the second probe from the source to move to the third point, an arc can be created and drawn across the phases.

Due to frequent access needed on modern machinery processes local disconnects are required to promote proper usage by operators. If they have to walk a significant distance to the lockout they will tend to cheat the proper procedures. Operators are not allowed to enter control rooms where only qualified electricians are allowed.

The need for local disconnects is complicated by the fact that usually multiple lockout points are needed. This requires more wire and conduit to be installed which can cost a significant amount of money, sometimes more than the disconnect switches themselves. But when series connected what if a coworker locked out an upstream device at the same time? The disconnect you just seemed to verify could have failed and when the upstream disconnect is re-energized the circuit you are working on will be re-energized.

Disconnect switches mounted local to the machine require a 36 to 42 inch free space in front of the switch. Most machines do not have room to mount multiple larger disconnects. This means the switch may be located in an inconvenient place for the operator which promotes misuse.

After a power failure, the disconnect remains ON so the potential of re- applying energy causing an unexpected start-up or Shock hazard exists.

Energy from all hazardous sources must have a disconnect device. This includes but is not limited to Electrical, Pneumatic and Hydraulic sources. This issue is compounded if multiple access points are needed. Large machines for paper industry, semiconductor industry and automotive industry require complex LOTO procedures prone to human failure to isolate a device.

Putting a disconnect local to the access point in a wash down food grade environment requires the operator to be in proximity of high voltage while performing wash down tasks. Operators typically are wet and standing in water when interacting with the equipment.

There are known incidents where an operator accessed the machine using safeguard control systems and when another operator or maintenance person decided to use a Isolation Device the act of isolating the energy caused motion and the person in the machine was injured. Some companies would prefer surpassing the standards requirements by using an Isolation Device for ALL access tasks. However this is not feasible due to manual isolation devices low cycle ratings.

The Solution:

ANSI/UL 6420 Equipment used for System Isolation rated as a unit

The Pilz SLS Safety Lockout System is the 1st Safety Isolation Control System to be certified as an Isolation System to the new ANSI/UL6420 standard for “Equipment used for system isolation and rated as a unit”. Pilz was involved in the invention of this type of system back in 1996 and has been working on standards committees to gain acceptance and approval ever since.

The SLS system uses redundant contactors mounted remote from the machine by the power equipment supplying the machine, usually an MCC or other power distribution system. Power contactors have typical mechanical life ratings of 1,000,000 to10,000,000 cycles.

Contactors can be controlled remotely by using Remote Lockout Stations (RLS). Multiple switches can be placed anywhere on the machine. They operate on 24VDC low current and are small, so they do not require a 36-42 inch space in front of the panel.

Contactors remain OFF once the main power is lost until the system is reset and re-started. Contactors can be designed to provide equal or better isolation protection than what is provided by a disconnect switch.

The SLS system prevents external voltage causing an unsafe condition with the use of a Safety PLC for control which uses test pulses to monitor not only shorting to external power but also internal short circuits in the dual channel architecture. The system is designed to category 4/ PLe according to ISO13849.

The system uses tamper seals to limit intentional intervention access to Pilz trained and certified SLS service technicians. Customers can be certified to make their own repairs.

The SLS system can control other sources of hazardous energy such as Pneumatic and Hydraulic, providing a single lockout point for all energy sources.

Zero Energy state is verified using redundant safety devices monitored by a Safety PLC. Contactor position feedback is employed to verify both contactors switch properly. If one contactor fails to isolate, the other provides the necessary isolation function and neither can turn back ON until the problem is fixed. The dual contactor system is short circuit tested at a high power test lab for the rated short circuit fault current to ensure both contactors do not weld on the same phase.

In addition, the SLS system uses the Pilz PU3Z Category 4/PLe voltage monitor which monitors via dual sense wires phase to phase, and phase to neutral/ground. Other systems on the market use a 3rd grounding contactor which is a single point of failure. On these systems it is a requirement per the manufacturer's manual, to manually check ground once a month to maintain a Category 4/PLe rating. This requires scheduling downtime to use a Mega Ohm meter to check the ground is still bonded properly. The Pilz PU3Z Voltage Monitor performs the check automatically every cycle.

