Equipment Lockout/Tagout (LOTO) Capability Improvement
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Abstract: This report from the ESHF004 project summarizes the results of a team effort by member companies, equipment manufacturers and consultants to identify lockout/tagout (LOTO) performance improvement opportunities for the industry. It includes a summary of best-known LOTO practices, a hybrid LOTO procedure template, an example LOTO program document, and recommendations for future study focus.

The report is intended as only one reference for lockout/tagout practices in the semiconductor manufacturing industry. It is intended as general information and not as a set of standards or requirements. Specific regulations and code compliance requirements may not be addressed. IT IS NOT INTERNATIONAL SEMATECH’S INTENT TO IMPART SPECIFIC LEGAL OR ESH ADVICE. STATUTORY AND REGULATORY REQUIREMENTS SUPERSEDE ANY SUGGESTIONS PROVIDED HEREIN AND EACH COMPANY MUST RELY ON THE ADVICE OF ITS OWN ESH PERSONNEL AND ATTORNEYS FOR ENSURING COMPLIANCE WITH THE LAW.

Keywords: Worker Protection, Procedures, Equipment Safety, Safety Standards

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Acknowledgments

The author wishes to thank all of the ISMT member company representatives, ISMT staff, equipment manufacturer representatives, and third parties who participated in this effort. Special thanks to the following:

Pete Dahlgren, ISMT Project Manager, IBM Assignee
Franck Coger, ISMT Project Manager, ST Microelectronics Assignee
Walter Worth, ISMT Project Manager
Bill Petry, IBM
Craig Ottesen, Texas Instruments
John Karner, AMD
Deb Crider, Motorola
Diana Hohmann, Motorola
Mike Sherman, FSI
Robert Morgan, Applied Materials
Leslie Stepanek, Applied Materials
James Wright, GS3
1 EXECUTIVE SUMMARY

The safe performance of maintenance tasks is an essential responsibility of all semiconductor manufacturing facilities. This covers all maintenance work, including maintenance of manufacturing and support equipment. For many maintenance tasks, it is necessary and prudent to remove sources of energy from equipment and lock or secure the equipment to prevent the unexpected release of hazardous energy during the maintenance activity. This technique, often referred to as “lockout,” is usually done in conjunction with a tagging process that displays essential information surrounding the lockout process. In many countries, this lockout/tagout (LOTO) activity is regulated by the government, which prescribes many of the basic expectations for safe job performance.

This report is intended to document the results of a team effort by member companies, equipment manufacturers, and consultants to identify LOTO performance improvement opportunities for the industry. The key elements contained in this report are as follows:

1. A summary of best known methods (BKMs) and practices for LOTO with both existing, installed-base equipment as well as new equipment design and installation practices.
3. An example LOTO program document for member companies to use as a baseline for new programs or comparison to existing programs.
4. A defined set of issues, concerns, and recommendations for future focus and improvement of LOTO practices in the industry.

2 INTRODUCTION

With the goal of improving safety in the semiconductor industry, a review of equipment LOTO practices for the semiconductor industry was conducted. One of the primary objectives of this study was to provide facility-level and equipment-specific recommendations for improving LOTO. This report summarizes best-known methods (BKMs) and provides guidelines for use by International SEMATECH (ISMT) member companies. Although the focus of LOTO is often on electrical energy isolation, other forms of hazardous energies are reviewed, including dissipation verification of stored (not related to electrical) energy. The basis for this activity centered on major regulations and government standards, BKMs used by the member companies and applicable Semiconductor Equipment and Materials International (SEMI) guidelines such as SEMI S2-0303, *Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment*, and SEMI S20-0303, *Safety Guideline for Identification and Documentation of Energy Isolation Devices for Hazardous Energy Control*.

This study comprised several tasks:

- Collect from member companies and several key equipment suppliers existing methods for localized energy isolation and to publish this information in a usable format.
- Refine some of these methods for use in the industry and, on a very limited basis, develop some new methods in conjunction with participating equipment manufacturers. Member companies were also encouraged to share their procedures and program.
descriptions as a benchmarking and industry improvement effort to arrive at best known methods (BKM) for the industry.

- Develop a set of recommendations for future development of additional hardware, equipment isolation points, and use of interlocks.

It is hoped that this effort will continue to drive the industry toward universally accepted solutions through the shared review and development of sound equipment environment, safety, and health (ESH) programs and practices. Further, it should facilitate equipment ESH performance consistent with member company expectations and International Technology Roadmap for Semiconductors (ITRS) goals.

ISMT believes that many current LOTO practices involving remote isolation of energy sources are sometimes infeasible or may impact productivity because of increased downtime of equipment. ISMT’s member companies would like to improve LOTO practices by achieving more localized point of use (POU)/point of maintenance energy isolation consistent with regulatory requirements and acceptable to local authorities having jurisdiction. This expectation will likely require developing more methods and hardware for downstream energy paths at the tool subsystem level within the wafer fab rather than at the remotely located main energy source (typically in the sub-fab).

3 DETAILED PROJECT APPROACH

To focus efforts, a defined scope and a set of objectives were established. Individual tasks in this study are listed below:

1. Collect and assemble from member companies and participating suppliers background information, concerns, needs, BKMs, program documents, written procedures, and photographic examples related to LOTO in the semiconductor industry.
2. Schedule and coordinate a series of teleconferences and face-to-face meetings with the ISMT project manager, member company core project team, and other key individuals during all phases of the project. Review data and explore methods for improving LOTO practices.
3. Define a “short list” of priority equipment with the greatest need for improvement, based on inputs from ISMT member companies.
4. Contact and discuss with several key suppliers opportunities for improvement with priority equipment.
5. Compile a model LOTO program document, sample LOTO procedure templates, and existing BKMs for the short list of tools identified.
6. Identify those areas where further information is needed to develop BKMs and recommendations for future focus with the equipment manufacturing community.

4 DATA AND INFORMATION COLLECTION

Background information, concerns, needs, BKMs, program documents, written procedures, graphics, and photographic examples related to LOTO in the semiconductor industry were collected. Participants engaged in discussions by teleconferences and provided their respective documentation in the form of example procedures, internal studies and analyses, lessons learned, product examples, etc.
Discussions centered on common and prevalent concerns and resulted in a focus of priorities on manufacturing equipment categories of greatest interest to the group. Efforts were then devoted to sharing and reviewing the data, and exploring methods for improving LOTO practices in the semiconductor industry.

5 EQUIPMENT PRIORITY LIST

One objective of this project was to define a short list of priority equipment with the greatest need for improvement based on inputs from ISMT member companies using the following criteria:

1. Risk and multiplicity of hazards and sources of energy
2. Member companies’ needs
3. Challenges, difficulties, and complexity of isolating energy
4. Availability of equipment manufacturers to assist with this project

Group discussions relying on these criteria resulted in the selection of the following equipment for this study:

1. Cluster tools with hazardous production materials (HPM) and radio frequency (RF) generation
2. Wet etch tools with feed from bulk distribution
3. Implanters
4. Epitaxial reactors

All ISMT member companies use these tools and have been faced with tool-related challenges. Each of these tools possesses multiple types of energy and, in some cases, multiple feeds of the same types of energies.

6 IDENTIFIED CONCERNS AND OPPORTUNITIES FOR IMPROVEMENT

Common challenges related to LOTO in the semiconductor industry and specifically to the equipment on the priority list were identified. Issues compiled from a series of teleconferences and correspondence are summarized below:

1. Mixed acceptance of locks/different types of locks used by ISMT’s member companies
2. Mixed acceptance of gang lock practices
3. Lockable energy isolation devices (EIDs) vs. “clamshells” or other similar devices
4. Physical location of isolation points, time constraints, ease of access, travel distances, etc.
5. Availability of lockable breakers and valves for equipment construction and installations
6. Energy verification methods
7. Integration of LOTO with subsystems purchased separately from process equipment
8. Comprehension of LOTO during equipment installation, including but not limited to energy exposures by equipment manufacturer’s personnel
9. The use of lockable emergency off (EMO) controls
10. Small breakers and plastic valves unable to support weight of locks and locking mechanisms
11. Partial vs. total shutdown of equipment (multiple energy feeds vs. single feed)
12. Steps in LOTO procedures and complexity of procedures
13. Equipment specific procedures vs. generic procedures
14. Manual vs. auto-purge requirements as a result of energy isolation
15. Impact of footprint on the placement of support equipment
16. Global acceptance of LOTO devices
17. Implementation of standardized labeling and signage

This report addresses several of these issues and identifies the need for further review and study by ISMT, its member companies, and equipment manufacturers and suppliers to the semiconductor industry.

7 MODEL LOCKOUT/TAGOUT PROGRAM

7.1 Challenges and Solutions

This assembly of BKMs extends beyond hardware solutions. Standard LOTO practices normally include documenting all related activities, procedures, responsibilities, training requirements, etc. ISMT member companies typically use control documents or specifications to define LOTO performance requirements and activities within the individual company’s operations. Often these consist of a company standardized “program” document that is modified from location to location based upon variables such as regulatory requirements, nature of the operation, and implementation.

No single program document is acceptable for all member companies. While practices vary worldwide, a program document template was drafted for member companies to adapt and use or to evaluate existing site-level programs. This document follows the convention and general expectations of the U.S. Occupational Safety and Health Administration (OSHA). A copy of this template is in Appendix A.

8 LOTO PROCEDURES

8.1 Challenges and Solutions

Steps required to follow LOTO procedures and complexity of procedures and the need for equipment-specific procedures vs. generic procedures.

