NIOSH

PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

Guidelines for Controlling Hazardous Energy During Maintenance and Servicing

GUIDELINES FOR CONTROLLING HAZARDOUS ENERGY

DURING MAINTENANCE AND SERVICING

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Safety Research
Morgantown, West Virginia 26505

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DISCLAIMER

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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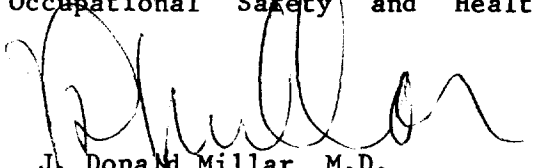
PREFACE

The Occupational Safety and Health Act of 1970 emphasized the need for standards to protect the health and safety of workers exposed to an ever increasing number of potential hazards in the workplace. Section 22(d)(2) of the Act authorizes the Director of the National Institute for Occupational Safety and Health (NIOSH) to make recommendations to the Occupational Safety and Health Administration (OSHA) concerning improved occupational safety and health standards. The purpose of this document is to provide recommendations for preventing injuries and disease caused by hazardous energy.

The document was developed through the use of "systems analysis" so as to provide a logical means of performing maintenance and servicing activities safely, with energy present, with energy removed, and during the process of reenergizing.

We gratefully acknowledge the contributions to this document made by representatives of other Federal agencies or departments, labor unions, trade and professional associations, consultants, and the staff of the Institute.

Whatever the contributions made by others, conclusions expressed in this document are those of the Institute, and we are solely responsible for them. However, all comments made by those outside NIOSH, whether or not incorporated, were considered carefully and were sent with the document to the Occupational Safety and Health Administration.



J. Donald Millar, M.D.
Assistant Surgeon General
Director, National Institute for
Occupational Safety and Health

The Division of Safety Research, NIOSH, had primary responsibility for development of the recommended guidelines for controlling hazardous energy during maintenance and servicing. Ted A. Pettit served as project officer and document manager. Boeing Aerospace developed the basic information for consideration by NIOSH staff and consultants under contract No. 210-79-0024.

The NIOSH division review of this document was provided by David L. West, Ph.D., Robert G. McDonald (Division of Standards Development and Technology Transfer), David J. Huebener (Division of Physical Sciences and Engineering), John R. Etherton, Murray L. Cohen, Ph.D., and James A. Oppold, Ph.D. (Division of Safety Research). Technical editing for the document was provided by Herbert Linn (Division of Safety Research).

ABSTRACT

This document has been developed to provide guidelines for controlling hazardous energy during maintenance and servicing operations. The guidelines were developed by associating work practices with attendant risks. Methods of obtaining information which contributed to the development of the guidelines included site visits to various industrial facilities, the collection and analysis of data related to maintenance techniques and processes, evaluation of accident case studies and incident report information, extensive searches of literature, and review of other pertinent data. The guidelines emphasize recognition of hazards and safe work procedures.

This document provides a logical system for performing maintenance and servicing activities safely, and recognizes that such activities can be performed safely with energy present, with energy removed, and while reenergizing. The recommended guidelines were developed through a systems analysis approach. The logic tree (Figure I) provides a step-by-step diagram for controlling hazardous energy that should be utilized in the formulation of specific maintenance and servicing procedures.

REVIEW CONSULTANTS

Frederick D. Broussard, P.E.
Safety and Training Services, Inc.
5615 Corporate Boulevard
Baton Rouge, Louisiana 70808

Leonard S. Corey
Engineering Supervisor
Eastman Kodak Company
1669 Lake Avenue
Rochester, New York 14650

Burleigh J. Fuselier
Oil, Chemical, and Atomic Workers Union
913 Bradley
Sulphur, Louisiana 70663

Kenneth L. Lauch
Industrial Relations Staff - Safety
General Motors Corporation
Detroit, Michigan 48202

J. F. Naber
Director of Health and Safety
Sun Petroleum Products Company
1608 Walnut Street
Philadelphia, Pennsylvania 19103

Frank J. Rapp, P.E.
Chief, Health and Safety Staff
UAW Social Security Department
8000 East Jefferson Avenue
Detroit, Michigan 48214

William L. Wachs
Manager, Quality Assurance
Cincinnati Milacron, Inc.
4701 Marburg Avenue
Cincinnati, Ohio 45209

Ray E. Witter
Director, Safety and Property Protection
Monsanto Company
800 North Lindbergh Boulevard
St. Louis, Missouri 63166

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I. INTRODUCTION

This document is primarily intended to outline methods of protecting workers engaged in maintenance and servicing of machines, processes, or systems from injury by the unexpected and unrestricted release of hazardous energy.

Maintenance activities can be performed with or without energy present. A probable, underlying cause of many accidents resulting in injury during maintenance is that work is performed without the knowledge that the system, whether energized or not, can produce hazardous energy. Unexpected and unrestricted release of hazardous energy can occur if: 1) all energy sources are not identified; 2) provisions are not made for safe work practices with energy present; or 3) deactivated energy sources are reactivated, mistakenly, intentionally, or accidentally, without the maintenance worker's knowledge.

Problems involving control of hazardous energy require procedural solutions. The logic of the guidelines proposed in this document for controlling hazardous energy is graphically represented in Figure I, Diagram for Controlling Hazardous Energy During Maintenance and Servicing. This diagram should be utilized by those personnel responsible for the design of safe work procedures specific to individual employer requirements.

Employers must adopt such procedural solutions for controlling hazards to ensure worker safety during maintenance. However, such procedures are effective only if strictly enforced. Employers must, therefore, be committed to strict implementation of such procedures.

A. MANAGEMENT COMMITMENT

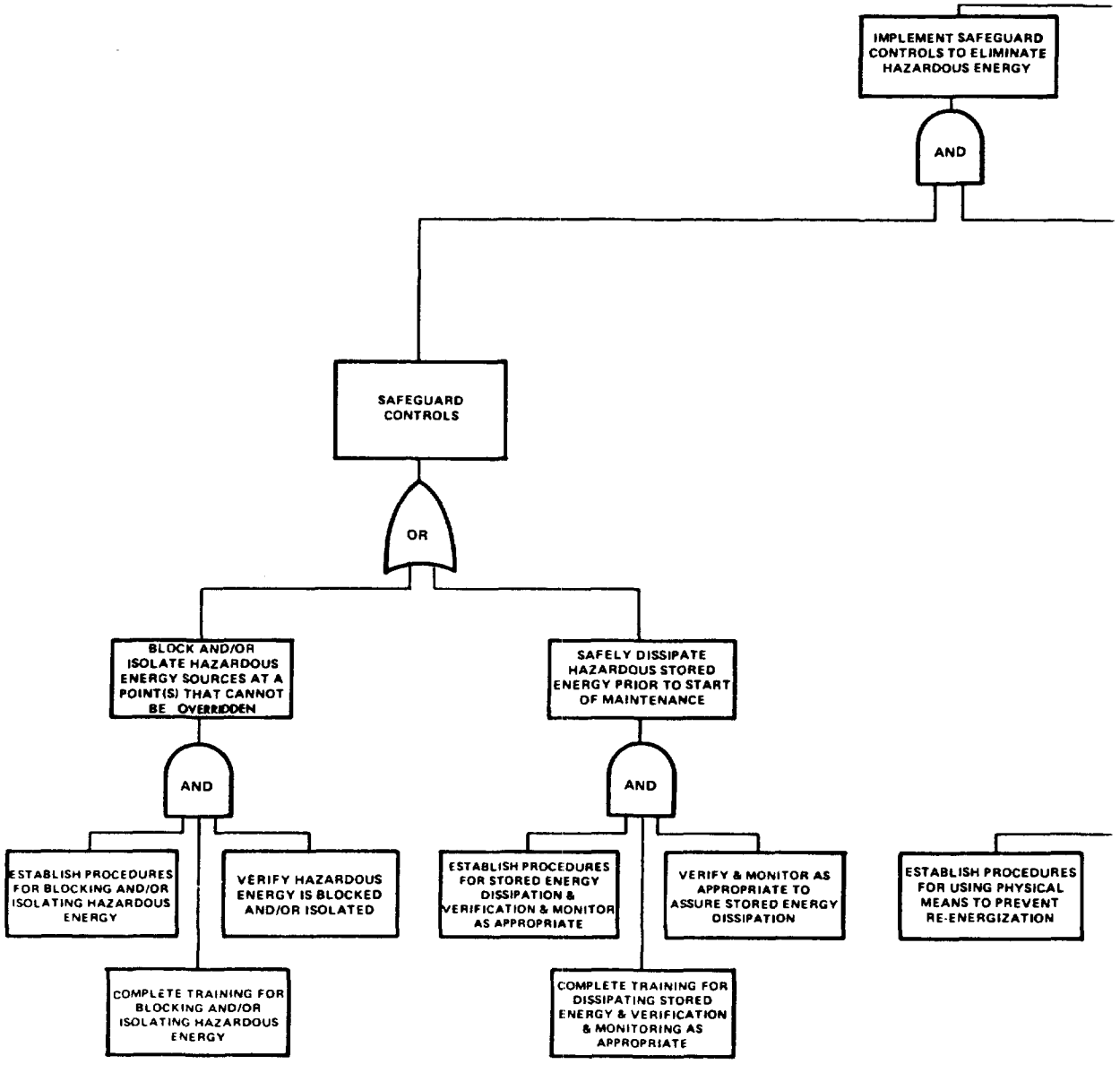
During visits to several plants conducted as part of this study, employers stressed that cooperation between management personnel and employees is essential to the implementation of safety programs, including energy control measures. Many employers believe that first line supervisors and employees comprise weak links in safety programs. Presumably, these employees remain unconvinced that employers really want to implement strict safety rules. Employee perception of management attitudes toward safety procedures, training, or motivation campaigns forms a basic, though intangible, influence upon the relative success or failure of any safety program. Safety programs are more likely to be effective if management demonstrates to employees a firm commitment to achieve safe working conditions.

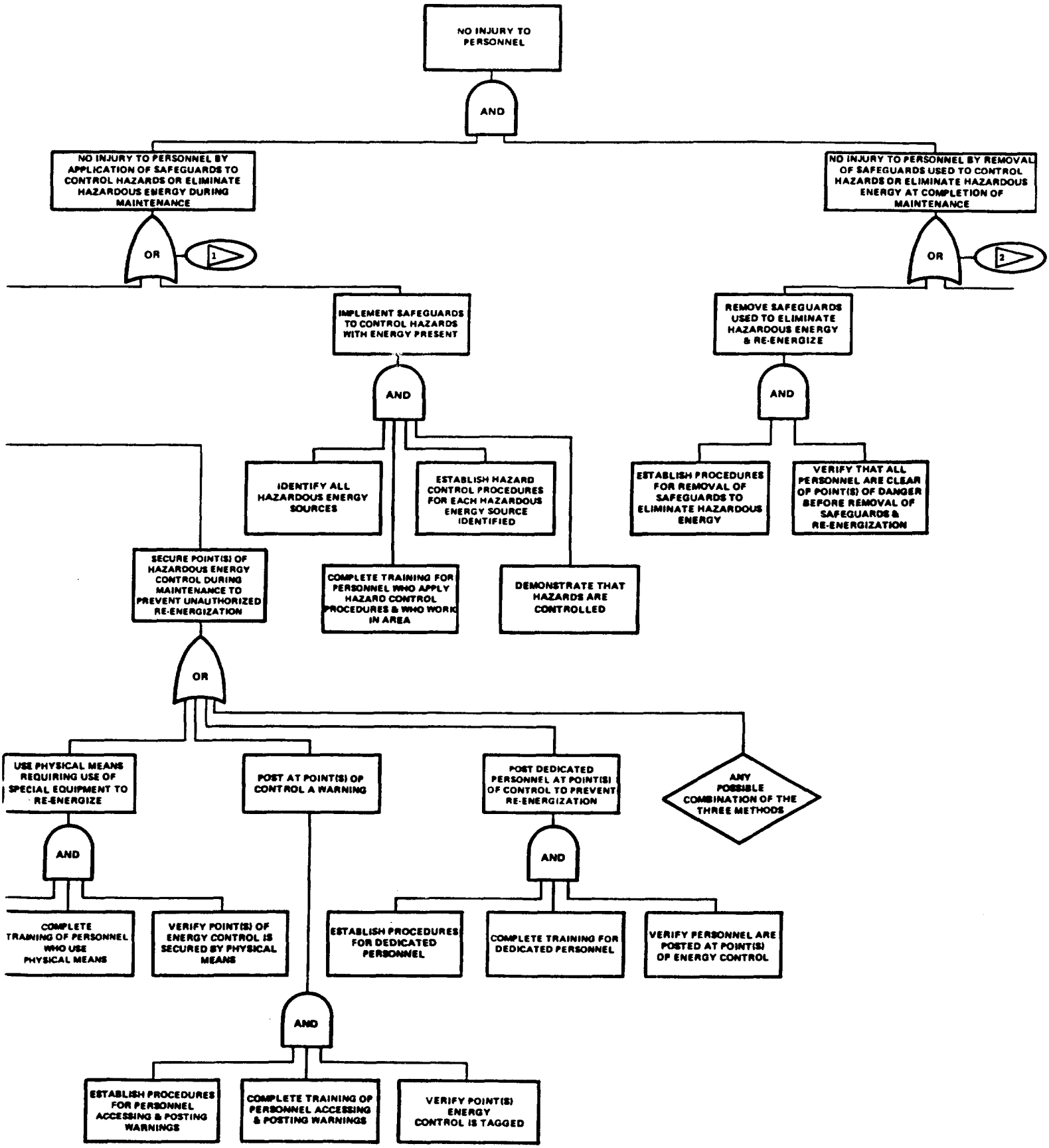
B. DEFINITIONS

Certain terms used throughout these guidelines may have different meaning to different people and may be topics of disagreement. A term may be self-explanatory for some industrial applications, but controversial in other applications. The terms below have the following definitions for the purpose of this document.

