PURPOSE

The purpose is to eliminate unsafe conditions involving electrical equipment and tools, including faulty insulation, improper grounding, loose electrical connections, defective parts, ground faults in equipment and unguarded live electrical parts.

SCOPE

This procedure applies to all operations within Midland Engineering Co., Inc.

REFERENCES

- 29 CFR 1910.300
- 29 CFR 1926.400 - Subpart K
- National Electrical Code (NEC)
- NFPA 70E

RESPONSIBILITY

One or more competent persons must be designated (as defined in 1926.32(f) to implement the program. All personnel must inspect and test each cord set, electric tool, piece of electrical equipment and receptacle: (1.) before first use, (2.) before equipment is returned to service following repairs, and (3.) before equipment is used after any incident which can be reasonably suspected to have caused damage.

DEFINITIONS

Qualified Person- Qualified persons must be certified by their managers or supervisors, complete the proper training requirements, be capable of working safely on energized circuits and familiar with proper use of special precautionary techniques, personal protective equipment (PPE), insulating/ shielding material, and insulated tools. Certification shall be based on training, experience and knowledge of the electrical hazards involved with the work being performed.

Non-qualified Person- The same as unqualified. This is a non- OSHA term sometimes used in place of unqualified.

Unqualified Person- Person not familiar with the construction and operation of the equipment and the hazard involved.

Alternating Current (ac) - The type of electric current which reverses at regularly recurring intervals of time and which has alternately positive and negative values.

Ampere – Is the unit of measurement for the rate of flow of electricity.

Capacitance - It is the ability to accumulate and give up charge. When the voltage across an electric circuit changes the capacitance causes the circuit to opposes this change. Capacitance affects dc circuits *only* when they are turned on and off. In ac circuits, however, the voltage is continuously changing, so that the effect if capacitance is *continuous.*

Closed Circuit - A closed circuit is a complete path allowing current to flow.

Conductor - A conductor is a material that gives up free electrons and offers only slight opposition to current flow. Metals are good conductors. Copper and aluminum are very good conductors.

Current - The rate of electricity in a circuit is a current. It is measured in amperes. The symbol for current is the letter I.

Direct Current (dc) - The type of electricity in which the electrons move continuously in one direction through the conductor is direct current.

Direction of Current Flow - Electrons flow from a negatively charged point to a positively charge point. When one point in an electrical circuit is marked (-) and the other is marked (+), by convention, the current in the circuit flows from the (+) to the (-).

High Voltage - Implies a voltage higher than 600 volts.

Induction - Induction is the act or process of producing voltage by the relative motion of a conductor across a magnetic field.

Insulator - An insulator is a material that does not give up free electrons easily and offers opposition to current flow. Some of the best insulators are polystyrene, mica, glass, and wood.

Open Circuit - An open circuit has a break in the circuit which stops current flow. In a series circuit, it means the complete circuit is dead.

Ohm - The basic unit of resistance measure is ohm. One ohm is equal to the resistance that allows 1 ampere of current to flow when an EMF of 1 volt is applied. The symbol for ohm is the Greek letter *omega* (Ω).
Power - The energy consumed in an electrical circuit. Power is the voltage times the current, and its symbol is the letter P. Power is measured in watts.

Resistance - The opposition to the flow of electrons or current flow in a circuit due to characteristics of the material is resistance. The resistivity of a pure material depends on the number of fee electrons available along the current path. Resistance is measured in ohms and its symbol is the letter R.

HAZARDS OF ELECTRICITY

The primary hazards associated with electricity and their uses are:

- **SHOCK.** Electric shock occurs when the human body becomes part of a path through which electrons can flow. The resulting effect on the body can be either *direct* or *indirect*.

- **BURNS.** Burns can result when a person touches electrical wiring or equipment that is improperly used or maintained. Typically, such burn injuries occur on the hands.

- **ARC-BLAST.** Arc-blasts occur from high-amperage currents arcing through air. This abnormal current flow (arc-flash) is initiated by contact between two energized points.

- **EXPLOSIONS.** Explosions occur when electricity provides a source of ignition for an explosive mixture in the atmosphere. Ignition can be due to overheated conductors or equipment, or normal arcing (sparking) at switch contacts.

- **FIRES.** Electricity is one of the most common causes of fire both in the home and workplace. Defective or misused electrical equipment is a major cause, with high resistance connections being one of the primary sources of ignition. High resistance connections occur where wires are improperly spliced or connected to other components such as receptacle outlets and switches.

EFFECTS OF ELECTRICITY ON THE HUMAN BODY

The effects of electric shock on the human body depend on several factors. The major factors are Current and Voltage, Resistance, Path through body, and Duration of shock. The muscular structure of the body is also a factor in that people having less musculature and more fat typically show similar effects as lesser current levels. A summary of the lethal effects of eclectic current as follows:

- Current flow greater than the "let-go" threshold of an individual may cause a person to collapse, become unconscious and can result in death. The current flow would most often have to continue for longer than five seconds. Although it may not be possible to determine the exact cause of death with certainty, asphyxiation or heart failure are the prime suspects.