LOTO procedures are typically prepared in one of three general formats:

1. The first is simply a generic set of instructions that include general steps for the isolation and securing (LOTO) of hazardous energy.
2. A more developed LOTO procedure is a standalone document that defines the actual hazardous energy sources relevant to a machine or installation and gives specific steps for how and where to isolate/secure energy and other specific measures to ensure work is performed safely.
3. The third approach is an integrated procedure. This involves a set of steps similar to the standalone procedure except that the steps are integrated into maintenance/service procedures and become an integral part of maintenance instructions.

Advantages and disadvantages of the three formats:

1. Generic procedures offer the simplest approach and require little effort to prepare. These procedures may be sufficient in some regulatory environments and with some simple equipment where energy sources are limited. They require maintenance personnel to be familiar with the equipment and installations. This type of procedure is sometimes used when a LOTO procedure from the manufacturer does not accompany the equipment.

2. Detailed standalone procedures offer a higher level of detail than generic procedures. Properly prepared, these procedures may define the exact type(s) of hazardous energy, their impact, how and where to isolate, how to secure (LOTO), types of devices to use, and other measures to take for a specific machine and/or installation. These procedures are less subjective than generic procedures, leave less to the judgment of field personnel, and not require maintenance workers to have as much specific knowledge. Much of the judgment required to work safely is made by knowledgeable personnel in advance of the work and is documented in the procedure. On the other hand, this type of procedure is often labor-intensive for smaller safety and technical staffs. The challenge is multiplied by the number of actual procedures required. Another disadvantage is that maintenance workers may need to work from a maintenance procedure and a separate LOTO procedure simultaneously. This can be cumbersome and complicated if the documents do not complement each other.

3. The third type of procedure, the “integrated” approach, blends the LOTO steps into the maintenance document(s). This may best be done by the equipment manufacturer when preparing a maintenance manual, but relies on the author being knowledgeable about both maintenance and LOTO requirements/methods. Best results are achieved when teams of knowledgeable personnel work together to develop a blended or integrated procedure. One limitation involves the installation configuration and modifications/options with the equipment. An equipment manufacturer designing an integrated procedure cannot always comprehend these variables at the time of delivery and subsequent changes and re-installations over the life of the product.

All three of these approaches have merit depending upon the resources available to prepare procedures, the regulatory environment, and the existence of procedures from the original manufacturer, installation and maintenance practices, complexity of the machine(s) in question, etc.

The ideal practice involves the original equipment manufacturer (OEM) comprehending the need for LOTO, designing LOTO features into the equipment, and preparing clear and precise LOTO procedures before the equipment is purchased. Such ideal procedures would also include some flexibility for adaptation based upon the end-use environment and would require the end-user to be knowledgeable, capable, and resourced to customize the procedures for this particular installation.

In some instances, the equipment end-user (such as an ISMT member company) may choose to develop any one of the three types of procedures with limited assistance or information from the OEM. Again, a team approach involving knowledgeable personnel produces the best results.
A flow chart for OEM’s to follow during the design process is recommended in SEMI S20-0303, *Safety Guideline For Identification And Documentation Of Energy Isolation Devices For Hazardous Energy Control*. The basic steps are as follows:

1. Equipment designer determines each source of energy
2. Equipment designer selects proper energy isolation devices
3. Equipment designer specifies which devices are necessary for energy control for each task
4. Equipment designer and technical editors create lockout procedures for each task
5. Equipment designer and technical editors create graphical representations for each task from equipment drawings or photographs
6. Equipment designer specifies labels for energy isolation devices

### 8.2 LOTO Procedure Template

A model LOTO procedure template has also been prepared that member companies can use for developing LOTO procedures (see Appendix B). While ideally equipment manufacturers will provide LOTO procedures when equipment is delivered, device manufacturers sometimes must develop equipment LOTO procedures from “scratch” when equipment has been heavily modified, when procedures have been supplied by third-party sources, or when procedures are inadequate or in other languages, etc. This template may also be useful for equipment manufacturers who want a better understanding of the format of LOTO procedures that their customers expect.

This procedure format is a hybrid document that includes inputs and information formatting techniques from several ISMT member companies and key OEMs. It is consistent with the example in “Related Information” of SEMI S20-0303, *Safety Guideline For Identification And Documentation Of Energy Isolation Devices For Hazardous Energy Control*. The format is pictorial, providing a quick reference to maintenance personnel to determine what hazards are present, where to locate energy isolation points, how to isolate energy, how to secure (LOTO) sources, what hardware is required, how to dissipate residual energy, how to test for zero energy states, what personnel protective equipment is required, what waste disposal is required, and what is meant by the “hazard zone.” It also supplies a quick reference checklist to ensure essential steps are followed.

### 9 EXAMPLE PROCEDURES FOR THE PRIORITY LIST

This report does not define the format of an integrated LOTO procedure simply because these vary widely depending upon the design and format of OEM maintenance manuals. However, a template for the development of detailed standalone LOTO procedures was developed as part of this project (see Appendix B). A set of sample procedures for the priority list of equipment was developed. These procedures do not represent actual OEM product; they only typify these machines/tools and give readers an example to follow for developing a procedure for their unique situation. The four sample procedures are included in Appendix C.
10 EQUIPMENT INSTALLATION AND LOCKOUT/TAGOUT

10.1 Challenges and Solutions

Partial vs. total shutdown of equipment (multiple energy feeds vs. single feed). Suppliers are routinely challenged to produce equipment with chamber and subsystem-level isolation capability. For new designs, this is often achievable but not without impacting cost. This approach also requires well thought out procedures and a strong comprehension by the end-user of the methods for isolation and the hazards associated with partial shutdowns. A successful approach may also depend on the installation of the equipment and the availability of multiple energy feeds. Some device manufacturers may wish to modify existing installations to adapt older equipment to this approach. This must be done with great care and likely involve the OEM to ensure a full comprehension of the hazards and impact to the machine.

Comprehension of LOTO when equipment is installed, including but not limited to energy exposures by equipment manufacturer’s personnel. In some instances, procedures for LOTO do not reflect installation, only maintenance after installation. Sometimes procedures and hardware for LOTO are not compatible for equipment manufacturer personnel and device manufacturer personnel. Better coordination between all parties is necessary to anticipate these differences before installation. This problem often impacts training requirements as well.

Physical location of isolation points, time constraints, ease of access, travel distances, etc. The downtime and practical difficulties associated with LOTO continue to be a burden on device manufacturers. These challenges are often compounded by the device manufacturer’s equipment installation practices. Remote isolation points, often outside the cleanroom space, may be perceived as defying regulatory requirements for ease of access. Several promising approaches are emerging. At least one member company has embarked upon a maintenance impact study examining the costs associated with remote isolation (i.e., decreasing tool downtime by moving isolation points closer to the tasks being performed). As a result of the study, they have determined that it is cost feasible to relocate breakers, valves, etc. to make them more accessible. For new equipment designs, device manufacturers are seeking greater isolation capability at the tool. Different customer needs and installation approaches (i.e., single vs. multiple energy feeds) may always present some variability in design, but more and more the trend is to provide greater energy isolation capability at the tool, including the partial shutdown of systems. The advantage of this approach is being able to perform maintenance on certain portions of equipment without a total shutdown (e.g., multi-chambered tools).

ISMT believes that many current LOTO practices involving the remote isolation of energy sources are impractical and impact productivity because of increased equipment downtime. ISMT member companies expect to improve LOTO practices by achieving more localized, point of use (POU)/point of energy isolation consistent with regulatory requirements and acceptable to local authorities. This expectation will likely require developing more methods and hardware for use on downstream energy paths at the tool subsystem level located within the wafer fab rather than solely at the main energy source located remotely (typically in the sub-fab).

ISMT member companies have investigated the feasibility and cost benefits associated with relocating or supplementing energy isolation points from remote locations (e.g., subfab area) to fab cleanrooms to provide better access for maintenance personnel. This could involve installing or moving breakers, valves, disconnects, or even equipment subsystems. While simple in concept, such workplace modifications are often viewed as costly, disruptive, and sometimes
infeasible because of space constraints that limit the amount of support equipment that can be placed in the cleanroom.

Key to understanding this problem is recognizing that each person performing maintenance must travel to and from energy isolation points, because regulations (in the United States and in some other countries) and good practice mandate that maintenance individuals must apply their own locking mechanism(s) to isolated energy sources, maintain control of those mechanisms, and eventually remove those mechanisms. Other personnel may not perform these actions. Improvements and gains to be achieved are associated with moving the isolation points closer to or within the cleanroom environment to reduce travel time and increase the likelihood that personnel can perform the task safely and reasonably quickly.

One member company conducted a study to determine the return on investment (ROI) of these types of modifications. Their primary focus was to determine the travel time for maintenance personnel to leave the work area (fab), unsmock and travel to the sub-fab to isolate and secure (LOTO) energy sources to the equipment to be maintained/serviced, and then smock-up and return to the fab/work area. This process is repeated when the maintenance task is completed and the lock(s) are to be removed. The study concluded that for some process tools, in particular multi-chambered tools, it was cost-effective to relocate electrical disconnects from the sub-fab to locations within the fab. The labor savings alone on travel time reduction justified the cost, but more importantly the move would substantially increase the accessibility and feasibility of proper energy isolation.

All member companies may benefit from feasibility studies to examine the access of energy isolation points and measures that can be taken to make them more accessible, including relocation. Making ready access to energy isolation points a high priority and not an afterthought would minimize or prevent the need for later relocations and modifications. This challenge begins with the design of factories and factory infrastructure as well as equipment designs that provide integral isolation points.