Maintenance and Servicing. The tasks necessary to keep a machine, process, or system in a state of repair or efficiency. This activity includes inspection, servicing, repair, troubleshooting, setup, clearing jams, and other related activities. These activities are not considered to commence on a new system

Figure I. DIAGRAM FOR CONTROLLING HAZARDOUS ENERGY DURING MAINTENANCE AND SERVICING



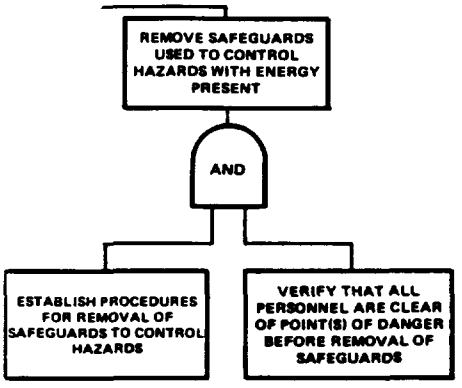

NO INJURY TO PERSONNEL
AND
NO INJURY TO PERSONNEL BY APPLICATION OF SAFEGUARDS TO CONTROL HAZARDS OR ELIMINATE HAZARDOUS ENERGY DURING MAINTENANCE
NO INJURY TO PERSONNEL BY REMOVAL OF SAFEGUARDS USED TO CONTROL HAZARDS OR ELIMINATE HAZARDOUS ENERGY AT COMPLETION OF MAINTENANCE
OR
1
OR
2
IMPLEMENT SAFEGUARDS TO CONTROL HAZARDS WITH ENERGY PRESENT
REMOVE SAFEGUARDS USED TO ELIMINATE HAZARDOUS ENERGY & RE-ENERGIZE
AND
AND
IDENTIFY ALL HAZARDOUS ENERGY SOURCES
ESTABLISH HAZARD CONTROL PROCEDURES FOR EACH HAZARDOUS ENERGY SOURCE IDENTIFIED
ESTABLISH PROCEDURES FOR REMOVAL OF SAFEGUARDS TO ELIMINATE HAZARDOUS ENERGY
VERIFY THAT ALL PERSONNEL ARE CLEAR OF POINT(S) OF DANGER BEFORE REMOVAL OF SAFEGUARDS & RE-ENERGIZATION
SECURE POINT(S) OF HAZARDOUS ENERGY CONTROL DURING MAINTENANCE TO PREVENT UNAUTHORIZED RE-ENERGIZATION
COMPLETE TRAINING FOR PERSONNEL WHO APPLY HAZARD CONTROL PROCEDURES & WHO WORK IN AREA
DEMONSTRATE THAT HAZARDS ARE CONTROLLED
OR
USE PHYSICAL MEANS REQUIRING USE OF SPECIAL EQUIPMENT TO RE-ENERGIZE
POST AT POINT(S) OF CONTROL A WARNING
POST DEDICATED PERSONNEL AT POINT(S) OF CONTROL TO PREVENT RE-ENERGIZATION
ANY POSSIBLE COMBINATION OF THE THREE METHODS
AND
AND
COMPLETE TRAINING OF PERSONNEL WHO USE PHYSICAL MEANS
VERIFY POINT(S) OF ENERGY CONTROL IS SECURED BY PHYSICAL MEANS
ESTABLISH PROCEDURES FOR DEDICATED PERSONNEL
COMPLETE TRAINING FOR DEDICATED PERSONNEL
VERIFY PERSONNEL ARE POSTED AT POINT(S) OF ENERGY CONTROL
AND
ESTABLISH PROCEDURES FOR PERSONNEL ACCESSING & POSTING WARNINGS
COMPLETE TRAINING OF PERSONNEL ACCESSING & POSTING WARNINGS
VERIFY POINT(S) ENERGY CONTROL IS TAGGED

Decision Criteria

1 IMPLEMENTATION OF SAFEGUARDS TO CONTROL HAZARDS WITH ENERGY PRESENT MAY BE CHOSEN INSTEAD OF HAZARDOUS ENERGY ELIMINATION BY DEVICES OR TECHNIQUES, WHEN IT CAN BE DEMONSTRATED THAT HAZARDS ARE CONTROLLED WITH ENERGY PRESENT BY:

1. IDENTIFYING ALL HAZARDOUS ENERGY SOURCES AND HAZARDOUS RESIDUAL ENERGY, AND
2. DOCUMENTING A PROCEDURE FOR AND DEMONSTRATING THAT THE PROCEDURE WILL CONTROL HAZARDS RESULTING FROM EACH HAZARDOUS ENERGY IDENTIFIED.

2 THE DECISION AT THIS POINT IS PREDETERMINED BY THE ORIGINAL OPTION CHOSEN IN 1.



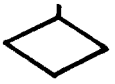
Legend

RECTANGLE SYMBOL – IDENTIFIES AN EVENT THAT RESULTS FROM THE COMBINATION OR EXCLUSION OF ACTIVITIES OR EVENTS.

AND GATE – DESCRIBES AN OPERATION WHEREBY CO-EXISTENCE OF ALL INPUTS ARE REQUIRED TO PRODUCE AN OUTPUT EVENTS.

OR GATE - DEFINES SITUATION WHEREBY AN OUTPUT EVENT WILL OCCUR IF ONE OF THE INPUTS EXIST.

DECISION GATE – EXCLUSIVE OR GATE WHICH FUNCTIONS AS AN OR GATE BUT PROVIDES A FOOTNOTED (▷) LIST OF DECISION CRITERIA ARE NOT SELF EVIDENT.



DIAMOND – DESCRIBES AN EVENT THAT IS CONSIDERED BASIC IN A GIVEN LOGIC SEQUENCE. EVENT IS NOT DEVELOPED FURTHER BECAUSE DEVELOPMENT IS OBVIOUS.

until it becomes operational. For simplification, "maintenance and servicing" are referred to as "maintenance" throughout much of the document.

"Inspection" is defined as checking or testing machinery, equipment, system, etc., against established standards. The definition suggests that the object being inspected has a function and should comply with a standard. From this, it is deduced that (1) a standard must exist that establishes the good or bad characteristics of the object being inspected and (2) the object must be complete so that it can perform its function; i.e., construction, assembly, or manufacture should be complete before the object can be maintained. If the object has more than one function, it may be necessary to change or add parts to the object so that it may perform the different functions. The activity required to make the changes or additions is considered maintenance. In some sectors of industry the term "set-up" is used to denote the activities needed to change the functions of the equipment.

"Service" is defined as repair or maintenance. The definition of service is synonymous with maintenance; however, service (as used in this report) refers to the activities needed to keep a machine, process, or system in a state of efficiency; e.g., changing crank case oil, greasing, cleaning, painting, adjusting, calibrating, etc.

Energy. For this document, "energy" means mechanical motion; potential energy due to pressure, gravity, or springs; electrical energy; or thermal energy resulting from high or low temperature.

As suggested by one of the approaches taken by industry, maintenance may be performed with power off or power on. Maintenance activities, however, are always performed with some form of energy on and some form of energy off. Thus, the concept of "power off" or "power on" implies that power, the time rate at which work is done or energy emitted or transferred, can be turned off. This concept is too restrictive because it does not consider gravity or temperature. The term "energy," as opposed to "power," is therefore suggested as an alternative, because current consensus standards and other literature on this subject use this term. The concept of energy (any quantity with dimensions mass times length squared divided by time squared), however, is too inclusive. The concept of energy, for the purpose of this document, is limited to:

1. Kinetic energy - energy possessed by a body by virtue of its motion.

2. Potential energy - energy possessed by a body by virtue of its position in a gravity field.

3. Electrical energy - energy as a result of a generated electrical power source or a static source.

4. Thermal energy - energy as a result of mechanical work, radiation, chemical reaction, or electrical resistance.

Radiation, the process by which electromagnetic energy is propagated, is not included because this type of energy affects internal organ tolerance, which is a health effect.

Personnel Hazard. A condition which could lead to injury or death. This condition should be recognized by a person familiar with the particular circumstances and facts unique to a particular industry. The following concept of personnel hazard was used to objectively identify hazards to humans: A personnel hazard exists when the environment, conditions, natural phenomena, or equipment characteristics may release levels of energy that exceed human tolerance. This concept encompasses the human physiological tolerance to trauma as well as internal organ tolerance to environment.

Isolated or Blocked Energy. Energy is considered isolated or blocked when its flow would not be reactivated by a foreseeable unplanned event. The term "isolate" means to set apart from others. The term "block" (noun) means an obstacle or obstruction; or, (verb) to make unsuitable for passage or progress by obstruction, to prevent normal functioning.

These terms are similar in meaning, but they cannot be used synonymously in all instances. Although they may describe the same function (i.e., prevention of the normal flow of energy), the way in which the function is performed is different. For instance, to control gravitational energy, the energy should be blocked in the sense that an obstacle or obstruction is placed. It would be incorrect to use the term "isolate" when referring to the control of gravitational energy. Electrical energy should be controlled by isolating it in the sense that it is set apart, or disconnected. It would be incorrect to use the term "blocked" when referring to the control of electrical energy.

The terms may be used synonymously in some cases, such as when referring to blocking the passage of fluid or isolating the pressure in a pipe. Sometimes the difference in meaning becomes evident only by the method used to implement the function.

Point(s) of Control. The point or points from which energy-blocking, -isolating, or -dissipating devices are controlled.

Securing the Point(s) of Control. The point(s) of control are secured to prevent unauthorized persons from reactivating the flow of energy. Securing is a separate and distinct action from isolating or blocking the energy sources. The use of locks, tags, or posting a qualified person or a combination thereof are methods of accomplishing these criteria.

Dissipate Energy. To cause energy to be spread out or reduced to levels tolerable by humans. When the word "dissipate" is applied to the word "energy," the term may be interpreted differently. The following concepts should be used to determine the dissipation activities:

1. Dissipate Mechanical Motion - Motion tends to continue because of inertia after removal of energy; therefore, mechanical motion should be dissipated. For example, a flywheel should be allowed to come to rest before starting work.

2. Dissipate Potential Energy - Potential energy can be manifested in the form of pressure (above or below atmospheric), springs, and gravity. Gravity

can never be eliminated or dissipated; it can only be controlled. Springs under tension or compression can be released (to dissipate stored energy) or the stored energy can be controlled. Pressure may be blocked, isolated, or dissipated. The term "dissipate pressure" implies reducing pressure to a level that would not harm humans. Normally, this pressure value is atmospheric.

3. Dissipate Electrical Energy - Dissipation of electricity may be accomplished by "grounding" the deelectrified portion of the circuit after it has been isolated. Grounding live circuits may be catastrophic. Dissipation of electrical energy includes the actions necessary to prevent the buildup of electrical potential (static electricity).

4. Dissipate Chemicals - Chemical reactions are exothermic or endothermic. Exothermic reactions raise temperatures, which may cause a variety of effects such as fires, explosions, burns, etc. Endothermic reactions lower temperatures and cause the need for additional heat. Some elements manufactured by endothermic reaction are used as explosives or have explosive characteristics because of their instability and rapid release of energy. For the purpose of this document, emphasis is placed on the effort necessary for the prevention or control of chemical reactions. Thus, the term "dissipation of chemicals" implies those actions needed to prevent chemical reactions that would (1) raise or lower temperatures or (2) cause effects which humans cannot tolerate.

5. Dissipate Thermal Energy - Human tolerance to temperature is very limited. Human tissue is harmed when it is exposed to temperatures above 45°C (113°F) or below 4°C (39°F). Since temperature cannot be isolated or blocked, the only way to control its effects on humans is through dissipation or employee protection. Mechanical motion, electrical resistance, chemical reactions, and radiation will raise the temperature of materials which, in turn, can burn or damage human tissue. Therefore, when energy sources that affect temperature are identified in equipment, processes, or systems, controls of the energy source should be effected to allow the temperature to dissipate to a tolerable level.

C. WORKING WITH OR WITHOUT ENERGY PRESENT

The basic decision that must be made before maintenance begins is: Can the task be accomplished safely with or without energy present or is it necessary to deenergize before initiating maintenance?

Concepts which should be considered in this decision include: 1) Energy is always present; 2) energy is not necessarily dangerous; and 3) danger is present only when energy is released in quantities which exceed human tolerances. Further, prior to the development of specific energy control measures, all energy sources should be: 1) identified; 2) analyzed independently; and 3) analyzed in combination with any other energy sources present.

The following paragraphs present criteria which should be considered during analysis of specific energy sources.

D. ENERGY SOURCES

Mechanical motion can be linear translation or rotation, or it can produce work which, in turn, produces changes in temperature. This type of energy can be turned off or left on.

Potential energy can be due to pressure (above or below atmospheric), springs, or gravity. Maintenance is always conducted with gravity on. Potential energy manifested as pressures or in springs can be dissipated or controlled; it cannot be turned off or on.

Electrical energy refers to generated electrical power or static electricity. In the case of generated electricity, the electrical power can be turned on or turned off. Static electricity may not be turned off; it can only be dissipated.

Thermal energy is manifested by high or low temperature. This type of energy is the result of mechanical work, radiation, chemical reaction, or electrical resistance. It cannot be turned off or eliminated; however, it can be dissipated or controlled.

Chemical reaction is manifested by exothermic or endothermic effects. In either case, the energy-on/energy-off approach does not apply. Any material which could chemically react should be eliminated, dissipated, or controlled. That is, some positive measures must be taken to (1) eliminate the chemical so that no chemical reaction can take place, or (2) control the reaction so that the energy released by the chemical reaction will not harm humans. Methods of controlling hazards due to chemicals or chemical reactions as energy sources have not been addressed in this document because of their complexity.

These criteria indicate that some energy sources can be turned off, some can be dissipated, other sources of energy can be eliminated, and some can only be controlled. The following examples illustrate how this concept is applied.

Example 1:

The task is the removal and replacement of a spring in a car. Potential energy is present due to the force of gravity and of the tension or compression of the spring. The force of gravity can be controlled only by blocking the car. The energy stored in the spring can be dissipated or controlled. It is usually controlled by blocking the release of the spring. Therefore, the decision logic indicates that maintenance must be done with energy present.

Example 2:

A large mixing drum with internal rotating blades is in need of repair. One of the mixing blades is out of alignment. The established maintenance procedure requires the entry of two men to realign the blade. The electrical energy source can be switched off and locked out and/or the mechanical linkages can be disconnected. The lockout at the switch will provide a physical barrier and a tag will identify the task being performed. In addition, if the mechanical linkages are disconnected, all energy sources, except gravity, will be removed from the system.

disconnected. The lockout at the switch will provide a physical

II. INVESTIGATION OF THE PROBLEM

Much of the data examined during this study did not include enough specific information to identify the factors causing or contributing to accidents which occur during maintenance as a result of inadequate energy control measures.

However, an extensive search of world literature related to maintenance hazards and maintenance hazard controls, revealed a number of accident scenarios which could be evaluated in the attempt to identify generic causes of maintenance-related accidents. Accidents which could be attributed to the presence of uncontrolled energy during maintenance activities were selected for closer study. Although the limited nature of the information precluded exact cause determination, the scenarios did provide a general indication of causes or contributing causes as well as illustrations of the types of accidents that can occur when hazardous levels of energy are not controlled.

A. THE ACCIDENT SCENARIOS

Out of 300 accident scenarios found in 14 different sources, 59 accidents were selected to illustrate that adequate energy control methods may have prevented the accidents. (A brief description of each accident is included in Appendix B.) Causes of these accidents have been categorized as follows:

1. Maintenance activities were initiated without attempting to deenergize the equipment or system, or control the hazards with energy present.

   Twenty-seven accidents fell into this category. Typical of these accidents was accident No. 10 (Appendix B), in which an experienced repairman saw a piece of wire stuck in a filter wheel. He attempted to remove the wire while the wheel was in motion. Losing his balance, he fell into the wheel. His leg was crushed and had to be amputated.

2. Energy blockage or isolation was attempted, but was inadequate.

   Six incidents were the result of ineffective energy isolation or blockage. An example was accident No. 30 (Appendix B), in which a worker attempted to prevent an elevator from moving by jamming the doors open with a plank while the elevator was on the second floor, and then turning off the outside panel switch on the main floor. He was killed while working on the main floor when the elevator returned to its home base rather than remaining on the second floor.

3. Residual (potential) energy was not dissipated.

   Accident No. 34 (Appendix B) resulted in injury due to failure to dissipate residual energy. The worker turned off the power to a packaging machine and attempted to remove a jam. Residual hydraulic pressure activated the holding device causing the injury.