- Current flow through the chest, neck, head or major nerve centers controlling respiration may result in a failure of the respiratory system. This is usually caused by a disruption of the nerve impulses between the respiratory control center and the respiratory muscles. Such a condition is dangerous since it is possible for the respiratory failure to continue even after the current flow has stopped.

- The most dangerous condition can occur when fairly small amounts of current flow though the heart area. Such current flow can cause ventricular fibrillation. This asynchronous movement of the heart causes the usual rhythmic pumping action to cease. Death results within minutes.

- Extensive tissue damage, including internal organ damage due to high temperatures, occurs when very large currents flow through major portions of the body.

- When relatively large currents flow through the heart area, heart action may be stopped entirely. If the shock duration is short and not physical damage to the heart has occurred, the heart may begin rhythmic pumping automatically when the current ceases.

- There are recorded cases of delayed death after a person has been revived following an electrical shock. This may occur within minutes, hours or even days after the event has occurred. Several assumptions for such delayed effects are internal or unseen hemorrhaging, emotional or psychological effects of the shock, and aggravation of a pre-existing condition

In many accidents, there is a combination of the above effects, or additional effects may develop after the initial accident, thus making an accurate diagnosis quite difficult.

TRAINING

Employees shall be trained in safety-related work practices and procedural requirements as necessary to provide protection from the electrical hazards associated with their respective jobs. Employees shall be trained to identify and understand the relationship between electrical hazards and possible injury. Safe work practices could consist of Lockout/Tagout, use of adequate PPE and industry accepted techniques. Only qualified employees may work on energized parts. Non-qualified employees are responsible for complying with the necessary training they receive to ensure safe work practices in accordance to their job responsibilities/ assignments. . Documentation shall be made when the employee demonstrates proficiency, be maintained for the duration of the employee's employment, and contain each employee's name and date of training.

SAFE WORK PRACTICES

All activities must be conducted in accordance with the applicable parts of the Occupational Safety and Health Administration (OSHA) 1910 Subpart S-Electrical for General Industry and 1926 Subpart K- Electrical for Construction Industry.

Individuals performing electrical servicing, individuals affected by electrical servicing, and individuals that operate electrical apparatus must be qualified and approved by management and safety.

When working under overhead lines clearance distance must be provided or lines shall be de-energized and grounded. The minimum safe approach distance (M.S.A.D.) and/or clearance distance chart defines the voltage range and distance required for qualified employees. Unqualified emlpoyees must maintain a minimum ten feet approach distances for 50kV plus four feet for every additional 10kV.

Minimum Safe Approach Distance/Clearance Distance Qualified Person

Voltage range (phase to phase)	Minimum approach distance
300V and less	Avoid Contact
Over 300V, not over 750V	1 ft. 0 in. (30.5 cm).
Over 750V, not over 2kV	1 ft. 6 in. (46 cm).
Over 2kV, not over 15kV	2 ft. 0 in. (61 cm).
Over 15kV, not over 37kV	3 ft. 0 in. (91 cm).
Over 37kV, not over 87.5kV	3 ft. 6 in. (107 cm).
Over 87.5kV, not over 121kV	4 ft. 0 in. (122 cm).
Over 121kV, not over 140kV	4 ft. 6 in. (137 cm).

Safe Work Practices Continued

Risks must be eliminated and or reduced in accordance with the hierarchy of control principals:

- Elimination (No working energized)
- Engineering Controls
- Administration Controls
- Personal Protective Equipment (PPE)

General Requirements:

Extension cords are for temporary use only, to supply electrical power to portable equipment such as hand power tools, portable lighting and fixed wiring. Cords must be properly rated and listed for the intended use. Extension cords are not to be used inside equipment for providing electrical power to components.

Extension cords shall not be using electrical boxes or duplex receptacles. Extension cords used in the workplace must be used in conjunction with a Ground Fault Circuit Interrupter (GFCI) protection. Extension cords are to be inspected routinely for external defects such as damage to insulation, loose parts and deformed or missing pins. Any found to be damaged must be removed from site. All extension cords must not be extended across aisles or doorways, or draped over equipment.

DE-ENERGIZED ELECTRICAL WORK

De-energizing to establish an Electrically Safe Working Condition is the preferred method of protection employees from serious injury or death. Every possible action must be taken to service, inspected and/or calibrated electrical systems and equipment with the power locked and tagged out.

Systems, equipment and components that are de-energized but not locked and tagged out of service are considered energized and service activities are to be performed in accordance with all work practices beginning with Definitions of Employees above, unless all the following criteria are met:

- The qualified employee doing the work disconnects the means immediately adjacent to where the work is performed.
- The disconnect means are clearly visible and in control of that employee
- The employee never leaves the system unattended
- The work does not extend beyond the shift.
- Use protective barriers/ shields to protect unqualified personnel from accidental contact.