Improvements in this area have been made in recent years, but greater coordination and common goals among facilities organizations, equipment installation teams, safety personnel, and equipment manufacturers are recommended (see section 15).

11 DESIGN FEATURES AND HARDWARE ENABLING LOCKOUT/TAGOUT

11.1 Challenges and Solutions

The semiconductor industry has always presented unique challenges for energy isolation and lockout/tagout. Because of the sensitivity of this type of process manufacturing, total equipment shutdown and isolation is not a readily feasible approach. In a wafer fabrication facility, power and even process chemical feeds to portions of the equipment must be maintained while other portions or subsystems are maintained and serviced. In some instances, this can be achieved safely while working with hazardous energies by administrative controls, personnel protective equipment, and carefully developed procedures. In other situations, subsystems are isolated from hazardous energy sources and, when possible, locked and tagged. Equipment manufacturers are increasingly being challenged to provide equipment that allows for localized (at the tool) isolation of subsystems and energy sources.
Integrating LOTO for subsystems purchased separately from process equipment. When subsystems are purchased separately, the suppliers may not be consulted on how to best adapt their products for integration with other equipment. For future designs, some flexibility in design and even the use of “template” procedures that can be adapted would be appropriate.

Partial vs. total shutdown of equipment (multiple energy feeds vs. single feed). As discussed in section 10, suppliers are routinely challenged to produce equipment with chamber and subsystem-level isolation capability. A successful approach sometimes depends upon the equipment installation and the availability of multiple energy feeds. Some device manufacturers may modify existing installations to adapt older equipment to this approach. This must be done with great care, likely involving the OEM to ensure a full comprehension of the hazards and impact to the machine.

Mixed acceptance of gang lock practices. Member company customers may have different expectations for gang lock systems. Gang locking provides some advantages such as multiple locks but also poses some drawbacks such as obscuring adjacent breakers/isolation points, making it difficult to verify energy states. No improvements have been proposed at this time for legacy or installed-base equipment, but the general consensus has been to make energy isolation points more accommodating for multiple locks.

Lockable energy isolation devices (EIDs) vs. use of "clamshells” or other similar devices. Problems are frequently encountered with installed-base equipment that lack an integral, lockable mechanism for energy isolation. With the continuing escalation of fab construction costs and the premium placed on floor space within a fab, suppliers are constantly challenged to minimize the footprint of their equipment. As component density becomes greater, the need to install EIDs designed to accept locks and tags becomes apparent when multiple LOTO “add-on” devices (e.g., clamshells and other attachable devices) are placed side by side on a group of EIDs. Because of their bulkiness, the add-on devices sometimes impede work by obscuring the view around the EID. Many EIDs are installed in small enclosures and when add-on devices are used for LOTO, the enclosure covers may not fully close. This is obviously not desirable in cases such as gas boxes. Equipment manufacturers should install EIDs that have integrated LOTO hardware to reduce the need for add-on devices.

While clamshells and similar devices often offer a pragmatic solution, strict interpretation of regulation or code may not be met. Clamshells and similar lockout devices further challenge the need for ready accessibility and availability in the LOTO process. In addition to bringing a lock and tag to the work area, maintenance personnel are also responsible for acquiring and bringing the right lockout devices for adaptation. Other factors are introduced as well: cost of clamshells, time and professional judgment to assure the proper device is selected, maintaining the devices in good working order, proper storage, and perhaps additional training.

For installed-base equipment, some modifications may be necessary to retrofit the equipment with integral LOTO mechanisms (lockable EIDs). This may be driven by regulatory requirements, cost, ease of use, etc. Some risk analysis and cost analysis may also be appropriate to determine the feasibility of making such changes. However, clamshells and similar devices appear to have a place in the adapted workplace and will likely always meet some LOTO needs.

For new equipment, the general recommendation is to perform a design analysis that fully comprehends maintenance activities and to subsequently provide integral means of LOTO for all forms of energy. Manufacturers should explore every possible source to use EIDs with integrated LOTO hardware in equipment design. SEMI S2 tasks suppliers to install EIDs for all hazards.
that could be encountered during normal service activities over the expected lifetime of the equipment. If such devices are not available, then add-on devices should be incorporated as a last resort.

This effort does not stop with the equipment manufacturer. The end-user must comprehend the need for integral LOTO means when installing equipment, including integrating separately purchased/acquired subsystems. The end-user may also install other EIDs upstream from the equipment EIDs to allow for fab-level LOTO in case an EID component on the supplier equipment fails or other isolation requirements must be met.

**Availability of lockable breakers and valves for equipment construction and installations.** One common challenge centers on the availability of appropriate lockable breakers and valves for equipment used in semiconductor manufacturing. Perceiving a gap in the supply of appropriate devices, several suppliers (and device manufacturers) have been working with OEMs to design, redesign, or modify products for semiconductor equipment. In many cases, installed-base equipment may be modified with these devices. New equipment design must benefit from the proliferation of these new items, and member companies should make other equipment manufacturers aware of the availability these products.

**Lockable EMOs.** Most equipment manufacturers still receive requests from customers to install “lockable” emergency off buttons on their products. Because this may be a violation of regulations in some countries, many suppliers will not do this. Suppliers are working to educate their customers but in general have requested that ISMT member companies standardize their position on this subject. For installed-base equipment, member companies should consider a plan for phase-out over time as part of “continuous improvement.”

**Small breakers and plastic valves not able to support weight of locks and locking mechanisms.** Cost, space, and chemical compatibility constraints often force suppliers to use small components and some made of lightweight materials (e.g., slim breakers, small plastic chemical valves) to isolate certain forms of energy. Costs for retrofitting installed-base equipment are substantial; however, a plan for normal replacement of some of these items with more robust fixtures is achievable. Not all parts need to be replaced, but those that may fail anyway could be replaced with lockable devices if such devices are located in advance and a ready supply is maintained. For new equipment, suppliers should work through this project to locate and promote the use of more robust devices in their product designs.

### 11.2 Design Criteria For Energy Isolation Devices

EIDs are defined by SEMI S20-0303, *Safety Guideline for Identification and Documentation of Energy Isolation Devices for Hazardous Energy Control*, as “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 devices are not considered to be energy isolation devices per OSHA 29 CFR 1910.147.”

Best practices for LOTO demand that EIDs be designed and installed so that they readily accept approved locks and tags for securing the EID in a safe position and in a manner that prevents energy flow. EIDs may be integral to manufacturing or other equipment as well as facilities infrastructure systems (i.e., electrical distribution systems, chemical delivery systems, etc.).
When this is not achievable or was not employed with older systems and installations, supplemental devices may be necessary to interface with locks and tags with isolation devices that cannot be locked directly.

Lockable EIDs must be a design consideration for all parties who construct and sell manufacturing, test, support, and related equipment. Likewise, device manufacturers and others who design, build, own, and operate facilities must design lockable EIDs into installations, affording the opportunity for maintenance personnel to secure energy during maintenance and service activities.

One former ISMT member company has established a policy at one site that requires lockable valves for all new chemical delivery systems. They are also implementing a plan to replace all defective valves with new lockable isolation valves.

12 LABELING AND SIGNAGE SCHEMES FOR LOCKOUT/TAGOUT

12.1 Challenges and Solutions

Implementation of standardized labeling and signage. Today’s global business climate presents unique challenges for safety-related documentation, signage, and labeling. Standardized (i.e., commonly accepted) symbols and signage have recently been developed and are gaining greater acceptance. This is true for both the semiconductor industry and LOTO equipment to control hazardous energy. Nevertheless, different practices for labeling and signage, including LOTO-related labels and signs, remain evident in the semiconductor industry.

Variations in practices are due largely to different regulatory requirements around the world, multiple languages, and two-party labeling implementation, which involves an end-user applying supplemental or replacement labels to equipment originally labeled by an OEM. Recent efforts to standardize practices by regulatory bodies and the acceptance of universal symbols have greatly improved this situation. In January 2003, the semiconductor industry took a step forward with the publication of SEMI S20-0303, Safety Guideline For Identification And Documentation Of Energy Isolation Devices For Hazardous Energy Control, a document “intended to establish a method for the unique identification of energy isolation devices (EID) used for lockout/tagout (LOTO).” The guideline primarily solidifies the industry’s best practices for communicating the location of EIDs, hazards, energy sources, and steps to isolate energy and verify that isolation.

12.2 Graphical Representations and Labeling

Ready access to and location of lockable EIDs in the workplace is essential. According to SEMI S20, “Each LOTO EID should be uniquely and consistently identified on the system, drawings, schematics, procedures, etc. to reduce confusion.” The pictorial example procedures discussed earlier simplify the location of isolation points. To further reduce confusion, SEMI S20 also defines requirements for marking LOTO EIDs on equipment and system installations. This is intended to help (1) locate an individual EID, and then (2) differentiate LOTO EIDs from other operating devices or control devices that might be confused with a LOTO EID. The recommended label for identifying LOTO EIDs is shown below. General recommendations for size, lettering, coloring, etc., are discussed in SEMI S20.
SEMI S20 also provides recommendations for color-coding hazardous energy sources. Such a scheme was incorporated into the LOTO procedure template developed for this project (see Appendices B and C). This system, while not mandatory, provides a consistent manner of color-coding the graphical energy source locators used in pictures and diagrams. Standard convention also relies on pictorial labels to readily identify hazards. Universally accepted hazard signage has also been incorporated into the procedure template.