4. Accidental activation of energy.

   Twenty-five of the accidents were caused by accidental activation. These accidents were caused by either (1) persons unintentionally

actuating controls, or (2) by other persons activating the controls, not realizing that maintenance was in progress. The result, in either case, can be disastrous.

An accident typical of this category was accident No. 36 (Appendix B) in which a mechanic was repairing an electrically operated caustic pump. A co-worker dragged a cable across the toggle switch that operated the pump, and the mechanic was sprayed with caustic. Another incident, accident No. 38 (Appendix B), occurred when an employee was cutting a pipe with a torch and diesel fuel was mistakenly discharged into the line. The ensuing ignition of the diesel fuel resulted in a fatality.

These types of accidents are preventable if effective energy control techniques or procedures are available, workers are trained to use them, and management provides the motivation to ensure their use. Table I summarizes the accident causes and indicates the applicable guidelines from Chapter III which, if followed, would have eliminated the hazard and prevented the accident. In Appendix B, an energy control method that would have been effective is identified for each entry. The methods shown are only examples. For many cases, several energy control techniques could have been used to prevent the accident. In addition, Appendix B identifies the hazard types, energy sources, and accident causes as well as consequences of each accident.

TABLE I

ACCIDENT CAUSE SUMMARY*

	ACCIDENT CAUSE	NUMBER OF ACCIDENTS	APPLICABLE GUIDELINES
1	INITIATED ACTIVITY WITHOUT ATTEMPTING TO CONTROL HAZARDOUS ENERGY	27	A.1., A.2., A.3., AND B.1., B.2., B.3.
2	ENERGY ISOLATION WAS ATTEMPTED BUT WAS INADEQUATE	6	A.2.a. and A.2.d.
3	RESIDUAL ENERGY WAS NOT DISSIPATED	1	A.2.b. and A.2.d.
4	ACCIDENTAL ACTIVATION OF ENERGY	25	A.2.a., A.2.c., A.2.d. and A.2.e.
	ALL CAUSES	59	

* See Appendix B for Accident Descriptions

B. STATISTICAL INVESTIGATION

Besides the literature search, a statistical investigation was undertaken in the attempt to obtain data that would help to identify factors causing or contributing to the type of accident under consideration.

It was planned that statistical accident data would be obtained that related to inadequate energy controls during maintenance. The data would help to identify ineffective control methods and particular problems that should be avoided. Manual and automated searches were conducted to locate the information. Most of the data found, however, did not include enough specific information to identify the factors causing or contributing to the accidents. This finding coincides with the results of a study conducted by the National Safety Council and reported on June 30, 1978 to the members of the National Safety Council President's Advisory Committee and Technical Work Session Participants of the National Program to Improve Occupational Injury Information. The report states:

> "Problems with the technical quality of current data. These include the lack of detail, consistency, and relevance for the development of countermeasures in current occupational injury data. Existing data are very limited.
>
> Occupational injury data are often gathered primarily for the purpose of processing worker's compensation claims rather than for developing countermeasures. Most current information systems emphasize data about the injury, not the accident, and about the end results of the accident sequence, rather than the precipitating events and conditions leading to the injuring event. Data of the latter type are often much more important for the development of countermeasures.
>
> The ANSI Z16.2 American National Standard Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries, or an adaptation of this coding method, is used almost exclusively among both the Federal and State Government agencies and private sector information systems. The ANSI Z16.2 method is extremely limited and is designed primarily as a monitoring tool for grouping accidents by major types and for flagging a limited number of isolated factors about accidents so that the cases can be recalled when data analysis begins. The ANSI Z16.2 method is not designed as an analytical tool for identifying the patterns, the precipitating events and conditions in an accident sequence, or the relationships among contributing causal factors in an accident that are normally needed for countermeasure development."

Attempts to obtain more specific data from such sources as associations, insurance companies, labor unions, and industry proved unsuccessful because of one or more of the following reasons:

1. Trade associations did not collect the data, or the data were not collected in a useful format or for specific enough instances.

2. Data from insurance companies, private companies, and unions are considered proprietary and/or involve liability considerations.

3. Changing format and editing the data would be too time consuming or costly (the data are considered proprietary without changing format and editing, and insurance companies are not interested in reworking the data).

III. GUIDELINES FOR CONTROLLING HAZARDOUS ENERGY DURING MAINTENANCE AND SERVICING

(The following guidelines for controlling hazardous energy during maintenance and servicing of machinery, processes, or systems are shown graphically in Figure I. References which support the use of each specific guideline may be found, cross-referenced to the text of this section, in Appendix E.)

In order to protect the worker from energy-related hazards during maintenance or servicing of a machine, process or system, method A or B of hazard control must be chosen.

Several factors must be considered in deciding if energy should be eliminated and determining what method of hazard control should be implemented for a particular application. Factors that should be considered include (1) the energy level, (2) the access or proximity to the energy source necessary to accomplish the work, and (3) whether proven methods exist for performing the task safely with hazardous energy present.

A. CONTROLLING HAZARDOUS ENERGY SOURCES

*1. **If deenergizing is chosen, a thorough inspection should be performed to identify <u>all</u> potentially hazardous energy sources, including adjacent equipment or energy sources that represent hazards to personnel.***

*2. **When all potentially hazardous sources of energy have been identified, each source must be controlled and the device controlling the energy source must be secured and verified. The following are steps to accomplish the control of hazardous energy sources:***

*a. **All energy sources identified as hazardous shall be isolated, blocked, or dissipated at points of control that cannot, with reasonable effort, be overridden or by-passed.*** These isolated points of control must be secured in accordance with paragraph A.2.c. of these guidelines to ensure complete blockage for the duration of the maintenance operation to preclude any possibility of reactivating the flow of energy.

Energy is considered adequately isolated, blocked, or dissipated when an unplanned event would not reactivate the flow of energy. Adequate isolation can be achieved by many methods or combinations of methods so long as the controls are not likely to be accidentally turned on. Appendix A identifies several examples of methods of effectively isolating or blocking energy.

*b. **Stored or residual energy that constitutes a personnel hazard shall be isolated, blocked, or dissipated.***

Another necessary step is to block or dissipate any hazardous residual energy once the decision is made to deenergize. Residual energy is not always as obvious a hazard as the incoming energy supplies. For this reason, special effort must be made to identify any stored energy that could result in personnel hazards. For example, if it is

necessary for a worker to climb or move about mechanical linkages, the potential energy due to the worker's weight may be sufficient to cause dangerous movements of the linkages. If this hazard is present, a mechanical block or pin can usually be used to block out the energy and potentially dangerous movement.

Forms of potential energy which may be stored in sufficient quantities to represent hazards include:

- Hydraulic or pneumatic pressure
- Pressure below atmospheric (as in vacuum systems)
- Compressed or extended springs
- Potential energy due to gravity
- Stored mechanical energy (as in flywheels)
- Static electricity
- Stored electrical energy (as in batteries)
- Stored electrical energy (as in capacitors)
- Thermal energy due to residual heat or low temperature
- Residual chemicals in pipe which may cause thermal or pressure buildups.

If stored hazardous energy is present in any form, care must be taken to ensure that the residual energy is reduced to a nonhazardous level. Extra care must be exercised to avoid reaccumulation of energy to hazardous levels. Special measures to continuously bleed off energy should be used if energy buildup is possible. In addition, monitoring to be sure energy has not accumulated to dangerous levels may be necessary.

c. ***The point(s) of control shall be secured so that unauthorized persons are prevented from reenergizing the machine, process, or system.***

A means of security must be implemented to ensure that the equipment being maintained or serviced is not somehow reenergized. The guidelines allow a choice of three methods. The selection should be based on the particular circumstances and characteristics of each respective facility or application. A farm employee working with potentially hazardous powered equipment in a remote field would not be expected to use a padlock for security. A padlock (or equivalent), however, would be a logical selection for a switch or valve accessible to a large number of people. The use of tags, when only trained personnel have access to the point(s) of control is an accepted industry practice. Any one of the following methods will prevent unwanted reenergization of equipment.

(1) Secure by physical means ("Lockout") such that reenergizing the system requires the use of special equipment routinely available only to the person who applied the control. A warning containing appropriate information shall be displayed at the point(s) of control. The method of securing the points of control by physical means that prevent unauthorized persons from reenergizing the machine, process, or system is widely used. The most common device used for security is the padlock. Often each worker is provided with his own padlock and the only key.

(2) Post a warning ("Tagout") at the point(s) of control providing information as to why the energy sources have been isolated, blocked, or dissipated, the date, the person(s) responsible for the control measure, and the person(s) responsible for the work to be accomplished. In addition, access to the control point(s) must be limited to persons who are trained to understand and observe the posted warning. Access may be limited by physical location (such as elevation) or by procedural means such as color-coded badges. When this method of security is used, each new employee should receive training to observe the guidelines before having access to the point(s) used for controlling energy. The training should include the purpose of the warning, the format and color of the warning, and should stress the responsibility of each person for his co-workers' safety. Retraining should be given as necessary so that the importance of observing the posted warning is not forgotten.

(3) Post qualified personnel, with the specific responsibility of protecting against unauthorized actuation, at the point(s) of control throughout the maintenance activity. This applies mainly to short duration work in the immediate vicinity of the control point(s).

d. Before starting maintenance, verify that steps a. through c. have been effective in isolating, blocking or dissipating hazardous energy, and securing the point(s) of control.

In applying any method or technique to isolate, block, or dissipate energy from specified areas, devices, machines, systems, or processes, it should be verified that deenergization has been effected prior to the start of maintenance. Verification should be accomplished each time energy is eliminated and reapplied, regardless of the time interval between removal and reapplication. Proven methods should be used to effectively demonstrate that all hazardous energy has been isolated, blocked, or dissipated in the areas where personnel will perform the required tasks. If there is the possibility of reaccumulation of energy to hazardous levels, verification should be continued until the maintenance activity is completed.

If sensing devices are used for verification, these devices shall be used according to established procedures that have been determined to safely and consistently indicate the presence of energy. These sensing devices should be primary; i.e., they should not depend upon secondary or derived indications which could induce greater probability

used according to established procedures that have been determined to

of error. The devices should be regularly and frequently inspected and/or calibrated to ensure that they are functional and accurate and to detect any potential device failures.

Good intentions to eliminate energy have failed and injuries have resulted when the wrong sources of energy were controlled. To avoid this possibility, the energy should be verified to be below hazardous levels before proceeding.

e. ***Verify that all personnel are clear of the point(s) of danger before reenergizing the machine, process, or system.***

This action is so obvious that many references fail to identify it; yet it is vitally important that it be included in each procedure.

3. For the five steps listed above to comprise a valid technique for controlling hazardous energy sources, the following two preconditions must be met:

a. ***The procedures to be used to accomplish the above steps shall be documented.***

Procedures for energy control applications should be documented to the detail required to provide a clear understanding of the devices and methods of application and removal, so that the controls are uniformly and safely applied and removed each time. The procedures should clearly assign responsibility for each step of the criteria as well as indicate where isolation, blocking, or dissipation of energy is to be accomplished, how deenergization is to be verified, what method is to be used for security, and how responsibility is to be transferred during shift changes. The procedures need not be unique for a single machine or task; procedures may be used which apply to a group of similar machines or tasks. Depending upon the complexity of the equipment and its application, good procedures may vary from one to many pages. No matter how simple and straightforward the procedures may seem, they should be documented so that all levels of personnel understand company policy, as well as the required safety procedures.

b. ***The personnel who implement the above steps shall be qualified. Each worker must thoroughly understand all documented procedures. Training shall be accomplished as necessary to establish and maintain proficiency, and to encompass procedural or equipment changes which affect energy control during maintenance.***

After the energy control need has been identified, the methods of implementation selected, and the procedures finalized, a training program should be instituted to ensure that the procedures are followed and the purpose and functions are understood. The training should involve elements of management and the workforce concerned with maintenance activities so that the criteria are expeditiously and uniformly applied. The training should ensure that the understanding and skills required for the safe application and removal of energy controls are available as required. Retraining should be scheduled as

the criteria are expeditiously and uni-

often as necessary to maintain proficiency and to introduce revised devices, practices, and methods.

If energy isolation, blocking, or dissipation are secured according to criterion 2.c.(2), then every person having job related access to the point(s) of control should be trained. This training is in addition to that required for personnel involved in applying energy controls. The training should include the purpose of the warning, the format and color of the warning, and should emphasize the extreme importance for all personnel to obey the warnings in order to protect their co-workers. The personnel who implement the procedures should be trained not only to know how to accomplish the steps required to control energy sources, but also to understand the hazards associated with energy sources. All levels of supervision concerned with maintenance and servicing, with special emphasis on first-line supervision, must be trained in order to ensure that procedures are followed.

B. CONTROLLING HAZARDS WITH ENERGY PRESENT

Controlling maintenance hazards with energy present is the only alternative to deenergizing to perform maintenance tasks safely. For some types of machines or processes, the conditions or combination of conditions that must be evaluated and controlled in energized systems can be much more complex than deenergized systems. The following paragraphs describe guidelines for maintaining "energized" systems.

1. ***Hazardous energy sources, including residual energy sources, shall be identified.***

   Identification of the hazards needs no justification, for a hazard cannot be controlled unless it is identified.

2. ***Documented procedures, which have been determined to control each hazardous energy source, shall be used. Procedures shall assign responsibility and accountability for controlling personnel hazards.***

   Before a worker is exposed to a hazard, the hazard controls must be known to be effective. Determination of hazard control effectiveness can be based on physical demonstration prior to implementation on a day-to-day basis. This can be by similarity to a demonstrably effective hazard control, or by analysis.

3. ***Personnel who perform the maintenance shall be qualified to use the procedures. Qualification to use the procedures may be obtained by education, experience and/or training.*** The personnel who perform the maintenance and servicing activities must be trained to understand the particular hazards, the controls for the hazards, and how to implement the controls effectively.

IV. CONCLUSIONS

This study confirms that the need to control hazardous energy during maintenance activities is recognized by industry, labor, and the Government. This need is manifested by the different approaches implemented by industry to reduce injuries, the evidence submitted to the Occupational Safety and Health Administration at public hearings on the subject of lockouts and tagouts, and results of the literature search in which a great number of articles were found which emphasize the need for some type of control.

The literature review did not produce statistical evidence of the effectiveness of any one specific type of energy control method over another, nor did it identify accident causative factors leading to injuries. No values could be developed which differentiate accidents and injuries occurring during maintenance from aggregate U.S. injury statistics; i.e., data to provide indices on the probability of injury occurrence, the magnitude of the injuries, and the exposure to the hazard (population of workers at risk) that correlate with the identified primary hazard causes.

Industrial accident and injury data available in the U.S. describe the injuries sustained by the workers in greater detail than the causes of the accidents that inflicted the injuries. The hazard causes found in the analyzed accident reports are categorized by fire, explosion, impact, fall, caught in or between, and others. The hazard causes identified by this study are different. Consequently, the published statistics (aggregates of accident/injury reports) cannot be broken down into accident causes identified as specific to maintenance and servicing activities.

The study identified the following hazard causes:

1. Maintenance activities were initiated without attempting to deenergize the equipment or system or control the hazard with energy present.