For Fluid Power Isolation Category 4/PLe safety dump valves are employed and use dual diverse pressure switches to verify zero pressure. These systems are designed to meet stringent requirements for Hydraulic and Pneumatic punch presses.

A light is used to verify when all energy is controlled by the system has been rendered safe; no light, no entry. The light uses test pulses to ensure stray voltage is not illuminating the light. Contactors are shut OFF until the fault is cleared and the system restarted. If the light fails while someone is inside the machine the system remains isolated and safe. In addition, the system can interface with any machine Safety Related Control System to monitor dual "System Isolated" contacts and prevent access to the hazard using locking guard access systems. A redundant Emergency Stop/Coast stop interface is also included. An optional Zero Speed interface allows preventing isolating the machine energy until the Safety Related Control System indicates a zero speed state.

Remote operation removes the operator from Arc Flash hazards when operating the switch.

The cost of installing 6 conductor 16ga tray rated cable to multiple Remote Isolation Switches is much less than copper power wires and conduit.

Dual Contactor system is NOT an isolation device unless proven through 3rd party Lab testing as a unit:
Normal contactor testing per IEC60947-4-1 for Short Circuit Current Rating (SSCR) type 2

coordination with the fault current protection device (fuse, circuit breaker) allows the contactor to tack weld closed if it can be broke free easily. Samples of each Pilz SLS design and any options offered have been subjected for lab testing as a unit.

Common Cause Failure- In a dual contactor arrangement both contactors will weld on same phase when subjected to a fault current. This is OK for inhibiting motion in a typical guard door interlock because the motor will single phase and will not cause motion. But this is not OK for energy isolation. To meet ISO13849 dual channel requirements for the Safety Function- Safe Energy Isolation, the system would have to be tested for this common cause failure to qualify for safe energy isolation using a contactor. ANSI/ UL6420 requires the same SCCR test as IEC60947-4-1, but contactors cannot weld.

After SCCR testing and again after make/break testing components are tested and UL witnessed for 600v Dielectric tested across each contact and 1000v all contacts to ground plus min 8kV Impulse voltage tests are performed to ensure isolation and simulate lightening strike.

Other common cause failures must be addressed and tested for such as EMC radiation and immunity to outside EMC sources. Below is a table regarding EMC lab tests.

EMC	Environment B Industrial
Immunity:	ANSI/UL6420 9.4.2.4 / IEC 61000-4-2
Electrostatic Discharge	ANSI/UL6420 9.4.2.5 / IEC 61000-4-3
Electromagnetic Field	ANSI/UL6420 9.4.2.6 / IEC 61000-4-4
Fast Transient Burst	ANSI/UL6420 9.4.2.7 / IEC 61000-4-5
Surges	
Emission:	ANSI/UL6420 9.4.3.2 / CISPR 11
Conducted Radio-Frequency	ANSI/UL6420 9.4.3.3 / CISPR 11
Radiated Radio-Frequency	

Normal contactor endurance testing per IEC60947-4-1 requires 6X rated current. For ANSI/UL6420 compliance contactors are tested for AC23a rating like a manual disconnect which requires 10X rated current and almost twice the cycle count. This usually means over-sizing the contactors to accomplish.

ANSI/UL6420 requires the Contactor “System” must be lab tested and rated AC23a as a unit, the same rating as a manual disconnect.

Applications include Automotive Assembly lines, Semiconductor Industry, Paper and Paper converting industry, Wash down Food Grade industry, Steel Industry, Printing Industry and Packaging Industry.

What do the Standards say for usage of System Isolation Equipment:

OSHA requires the use of a disconnecting means to render a machine or process safe when servicing or operating the equipment. The exception is if the task is Routine, Repetitive and Integral to production, in which case, a risk assessment is done to document why a traditional disconnect will not work well or why System Isolation Equipment is a safer alternative.