It is recommended that member companies adhere to a standardized approach, following the SEMI S20 document for new equipment and installations, and implement a long-term plan to phase out old labels and inconsistent patterns of hazard notification.

13 CUSTOMER-EQUIPMENT MANUFACTURER COMMUNICATION

13.1 Challenges and Solutions
Maximizing resources and gaining standardized, specific, and optimal LOTO procedures and equipment design must involve open communication between OEMs and customers. International SEMATECH should serve as one forum for this effort. The ongoing development of SEMI guidelines is another. The SEMI forum allows for the development and publication of guidance for standardization. The ISMT forum provides a complementary and more rapid means of communication between ISMT member companies and OEMs.

It is recommended that ISMT establish an on-going, formalized roundtable to address LOTO and other equipment-related safety issues. At a minimum, regularly scheduled summits should be facilitated to resolve common issues and to align member company positions on equipment expectations. In the near-term, member companies should work to resolve some inconsistencies and open issues as defined in section 15.

14 CONCLUSIONS
Ideal conditions for LOTO are generally characterized as follows:

1. All aspects of a member company’s LOTO activities are properly defined, documented, communicated, controlled, practiced, audited, and continuously improved.

2. All aspects of a member company’s LOTO activities are planned and maintained according to applicable regulations and laws.

3. All impacted personnel receive thorough and periodic training for their LOTO responsibilities.

4. All impacted personnel are
   a) Provided with appropriate hardware and equipment to perform their responsibilities associated with LOTO
b) Provided with accessible storage facilities for LOTO-related items

c) Provided the ability to use, care for, and maintain those items

5. Facilities and installations are designed and constructed to

a) Provide and accommodate ready access to energy isolation points for energy feeds, minimizing the need for lengthy travel to remote locations for energy isolation

b) Accommodate equipment and support systems to achieve safe and ready access to energy isolation points integral to the equipment

c) Provide, when appropriate, multiple lockable energy feeds to equipment to allow for maximum flexibility during maintenance

d) Provide, when appropriate, secondary breaker panels and manual gas isolation valves to allow more flexibility during maintenance

6. Capital and non-capital acquisition of manufacturing, test, and support equipment results in the delivery of the following:

a) Equipment with integral, lockable energy isolation devices (EIDs) and any other devices needed to properly implement LOTO.

b) Equipment that offers safe and maximum flexibility for isolating subsystems, while allowing redundant or complementary systems to remain in operation (i.e., avoiding the full shutdown of systems whenever possible).

c) Specific, explicit, effective procedures for safe energy isolation and lockout/tagout of equipment, relevant to the installation and flexible enough to be adapted for anticipated modifications.

d) Equipment that is properly labeled to identify possible hazardous energies and locations of LOTO EIDs.

7. Equipment manufacturers maintain a comprehensive product safety program that includes the following LOTO aspects:

a) Comprehensive training for designers to integrate hazardous energy safety into all designs.

b) Policies and procedures that ensure the following steps are taken during the design of product (consistent with recommendations in SEMI S20, Related Information):
   - Equipment designer determines each source of energy
   - Equipment designer selects proper energy isolation devices
   - Equipment designer specifies which devices are necessary for energy control for each task
   - Equipment designer and technical editors create lockout procedures for each task
   - Equipment designer and technical editors create graphical representations for each task from equipment drawings or photographs
   - Equipment designer specifies labels for energy isolation devices

c) Product support personnel capable and resourced to assist customers with necessary procedural modifications, installation aspects of LOTO, and sustaining efforts through the lifecycle of the product.
8. Development, implementation, use, and continuous improvement of LOTO procedures that are
   a) Specific to equipment being maintained
   b) Reflect the specific installation characteristics
   c) Illustrate and define the hazards, isolation points, method(s) for energy isolation, locking, tagging, and energy state verification methods

9. Adapt, where necessary, to ensure optimal safety by
   a) Upgrading labeling systems to current standards and expectations
   b) Examining the feasibility of relocating existing energy isolation points for optimum LOTO performance
   c) Developing a feasibility plan to replace older energy isolation devices
      • When they fail
      • During system replacements/modifications
      • Based upon improvement feasibility reviews
   d) Providing supplemental LOTO devices when locks cannot be directly applied to energy isolation points

10. Standardize practices and design expectations when such efforts will ensure greater safety and reduce cost. Some opportunities for standardization can be found in section 15.

15 RECOMMENDATIONS FOR FURTHER ACTIONS

It is recommended that ISMT establish an ongoing, formalized roundtable to address LOTO and other equipment-related safety issues. At a minimum, regularly scheduled summits should be facilitated to resolve common issues and to align member company equipment expectations. Through this dialogue, future issues may be addressed as well.

Energy verification methods. LOTO regulations in the U.S. (and perhaps elsewhere) require maintenance personal to perform definitive tests to verify the absence of energy after lockout and before maintenance. A variety of methods satisfy this requirement. Some are standard tests while others are improvised in the field. Often energy verification is hampered by some LOTO techniques (e.g., gang locking). This area will need further discussion. One general recommendation is to develop a standard list of energy verification methods and techniques. While this will not address all needs, it may help to standardize practices and influence design. Also worthy of documentation are improvised or unique methods developed within individual companies that could be shared with all. Equipment-integral verification would also be an appropriate topic for this issue.

Manual vs. auto-purge requirements as a result of energy isolation. End-users often encounter this dilemma when taking equipment to a “safe state.” Removal of residual energy is often required before maintenance, but once an energy supply is isolated some residual energy removal tasks become more difficult (e.g., the inability to auto-purge once power is removed). This issue has been set aside for further review by the team.

Impact of footprint on the placement of support equipment. Scaling-up wafer sizes has resulted in larger equipment. This often means that support systems cannot fit in a tool’s
footprint and consequently must be located remotely. Remote subsystems increase the difficulty of LOTO because of travel distances, etc. This issue has been set aside for future review by the team.

**Mixed acceptance of locks/different types of locks used by ISMT member companies.** This includes size variances and even the use of small “luggage” locks when the isolation point does not accommodate standardized locks. Suppliers are seeking a member company standard position on lock specifications.

**Global acceptance of LOTO devices is a goal.** Different practices, traditions, and regulations around the world result in different products and approaches to LOTO. Equipment manufacturers are seeking the ISMT member companies’ assistance to better standardize the acceptance of LOTO devices.

### 16 SUMMARY

This report is intended to document the results of a team effort by member companies, equipment manufacturers, and consultants to identify LOTO performance improvement opportunities for the industry. The key elements contained in this report are as follows:

1. A summary of BKMs and practices for LOTO with both existing, installed-base equipment as well as new equipment design and installation practices.
3. An example LOTO program document for member companies to use as a baseline for new programs or comparison to existing programs.
4. A defined set of issues, concerns, and recommendations for future focus and improvement of LOTO practices in the industry.

The improvements are more or less universal to LOTO and not unique to the example tools identified. The four tools were selected primarily to stimulate thought about those tools that pose the most difficulty for LOTO. The solutions/BKMs identified actually work across an entire tool set. Furthermore, since the suppliers of the four tools did not want their products featured in the report, the *Sample LOTO Procedures* in Appendix C do not represent a real tool. However, they demonstrate how the *LOTO Procedure Template* in Appendix B can be used for developing a procedure for any type of equipment including the four selected tools.

The *LOTO Program Template* in Appendix A outlines the general requirements for a written LOTO program in the United States. Written programs are a significant part of LOTO compliance in the U.S., and all member companies probably use a similar document. This template was added to this report for completeness only.
A.1 Purpose

The purpose of the lockout/tagout (LOTO) program is to define protection from the potential hazards associated with the unexpected release of hazardous energy for employees performing equipment maintenance. This program establishes the minimum requirements for the use of LOTO procedures and energy isolating devices.

This document shall be used in conjunction with LOTO procedures to ensure that machinery or equipment is isolated from all potential hazardous energy sources and locked or tagged out before employees perform any servicing or maintenance activities where the unexpected energization, start-up, or release of stored energy could cause injury.

This program describes

- The responsibilities of INSERT COMPANY NAME employees, contractors, and vendor representatives.
- The equipment to be used to isolate energy sources and lock and tag the energy isolation devices.
- The template of procedures to be used for shutting down, isolating energy sources, and restarting equipment.
- Training requirements.
- Records and documentation requirements.

A.2 Scope

This program and its associated procedures apply to employees or contractors performing maintenance, service work, or unscheduled repairs on machines or equipment including

- Installing, setting up, adjusting, inspecting, modifying, maintaining, servicing, and removing equipment from service.
- Bypassing any guard or safety device.
- Requiring an employee to place any part of the body into the “point of operation” or danger zone of a machine.

An exception to LOTO may be made by the (INSERT RESPONSIBLE PARTY HERE) under the limited circumstances listed below. The exception can be made only if work is performed using alternative measures that provide effective protection such as guards, personal protective equipment, or other provisions that prevent the employee from being exposed to the hazard. Exceptions may apply to

- Minor adjustments and other servicing activities that take place during normal production operations if they are routine, repetitive, and integral to the use of the equipment for production.
- Cord and plug type of equipment where the employee performing the maintenance has “control” of the power cord and all sources of hazardous energy are removed by disconnecting the plug. If absolute control of the plug cannot be assured, an appropriate lockout device shall be used.
- Absolute control of the plug shall be defined as
– The plug is disconnected from the supply by the person in control
– The plug is within the direct line of sight of the person in control
– The plug is within reach of the person in control during maintenance activities
– Only one piece of equipment is being maintained at a time per individual
– Only one person is performing the maintenance or service task

A.3 Responsibilities

The INSERT RESPONSIBLE PARTY is responsible for defining the process and procedures outlined in this document and for the review and changes to this document.