2. Energy blockage or isolation was attempted, but was inadequate.

3. Residual energy was not dissipated.

4. Energy was accidentally activated.

The worker population at risk could not be defined because employers who implement procedural controls may choose to make the procedures applicable to (1) all personnel; (2) personnel engaged in any one or any combination of activities such as construction, operations, manufacturing, testing, etc.; or (3) maintenance personnel only. Thus, the effectiveness of any one method of control with respect to another cannot be determined. However, the implementation of any method which increases worker awareness of potentially hazardous energy sources is better than no method at all.

Existing Federal and State Government safety regulations (California and Michigan excepted) of energy control during maintenance are inconsistent, fragmented, and only applicable to certain equipment, processes, and industries (e.g., telecommunication and construction). Most of these existing regulations use the concept of "power off" to prevent injuries, and do not

provide guidance on how to discern when to apply locks, tags, or a combination of locks and tags. They also do not allow for the performance of maintenance with power on, even under normal, everyday conditions, or when such maintenance cannot be performed with power off.

V. RESEARCH NEEDS

While developing the guidelines, areas were identified in which additional research would prove valuable.

A. STUDY CONTINUATION

The result of this study, "Guidelines for Controlling Hazardous Energy During Maintenance and Servicing," is a consolidation of different approaches already in use. These guidelines increase the latitude of implementation methods available. The greater latitude, in turn, may create problems which have not been anticipated. It is therefore recommended that studies be conducted to:

1. Develop universal procedures for the recommended guidelines
2. Identify problems created by the guidelines, if any
3. Identify effectiveness of different hazard control methods in preventing injuries
4. Identify costs of implementing the guidelines.

B. GUIDELINES FOR OTHER MAINTENANCE HAZARDS

This technical report addresses one of several maintenance activities which require decision criteria. These activities are: selection and use of tools; selection and use of ancillary equipment; selection of access routes to and from the maintenance area; evaluation of the maintenance environment; selection of skilled personnel; and identification and verification of energy sources. The guidelines herein suggest actions that should be taken after the energy sources have been identified. Guidelines which address the selection and use of tools, as well as the selection of personnel, should be developed. Further, guidelines addressing selection of access methods to and from the maintenance area, and evaluation of maintenance environments should be developed.

Materials having toxic, caustic, or asphyxiant properties can present serious hazards to maintenance personnel. Suitable control measures for materials having these dangerous properties do not necessarily match the criteria for control of hazardous energy recommended within this document. In fact, personnel can be harmed by toxic, caustic, or asphyxiant materials with no concurrent release of energy. It is therefore recommended that criteria be developed specifically to protect maintenance personnel from such hazardous materials.

C. POTENTIAL HAZARDS IN NEW TECHNOLOGICAL APPLICATIONS

Currently, U.S. industries utilize many old machines and processes. To compete more effectively in the world marketplace, U.S. industry will have to replace aging machines and processes with new, more efficient equipment including robotic and fully automatic machines. In some cases, the influx of new machines and technology into U.S. industry may mean greater safety for the worker; in other cases, it may pose new or unknown hazards. A research effort is needed to assess the safety of these new technologies and materials.

Some examples of recent advances in manufacturing techniques and materials that could pose unique hazards to workers include: numerical control; robotic machines; laser applications; new materials for tools, workpieces, finishes, lubricants, molds, bonding, and welding; ultrasonic applications; and explosive forming. The research effort should focus on identifying potential hazards and determining corrective action which either reduces hazardous energy levels or changes the worker's proximity to hazardous energy.

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VII. APPENDIX A

EXAMPLES OF ALTERNATE METHODS OF ISOLATING OR BLOCKING ENERGY AND SECURING THE POINT(S) OF CONTROL

APPENDIX A

EXAMPLES OF ALTERNATE METHODS OF ISOLATING OR BLOCKING ENERGY AND SECURING THE POINT(S) OF CONTROL

ENERGY TYPE	METHOD OF ISOLATING OR BLOCKING ENERGY	METHOD OF SECURING THE POINT OF CONTROL	REMARKS
Mechanical Motion Rotation Translation Linear Oscillation	1. Remove segments of operating mechanical linkages such as dismantling push rods, removing belts, and removing flywheels.	(1) Tag the linkages and place them in a locked cabinet away from the machine. or (2) Attach warning tags where the linkages were removed and restrict access to trained personnel. or (3) Post a person to protect against unauthorized reinstallation of the linkages.	
	2. Use blocking devices such as wood or metal blocks.	(1) Chain and lock in point of control or use metal pins driven or welded in place. or (2) Attach warning tags on the blocking devices and restrict access into the area to trained personnel. or (3) Post a person to protect against unauthorized removal of the blocking devices.	

ENERGY TYPE	METHOD OF ISOLATING OR BLOCKING ENERGY	METHOD OF SECURING THE POINT OF CONTROL	REMARKS
Mechanical Motion (continued)	3. Remove power or energy from the driving mechanism, such as: a. Disconnect main electrical source. b. Close hydraulic or pneumatic valves, bleed.	(1)a. Padlock in the "off" position. b. Disconnect pneumatic and hydraulic lines and tag. or (2) Attach warning tags at control points and restrict access to trained personnel. or (3) Post a person to protect against unauthorized reconnection of the energy sources.	Check for alternate sources of power. Check for residual pneumatic and hydraulic energy.
Electrical	1. Place the main electrical disconnect switch in the "off" position.	(1) Secure by a padlock, a clip and padlock, or a bar and padlock. or (2) Attach a warning tag and restrict access into the area to trained personnel. or (3) Post a person to protect against unauthorized actuation of the switch.	Check for alternate sources of power.

ENERGY TYPE	METHOD OF ISOLATING OR BLOCKING ENERGY	METHOD OF SECURING THE POINT OF CONTROL	REMARKS
Electrical (continued)			
	2. Remove segments of electrical circuit, such as printed circuit modules.	(1) Tag the module and place in a locked cabinet away from the control center and tag the control center door. or (2) Attach a warning tag at the module location and restrict access to trained personnel. or (3) Have a person remain at the control center to protect from unauthorized installation of a spare or replacement module.	
Thermal (Steam)	1. Close valves and maintain an open bleed.	(1) Chain and padlock valve or use blind flanges or slip blinds. or (2) Attach warning tags to the valves and restrict access to the area to trained personnel. or (3) Station a person at the valve locations to protect against unauthorized or inadvertent opening of valves.	Allow time for residual heat to dissipate.

ENERGY TYPE	METHOD OF ISOLATING OR BLOCKING ENERGY	METHOD OF SECURING THE POINT OF CONTROL	REMARKS
Potential Pressure	1. Close valves and maintain open vent to relieve.	(1) Secure, block, blind flange, slip blind, or valve with locking device. or (2) Attach warning tags and restrict access to trained personnel. or (3) Station a person at the valves to protect against unauthorized actuation.	
Potential Gravity	2. Block in place by using metal or wood blocks under the mechanism or pin the linkages in a position where gravity will not cause the mechanism to inadvertently fall.	(1) Secure, block, or pin with a locking device. or (2) Attach warning tags to blocks, linkages, and pins and restrict access to trained personnel. or (3) Station a person at the mechanism to prevent unauthorized removal of blocks and pins and reinstallation of linkages.	Energy could be dissipated by lowering to a point where gravity could no longer cause inadvertent falling.

ENERGY TYPE	METHOD OF ISOLATING OR BLOCKING ENERGY	METHOD OF SECURING THE POINT OF CONTROL	REMARKS
Potential (continued)			
Springs	3. Block in a safe position by pinning or clamping the device eliminating the potential of unrestricted and undesired travel.	(1) Secure pin or clamp in place with a locking device. or (2) Attach warning tags to the pins and clamps and restrict release or access to trained personnel. or (3) Station a person at the control point to protect against pin or clamp removal and unauthorized activation of the spring mechanisms.	Spring energy could be dissipated by release or dismantling of the mechanism.

VIII. APPENDIX B

EXAMPLES OF ACCIDENTS PREVENTABLE BY GOOD ENERGY CONTROL TECHNIQUES

APPENDIX B

DESCRIPTION OF ACCIDENT	REFERENCE [NO. IN BRACKETS]	HAZARD TYPE	ACCIDENT CAUSES	ENERGY SOURCE	ENERGY CONTROL METHOD
1. WITHOUT DISCONNECTING THE ELECTRICAL SOURCE, AN EMPLOYEE ATTEMPTED TO BREAK A CONNECTION IN A 2300-VOLT CIRCUIT (WITHOUT ALSO TESTING THE CIRCUIT), RESULTING IN FATAL ELECTROCUTION.	[4]	SHOCK FATALITY	1	ELECTRICAL	ELECTRICAL DISCONNECT
2. WHILE MAKING ADJUSTMENTS TO A DUMB WAITER, THE BACK OF A MECHANIC'S HEAD MADE CONTACT WITH AN OPEN ELECTRICAL RESET SWITCH RESULTING IN CONVULSIVE SHOCK AND A SEPARATED AND FRACTURED SHOULDER.	[1]	SHOCK FRACTURE	1	ELECTRICAL	ELECTRICAL DISCONNECT
3. AN ELECTRICIAN WAS ELECTROCUTED WHILE REPAIRING A 480-VOLT ELECTRICAL CABLE IN AN AUTOMOBILE MANUFACTURING PLANT.	[2]	SHOCK FATALITY	1	ELECTRICAL	ELECTRICAL DISCONNECT
4. AN EMPLOYEE WAS DISMANTLING A DRILLING RIG. AFTER REMOVING THE MAIN PIN ON THE BOOM, HE WAS MOVING TO THE CONTROL STATION WHEN THE BOOM FELL AND STRUCK HIM. HE HAD FAILED TO INSTALL THE SAFETY PIN.	[2]	IMPACT FATALITY	1	GRAVITY	BLOCKING DEVICE
5. THE CONVEYOR STARTED UP AS THE MAN WAS STANDING ON IT TO WORK ON AN OVERHEAD CHUTE.	[88]	IMPACT FATALITY	1	TRANSLATION	ELECTRICAL DISCONNECT
6. A MAN WAS CAUGHT BETWEEN A VERTICAL CONVEYOR AND A BARRIER GUARD.	[89]	CRUSHED FATALITY	1	TRANSLATION	ELECTRICAL DISCONNECT

7. [4] A REPAIRMAN WAS CRUSHED BETWEEN TWO PATTERNS OF COPE MACHINE UNDER AIR PRESSURE.	CRUSHED FATALITY	1	TRANSLATION	BLOCKING DEVICE
8. [13] A HOPPER GATE CLOSED ON THE TORSO OF A WELDER WHO WAS REPAIRING THE HOPPER LINING.	CRUSHED FATALITY	1	TRANSLATION	ELECTRICAL DISCONNECT
9. [2] AN EMPLOYEE WAS CLEANING ON THE UNGUARDED SIDE OF A GRANITE WIRE SAW WHEN HE SLIPPED AND FELL. HE WAS CAUGHT BY THE WIRE CLOSEST TO THE OUTSIDE OF THE IDLER WHEEL AND PULLED INTO THE NIP POINT AREA, RESULTING IN FATAL INJURIES.	LACERATIONS FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
10. [1] A REPAIRMAN ATTEMPTED TO CLEAN A FILTER WHEEL WHILE IT WAS IN OPERATION. LOSING HIS BALANCE, HE FELL ON THE WHEEL; HIS LEG WAS CAUGHT BETWEEN THE MOVING WHEEL AND THE ROLLER RESULTING IN A CRUSHED LEG THAT HAD TO BE AMPUTATED.	AMPUTATION INJURED	1	ROTATION	ELECTRICAL DISCONNECT
11. [89] A JOBSETTER WAS HAVING PROBLEMS WITH A SWITCH ON AN UNLOADING FIXTURE OF AN AUTOMATIC TRANSFER LINE. THE GUARD WAS REMOVED TO OBSERVE THE OPERATION OF THE SWITCH. AS THE UNLOADER ACTUATED, IT CAUGHT THE MAN AND SQUEEZED HIM BETWEEN THE MOVING UNLOADER AND THE SUPPORT POST FOR THE GUARD.	CRUSHED FATALITY	1	TRANSLATION	ELECTRICAL DISCONNECT
12. [2] AN EMPLOYEE WAS LUBRICATING THE CHAIN DRIVE LINKS IN A CONVEYOR BELT SYSTEM THROUGH A 10" X 12" OPENING BETWEEN THE BINS AND THE METAL GUIDE POST OF THE UNSTACKER WHILE THE MACHINERY WAS RUNNING. AS THE BINS MOVED FORWARD, HIS HEAD WAS CAUGHT BETWEEN THE BIN AND THE GUIDE POST.	CRUSHED FATALITY	1	TRANSLATION	ELECTRICAL DISCONNECT

AS THE BINS MOVED FORWARD, HIS

13. [1] AN EMPLOYEE WAS WORKING ON FOUR DIVERTER VALVES INSIDE A CABINET WHEN A VALVE WAS ACTIVATED BY COMPUTER CONTROL. THE EMPLOYEE WAS STRUCK ON THE SIDE OF HEAD BY THE VALVE ARM.	CONTUSION INJURED	1	TRANSLATION	ELECTRICAL DISCONNECT
14. [2] AN EMPLOYEE HAD BEEN FEEDING WASTE PAPER INTO AN INTAKE DUCT FAN ASSEMBLY OF A PAPER SHREDDER AFTER REMOVING THE FAN COVER. WITH THE FAN STILL OPERATING, HE ATTEMPTED TO REPLACE THE COVER WHEN HE WAS PULLED INTO THE FAN RESULTING IN A FATALITY.	LACERATIONS FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
15. [2] AN EMPLOYEE WAS STANDING ON A STRUCTURAL BEAM OF A SHAKER ATTEMPTING TO UNJAM SAWDUST IN AN AUGER WITH A STICK WHEN HE WAS PULLED INTO THE AUGER AND CRUSHED TO DEATH.	CRUSHED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
16. [2] WHILE AN EMPLOYEE WAS CLEANING A BRICK CUTTER MACHINE WITHOUT TURNING OFF AIR PRESSURE, THE MACHINE WAS ACCIDENTALLY ACTIVATED, AND HE WAS DRAGGED INTO THE CUTTER.	LACERATIONS FATALITY	1	ROTATION	PNEUMATIC DISCONNECT
17. [1] AN OPERATOR REMOVED THE SLEEVE FROM A BAGGING MACHINE TO CLEAR AN OBSTRUCTION FROM THE FEED SCREW. THE MACHINE WAS STILL RUNNING, AND HIS FINGER WAS CAUGHT.	AMPUTATION INJURED	1	ROTATION	ELECTRICAL DISCONNECT
18. [1] A MACHINE OPERATOR WAS ATTEMPTING TO UNJAM VINYL MATERIAL IN THE AIR LOCK PORTION OF A RECLAIM SYSTEM. A HATCH ABOVE THE AIR LOCK WAS OPENED, AND HE REACHED INTO THE THROAT WITH HIS HAND TO PUSH THE MATERIAL FREE. HIS HAND WENT DOWN INTO THE ROTATING VANES AND HIS FINGER WAS AMPUTATED.	AMPUTATION INJURED	1	ROTATION	ELECTRICAL DISCONNECT