In the 1998 OSHA had originally accepted the concept of System Isolation Equipment, utilizing Pilz Voltage Monitor technology developed specifically for the application, as a Isolation Device but rescinded the opinion citing complexity of the system design and installation and that there was no product standard for such equipment.

Since then The National Electrical Code (NFPA70: 2005) included a definition of such systems and allows their usage if listed to a standard. ANSI/ASSE Z244.1-2003 Control of Hazardous Energy, Lockout Tagout and Alternative Methods attempted to provide some requirements for such systems. However, it did not provide enough information to design, install and operate a system properly.

ANSI/ASSE Z244.1 is currently being rewritten in regards to System Isolation Equipment to align with the NFP79, NEC and ANSI/UL6420 wording and is expected to be released in 2016. Additional guidance for justification and usage is provided.

In the 90's Battelle Integrated Risk Management Company of Columbus Ohio conducted a study for a major international manufacturing company which compared traditional disconnecting means with other alternative Isolation methods including the predecessor to the Pilz SLS system which used the Pilz PU3Z safe voltage monitor. The study found that of all the technologies analyzed the manual disconnects where least safe and the PU3Z system using dual contactors was the safest, especially when multiple lockout points require complicated procedures prone to mistake when implementing the procedure. It was this study that was the basis for development of the ANSI/UL6420 standard.

ANSI/UL6420 System Isolation Equipment rated as a unit was released in 2012. This is the 1st Product Standard worldwide addressing using a contactor "System" as an Isolation Device. The current standard is for electrical isolation. ANSI/UL6420 was written in the IEC standards format in hopes IEC will adopt some form of it for use internationally. As such it meets the requirements of IEC60204 clause 5.3.2(d).

The current ANSI/UL6420 standard does not include Fluid Power. The focus was to get the electrical portion released and add fluid power later. Fluid power isolation requirements will either be added to the standard or another standard will be created. There are safe methods of controlling Hydraulic and Pneumatic energy using control systems based on Punch Press standards EN692, EN693 and ISO13849. Pilz provides a plug in Ross or Festo pneumatic panel with Inlet PS and dual Zero Pressure Verification Pressure Switches factory pressure tested and calibrated. OSHA allows only for Operator tasks and minor servicing exceptions for the prevention of Unexpected Startup. Tasks requiring fluid power Isolation require manual lockout.

In March 2014 OSHA accepted the ANSI/UL6420 standard as an appropriate standard product can be certified and listed to by a qualifying National Recognized Testing Laboratory. (Reference OSHA 1910.7) This means equipment certified to the ANSI/UL6420 standard is acceptable for the purpose of Energy Isolation

OSHA 29 CFR, Subpart S, Electrical
1910.399, Definitions applicable to this subpart
Acceptable. An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this Subpart S:
(1) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory recognized pursuant to § 1910.7; or
(2) ...
Accepted. An installation is "accepted" if it has been inspected and found by a nationally recognized testing laboratory to conform to specified plans or to procedures of applicable codes.

Because ANSI/UL 6420 was written to include IEC testing IEC 60204 already accepts its use. At this moment Only Pilz SLS qualifies!

5.3.2 Type—The supply disconnecting device shall be one of the following types:

a) switch-disconnector, with or without fuses, in accordance with IEC 60947-3, utilization category AC-23B or DC-23B;

b) disconnector, with or without fuses, in accordance with IEC 60947-3, that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector;

c) a circuit-breaker suitable for isolation in accordance with IEC 60947-2;

d) any other switching device in accordance with an IEC product standard for that device and which meets the isolation requirements of IEC 60947-1 as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads;

e) a plug/socket combination for a flexible cable supply.

ANSI/ASSE Z244.1-2016 Draft New Updated Version Coming Soon. At this moment Only Pilz SLS qualifies!