The INSERT RESPONSIBLE PARTY HERE is responsible for providing continual input, resources, and tool-specific information to the safety engineer.

The INSERT RESPONSIBLE PARTY HERE is responsible for having a working knowledge of the lockout/tagout (LOTO) specification, purchasing and distributing appropriate LOTO devices to all authorized personnel, assisting in developing tool specific LOTO procedures, and auditing and enforcing compliance with LOTO procedures.

The INSERT RESPONSIBLE PARTY HERE is responsible for ensuring that all authorized personnel are trained on the INSERT COMPANY NAME LOTO program and the general and tool-specific LOTO procedures outlined in training. The INSERT RESPONSIBLE PARTY shall assure that adequate general training is available.

All authorized personnel are responsible for adhering to the general and tool-specific LOTO procedures, proper care of locking devices, and notification of supervisors and LOTO program owners regarding program deficiencies, the need for new LOTO devices, procedural issues, or any other conditions that would prevent compliance with LOTO procedures.

Each contractor/vendor shall be informed of the requirement to provide LOTO protection equivalent to the INSERT COMPANY NAME LOTO program before beginning any work. It will be the responsibility of the INSERT COMPANY NAME manager escorting the contractor on site to inform that contractor of safety requirements and to verify the contractor(s) possess adequate knowledge, procedures, and hardware to safely perform LOTO. The responsible INSERT COMPANY NAME manager shall ensure that INSERT COMPANY NAME employees and other impacted contract personnel comply with restrictions and prohibitions of the outside contractor’s hazardous energy control procedures.

A.4 Referenced Documents

OSHA 29 CFR 1910.147 – Control of Hazardous Energy

A.5 Equipment

A.5.1 LOTO Devices

Locks and tags are issued to all authorized employees.

Locks must be durable, identifiable, and standardized. Site specifications for locks and tags are shown in Attachment 4.
Only one key is issued for each lock. An authorized employee may have multiple locks that are keyed alike. Only the INSERT RESPONSIBLE PARTY HERE is authorized to physically remove a lock or tag and start up equipment if the authorized employee is unable or unavailable. This practice may be performed only under strict controls and the procedure described in Attachment 3.

Each lock is identified/labeled with the authorized employee’s initials.

Records of assigned locks are maintained by the authorized employee’s supervisor and consolidated on a master list by the INSERT RESPONSIBLE PARTY.

Making duplicate keys is strictly prohibited.

Locks are issued only for LOTO purposes by authorized employees. LOTO equipment must not be used for any other purpose.

Multi-lock hasps are available for jobs requiring more than one lock.

Tag alone is used ONLY where locks cannot physically be installed to isolation devices.

All locks, adapters, and locking devices shall be inventoried routinely and shall have defined storage and/or staging locations at the site. These locations shall provide reasonable and timely access to employees required to use them.

When appropriate, individual locks and devices assigned to personnel may be kept under the control of the authorized employee in tool boxes, etc.

All such devices are subject to routine audits to verify availability and operating condition regardless of storage location.

A.6 Definitions, Procedures, and Responsibilities

A.6.2 Definitions

Authorized Employees – Designated workers who are trained and permitted to perform LOTO and startup procedures.

Affected Employees – Workers who operate or use the equipment that is going to be locked or tagged out.

Control of Hazardous Energy Procedure – A written document that details the sources of hazardous energy associated with a specific piece of equipment and the steps to be followed during the shutdown, isolation, testing, and restart of the equipment.

Energy Isolation – A barrier or air gap that prevents the flow of energy from the energy source to the equipment. The energy isolation can be accomplished by closing valves, opening circuit switches, disconnecting piping, unplugging power cords, or placing solid (blind) flanges in a pipeline.

Exposure/Exposed – Physical contact with, but not limited to, hazardous chemicals, stored energy, hazardous energy such as electric currents, high temperatures, moving parts that create pinch points, or the discharge point of a gas at pressures greater than 29 psig. Also contact with hazardous levels of radiant energy such as ultraviolet light, radio frequency energy, laser light, or radiant heat.
**Hazardous Energy** – Any potential or kinetic energy to which an employee may be exposed that can cause injury to the employee. This includes, but is not limited to, the following examples:

a) Any hazardous chemicals including, but not limited to, bulk feed, in situ, or exhaust/effluent by-products
b) Any nonhazardous liquid at a temperature above 115°F
c) Any surface at a temperature above 115°F
d) Any cold surface at 32°F or less
e) Any compressed gas at a pressure greater than 29 psig
f) Any exposed electrical component at a potential greater than 49 volts
g) Any magnetic field at a strength greater than 600 gauss
h) Any laser energy generated by a Class III or Class IV laser (some lasers such as Class IIIb may be exempted)
i) Ultraviolet (or high intensity light) radiation exposures must be evaluated according to calculations depending on frequency. Follow warning labels and manufacturer’s recommendations or consult INSERT RESPONSIBLE PARTY.
j) Gravity
k) Any other energy that can reasonably be expected to cause an injury

**Hazardous Energy Sources** – Sources of electrical, mechanical, chemical, thermal, hydraulic, or pneumatic energy or other type of energy and any residual energy stored in the equipment.

**Lockout** – Locking an energy isolation device so that only the authorized employee placing the lock can restore the energy.

**Safety Professional/Department** – The ranking person responsible for safety on the site.

**Tagout** – Placement of a prominent warning tag on an energy isolating device.

**Zero Energy State** – All sources of hazardous energy in a system are isolated and locked or tagged out.

### A.7 Inspections, Enforcement, and Audits

**INSERT RESPONSIBLE PARTY HERE** will conduct frequent inspections of their employees for compliance with all LOTO procedures. Employees failing to lockout or tagout equipment properly are disciplined in accordance with **INSERT POLICY DOCUMENT OR STATEMENT**.

If the inspections reveal improper use of LOTO procedures, retraining will be conducted.

Audits of the LOTO program and procedures will be conducted periodically (at least on an annual basis). The audit shall be performed by **INSERT RESPONSIBLE PARTY HERE**. The **INSERT RESPONSIBLE PARTY** will document these audits and recommend, facilitate, and make changes or updates to the LOTO program as appropriate.

### A.8 Training

**Frequency**

- During facility or job orientation
- Before new job assignment
- When work area changes present new hazards
• When energy control procedures change
• Whenever there is an indication that an employee is not adequately performing lockout procedures
• Periodic refresher training on general LOTO procedures as deemed appropriate by site management or safety personnel (OR OTHER FIXED SCHEDULE INSERTED HERE).

Affected Employees
Purpose and function of the Lockout/Tagout program and responsibilities during LOTO activities.

Authorized Employees
• Company policy
• Purpose, function, and general practices covered by the LOTO program
• Responsibilities
• Recognition of the type/magnitude of hazardous energy sources
• General LOTO procedures
• Methods and means of isolation
• Equipment-specific LOTO procedures

Retraining
• When inspection/audit reveals non-compliance
• When an accident or undesirable incident occurs due to non-compliance
• To communicate changes in program or procedures
• To communicate any changes in equipment or machinery

A.9 Records
INSERT RECORDS OWNER
General LOTO training records
Annual audit records
Master lock and key inventory (typically maintained at a workgroup level)

Training Department
General LOTO training records

Supervisors
Equipment-specific LOTO training records
LOTO device records and logs
Inspection/compliance records
INSERT ANY DATABASE REQUIREMENTS

All records are maintained per INSERT MEMBER COMPANY NAME HERE file retention program.
A.10 Forms/Attachments

Attachment 1 – General LOTO Procedures
Attachment 2 – Multiple Lockouts and Shift Changes
Attachment 3 – Lock Removal by Other Personnel
Attachment 4 – Lock and Tag Specifications

ATTACHMENT 1 – GENERAL LOTO PROCEDURES

The following is a description of the six general steps for proper LOTO. Each maintenance group is responsible for developing and maintaining equipment specific Control of Hazardous Energy (LOTO) Procedures that detail which energy sources must be isolated and locked or tagged out. A template for developing a specific procedure is shown in Attachment 4. Equipment-specific procedures generated from this template are defined and outlined in the appropriate preventive maintenance (PM) specification or in standalone LOTO procedures.

1) Preparation (Step 1)
   a) Before shutdown, the authorized employee must know and understand
      i) The specific equipment
      ii) The types of energy involved
      iii) The hazards of the energy to be controlled
      iv) The lockout procedures to control all energy sources
      v) Methods/procedures to verify a “zero-energy” state
   b) The authorized employee must notify all affected employees (or other workers) that a lockout or tagout procedure will be implemented and why.
   c) Notification may be made during group meetings, by written notification, or verbally at the location of the work to be performed.
   d) Notification shall be timely and effective to protect affected workers and authorized workers from risk associated with the shutdown, unintentional start-up of equipment, or hazards associated with the maintenance task(s).
   e) INSERT OTHER SPECIFIC MEANS OF NOTIFICATION HERE.

2) Shutdown (Step 2)
   a) The authorized employee shuts down the equipment by the normal stopping procedure (depress stop button, flip toggle switch, etc.).