19. AN OPERATOR ATTEMPTED TO CLEAN OUT THE DOOR TRACK OF A DRYER WITHOUT TURNING THE MACHINE OFF WHEN THE AGITATOR STRUCK HIS FINGER.	[1]	LACERATIONS INJURED	1	ROTATION	ELECTRICAL DISCONNECT
20. AN EMPLOYEE REMOVED A COVER FROM A SCREW CONVEYOR TO CHECK IF IT WAS RUNNING. HE LOST HIS BALANCE AND STUCK HIS FOOT INTO THE CONVEYOR.	[1]	AMPUTATION INJURED	1	ROTATION	ELECTRICAL DISCONNECT
21. AN EMPLOYEE ATTEMPTED TO REMOVE SOME CLOGGED COMPOST MATERIAL THAT HAD JAMMED AN OPERATING KILN DISCHARGE CONVEYOR. HIS CLOTHING BECAME ENTANGLED IN THE UNGUARDED REVOLVING ROLLERS. HIS ARM WAS CAUGHT IN THE MACHINE. HE WAS PULLED AGAINST THE MACHINE AND WAS CHOKED TO DEATH.	[2]	CHOKED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
22. AN EMPLOYEE WAS ATTEMPTING TO CLEAR A JAM ON A GARNETT MACHINE WHILE IT WAS IN OPERATION. HE CRAWLED INSIDE THE MACHINE THROUGH AN UNGUARDED HOLE WHERE HE BECAME ENTANGLED IN MOVING PARTS, WAS DRAWN INTO THE ROLLER AND WAS CRUSHED.	[2]	CRUSHED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
23. AN EMPLOYEE WAS CLEANING AN EDGER SAW IN A SAWMILL. PROTECTIVE PANELS WERE REMOVED. HE REQUESTED ANOTHER EMPLOYEE TO START THE SAW. HIS CLOTHES BECAME ENTANGLED AND HE WAS PULLED INTO THE SAW.	[2]	LACERATIONS FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
24. AN EMPLOYEE WAS EMPTYING DOUGH FROM A MIXER WHILE IT WAS STILL RUNNING. WHEN HE REACHED INTO THE MACHINE HIS ARM WAS CAUGHT AND HE WAS PULLED INTO THE MACHINE.	[2]	CRUSHED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT

25. [2] AN EMPLOYEE REACHED TO FREE A CLOTH THAT HAD WRAPPED AROUND THE WHIPROLL OF AN OPERATING TEXTILE DOLLEY WASHER. HIS HAND WAS CAUGHT IN THE CLOTH AND HE WAS DRAGGED INTO THE WHIPROLL.	CRUSHED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
26. [2] AN EMPLOYEE WAS USING A HOOK TO CLEAN THE WOOL FROM THE BRUSH ROLLER OF A YARN CARDING MACHINE WHILE IT WAS RUNNING. HE WAS PULLED INTO THE MACHINE.	CRUSHED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
27. [2] AN EMPLOYEE WAS WIPING THE MIXER SHAFT WITH A LARGE RAG WHILE THE MIXER WAS RUNNING. THE CLOTH BECAME ENTANGLED AND PULLED HIM AGAINST THE STEEL ARM THAT HELD THE SHAFT.	CRUSHED FATALITY	1	ROTATION	ELECTRICAL DISCONNECT
28. [1] AN ELECTRICIAN WAS REPAIRING A BURNED FEEDER TO A FURNACE. HE GRASPED A AND B PHASE FEEDERS, A CURRENT PASSED THROUGH BOTH ARMS AND CHEST CAUSING BURNS TO BOTH HANDS AND A FALL. AUXILIARY POWER WAS STILL ON.	BURNS INJURED	2	ELECTRICAL	ELECTRICAL DISCONNECT
29. [5] A PLANT ELECTRICIAN WAS REPAIRING SOME DAMAGED ELECTRICAL CABLES. CIRCUIT BREAKERS HAD BEEN OPENED IN A SUBSTATION. AS HE CUT ONE OF THE CABLES, HE WAS ELECTROCUTED. PROPER VOLTAGE TESTS WERE NOT MADE PRIOR TO BEGINNING WORK.	SHOCK FATALITY	2	ELECTRICAL	ELECTRICAL DISCONNECT

30. [2] AN EMPLOYEE WAS PERFORMING DRYWALL REPAIRS FROM THE INSIDE OF AN ELEVATOR SHAFT RATHER THAN FROM THE OUTSIDE AS INSTRUCTED. A WOODEN BEAM WAS USED TO JAM THE ELEVATOR DOOR ON THE SECOND FLOOR AND THE OUTSIDE PANEL SWITCH ON THE MAIN FLOOR HAD BEEN TURNED OFF. THE EMPLOYEE WAS CRUSHED TO DEATH BY THE ELEVATOR WHEN WORKING ON THE MAIN FLOOR BECAUSE THE ELEVATOR RETURNED TO ITS HOME BASE RATHER THAN REMAINING ON THE SECOND FLOOR.	CRUSHED FATALITY	2	TRANSLATION	ELECTRICAL DISCONNECT
31. [2] THE WASTE HOGGER OPERATOR CLEANING THE MACHINE FELL INTO A CONVEYOR AND WAS PULLED INTO A 14-INCH OPENING AND CRUSHED. THE HOGGER HAD BEEN TURNED OFF BUT NOT THE CONVEYOR.	CRUSHED FATALITY	2	TRANSLATION	ELECTRICAL DISCONNECT
32. [2] AN EMPLOYEE WAS PARTIALLY INSIDE AN ASPHALT MIXING MACHINE CHANGING PADDLES. ANOTHER EMPLOYEE ACCIDENTALLY HIT A TOGGLE SWITCH WHICH CLOSED THE DOOR OF THE MIXER, STRIKING THE MAN.	IMPACT FATALITY	2	TRANSLATION	ELECTRICAL DISCONNECT OR BLOCKING DEVICE
33. [1] A WORKER WAS REPLACING A V-BELT ON A DUST COLLECTOR BLOWER. HE HAD SHUT DOWN THE UNIT BY A LOCAL SWITCH ONLY. AN OPERATOR IN THE CONTROL ROOM RESTARTED THE UNIT, USING A REMOTE SWITCH CENTER. THE WORKER'S HAND WAS CAUGHT BETWEEN THE PULLEY AND BELTS RESULTING IN CUTS AND A FRACTURED FINGER.	FRACTURE INJURED	2	ROTATION	ELECTRICAL DISCONNECT
34. [91] AN EMPLOYEE REMOVED A JAM FROM A PACKAGING MACHINE WITH THE POWER TURNED OFF. RESIDUAL HYDRAULIC PRESSURE ACTIVATED THE HOLDING DEVICE.	CRUSHED INJURED	3	TRANSLATION	BLOCKING DEVICE

35. TWO EMPLOYEES HAD OPENED A PIPE-LINE FOR REPAIRS WHEN A THIRD EMPLOYEE STARTED A FEED PUMP. TWO EMPLOYEES WERE SPRAYED WITH ACID.	[1]	ACID BURNS INJURED	4	ELECTRICAL	ELECTRICAL DISCONNECT AND/OR SLIP BLIND
36. A MECHANIC WAS REPAIRING A CAUSTIC PUMP WHEN A COWORKER ACCIDENTALLY ENERGIZED THE PUMP AND SPRAYED THE MECHANIC WITH CAUSTIC.	[1]	CAUSTIC BLIND INJURED	4	ELECTRICAL	ELECTRICAL DISCONNECT
37. AN EMPLOYEE RECEIVED CHEMICAL BURNS WHEN A COWORKER IN THE CONTROL ROOM OPENED A VALVE TO A DISCONNECTED LINE THAT WAS IN THE PROCESS OF BEING TESTED.	[1]	CHEMICAL INJURED	4	PRESSURE	SLIP BLIND OR VALVE CHAINED IN CLOSED POSITION
38. AN EMPLOYEE WAS IN THE PROCESS OF CUTTING A PIPE WHEN DIESEL FUEL WAS MISTAKENLY DISCHARGED INTO LINE AND WAS IGNITED BY THE TORCH.	[4]	BURNS FATALITY	4	THERMAL	SLIP BLIND OR VALVE CHAINED IN CLOSED POSITION
39. A REPAIRMAN WAS CRUSHED WHEN ANOTHER EMPLOYEE ACTIVATED A CONVEYOR IN A COKE FURNACE.	[91]	CRUSHED INJURED	4	TRANSLATION	ELECTRICAL DISCONNECT
40. AN EMPLOYEE WAS GREASING BEARINGS ON THE ROLLERS OF A LOG CART MACHINE. HE ACCIDENTALLY TRIPPED A LEVER CAUSING A ROLLER TO MOVE WHICH CRUSHED HIM.	[2]	CRUSHED FATALITY	4	TRANSLATION	ELECTRICAL DISCONNECT
41. WHILE SETTING UP A VACUUM FORMING PRESS, AN EMPLOYEE LEANED OVER THE PRESS AND ACCIDENTALLY ACTIVATED THE START SWITCH AND WAS CRUSHED.	[2]	CRUSHED FATALITY	4	TRANSLATION	ELECTRICAL AND/OR PNEUMATIC DISCONNECT

42. [2] AN EMPLOYEE WAS REPAIRING A CONVEYOR INSIDE A COKE FURNACE WHEN ANOTHER EMPLOYEE ACTIVATED THE CONVEYOR.	CRUSHED FATALITY	4	TRANSLATION	ELECTRICAL DISCONNECT
43. [1] AN EMPLOYEE WAS WORKING AT TOP OF A KILN LARRY WHEN ANOTHER EMPLOYEE CAUSED THE COUNTERWEIGHT TO DROP.	AMPUTATION INJURED	4	TRANSLATION	ELECTRICAL DISCONNECT
44. [2] AN EMPLOYEE ACCIDENTALLY ACTIVATED THE CARRIAGE CONTROL LEVER IN THE BOOTH. THE BOOTH MOVED, THROWING HIM INTO THE 36-INCH SAW BLADE.	LACERATIONS FATALITY	4	ROTATION	ELECTRICAL DISCONNECT
45. [1] A MAINTENANCE MAN INSIDE A LARGE MIXING DRUM MAKING REPAIRS WAS STRUCK BY THE BEATER BLADES WHEN THEY WERE INADVERTENTLY ACTIVATED.	IMPACT FATALITY	4	ROTATION	ELECTRICAL DISCONNECT
46. [1] A UTILITY MAN WAS USING A TOOL TO TURN THE FEED ROLL MOTOR OF A STAPLE MACHINE FOR CLEANING. THE MOTOR WAS TURNED ON ACCIDENTALLY AFTER HE GAVE VERBAL INSTRUCTIONS, "DON'T START MOTOR." HE WAS STRUCK ON THE ARM BY THE TOOL.	IMPACT INJURED	4	ROTATION	ELECTRICAL DISCONNECT
47. [1] AN EMPLOYEE WAS WORKING ON AN AGITATOR IN A PIT WHEN SOMEONE ELSE STARTED THE AGITATOR AND ALSO COMMENCED FILLING THE PIT WITH WATER AND STOCK. HE RECEIVED MULTIPLE CONTUSIONS, ABRASIONS, AND LACERATIONS TO LEGS, HIP, AND SCALP.	LACERATIONS INJURED	4	ROTATION	DISCONNECT ALL ENERGY
48. [91] AN EMPLOYEE WAS INJURED WHEN THE PLASTIC PELLETIZER HE OPERATED ACCIDENTALLY ACTIVATED WHILE HE WAS REACHING THROUGH AN UNGUARDED PORTHOLE TO CLEAN IT.	CRUSHED INJURED	4	TRANSLATION	ELECTRICAL DISCONNECT

49. [2] AN EMPLOYEE WAS WORKING ON A MOLDING MACHINE TURNTABLE. HE WAS STANDING BETWEEN THE TRANSFER ARM AND THE WEIGHT CHANGER WHEN HE ACCIDENTALLY ACTIVATED THE CONTROLS OF THE TRANSFER ARM. THE TRANSFER ARM CRUSHED HIM AGAINST THE WEIGHT CHANGER.	CRUSHED FATALITY	4	TRANSLATION	ELECTRICAL DISCONNECT
50. [2] AN EMPLOYEE WAS INSIDE A TIE-BORING MACHINE ADJUSTING THE SWITCHES TO RELIEVE A JAM WHEN THE CONVEYOR SYSTEM STARTED MOVING CAUSING HIM TO BE CAUGHT BETWEEN A TIE AND THE BORING MILL.	CRUSHED FATALITY	4	TRANSLATION	ELECTRICAL DISCONNECT
51. [2] TWO EMPLOYEES WERE OPERATING A PRESS BRAKE. THE WORK PIECE WAS BEING REPOSITIONED FOR THE NEXT OPERATION. ONE EMPLOYEE HAD HIS HEAD IN THE POINT OF OPERATION WHEN THE PRESS WAS ACTIVATED ACCIDENTALLY BY THE OTHER EMPLOYEE.	CRUSHED FATALITY	4	TRANSLATION	ELECTRICAL CONNECT OR BLOCKING DEVICE
52. [18] AN EMPLOYEE WAS CLEANING A FLOUR BATCH MIXER WHEN THE START SWITCH WAS INADVERTENTLY ACTIVATED CRUSHING HIS NECK.	CRUSHED FATALITY	4	ROTATION	ELECTRICAL DISCONNECT
53. [2] AN EMPLOYEE WAS CLEANING THE INSIDE OF A PUG MILL MIXER SILO WHEN ANOTHER EMPLOYEE STARTED THE MACHINE.	CRUSHED FATALITY	4	ROTATION	ELECTRICAL DISCONNECT
54. [1] AN EMPLOYEE WAS REPLACING A ROLLER CHAIN KEY AND SPROCKET FOR A SET OF ROLLS ON METAL SCRUBBER WHEN SOMEONE ELSE JOGGED THE MACHINE AND CAUGHT HIS FINGERS.	AMPUTATION INJURED	4	ROTATION	ELECTRICAL DISCONNECT

55. AN EMPLOYEE WAS CLEANING A PELLET MACHINE WHILE THE GUARD OVER THE FEED ROLLS WAS REMOVED. HE ACCIDENTLY STARTED THE MACHINE AND HIS HAND BECAME CAUGHT IN THE ROLLS.	[1]	CRUSHED INJURED	4	ROTATION	ELECTRICAL DISCONNECT
56. AN EMPLOYEE WAS TRAPPED BETWEEN THE BLENDER SHELL AND THE OPENED DOOR HE WAS WORKING THROUGH WHEN THE BLENDER WAS ACCIDENTALLY ENERGIZED.	[1]	CRUSHED INJURED	4	ROTATION	ELECTRICAL DISCONNECT
57. AN EMPLOYEE WAS TRAPPED INSIDE A MIXER WHEN IT WAS ACCIDENTALLY ENERGIZED BY ANOTHER EMPLOYEE.	[1]	LACERATIONS INJURED	4	ROTATION	ELECTRICAL DISCONNECT
58. AN EMPLOYEE REMOVED THE HOSE FROM THE CLEANOUT OPENING OF A PUMP AND COMMENCED CLEANING OUT THE PUMP WITH HIS HAND. A COWORKER STARTED THE PUMP RESULTING IN AMPUTATION OF A FINGER.	[1]	AMPUTATION INJURED	4	ROTATION	ELECTRICAL DISCONNECT
59. AN EMPLOYEE WAS CLEANING THE DRIVE PULLEY OF A CENTRIFUGE CONVEYOR. THE CONVEYOR SUDDENLY BEGAN MOVING DRAWING HIS ARM IN BETWEEN THE PULLEY AND THE BELT RESULTING IN FRACTURES OF HIS ARM. A COWORKER HAD ENERGIZED THE CONVEYOR.	[1]	FRACTURE INJURED	4	ROTATION	ELECTRICAL DISCONNECT

IX. APPENDIX C

EVALUATION OF EXISTING STANDARDS

INTERNATIONAL, NATIONAL, STATE, AND CONSENSUS

Appendix C

EVALUATION OF EXISTING STANDARDS - INTERNATIONAL, NATIONAL, STATE, CONSENSUS

The following paragraphs compare and evaluate the current national, state, international, and consensus standards related to energy controls (lockout/tagouts) for accomplishing maintenance and servicing activities safely. Specifically, the guidelines recommended are compared with: OSHA General Industry Standards (29 CFR 1910) and OSHA Construction Standards (29 CFR 1926); State Standards (with approved OSHA plans); criteria developed in Canada (Alberta), Germany, and Britain; and consensus standards ANSI Z244.1-1982 and NFPA 70E part II.