(Note- This standard has not yet been released. However it is in the final version and expected to pass fall 2016)

3.12 Energy Isolating Device. A means of preventing the transmission or release of energy.

Note 4: System isolation equipment that incorporates control lockout stations and is listed for disconnection purposes where located on the load side of the main supply circuit disconnecting means and over-current protection can be energy isolating devices.— See NFPA 79.

8.4.4 Other Means of Hazardous Energy Isolation
Remotely activated electromechanical lockout systems are an acceptable alternative to be used in selected applications such as long machines and inaccessible or inconvenient locations of primary isolation devices. The user shall install and operate such systems (e.g., remote low voltage lockout system, pneumatics systems) in accordance with the manufacturer's directions. (See Annex B for further details. See NFPA 79 for additional information.)

5.4.1 Location.
Energy isolating devices shall be accessible and, where practicable, be conveniently located to facilitate the application of isolating devices during necessary tasks. Energy isolating device should be located outside hazardous areas and at a convenient height from an adjacent walking area (i.e. not overhead or under machinery).

If unable to position or install isolating device(s) at a convenient location, measures shall be taken to provide proper access to the devices.

Note: As an example, a remote lockout or a system isolation equipment rated as a unit and listed for the purpose of isolating energy may be implemented as one such measure. See Annex B.

ANSI/ASSE Z244.1-2016 Draft Annex B describes basic system and provides justification for use

Justification to use a remote lockout system instead of a manual disconnect for service disconnect isolation purposes includes:

- When frequency of the task exceeds the capability of a manual disconnect. Changing the disconnect frequently due to failures is an inherently dangerous task.
- When environment is not acceptable to place a manual disconnect.
- Large complicated machinery involving many lockout devices making the lockout procedure too cumbersome
- Reduces multiple lockout points to a single lock point directly at the access point.
- To prevent machine operators from standing in front of large disconnect switches in case of short circuit fault
- Large disconnects can be physically hard to operate for some operators
- Required space is not available (service access, electrical hazards, adequate ventilation, etc.) *Note: Types of electrical lockout systems available include, but are not limited to remote low voltage system, and listed system isolation equipment.*

ANSI/ASSE Z244.1 Annex R: Steel Forming Industry

Annex R reveals a need for System Isolation Equipment in Steel industry

ANSI/ASSE Z244.1 Annex S Semiconductor Industry

Annex S is quite lengthy and describes a need for control systems in semiconductor industry instead of traditional LOTO due to system complexity. System Isolation Equipment Listed for disconnect purposes provides equal protection to a manual LOTO device.

Conclusion:

The Pilz SLS System Isolation Equipment can be used for all production operation tasks. In addition it can be used for minor servicing tasks that are Routine, Repetitive and Integral to Production including single point lockout of all types of energy. The Pilz SLS can also be used for tasks that require Electrical Isolation including maintenance.

Paths for using an SLS in the US:

- Path 1- All Production Tasks- OSHA already allows unlisted System Isolation Equipment for prevention of unexpected startup. Customers who want to go beyond standards requirements and provide Energy Isolation for all tasks choose the SLS over a disconnect because a disconnect will not last.
- Path 2- Minor Servicing Tasks- OSHA Minor servicing exception if Routine, Repetitive and Integral to production and provides Effective protection vs using an isolation device.
    - OSHA has historically been stingy in allowing Subpart O (Safeguard control systems) for alternative protective Measures. Users must document risk assessment showing why using manual disconnect device is impractical. Ref OSHA LOTO Interpretations document CPL_02-00-147 on OSHA's Website. If the machine is not moving it is not in production.
    - The Pilz SLS, being the only ANSI/UL6420 Certified SIE on the Market, is a Game Changer- per NEC, NFPA79, ANSI/ASSE Z244.1-2016 Draft and IEC60204 - and can be used for all tasks including grade changes and electrical servicing downstream of the SLS system as it provides effective and equivalent protection to a manual disconnect device.
- Path 3- When lockout of energy sources are required but a risk assessment proves a manual disconnect is a less safe approach such as large complicated machinery or frequent access is needed.