3) Isolation (Step 3)
   a) All energy sources needing isolation are located. For equipment that cannot be “totally” powered down, locate the switch or isolation mechanism that isolates energy to the area to be serviced.
   b) The main power switches, circuits, or other sources of energy are moved to the “off” position or otherwise rendered inoperative.
c) Where energy such as thermal, chemical, flammable, pneumatic or hydraulic is stored in lines of pipes, valves will be closed and lines disconnected or purged to remove the contents.

d) All stored or residual energy is to be relieved, disconnected, restrained, or otherwise made safe.

4) LOTO (Step 4)

a) Lockout – Locks are placed on switches, circuits, or other energy sources in the “safe” or “off” position. During a group lockout, a multi-lock hasp is used and all members of the group must place their own lock on the hasp.

b) Warning tags are securely applied with each lock. Warning tags indicate the energy isolating device and the equipment being controlled may not be operated until the tag is removed. The tag also includes the name of the authorized employee and the date applied.

c) Tagout – For hazardous energy sources that cannot be locked out, place an approved tag on the energy-isolating device. The INSERT RESPONSIBLE PARTY must approve all “tagout only” operations individually on a case-by-case basis. In most situations, tagout alone will not satisfy the requirements of this standard.

d) All tags will be attached with self-locking, non-resealable nylon ties (or equivalent).

5) Stored Energy (Step 5)

a) All potentially hazardous stored energy or residual energy (i.e., springs, elevated parts, rotating flywheels, pneumatics, gravity, hydraulic systems, electrical systems, and air, gas, or water pressure, etc.) are relieved, disconnected, or otherwise made safe by repositioning, blocking, bleeding down, etc., and verified to be in a “zero-energy” state.

b) If there is a possibility that stored energy could accumulate to a hazardous level, verification of isolation and dissipation continues until servicing or maintenance is completed or until the possibility of such accumulation no longer exists.

6) Testing (Step 6)

a) After ensuring no personnel are exposed, the authorized employee confirms the equipment cannot be started or powered up by pressing the piece of equipment’s “on” button or other normal operating control.

b) Caution: After testing the equipment, return the operating switch(s) to the “neutral” or “off” position.

7) Restart Procedures

a) The following procedures outline the three general steps for restarting equipment that is locked/tagged out.

8) Inspection (Step 7)

a) The authorized employee inspects the work area, ensuring tools and other items are removed from the hazard zone, machine/equipment components are fully reassembled, and all interlocks and guards are reinstalled.

9) Notification (Step 8)
a) After inspecting the equipment and work area, the authorized employee notifies all affected employees that service and/or maintenance of the equipment is complete. Then the authorized employee ensures that all affected employees are safely positioned clear of danger zones during restart procedures.

b) Notification may be made during group meetings, by written notification, or verbally at the location of the work that has been performed.

c) Notification shall be timely and effective to protect affected workers and authorized workers from risk associated with the restart or energization of the equipment.

10) Remove and Restart (Step 9)

a) Locks, tags and isolation devices are removed from each energy source by the authorized employee(s) who applied them.

b) The machine or equipment is now restarted by the authorized employee only.

c) The authorized employee notifies affected employees that the equipment is operational.

d) Notification may be made during group meetings, by written notification, or verbally at the location of the work to be performed.

e) Notification shall be timely and effective to protect affected workers and authorized workers from risk associated with operational equipment.

f) INSERT OTHER SPECIFIC MEANS OF NOTIFICATION HERE.

ATTACHMENT 2 – MULTIPLE LOCKOUTS AND SHIFT CHANGES

1) General Lockout Procedure: Multiple Lockouts

a) If more than one individual is required to lockout or tagout equipment, each places his or her own personal lockout or tagout device on the energy isolation device(s). When an energy isolation device cannot accept multiple locks or tags, a multiple lockout or tagout hasp is used.

b) When a person no longer needs to maintain lockout protection, that person removes his or her lock from the locking device (such as a multiple lock hasp).

c) The last authorized employee to remove his or her lock is responsible for performing the equipment restart procedures as follows:

i) Notifies affected employees

ii) Checks the area around equipment making certain no one is exposed to hazards at startup, all guards and interlocks are in place, and all tools are removed from the machine.

iii) Restore energy to the machine or equipment.

d) General Lockout Procedure: Shift Changes

e) If equipment is locked out during a shift change, the authorized employee(s) on the next shift must apply his or her lock(s) before the authorized employee(s) who is leaving can remove his or her lock(s).

f) Responsibility for energy control and restarting activities is formally reassigned to the employee(s) on the new shift.
ATTACHMENT 3 – LOCK REMOVAL BY OTHER PERSONNEL

1) Removal of LOTO Devices By Other Personnel
   
a) Unavailable Authorized Employee: If the employee who applied the lock or tag is not available to remove it, the following procedures must be followed.
   
i) Determine the status of the locked out equipment and make a thorough attempt to contact the Authorized Employee who installed the lockout device.
   
 ii) The appropriate manager will make a reasonable attempt to contact the authorized employee whose lock is to be removed. If the Authorized employee who installed the lock cannot be reached, the manager will proceed in accordance with the procedure stated below.
   
 iii) The (INSERT AUTHORIZED PARTY) inspects the machine or equipment to determine if the repairs or service is complete, if the guards and interlocks are properly installed, and if the machine or equipment is safe for restart and operation.
   
 iv) The appropriate manager notifies the affected employees of the impending startup. Only the facilities manager and maintenance manager are authorized to physically remove a lock or tag and startup equipment.
   
v) The lock is returned to the authorized employee with written notification of the actions taken.
   
b) Lost/Broken Key Procedure
   
i) Authorized user with lost/broken key must notify INSERT RESPONSIBLE PARTY that key is lost or broken.
   
 ii) INSERT RESPONSIBLE PARTY notifies INSERT RESPONSIBLE PARTY who will authorize lock removal (if applicable) and provide the spare key.
   
 iii) A new lock and key will be issued to the authorized user.
   
 iv) In the case of a malfunctioning lock (or a lock for which the key has been lost) only the INSERT RESPONSIBLE PARTY can authorize cutting off the lock.
   
   i) All cut or malfunctioning locks (including the keys) must be returned to the INSERT RESPONSIBLE PARTY for evaluation, tracking, and disposal.

ATTACHMENT 4 – LOCK AND TAG SPECIFICATIONS

1) Each site will specify locks, tags, and locking devices to be used.

2) Basic Requirements:
   
a) Locks and lockout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with bolt cutters or other metal cutting tools.

   b) Each authorized employee will be issued his/her own lock.

   c) Each lock will be keyed individually with no two locks having the same key (exception: one person may have multiple locks keyed the same but only one key).

   d) Each lock will have only one key.
e) All locks used for LOTO will have be uniquely color-coded to distinguish it from other locks used at the SITE/LOCATION/DEPARTMENT.

f) All locks will be numbered and logged in the SITE/LOCATION/DEPARTMENT inventory.

g) A system will be employed to identify the owner of each lock.

h) Locks and keys will be taken from service by the INSERT RESPONSIBLE PARTY when the employee they are issued to is no longer working in an “authorized employee” role. The INSERT RESPONSIBLE PARTY will have the responsibility to assure name markings are changed before the key and lock are reassigned. If the keys for such locks are not recovered, the lock shall be destroyed and disposed.

i) Additional locks will be maintained as necessary for situations that require multiple lockouts. These spare locks will also be numbered and inventoried.

j) Records shall be kept of individually assigned and spare locks checked out to authorized users.

k) Records will indicate the name of the authorized user checking out the lock, the lock number, and the date of issuance and return.

l) Tags will be made of a durable material substantial enough to prevent inadvertent or accidental removal and to withstand conditions of the work environment including, but not limited to, chemical attack.

m) Tags will be clearly and plainly marked to indicate their purpose and have a place for the user’s name and the date and time applied.

n) Tags must be marked with indelible ink. Tags may be solvent-cleaned and revised if all previous marking is removed before reuse.

o) It is recommended that tags be attached directly to the lock during LOTO to avoid additional attachment hardware.
APPENDIX B – LOCKOUT/TAGOUT PROCEDURE TEMPLATES

Tool Name

Lockout/Tagout Procedure For Insert Task Here

BEFORE SERVICING THIS MACHINE NOTIFY ALL AFFECTED PERSONNEL

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>ENERGY SOURCE(S)</th>
<th>WHERE TO LOTO</th>
<th>LOCATOR</th>
<th>PERFORM ACTION</th>
<th>WHAT LOTO DEVICE TO USE</th>
<th>ENERGY DISSIPATION</th>
<th>HOW TO TEST OR VERIFY</th>
</tr>
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<tbody>
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</tbody>
</table>

RESOURCES/RESTRICTIONS

- Personal Protective Equipment
- Necessary LOTO Devices/Equipment
- Hazard Zone
- Waste Disposal

Insert Picture Here

PRIOR TO MAINTENANCE

1) Notify workers of intent to de-energize
2) Obtain lock(s), tag(s), and locking and/or blocking devices
3) Shut down, de-energize, dissipate any residual energies (SEE ABOVE)
4) Apply lock, tag, and locking and/or blocking devices (SEE ABOVE)
5) Verify effectiveness of lockout by attempting to restart (SEE ABOVE)
6) Verify that zero hazardous energies are present (SEE ABOVE)
7) Don proper PPE
8) Complete Work/Maintenance Task

AFTER MAINTENANCE

1) Notify workers of intent to re-energize
2) Conduct visual inspection to confirm that the danger zone is clear of workers
3) Conduct visual inspections to confirm tools, support or test equipment is clear of the danger zone
4) Remove electrical jumpers, bypass lines and other such devices
5) Reposition any safety devices (interlocks, valves, guards, covers, sensors)
6) Unlock or remove blocking devices
7) Re-energize
8) Confirm the system is operating properly & safely
9) Doff and decontaminate PPE
10) Discard disposable PPE; return reusable
# Appendix C – Sample LOTO Procedures