Summary

Appendix Tables C-1, C-2, and C-3 present an overall comparison of the recommended guidelines with the respective national, state, international, and consensus standards. Even though the types of energy applicable and the industries affected vary, a considerable consistency is found in the guidelines required for all except the OSHA national standards and the state OSHA standards (with the exceptions of California and Michigan). The primary criteria elements eliminating energy, securing the means by which the energy is eliminated, verifying that energy has dissipated to safe levels, documenting the procedures, and training the personnel involved, are found consistently in the other standards.

The existing national OSHA standards are inadequate because of incomplete industry coverage and incomplete and inconsistent criteria where standards exist. The existing state standards, with the exception of those for California and Michigan, are reprints of the national standards. The California and Michigan standards closely parallel the recommended guidelines; however, they do not provide the three alternate means of securing the point(s) of control as provided by the recommended guidelines. The California standards are also limited to electrical energy and mechanical motion of equipment; whereas, the recommended criteria cover electrical, mechanical, and thermal energy.

The existing Alberta, Canada, regulations lack effectiveness since they do not include mechanical motion or thermal energy as applicable forms of energy that personnel must be safeguarded against. Also, the Alberta regulations do not specify the documenting of procedures and training of personnel as necessary requirements for an effective program for controlling hazards during maintenance.

The draft German Accident Prevention Specifications do not include electrical, chemical, or thermal as applicable forms of energy to be controlled during maintenance and servicing. Industries affected by the specifications are limited to "power driven equipment" which excludes many industries that expose workers to hazardous levels of energy during maintenance. The German specifications do not require verification that hazards have been controlled, documenting of procedures, or training of personnel in safe work practices.

TABLE C-1
COMPARISON SUMMARY OF
TYPES OF ENERGY

RECOMMENDED GUIDELINES: Mechanical motion; potential energy due to pressure, gravity, or springs; electrical energy; thermal energy resulting from high or low temperature.

NATIONAL	STATES*	INTERNATIONAL			CONSENSUS	
		ALBERTA CANADA [92]	GERMANY [46]	BRITAIN [71]	ANSI Z244.1-1982 [5]	NFPA 70E Part II [54]
Electrical energy; hydraulic pressure; thermal energy. Mechanical motion is implied but not stated.	Essentially identical to the national OSHA standard except for California. California standards apply to electrical energy and mechanical motion.	Potential energy, power, chemical energy.	Mechanical motion, potential energy.	Mechanical motion.	Electrical, mechanical, hydraulic, chemical, nuclear, and thermal energy.	Electrical energy.

*States reviewed: AL, AZ, CA, HI, IN, IA, KY, MD, MI, MN, NC, NV, OR, SC, TN, VT, WA, and WY.

TABLE C-2
COMPARISON SUMMARY OF
INDUSTRIES AFFECTED

RECOMMENDED GUIDELINES: Those industries that expose workers to hazardous levels of energy during maintenance.

NATIONAL	STATES*	INTERNATIONAL			CONSENSUS	
		ALBERTA CANADA [92]	GERMANY [46]	BRITAIN [71]	ANSI Z244.1-1982 [5]	NFPA 70E Part II [54]
Overhead and gantry cranes; woodworking; mechanical power presses; forging machines; pulp, paper, and paper-board mills; textiles; bakeries; sawmills; tele-communications; and construction.	Same as the national OSHA standard except for California. California lock-out standards are applicable to electrical and general industry.	Machinery and equip-ment, powered mobile equipment and hoists.	Power driven equipment.	Machinery and processes applicable to all sectors of industry.	Not specified.	Not specified. Applies to anyone who works on, near or with electric circuits and equipment.

*States reviewed: AL, AZ, CA, HI, IN, IA, KY, MD, MI, MN, NC, NV, OR, SC, TN, VT, WA, and WY.

TABLE C-3
COMPARISON SUMMARY OF
CRITERIA REQUIREMENTS

RECOMMENDED GUIDELINES: Energy shall be isolated, blocked, dissipated, secured, verified. Procedures shall be documented and personnel shall be trained.

NATIONAL	STATES*	INTERNATIONAL			CONSENSUS	
		ALBERTA CANADA [92]	GERMANY [46]	BRITAIN [71]	ANSI Z244.1-1982 [5]	NFPA 70E Part II [54]
Incomplete and inconsistent. Some sections require provisions for lockout only while other sections require physical lockout or tagout but do not require verification, procedures, or training.	Essentially identical to the national OSHA standard except in California. California requires that energy be isolated, blocked, dissipated, secured, a warning be posted, and verified. Procedures shall be documented and personnel shall be trained.	Energy shall be isolated, blocked, dissipated, secured against accidental movement or use a physical means on the power control, a warning tag, and verified.	Energy shall be isolated, blocked, and dissipated. Unauthorized erroneous or unexpected initiation of hazardous movements shall be avoided.	Document a written "permit to work" system procedure and train personnel in safe practices.	Energy sources shall be blocked, dissipated, secured by lockout devices or tagout devices, and verified. Procedures shall be documented and personnel shall be trained.	Energy sources shall be blocked, dissipated, secured by tag only, or lock only, or no locks or tags, and verified. Procedures shall be documented and personnel shall be trained.

*States reviewed: AL, AZ, CA, HI, IN, IA, KY, MD, MI, MN, NC, NV, OR, SC, TN, VT, WA, and WY.

The existing British Code of Practice relies on the human element to follow a documented "permit to work" system for performing maintenance. It closely parallels the recommended guidelines, and relies on the documented system to serve as a record of all the foreseeable hazards which have been considered in advance. It also relies heavily on supervision to see that the system operates properly.

The Consensus Standards are similar to the recommended guidelines. They provide the options of (1) securing the point(s) of control by lockout or tagout devices or (2) having no locks or tags, provided other requirements are met. These standards, however, do not allow the option of having a person remain at the point(s) of control to protect against unauthorized actuation of the machine or process during maintenance and servicing. Also, the standards do not cover the broad spectrum of hazards as do the recommended guidelines.

National Standards

The existing national standards as shown in Table C-4 are not uniform in their coverage. Inconsistencies in the requirements exist between industries and between equipment within the same industry. Some sections of the General Industry Standards imply locking out or tagging out energy rather than specifying that lockouts or tagouts be performed. Sections of the standard covering industries or equipment requiring provisions for only locking out or tagging out energy are: overhead and gantry cranes; woodworking machinery; mechanical power presses; certain forging machines; certain pulp, paper, and paperboard mills; textiles; certain bakery equipment; and certain sawmill equipment. Other sections of the General Industry Standard are more positive and explicit in their coverage in that they specify that lockouts or tagouts shall be utilized. Industries or equipment in this category are: certain forging machines; certain pulp, paper, and paperboard mill equipment; certain bakery equipment; certain sawmill equipment; and telecommunications systems. The Construction Standard is also inconsistent in its requirements. Sections of the standard covering industries or equipment wherein provisions for only locking out or tagging out energy are specified consist of: woodworking tools, base-mounted drum hoists, motor vehicles, and pile-driving equipment. Sections of the Construction Standard covering industries or equipment which specify that lockouts or tagouts be performed are: general contractor machinery, electrical circuits, conveyors, construction equipment such as bulldozers and end-loaders, electric blasting equipment, power transmission and distribution lines and equipment, and electrical substations. The existing national standards have only limited effectiveness because of the lack of uniformity (lockouts for some industries and only provisions for lockouts for others) and because they are written only for specific industries. The existing General Industry and Construction Standards related to this subject, as compiled by OSHA, are contained in Appendix D.

State Standards

The existing state standards (Table C-5), with the exception of those for California and Michigan, are essentially identical to the national standards. California has horizontal standards which recommend isolating or blocking energy sources; dissipating or blocking stored energy that constitutes a personnel hazard; using physical means or devices to secure the point of control

TABLE C-4

LOCKOUT AND TAGOUT NATIONAL STANDARDS

GENERAL INDUSTRY, OSHA SAFETY AND HEALTH STANDARDS (29 CFR 1910)

These standards are written for specific industries only. The following sections of the standards make provisions for locking out or tagging out energy.

1910.145(f)(1)(i)
145(f)(3)(iii)
179(g)(5)(i)
179(g)(5)(ii)
179(g)(5)(iii)
179(1)(2)(i)(c)
181(f)(2)(i)(c)
213(a)(10)
213(b)(5)
217(b)(8)(i)
217(d)(9)(iv)
218(a)(3)(iii)
218(a)(3)(iv)
218(d)(2)
218(e)(1)(ii)
218(f)(1)
218(f)(2)
218(g)(1)
218(h)(2)
218(h)(5)
218(i)(1)
218(i)(2)
218(j)(1)
252(c)(1)(i)
261(b)(4)
261(b)(5)
261(e)(2)
261(e)(10)
261(e)(12)(iii)
261(e)(13)
261(f)(6)(i)
261(g)(4)(ii)
261(g)(15)(i)
261(g)(16)(i)
261(g)(19)(iii)
261(g)(21)
261(j)(1)(iii)
261(j)(4)(iii)
261(j)(5)(iii)
261(j)(6)(i)
261(k)(2)(ii)
262(c)(1)
262(n)(2)
262(p)(1)
262(q)(2)
263(k)(12)(i)
263(1)(3)(iii)(b)
263(1)(8)(iii)
265(c)(12)(v)
265(c)(13)
265(c)(26)(iii)
265(c)(26)(v)
265(e)(1)(iv)
268(1)(2)
268(m)(7)(i)

29 CFR PART 1926, OSHA SAFETY AND HEALTH REGULATIONS CONSTRUCTION, FEDERAL REGISTER

These regulations are written for general use equipment, specific purpose equipment, and special systems with limited applicability. The following sections of the regulations make provisions for locking out or tagging out energy.

1926.20(b)(3)
200(h)(1)
200(h)(2)
304(a)
400(a)
555(a)(7)
601(b)(10)
906(j)
906(1)
950(d)(1)(ii)(b)
950(d)(2)

TABLE C-5

STATE STANDARDS

STATE OF CALIFORNIA STANDARDS	STANDARDS FROM OTHER STATES AND THE TERRITORY OF PUERTO RICO
These standards parallel the recommended guidelines. The standards are written for electrical equipment or systems, prime movers, machinery, and equipment in general.	These standards are written for specific industries only and are not horizontal standards. They are essentially identical to and parallel to the 29 CFR 1910 national standards. The Michigan standards closely parallel the recommended guidelines except they do not include verification prior to starting maintenance.

to prevent unauthorized persons from reenergizing the system; using warning tags to caution personnel that energy has been isolated and the reason for isolation; verifying that isolation of energy has been effective; verifying that personnel have cleared the area prior to reenergizing the machine or system; documenting procedures; and ensuring that personnel who implement the criteria have been adequately trained to thoroughly understand the procedures.

The Michigan standards closely parallel the recommended guidelines except Michigan does not include verification that blocking, isolating, and dissipating hazardous energy have been effected before starting maintenance.

International Standards

International standards from Canada, Germany, and Britain (summarized in Table C-6) parallel portions of the recommended criteria. The Alberta, Canada, regulations for machinery and equipment state that no maintenance or repairs shall be carried out until the machinery or equipment has been shut down and secured against accidental movement or the power control devices have been locked out in an inoperative mode by the installation of lockout devices and warning tags. Dissipation of stored energy, verification that isolation and dissipation have been effected prior to starting maintenance, and verification that upon completion of maintenance, personnel are clear of the danger points before the machine or equipment is reenergized are also included as requirements.

The German specifications for setup, troubleshooting, and maintenance of power-driven equipment state that these tasks must only be performed when: (1) The hazardous movements are brought to a halt; (2) the initiation of hazardous movements as a consequence of stored power or energy is prevented; and (3) unauthorized, erroneous, or unexpected initiation of hazardous movements is avoided by some adequate means.

The British Code of Practice for Safeguarding of Machinery states that effective control of hazards during maintenance can be achieved by having a written "permit to work" system. Such a system must clearly identify the hazards and document the practices to be followed, precautions to be taken, and responsibilities of the workers and of management. The code of practice also calls for adequate training of workers and supervision in safe systems of work and lockout systems for maintenance operation.

Consensus Standards

The ANSI and NFPA standards (Table C-7) establish requirements and procedures for lockout/tagout of energy sources for stationary machines and equipment and for electrical circuits and electrical equipment, respectively. These standards require (1) that energy sources be isolated or blocked for maintenance, (2) that stored energy be dissipated prior to beginning maintenance, (3) that physical means or devices be used to secure the energy sources, (4) verification that the energy sources have been isolated prior to starting work, (5) verification that all personnel are clear of hazards before reenergizing the machines or systems, (6) assurance that the procedures for lockout/tagout have been documented, and (7) that personnel have been adequately trained to understand and implement the recommended guidelines.

Applicability of the ANSI standard is limited to unexpected energization, startup, or release of stored energy of equipment or process. The NFPA standard does not have such a limitation but covers only electrical energy. The recommended guidelines are applicable for all phases of maintenance and servicing.

TABLE C-6

INTERNATIONAL STANDARDS

OCCUPATIONAL HEALTH AND SAFETY REGULATIONS, ALBERTA, CANADA [92]	ACCIDENT PREVENTION SPECIFICATION (DRAFT) "POWER-DRIVEN EQUIPMENT," GERMANY [46]	SAFEGUARDING OF MACHINERY, BSI CODE OF PRACTICE, BRITAIN [71]
These regulations contain both horizontal and vertical standards for specific equipment and a limited number of specific industries. This regulation parallels the recommended guidelines.* *"When machinery or equipment is shut down for maintenance or repairs, no work shall be carried out until all parts, extensions and attachments thereto have been secured against accidental movement or the power control devices have been locked out in an inoperative position with a supplemental tag which describes the work to be performed and the name of the worker responsible for the installation of the lockout device."	This specification parallels certain sections of the recommended guidelines.* *"Setup, troubleshooting or maintenance tasks must be performed only in the area provided for this purpose when unauthorized, erroneous, or unexpected initiation of hazardous movements is avoided." The specification does not describe how hazardous movements shall be avoided.	This standard states that maintenance hazards can be effectively controlled by documenting a "permit to work" system identifying hazards and precautions to be taken, defining practices to be followed and defining worker and management responsibilities for maintenance. Adequate training of workers and supervision in the application of safe work practices during maintenance is also a requirement.