## Blitz K Cluster Tool

**Lockout/Tagout Procedure For Chamber 01 PM**

**Before Servicing This Machine Notify All Affected Personnel**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Energy Source(s)</th>
<th>Where To Loto</th>
<th>Locator</th>
<th>Perform Action</th>
<th>What Loto Device To Use</th>
<th>Energy Dissipation</th>
<th>How To Test Or Verify</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BKP RF Generator No.17</td>
<td>No.17 Power Plug at outlet No.166</td>
<td>PP</td>
<td>Unplug Generator, lock/tag plug</td>
<td>Small plug lockout box and standard lock &amp; tag</td>
<td>None</td>
<td>Attempt to restart DC Power Supply</td>
</tr>
<tr>
<td></td>
<td>Heater Circuit Breaker</td>
<td>System Controller</td>
<td>CB</td>
<td>Place breaker in off position, Lock &amp; tag</td>
<td>277V No-hole lockout device w/ standard lock &amp; tag</td>
<td>None</td>
<td>Attempt to power on</td>
</tr>
<tr>
<td></td>
<td>Chamber Process Gas Valve1</td>
<td>VMB</td>
<td>GV</td>
<td>Close Gas Valve and Purge Line, Lock &amp; tag</td>
<td>Gate valve clamshell, Part no. 2601 w/ standard lock &amp; tag</td>
<td>Complete purge per spec</td>
<td>Verify purge. Line gauges read zero</td>
</tr>
<tr>
<td></td>
<td>Chamber Process Gas Valve2</td>
<td>VMB</td>
<td>GV</td>
<td>Close Gas Valve and Purge Line, Lock &amp; tag</td>
<td>Gate valve clamshell, Part no. 2601 w/ standard lock &amp; tag</td>
<td>Complete purge per spec</td>
<td>Verify purge. Line gauges read zero</td>
</tr>
<tr>
<td></td>
<td>Cryo Compressor Electrical Disconnect</td>
<td>BKP1A</td>
<td>ED</td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM at Cryo coldhead</td>
</tr>
<tr>
<td></td>
<td>Pump Compressor Electrical Disconnect</td>
<td>BKP1B</td>
<td>ED</td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM</td>
</tr>
<tr>
<td></td>
<td>Chamber Lid</td>
<td>Chamber 1 Lid</td>
<td>LP</td>
<td>Place pin in hinge hole, Lock/tag pin</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Attempt to close lid</td>
</tr>
</tbody>
</table>

## Resources/Restrictions

<table>
<thead>
<tr>
<th>Personal Protective Equipment</th>
<th>Safety glasses, and neoprene gloves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Necessary LOTO Devices/Equipment</td>
<td>(1) 277V No-hole Breaker lockout device</td>
</tr>
<tr>
<td></td>
<td>(2) Gate valve clamshell PN 2601</td>
</tr>
<tr>
<td></td>
<td>(1) Small plug lockout</td>
</tr>
<tr>
<td></td>
<td>(1) Chamber lid lock pin</td>
</tr>
<tr>
<td></td>
<td>(7) Standard locks</td>
</tr>
<tr>
<td></td>
<td>(1) Digital volt meter</td>
</tr>
<tr>
<td>Hazard Zone</td>
<td>Use barrier tape and isolate access to chamber one</td>
</tr>
<tr>
<td>Waste Disposal</td>
<td>Place all wipes used with IPA in the flammable waste container</td>
</tr>
</tbody>
</table>
### PRIOR TO MAINTENANCE

1) Notify workers of intent to de-energize
2) Obtain lock(s), tag(s), and locking and/or blocking devices
3) Shut down, de-energize, dissipate any residual energies (SEE ABOVE)
4) Apply lock, tag, and locking and/or blocking devices (SEE ABOVE)
5) Verify effectiveness of lockout by attempting to restart (SEE ABOVE)
6) Verify that zero hazardous energies are present (SEE ABOVE)
7) Don proper PPE
8) Complete Work/Maintenance Task

### AFTER MAINTENANCE

1) Notify workers of intent to re-energize
2) Conduct visual inspection to confirm that the danger zone is clear of workers
3) Conduct visual inspections to confirm tools, support or test equipment is clear of the danger zone
4) Remove electrical jumpers, bypass lines and other such devices
5) Reposition any safety devices (interlocks, valves, guards, covers, sensors)
6) Unlock or remove blocking devices
7) Re-energize
8) Confirm the system is operating properly & safely
9) Doff and decontaminate PPE
10) Discard disposable PPE; return reusable
### SliceMaster VI Epitaxial Processor

**Lockout/Tagout Procedure For Comprehensive Maintenance**

**BEFORE SERVICING THIS MACHINE NOTIFY ALL AFFECTED PERSONNEL**

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>ENERGY SOURCE(S)</th>
<th>WHERE TO LOCATE</th>
<th>LOCATOR</th>
<th>PERFORM ACTION</th>
<th>WHAT LOTO DEVICE TO USE</th>
<th>ENERGY DISSIPATION</th>
<th>HOW TO TEST OR VERIFY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Power Switch</td>
<td>SM EPI Power Module, EPI Maintenance Chase</td>
<td></td>
<td></td>
<td>Power down the tool, switch power off. Lock/tag</td>
<td>Standard lock and tag</td>
<td>Allow tool to cool off for 15 minutes</td>
<td>Attempt to power up at the control panel. Check indicator lights.</td>
</tr>
<tr>
<td>Power Disconnect</td>
<td>Main Breaker Subfloor Coordinates b27</td>
<td></td>
<td></td>
<td>Open connect and lock/tag</td>
<td>No-hole lockout device w/ standard lock &amp; tag</td>
<td>None</td>
<td>Check load side of the circuit breaker using a digital volt meter (DVM)</td>
</tr>
<tr>
<td>Slick50 Pump1 Electrical Disconnect</td>
<td>SMP1 Coordinates b16</td>
<td></td>
<td></td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM</td>
</tr>
<tr>
<td>TorrMeister Pump2 Electrical Disconnect</td>
<td>SMP2 Coordinates b16</td>
<td></td>
<td></td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM</td>
</tr>
<tr>
<td>TorrMeister Pump3 Electrical Disconnect</td>
<td>SMP3 Coordinates b16</td>
<td></td>
<td></td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM</td>
</tr>
<tr>
<td>KyotoViro Abatement System</td>
<td>Bay 2, SM EPI Maintenance Chase</td>
<td></td>
<td></td>
<td>Power down abatement system. Open main power switch. Lock and tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Attempt to power up at the control panel. Check indicator lights. Check load side of disconnect using DVM</td>
</tr>
</tbody>
</table>

Process Cooling Water (PCW) and Process Chilled Water (PCHW) | Supply and return valves located near the power module at rear of tool. | Shut off supply valves first and then shut off return valves. Lock and tag. | Standard locks and tags | Bleed off residual pressure. | Attempt to open valves with locks in place. Verify gauge pressure to be zero.

Chamber Lid | Chamber Lid | Place pin in hinge hole. Lock/tag pin | Standard lock and tag | None | Attempt to close lid

**RESOURCES/RESTRICTIONS**

**Personal Protective Equipment**
- Safety glasses, and neoprene gloves

**Necessary LOTO Devices/Equipment**
- (1) No-hole Breaker lockout device
- (1) Gate valve clamshell. Part no. 2601
- (15) Standard locks
- (15) Standard tags
- (1) lid pin
- (1) Digital volt meter

**Hazard Zone**
- Use barrier tape and isolate access to tool

**Waste Disposal**
- √

### PRIOR TO MAINTENANCE

1) Notify workers of intent to de-energize
2) Obtain lock(s), tag(s), and locking and/or blocking devices
3) Shut down, de-energize, dissipate any residual energies (SEE ABOVE)
4) Apply lock, tag, and locking and/or blocking devices (SEE ABOVE)
5) Verify effectiveness of lockout by attempting to restart (SEE ABOVE)
6) Verify that zero hazardous energies are present (SEE ABOVE)
7) Don proper PPE
8) Complete Work/Maintenance Task
9) √

### AFTER MAINTENANCE

1)Notify workers of intent to re-energize
2) Conduct visual inspection to confirm that the danger zone is clear of workers
3) Conduct visual inspections to confirm tools, support or test equipment is clear of the danger zone
4) Remove electrical jumpers, bypass lines and other such devices
5) Reposition any safety devices (interlocks, valves, guards, covers, sensors)
6) Unlock or remove blocking devices
7) Re-energize
8) Confirm the system is operating properly & safely
9) Doff and decontaminate PPE
10) Discard disposable PPE; return reusable
# ImpactoMatic 2000 Ion Implanter