TABLE C-7

CONSENSUS STANDARDS

ANSI Z244.1-1982 SAFETY STANDARD FOR THE LOCKOUT/TAGOUT OF ENERGY SOURCES [5]	NFPA 70E PART II LOCKOUT SAFETY RELATED WORK PRACTICES [54]
This standard parallels the recommended guidelines. This standard allows that either lockout devices shall be attached to hold the energy isolating devices in a safe position or tagout devices shall be attached to forbid the operation of the energy isolating devices.	These safety related work practices cover procedures for employees who work with electric circuits and equipment. These procedures are essentially identical to the recommended guidelines. This standard allows the use of tags only when it is not feasible to apply locks to effect lockout. Where circuits or equipment are deenergized for minor maintenance, servicing, adjusting, etc., the work shall be permitted to be performed without the placement of locks or tags on the disconnecting device.

X. APPENDIX D

EXISTING OSHA STANDARDS RELATED TO LOCKOUT, TAGOUT, OR THE CONTROL OF ENERGY DURING MAINTENANCE

NOTE: THE INFORMATION IN THIS APPENDIX WAS ADAPTED FROM INFORMATION SUPPLIED BY OSHA.

General Industry Lockout Related

Standard Provisions

SPECIFICATIONS FOR ACCIDENT PREVENTION SIGNS AND TAGS

No.	STANDARD
1910.145(f)(1)	(i) The tags are a temporary means of warning all concerned of a hazardous condition, defective equipment, radiation hazards, etc. The tags are not to be considered as a complete warning method, but should be used until a positive means can be employed to eliminate the hazard; for example, a "Do not Start" tag on power equipment shall be used for a few moments or a very short time until the switch in the system can be locked out; a "Defective Equipment" tag shall be placed on a damaged ladder and immediate arrangements made for the ladder to be taken out of service and sent to the repair shop.
1910.145(f)(3)	(iii) Do Not Start tags shall be placed in a conspicuous location or shall be placed in such a manner that they effectively block the starting mechanism which would cause hazardous conditions should the equipment be energized.
1910.145(f)(4)	(i) Danger tags should be used only where an immediate hazard exists. There should be no variation in the type of design of tags posted or hung to warn of specific dangers.
1910.145(f)(5)	(i) Caution tags should be used only to warn against potential hazards or to caution against unsafe practices.
1910.145(f)	(6) Out of order tags. Out of Order tags should be used only for the specific purpose of indicating that a piece of equipment, machinery, etc., is out of order and to attempt to use it might present a hazard.

POWERED INDUSTRIAL TRUCKS

1910.178(q)	(4) Trucks in need of repairs to the electrical system shall have the battery disconnected prior to such repairs.

OVERHEAD AND GANTRY CRANES

1910.179(g)(5)	(i) The power supply to the runway conductors shall be controlled by a switch or circuit breaker located on a fixed structure, accessible from the floor, and arranged to be locked in the open position.

(ii) On cab-operated cranes a switch or circuit breaker of the enclosed type, with provision for locking in the open position, shall be provided in the leads from the runway conductors. A means of opening this switch or circuit breaker shall be located within easy reach of the operator.

(iii) On floor-operated cranes, a switch or circuit breaker of the enclosed type, with provision for locking in the open position, shall be provided in the leads from runway conductors. This disconnect shall be mounted on the bridge or footwalk near the runway collectors. One of the following types of floor-operated disconnects shall be provided:

1910.179(l)(2) (i) Before adjustments and repairs are started on a crane the following precautions shall be taken:

(b) All controllers shall be at the off position.

(c) The main or emergency switch shall be open and locked in the open position.

(d) Warning or "out of order" signs shall be placed on the crane, also on the floor beneath or on the hook where visible from the floor.

DERRICKS

1910.181(f)(2)(i) (c) The main or emergency switch shall be locked in the open position, if an electric hoist is used.

(d) Warning or out of order signs shall be placed on the derrick and hoist.

WOODWORKING MACHINERY REQUIREMENTS

1910.213(a) (10) It is recommended that each power-driven wood working machine be provided with a disconnect switch that can be locked in the off position.

1910.213(b) (3) On applications where injury to the operator might result if motors were to restart after power failures, provision shall be made to prevent machines from automatically restarting upon restoration of power.

1910.213(b) (5) On each machine operated by electric motors, positive means shall be provided for rendering such controls or devices inoperative while repairs or adjustments are being made to the machines they control.

MECHANICAL POWER PRESSES

1910.217(b)(8) (i) A main power disconnect switch capable of being locked only in the Off position shall be provided with every power press control system.

1910.217(d)(9) (iv) The employer shall provide and enforce the use of safety blocks for use whenever dies are being adjusted or repaired in the press.

FORGING MACHINES

1910.218(a)(3) (iii) Means shall be provided for disconnecting the power to the machine and for locking out or rendering cycling controls inoperable.

(iv) The ram shall be blocked when dies are being changed or other work is being done on the hammer. Blocks or wedges shall be made of material the strength and construction of which should meet or exceed the specifications and dimensions shown in Table O-11.

1910.218(d) (2) Shutoff valve. Steam hammers shall be provided with a quick closing emergency valve in the admission pipe line at a convenient location. This valve shall be closed and locked in the off position while the hammer is being adjusted, repaired, or serviced, or when the dies are being changed.

1910.218(e)(1) (ii) Air-lift hammers shall have an air shutoff valve as required in paragraph (d)(2) of this section and should be conveniently located and distinctly marked for ease of identification.

(iii) Air-lift hammers shall be provided with two drain cocks: one on main head cylinder, and one on clamp cylinder.

1910.218(f) (1) Mechanical forging presses. When dies are being changed or maintenance is being performed on the press, the following shall be accomplished:

(i) The power to the press shall be locked out.

(ii) The flywheel shall be at rest.

(iii) The ram shall be blocked with a material the strength of which shall meet or exceed the specifications or dimensions shown in Table O-11.

1910.218(f) (2) Hydraulic forging presses. When dies are being changed or maintenance is being performed on the press, the following shall be accomplished.

(i) The hydraulic pumps and power apparatus shall be locked out.

(ii) The ram shall be blocked with a material the strength of which shall meet or exceed the specifications or dimensions shown in Table O-11.

1910.218(g) (1) Hot trimming presses. The requirements of paragraph (f)(1) of this section shall also apply to hot trimming presses.

1910.218(h) (2) Lockout. Upsetters shall be provided with a means for locking out the power at its entry point to the machine and rendering its cycling controls inoperable.

(5) Changing dies. When dies are being changed, maintenance performed, or any work done on the machine, the power to the upsetter shall be locked out, and the flywheel shall be at rest.

1910.218(i) (1) Boltheading. The provisions of paragraph (h) of this section shall apply to boltheading.

(2) Rivet making. The provisions of paragraph (h) of this section shall apply to rivet making.

1910.218(j) (1) Billet shears. A positive-type lockout device for disconnecting the power to the shear shall be provided.

WELDING, CUTTING, AND BRAZING

1910.252(c)(1) (i) Installation. All equipment shall be installed by a qualified electrician in conformance with subpart S of this part. There shall be a safety-type disconnecting switch or a circuit breaker or circuit interrupter to open each power circuit to the machine, conveniently located at or near the machine, so that the power can be shut off when the machine or its controls are to be serviced.

1910.252(c)(2) (ii) Capacitor welding. Stored energy or capacitor discharge type of resistance welding equipment and control panels involving high voltage (over 550 volts) shall be suitably insulated and protected by complete enclosures, all doors of which shall be provided with suitable interlocks and contacts wired into the control circuit (similar to elevator interlocks). Such interlocks or contacts shall be so designed as to effectively interrupt power and short circuit all capacitors when the door or panel is open. A manually operated switch or suitable positive device shall be installed, in addition to the mechanical interlocks or contacts, as an added safety measure assuring absolute discharge of all capacitors.

positive device shall be installed

1910.261(b)

(4) Lockouts. Devices such as padlocks shall be provided for locking out the source of power at the main disconnect switch. Before any maintenance, inspection, cleaning, adjusting, or servicing of equipment (electrical, mechanical, or other) that requires entrance into or close contact with the machinery or equipment, the main power disconnect switch or valve, or both, controlling its source of power or flow of material, shall be locked out or blocked off with padlock, blank flange, or similar device.

(5) Vessel entering. Lifelines and safety harness shall be worn by anyone entering closed vessels, tanks, ship bins, and similar equipment, and a person shall be stationed outside in a position to handle the line and to summon assistance in case of emergency. The air in the vessels shall be tested for oxygen deficiency and the presence of both toxic and explosive gases and vapors, before entry into closed vessels, tanks, etc., is permitted. Self-contained air- or oxygen-supply masks shall be readily available in case of emergency. Work shall not be done on equipment under conditions where an injury would result if a valve were unexpectedly opened or closed unless the valve has been locked in a safe position.

1910.261(e)

(2) Slasher tables. Saws shall be stopped and power switches shall be locked out and tagged whenever it is necessary for any person to be on the slasher table.

(10) Stops. All control devices shall be locked out and tagged when knives are being changed.

1910.261(e)(12)

(iii) Whenever it becomes necessary for a workman to go within a drum, the driving mechanism shall be locked and tagged, at the main disconnect switch, in accordance with paragraph (b)(4) of this section.

1910.261(e)

(13) Intermittent barking drums. In addition to motor switch, clutch, belt shifter, or other power disconnecting device, intermittent barking drums shall be equipped with a device which may be locked to prevent the drum from moving while it is being emptied or filled.

1910.261(f)(6)

(i) When cleaning, inspection, or other work requires that persons enter rag cookers, all steam and water valves, or other control devices, shall be locked and tagged in the closed or "off" position. Blank flanging of pipelines is acceptable in place of closed and locked valves.

1910.261(g)(4)	(ii) A man shall be stationed outside to summon assistance if necessary. All intake valves to a tank shall be blanked off or disconnected.
1910.261(g)(15)	(i) Valves controlling lines leading into a digester shall be locked out and tagged. The keys to the locks shall be in the possession of a person or persons doing the inspecting or making repairs.
1910.261(g)(16)	(i) Safety regulations governing inspection and repairing of pressure tanks-accumulators (acid) shall be the same as those specified in subparagraph (15) of this paragraph.
1910.261(g)(19)	(iii) When blow lines from more than one digester lead into one pipe, the cock or valve of the blow line from the tank being inspected or repaired shall be locked or tagged out, or the line shall be disconnected and blocked off.
1910.261(g)(21)	Inspection and repair of tanks. All piping leading to tanks shall be blanked off or valved and locked or tagged. Any lines to sewers shall be blanked off to protect workers from air contaminants.
1910.261(j)(1)	(iii) Repairs for cleaning of blockage shall be done only when the shredder is shutdown and control devices locked.
1910.261(j)(4)	(iii) When cleaning, inspecting, or other work requires that persons enter the beaters, all control devices shall be locked or tagged out, in accordance with paragraph (b)(4) of this section.
1910.261(j)(6)	(i) All control devices shall be locked or tagged out when persons enter stock chests, in accordance with paragraph (b)(4) of this section.
1910.261(j)(5)	(iii) When cleaning, inspecting, or other work requires that persons enter pulpers, all steam, water, or other control devices shall be locked or tagged out. Blank flanging and tagging of pipe lines are acceptable in place of closed and locked or tagged valves. Blank flanging of steam and water lines shall be acceptable in place of valve locks.
1910.261(k)(2)	(ii) All drives shall be provided with lockout devices at the power switch which interrupts the flow of current to the unit.

Textiles

1910.262(c) (1) Means of stopping machines. Every textile machine shall be provided with individual mechanical or electrical means for stopping such machines. On machines driven by belts and shafting, a locking-type shifter or an equivalent positive device shall be used. On operations where injury to the operator might result if motors were to restart after failures, provision shall be made to prevent machines from automatically restarting upon restoration of power.

1910.262(n) (2) Protection for loom fixer. Provisions shall be made so that every loom fixer can prevent the loom from being started while he is at work on the loom. This may be accomplished by means of a lock, the key to which is retained in the possession of the loom fixer, or by some other effective means to prevent starting the loom.

1910.262(p) (1) J-box protection. Each valve controlling the flow of steam, injurious gases, or liquids into a J-box shall be equipped with a chain, lock, and key, so that any worker who enters the J-box can lock the valve and retain the key in his possession. Any other method which will prevent steam, injurious gases, or liquids from entering the J-box while the worker is in it will be acceptable.

1910.262(q) (2) Kier valve protection. Each valve controlling the flow of steam, injurious gases, or liquids into a kier shall be equipped with a chain, lock, and key, so that any worker who enters the kier can lock the valve and retain the key in his possession. Any other method which will prevent steam, injurious gases, or liquids from entering the kier while the worker is in it will be acceptable.

BAKERY EQUIPMENT

1910.263(k)(12) (i) Where pan cooling towers extend to two or more floors, a lockout switch shall be provided on each floor in order that mechanics working on the tower may positively lock the mechanism against starting. Only one start switch shall be used in the motor control circuit.

1910.263(l)(3)(iii) (b) Main shutoff valves shall be locked in the closed position when men must enter the oven or when the oven is not in service.

1910.263(l)(8) (iii) A main disconnect switch or circuit breaker shall be provided. This switch or circuit breaker shall be so located that it can be reached quickly and safely.

The main switch or circuit breaker shall have provisions for locking it in the open position if any work on the electrical equipment or inside the oven must be performed.

SAWMILLS

1910.265(c)(12) (v) Open switches. Before working on electrical equipment, switches shall be open and shall be tagged, blocked, or locked out.

1910.265(c) (13) Hydraulic systems. Means shall be provided to block, chain, or otherwise secure equipment normally supported by hydraulic pressure so as to provide for safe maintenance.

1910.265(c)(26) (iii) Blocking hoisting platform. Means shall be provided to positively block the hoisting platform when employees must go beneath the stacker or unstacker hoist.

(v) Locking main control switches. Main control switches shall be so designed that they can be locked in the open position.

1910.265(e)(1) (iv) Carriage control. A positive means shall be provided to prevent unintended movement of the carriage. This may involve a control locking device, a carriage tie-down, or both.

1910.268(1) (2) Before the voltage is applied, cable conductors shall be isolated to the extent practicable. Employees shall be warned, by such techniques as briefing and tagging at all affected locations, to stay clear while the voltage is applied.

1910.268(m)(7) (i) Prior to grounding a radio transmitting station antenna, the employer shall insure that the rigger in charge: (A) Prepares a danger tag signed with his signature, (B) Requests the transmitting technician to shutdown the transmitter and to ground the antenna with its grounding switch, (C) Is notified by the transmitting technician that the transmitter has been shutdown, and (D) Tags the antenna ground switch personally in the presence of the transmitting technician after the antenna has been grounded by the transmitting technician.

NATIONAL ELECTRICAL CODE

1910.309
NEC Article 430-86(a) 430-86. Motor Not in Sight from Controller. Where a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(a) The controller disconnecting means is capable of being locked in the open position.

GENERAL SAFETY AND HEALTH PROVISIONS

1926.20(b) (3) The use of any machinery, tool, material or equipment which is not in compliance with any applicable requirement of this part is prohibited. Such machine, tool, material, or equipment shall either be identified as unsafe by tagging or locking the controls to render them inoperable or shall be physically removed from its place of operation.

NONIONIZING RADIATION

1926.54 (e) Beam shutters or caps shall be utilized, or the laser turned off, when laser transmission is not actually required. When the laser is left unattended for a substantial period of time, such as during lunch hour, overnight, or at change of shifts, the laser shall be turned off.

FIRE PROTECTION AND PREVENTION

1926.150(d)(1) (ii) During demolition or alterations, existing automatic sprinkler installations shall be retained in service as long as reasonable. The operation of sprinkler control valves shall be permitted only by properly authorized persons. Modification of sprinkler systems to permit alterations or additional demolition should be expedited so that the automatic protection may be returned to service as quickly as possible. Sprinkler control valves shall be checked daily at close of work to ascertain that the protection is in service.

1926.200(h) (1) Accident prevention tags shall be used as a temporary means of warning employees of an existing hazard, such as defective tools, equipment, etc. They shall not be used in place of, or as a substitute for, accident prevention signs.

(2) Specifications for accident prevention tags similar to those in Table G-1 shall apply.

1926.304 (a) All fixed power driven woodworking tools shall be provided with a disconnect switch that can either be locked or tagged in the off position.

WELDING AND CUTTING

1926.352 (g) For the elimination of possible fire in enclosed spaces as a result of gas escaping through leaking or

improperly closed torch valves, the gas supply to the torch shall be positively shut off at some point outside the enclosed space whenever the torch is not to be used or whenever the torch is left unattended for a substantial period of time, such as during the lunch period. Overnight and at the change of shifts, the torch and hose shall be removed from the confined space. Open end fuel gas and oxygen hoses shall be immediately removed from enclosed spaces when they are disconnected from the torch or other gas-consuming device.

ELECTRICAL-GENERAL REQUIREMENTS

1926.400(g) (1) Equipment or circuits that are deenergized shall be rendered inoperative and have tags attached at all points where such equipment or circuits can be energized.

(2) Controls that are to be deactivated during the course of work on energized or deenergized equipment or circuits shall be tagged.

(3) Tags shall be placed to identify plainly the equipment or circuits being worked on.

BASE-MOUNTED DRUM HOISTS

1926.553(a)(3) (i) A device to disconnect all motors from the line upon power failure and not permit any motor to be restarted until the controller handle is brought to the "off" position.

(iii) A means whereby remotely operated hoists stop when any control is ineffective.

CONVEYORS

1926.555(a) (7) Conveyors shall be locked out or otherwise rendered inoperable, and tagged out with a "Do Not Operate" tag during repairs and when operation is hazardous to employees performing maintenance work.

MOTOR VEHICLES, MECHANIZED EQUIPMENT, AND MARINE OPERATIONS

1926.600(a)(3) (i) Heavy machinery, equipment, or parts thereof, which are suspended or held aloft by use of slings, hoists, or jacks shall be substantially blocked or cribbed to prevent falling or shifting before employees are permitted to work under or between them. Bulldozer and scraper blades, end-loader buckets, dump bodies, and similar equipment, shall be either fully lowered or blocked when being repaired or when not in use. All

permitted to work under or between them. Bulldozer and

controls shall be in a neutral position, with the motors stopped and brakes set, unless work being performed requires otherwise.

1926.600(a)(3) (ii) Whenever the equipment is parked, the parking brake shall be set. Equipment parked on inclines shall have the wheels chocked and the parking brake set.

1926.601(b) (10) Trucks with dump bodies shall be equipped with positive means of support, permanently attached, and capable of being locked in position to prevent accidental lowering of the body while maintenance or inspection work is being done.

(11) Operating levers controlling hoisting or dumping devices on haulage bodies shall be equipped with a latch or other device which will prevent accidental starting or tripping of the mechanism.

1926.603(a) (5) A blocking device, capable of safely supporting the weight of the hammer, shall be provided for placement in the leads under the hammer at all times while employees are working under the hammer.

INITIATION OF EXPLOSIVE CHARGES-ELECTRICAL BLASTING

1926.906 (j) In underground operations when firing from a power circuit, a safety switch shall be placed in the permanent firing line at intervals. This switch shall be made so it can be locked only in the "Off" position and shall be provided with a short-circuit arrangement of the firing lines to the cap circuit.

(1) When firing from a power circuit, the firing switch shall be locked in the open or "Off" position at all times, except when firing. It shall be so designed that the firing lines to the cap circuit are automatically short-circuited when the switch is in the "Off" position. Keys to this switch shall be entrusted only to the blaster.

POWER TRANSMISSION AND DISTRIBUTION

1926.950 (d) Deenergizing lines and equipment

(1) When deenergizing lines and equipment operated in excess of 600 volts, and the means of disconnecting from electric energy is not visibly open or visibly locked out, the provisions of subdivisions (i) through (vii) of this subparagraph shall be complied with:

(i) The particular section of line or equipment to be deenergized shall be clearly identified, and it shall be isolated from all sources of voltage.

(ii) Notification and assurances from the designated employee shall be obtained that:

(a) All switches and disconnectors through which energy may be supplied to the particular section of line or equipment to be worked have been deenergized;

(b) All switches and disconnectors are plainly tagged indicating that men are at work;

(c) And that where design of such switches and disconnectors permits, they have been rendered inoperable.

(iii) After all designated switches and disconnectors have been opened, rendered inoperable, and tagged, visual inspection or tests shall be conducted to insure that equipment or lines have been deenergized.

(iv) Protective grounds shall be applied on the disconnected lines or equipment to be worked on.

(v) Guards or barriers shall be erected as necessary to adjacent energized lines.

(vi) When more than one independent crew requires the same line or equipment to be deenergized, a prominent tag for each such independent crew shall be placed on the line or equipment by the designated employee in charge.

(vii) Upon completion of work on deenergized lines or equipment, each designated employee in charge shall determine that all employees in his crew are clear, that protective grounds installed by his crew have been removed, and he shall report to the designated authority that all tags protecting his crew may be removed.

(2) When a crew working on a line or equipment can clearly see that the means of disconnecting from electric energy are visibly open or visibly locked-out, the provisions of subdivisions (i) and (ii) of this subparagraph shall apply:

(i) Guards or barriers shall be erected as necessary to adjacent energized lines.

(ii) Upon completion of work on deenergized lines or equipment, each designated employee in charge shall determine that all employees in his crew are clear, that protective grounds installed by his

designated employee in charge

crew have been removed, and he shall report to the designated authority that all tags protecting his crew may be removed.

1926.957 (b) Deenergized equipment or lines

When it is necessary to deenergize equipment or lines for protection of employees, the requirements of paragraph 1926.950(d) shall be complied with.

XI. APPENDIX E

REFERENCES SUPPORTING GUIDELINES FOR CONTROLLING HAZARDOUS ENERGY DURING MAINTENANCE AND SERVICING

APPENDIX E

REFERENCES SUPPORTING GUIDELINES FOR CONTROLLING HAZARDOUS ENERGY DURING MAINTENANCE AND SERVICING

A.2.a. - Among the organizations concurring in this requirement are the United Automobile, Aerospace, and Agricultural Implementation Workers of America [2], the American National Standards Institute [5], the National Safety Council [6], the Rubber Manufacturing Association [7], the International Brotherhood of Electrical Workers [8], the American Iron and Steel Institute [9], and the Conveyor Equipment Manufacturers Association [10]. Other supporting references for this first essential guideline are as follows: [7-45].

A.2.b. - Publications supporting this requirement include the German Accident Prevention Specifications (draft) [46] which indicate that the initiation of hazardous movements may result from stored energy and that this stored energy may be in the form of potential or kinetic energy. The ANSI Safety Standard for the Lockout/Tagout of Energy Sources [5] indicates in Section 5.2.5 that all equipment and processes "shall be carefully examined to detect and relieve, disconnect, or restrain any residual energy." The Edison Electric Institute in describing procedures for deenergizing [47] states: "Reliance also should be placed on work procedures which assure the removal of residual energy from lines and equipment before work is begun." Other supporting references are: [3, 15, 17, 19, 22, 23, 25, 26, 31, 35, 37, 39-43, 46-51].

A.2.c.(1) - Physical means of security are utilized in many applications and industries as indicated by the ANSI Safety Standard for the Lockout/Tagout of Energy Sources [5] presentation of a generic lockout procedure. The UAW strongly advocates the use of physical lockouts in their Machinery Lockout Procedures [4]. The National Safety Council describes physical lockout provisions in their Accident Prevention Manual for Industrial Operations [6]. An article entitled "Lockouts Prevent Serious Accidents" in the Industrial Supervisor magazine recommends the use of physical locks [52]. Other references supporting the use of physical means to secure point(s) of control include: [4-6, 8, 9, 11-13, 17, 19, 22-25, 27-30, 34, 37, 38, 45, 47, 51-70].

A.2.c.(2) - The summary of a Panel Presentation on Lockout and Tagout Safety Procedures [11] clearly indicates the current use and acceptability of tagout practices in industry by detailing sample tagout procedures which have proven to be effective. The American Iron and Steel Institute [9] states that tagout procedures have long been acceptable as an alternate to locking procedures in the United States. The Pratt and Whitney Aircraft Group of United Technologies, East Hartford, Connecticut, states that "a tagout system is more reliable than a lock system" for their facility [53]. Other supporting references for using this method of security include: [3, 6, 9, 11-13, 15, 38-41, 43, 44, 47, 48, 53, 54, 58-61, 63, 66, 68-70].

A.2.c.(3) - The Square D Company indicates that minor maintenance, inspection, adjustment, and cleaning tasks can be performed safely with the power off, but not locked or tagged out as long as the operator maintains visual control of the energy control point [12]. A similar instance is adopted by the Wisconsin Electrical Power Company in a letter to the U.S. Department of Labor [48].

adjustment, and cleaning tasks can be performed safely with the power off, but

The "Report of the Committee on Electrical Safety Requirements for Employee Workplaces" [54] makes specific provisions for performing maintenance functions without benefit of lockout or tagout procedures. Other supporting references are: [9, 12, 35, 40, 45, 48, 51, 54, 58].

A.2.d. - An article in the Plant Engineering magazine [13] describing points to consider when drafting an electrical clearance (lockout/tagout) system states: "The system should indicate that no clearance shall be considered complete until the circuit has been tested with a voltage tester . . . ." An article from the Czechoslovakian Occupational Safety Inspection Office Publication entitled Power Switching - Effective Accident Prevention [14] states (after shutoff of the electrical energy): "Before starting such work, however, the parts of the machine involved must be trial started to assure that they are not energized." Monsanto, in its response to the OSHA Advance Notice of Proposed Rulemaking [15], states: "Verification that the system has been deenergized should be established, but the method may vary depending on the energy source." Other references supporting the need for verification include: [3, 6, 9, 13-15, 17, 24-27, 30, 31, 33, 39, 40, 43, 47, 48, 50-52, 54, 57, 58, 64, 71, 72].

A.2.e. - Many procedures were found to state this requirement in one way or another, but three of the best were the UAW "Machinery Lockout Procedures" [4], the ANSI "Safety Standard for the Lockout/ Tagout of Energy Sources" [5], and the "Report of the Committee on Electrical Safety Requirements for Employee Workplaces" [54]. Other supporting references are: [3, 5, 12, 26, 37, 48, 51, 54, 65, 73-75].

A.3.a. - Though not pertaining directly to written procedures, the UAW "Machinery Lockout Procedures" [4] makes the following statement: "Risk of accident will be reduced if workers are not required to rely on memory. . . ." The BSI Code of Practice, "Safeguarding of Machinery" [71], addresses the need for such a criterion as follows: "Oral instructions, requests, or promises are liable to be misheard, misinterpreted, or forgotten and are, therefore, not a satisfactory basis for action on which men's lives may depend." The unsatisfactory working of such procedures has been proven time and again. The American National Standards Institute [5], the Committee on Electrical Safety Requirements for Employee Workplaces [54], and the Manufacturing Chemists Association [16] agree that documented procedures are essential. During emergencies it should be assured that energy is isolated, blocked, dissipated, and secured. Also, provisions for close supervision and validation should be made, because emergency activities can pose serious and unexpected hazards. Actions taken during emergencies should be documented in the event reuse is required. Other references supporting documented procedures are: [3, 5, 8-10, 13, 16, 21, 27, 33, 37, 39-41, 48, 54, 56, 58, 64, 65, 71].

A.3.b. - The UAW "Machinery Lockout Procedures" [4] encourage training for workers in all aspects of safety, including the recognition of hazards as well as safety procedures. The National Safety Council in the Accident Prevention Manual for Industrial Operations [6] emphasizes that ". . . control can be maintained only by constant supervision and by training maintenance men in the safe routine." Both the ANSI Safety Standard for the Lockout/Tagout of Energy Sources [5] and the Report of the Committee on Electrical Safety Requirements for Employee Workplaces [54] emphasize training not only for personnel

actually involved in utilizing the hazard control techniques but also for those supervising and those working in the affected areas. Training is strongly supported by the following references: [5, 6, 9, 12, 21, 26, 27, 32, 37, 39, 41, 45, 48, 54, 56, 58, 62, 69, 71, 73, 74, 76, 77].

B.1. - The requirement is substantiated by noting that ANSI [5] requires that effective protection shall be provided when work is done on energized equipment or systems. Hazardous energy sources must be identified before this requirement can be met. The report of the Committee on Electrical Safety Requirements for Employee Workplaces [54] requires that when work is to be accomplished near energized circuits, employees shall consider all exposed conductors and circuit paths that are dangerous. Other supporting references for energized work include PPG Industries [78], which contains a requirement to "analyze work (in) each specific case for specific potential hazards . . ." Central Soya [79] states ". . . an awareness of potential hazards" is necessary when performing energized work.

B.2. - A letter to OSHA from the Davenport Machine Tool Division [80] states the need for safe operating, setup, and maintenance procedures performed with equipment energized. In a letter to OSHA from the Printing Industries of America, Inc. [81], the statement that "much of the equipment currently used in the printing process is designed to be cleaned, and to a lesser degree repaired, while energized" highlights the need to protect workers from energized equipment. The only way to protect the worker under these conditions is to be sure the procedures used are safe. Additionally, the ANSI Safety Standard for the Lockout/Tagout of Energy Sources [5] states that "where energized work is required, acceptable procedures and equipment shall be employed to provide effective protection to personnel." The terms "acceptable" and "effective protection" indicate a definite need to determine that the procedures used are safe.

B.3. - The documents referred to in the foregoing ([5], [54], and [80]) detail the need for safe procedures and the implied need to demonstrate that these procedures are safe. They also cite the need for training the maintenance workers and their supervisors in the hazards and procedures required to ensure safety. Justification for training workers in how to control hazards to which they would otherwise be exposed should be evident. References supporting safe performance of maintenance on energized systems are: [5, 7, 9, 15, 26, 27, 32, 38, 39, 47, 48, 51, 54, 58, 62, 65, 66, 68, 71, 73, 75, 76, 77, 79-87].

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PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
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