## Lockout/Tagout Procedure For Comprehensive Maintenance

### BEFORE SERVICING THIS MACHINE NOTIFY ALL AFFECTED PERSONNEL

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>ENERGY SOURCE(S)</th>
<th>WHERE TO LOTO</th>
<th>LOCATOR</th>
<th>PERFORM ACTION</th>
<th>WHAT LOTO DEVICE TO USE</th>
<th>ENERGY DISSIPATION</th>
<th>HOW TO TEST OR VERIFY</th>
</tr>
</thead>
<tbody>
<tr>
<td>⚠️</td>
<td>Main Power Switch</td>
<td>Impacto Power Module, Maintenance Chase behind tool</td>
<td><strong>ED</strong></td>
<td>Power down the tool, switch power off. Lock/tag</td>
<td>Standard lock and tag</td>
<td>Allow tool to cool off for 30 minutes</td>
<td>Attempt to power up at the control panel. Check indicator lights.</td>
</tr>
<tr>
<td>⚠️</td>
<td>Power Disconnect</td>
<td>Main Breaker Subfloor Coordinates b15</td>
<td><strong>CB</strong></td>
<td>Open disconnect and lock/tag</td>
<td>None</td>
<td></td>
<td>Check load side of the circuit breaker using a digital volt meter (DVM)</td>
</tr>
<tr>
<td>⚠️</td>
<td>Gas Supply Valves</td>
<td>Gas Module at rear of tool.</td>
<td><strong>GV</strong></td>
<td>Close All Gas Valves and Purge Line. Lock &amp; tag</td>
<td>Gate valve clamshell. Part no. 2601 w/ standard lock &amp; tag</td>
<td>Bleed off any residual pressure and purge lines</td>
<td>Verify purge. Line gauges read zero. Attempt to operate valve with lock in place.</td>
</tr>
<tr>
<td>⚠️</td>
<td>Slick50 Source Pump 1 Electrical Disconnect</td>
<td>Pump 1 Coordinates b12</td>
<td><strong>ED</strong></td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM. Verify source controller pressure meter. Verify source pressure</td>
</tr>
<tr>
<td>⚠️</td>
<td>TorrMeister Beamline Pump 2 Electrical Disconnect</td>
<td>Pump 2 Coordinates b12</td>
<td><strong>ED</strong></td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM. Verify source controller pressure meter. Verify source pressure</td>
</tr>
<tr>
<td>⚠️</td>
<td>TorrMeister Diffusion Pump Package 3 Electrical Disconnect</td>
<td>Pump Package 3 Coordinates b12</td>
<td><strong>ED</strong></td>
<td>Shut down pump, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>None</td>
<td>Measure with DVM. Verify source controller pressure meter. Verify source pressure</td>
</tr>
</tbody>
</table>

- Allow Coolant Pump 4 to run for 30 minutes to cool ion source.
### RESOURCES/RESTRICTIONS

<table>
<thead>
<tr>
<th>Personal Protective Equipment</th>
<th>Safety glasses, respirator, and neoprene gloves</th>
</tr>
</thead>
</table>
| Necessary LOTO Devices/Equipment | (1) No-hole Breaker lockout device  
                                  (2) Gate valve clamshell. Part no. 2601  
                                  (11) Standard locks  
                                  (11) Standard tags  
                                  (1) Digital volt meter |
| Hazard Zone | Use barrier tape and isolate access to tool |
| Waste Disposal |

### PRIOR TO MAINTENANCE

1) Notify workers of intent to de-energize
2) Obtain lock(s), tag(s), and locking and/or blocking devices
3) Shut down, de-energize, dissipate any residual energies (SEE ABOVE)
4) Apply lock, tag, and locking and/or blocking devices (SEE ABOVE)
5) Verify effectiveness of lockout by attempting to restart (SEE ABOVE)
6) Verify that zero hazardous energies are present (SEE ABOVE)
7) Don proper PPE
8) Complete Work/Maintenance Task

### AFTER MAINTENANCE

1) Notify workers of intent to re-energize
2) Conduct visual inspection to confirm that the danger zone is clear of workers
3) Conduct visual inspections to confirm tools, support or test equipment is clear of the danger zone
4) Remove electrical jumpers, bypass lines and other such devices
5) Reposition any safety devices (interlocks, valves, guards, covers, sensors)
6) Unlock or remove blocking devices
7) Re-energize
8) Confirm the system is operating properly & safely
9) Doff and decontaminate PPE
10) Discard disposable PPE; return reusable
Zamboni 500 Wet Process Tool

Lockout/Tagout Procedure For Comprehensive Maintenance

BEFORE SERVICING THIS MACHINE NOTIFY ALL AFFECTED PERSONNEL

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>ENERGY SOURCE(S)</th>
<th>WHERE TO LOTO</th>
<th>LOCATOR</th>
<th>PERFORM ACTION</th>
<th>WHAT LOTO DEVICE TO USE</th>
<th>ENERGY DISSIPATION</th>
<th>HOW TO TEST OR VERIFY</th>
</tr>
</thead>
<tbody>
<tr>
<td>⚠️</td>
<td>Nitrogen Input Supply Valve</td>
<td>Facilities Shutoff Panel No. 5</td>
<td>⬛️</td>
<td>Move N2 input valve knob to off position. Attach device on valve, lock and tag</td>
<td>Mechanical shield isolation device with standard lock and tag</td>
<td>Relieved stored pressure in line by toggling on the atomizer function</td>
<td>Verify gauge pressure.</td>
</tr>
<tr>
<td>⚠️</td>
<td>Chemical Delivery System</td>
<td>CDS valves located in subfloor at B3.1</td>
<td>⬛️</td>
<td>Follow normal CDS shutdown procedures. Close all (3) CD valves, lock and tag.</td>
<td>standard locks &amp; tags</td>
<td>Depressurize lines and canisters</td>
<td>Attempt to open valves. Check control screen for zero pressure.</td>
</tr>
<tr>
<td>⚠️</td>
<td>CDS Circuit Breaker System Controller</td>
<td></td>
<td>⬛️</td>
<td>Place breaker in off position. Lock &amp; tag</td>
<td>No-hole lockout device w/ standard lock &amp; tag</td>
<td>None</td>
<td>Attempt to power on</td>
</tr>
<tr>
<td>⚠️</td>
<td>Chemical tanks Control valves located behind tool</td>
<td></td>
<td>⬛️</td>
<td>Close all (3) CD valves, lock and tag. Switch on tank dump function control and fully drain tanks.</td>
<td>Standard locks and tags</td>
<td>Empty tanks</td>
<td>Verify tanks are empty.</td>
</tr>
<tr>
<td>⚠️</td>
<td>Zamboni Main Electrical Disconnect Rear of Tool in clean room</td>
<td></td>
<td>⬛️</td>
<td>Power down the tool, open disconnect and lock/tag</td>
<td>Standard lock and tag</td>
<td>Allow ten minutes for capacitors to dissipate.</td>
<td>Measure with DVM</td>
</tr>
</tbody>
</table>
### RESOURCES/RESTRICTIONS

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Protective Equipment</td>
<td>Safety goggles, and acid gloves</td>
</tr>
<tr>
<td>Necessary LOTO Devices/Equipment</td>
<td>(1) No-hole Breaker lockout device</td>
</tr>
<tr>
<td></td>
<td>(1) Mechanical shield isolation device No.32322</td>
</tr>
<tr>
<td></td>
<td>(9) Standard locks</td>
</tr>
<tr>
<td></td>
<td>(9) Standard tags</td>
</tr>
<tr>
<td></td>
<td>(1) Digital volt meter</td>
</tr>
<tr>
<td>Hazard Zone</td>
<td>Use barrier tape and isolate access to tool</td>
</tr>
<tr>
<td>Waste Disposal</td>
<td></td>
</tr>
</tbody>
</table>

### FAB LEVEL
- **Zamboni 500 Wet Process Tool**
- **Front of Tool**
- **Rear of Tool**

### SUBFAB LEVEL
- **CBS**
- **Canister Bank**
- **CBS Controller**
- **Facility Shut-off Panel 56 (H2)**

### PRIOR TO MAINTENANCE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Notify workers of intent to de-energize</td>
</tr>
<tr>
<td>2</td>
<td>Obtain lock(s), tag(s), and locking and/or blocking devices</td>
</tr>
<tr>
<td>3</td>
<td>Shut down, de-energize, dissipate any residual energies (SEE ABOVE)</td>
</tr>
<tr>
<td>4</td>
<td>Apply lock, tag, and locking and/or blocking devices (SEE ABOVE)</td>
</tr>
<tr>
<td>5</td>
<td>Verify effectiveness of lockout by attempting to restart (SEE ABOVE)</td>
</tr>
<tr>
<td>6</td>
<td>Verify that zero hazardous energies are present (SEE ABOVE)</td>
</tr>
<tr>
<td>7</td>
<td>Don proper PPE</td>
</tr>
<tr>
<td>8</td>
<td>Complete Work/Maintenance Task</td>
</tr>
</tbody>
</table>

### AFTER MAINTENANCE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Notify workers of intent to re-energize</td>
</tr>
<tr>
<td>2</td>
<td>Conduct visual inspection to confirm that the danger zone is clear of workers</td>
</tr>
<tr>
<td>3</td>
<td>Conduct visual inspections to confirm tools, support or test equipment is clear of the danger zone</td>
</tr>
<tr>
<td>4</td>
<td>Remove electrical jumpers, bypass lines and other such devices</td>
</tr>
<tr>
<td>5</td>
<td>Reposition any safety devices (interlocks, valves, guards, covers, sensors)</td>
</tr>
<tr>
<td>6</td>
<td>Unlock or remove blocking devices</td>
</tr>
<tr>
<td>7</td>
<td>Re-energize</td>
</tr>
<tr>
<td>8</td>
<td>Confirm the system is operating properly &amp; safely</td>
</tr>
<tr>
<td>9</td>
<td>Doff and decontaminate PPE</td>
</tr>
<tr>
<td>10</td>
<td>Discard disposable PPE; return reusable</td>
</tr>
</tbody>
</table>