Energized Electrical Work Practices (Reference NFPA 70E chapter of this manual)

All work practices for energized work must protect against electrical shock and Arc/Flash/Burn to the body based upon an evaluation of the specific work conditions, exposed voltage, and available fault current; the requirements of NFPA 70E will be followed.

Safe Work Practices for Working within the Limited Approach Boundary

The limited approach boundary is the distance from an exposed live part within which a shock hazard exists.

The restricted approach boundary is the closest distance to exposed live parts a qualified person can approach with without proper PPE and tools. Inside this boundary, accidental movement can put a part of the body or conductive tools in contact with live parts or inside the prohibited approach boundary. To cross the restricted approach boundary, the qualified person must:

- Have an energized work permit that is approved by the supervisor or manager responsible or the safety plan.
- Use PPE suitable for working near exposed lived parts and rated for the voltage and energy level involved.
- Be certain that no part of the body enters the prohibited space.
- Minimize the risk from unintended movement, by keeping as much of the body as possible out of the restricted space; body parts in the restricted space should be protected.

The prohibited approach boundary is the minimum approach distance to exposed live parts to prevent flashover or arcing. Approaching any closer is comparable to making direct contact with a live part. To cross the prohibited approach boundary, the qualified person must:

- Have specified training to work on exposed live parts.
- Have a permit with proper written work procedures and justifying the need to work that close.
- Do a risk analysis.
- Have (2) and (3) approved by the appropriate supervisor.
- Use PPE appropriate for working near exposed live parts and rated for the voltage and energy level involved.

The Flash Protection Boundary is the approach limit at a distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur.

- Use PPE appropriate for working near exposed live parts and rated for the voltage and energy level involved.
- For systems of 600 volts and less, the flash protection boundary is 4 feet, based on an available bolted fault current of 50 kA and a clearing time of 6 cycles for the circuit breaker to act, or any combination of fault currents and clearing times not exceeding 300 kA cycles.
- When working on de-energized parts and inside the flash protection boundary for nearby live exposed parts - If the parts cannot be de-energized, use barriers such as insulted blankets to protect against accidental contact or wear proper PPE.

Arc Flash Hazard Analysis
An arc flash hazard analysis includes the following:

- Collect data on the facility's power distribution system.
    - Arrangement of components on a one-line drawing with nameplate specifications of every device.
    - Lengths and cross-section area of all cables.
- Contact the electric utility for information including the minimum and maximum fault currents that can be expected at the entrance to the facility.
- Conduct a short circuit analysis followed by a coordination study is performed.
- Feed the resultant data into the NFPA 70E equations.
    - These equations produce the necessary flash protection boundary distances and incident energy to determine the minimum PPE requirement.
    - The flash protection boundary is the distance at which PPE is needed to prevent incurable burns (2nd degree or worse) if an arc flash occurs. (It is still possible to suffer 1st or 2nd degree burns.)
- For systems of 600 volts and less, the flash protection boundary is 4 feet, based on an available bolted fault current of 50 kA (kiloamps) and a clearing time of 6 cycles (0.1 seconds) for the circuit breaker to act, or any combination of fault currents and clearing times not exceeding 300 kA cycles (5000 ampere seconds).

When working on de-energized the parts, but still inside the flash protection boundary for nearby live exposed parts:

- If the parts cannot be de-energized, barriers such as insulated blankets must be used to protect against accidental contact or PPE must be worn.
- Employees shall not reach blindly into areas that might contain exposed live parts.
- Employees shall not enter spaces containing live parts unless illumination is provided that allows the work to be performed safely.

- Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) shall not be worn where they present an electrical contact hazard with exposed live parts.
- Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that prevents accidental contact with live parts. Such materials and equipment include, but are not limited to long conductive objects such as ducts, pipes, tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.
- When an employee works in a confined space or enclosed spaces (such as a manhole or vault) that contains exposed live parts, the employee shall use protective shields, barriers or insulating materials as necessary to avoid contact with these parts. Doors, hinged panels, and the like shall be secured to prevent them from swinging into employees. Refer to the confined space entry program.

Inspections

- Electrical equipment, tools, and appliances must be inspected prior to each use.
- The use of a hard fixed GFCI or a portable GFCI adapter shall be used with all portable hand tools, electric extension cords, drop lights and all 110 volt equipment.
- Faulty equipment, tools, or appliances shall be removed from service immediately and tagged "Out of Service", dated and signed by the employee applying the tag.

Equipment

Test instruments, equipment, and their accessories shall meet the requirements of ANSI/ISA-61010-1-Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use Part 1 General Requirements, for rating and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 Volts and below. In addition, vehicular and mechanical equipment require a ten feet clearance distance.

When test instruments are used for the testing for the absence of voltage on conductors or circuit parts operating at 50 volts or more, the operation of the test instrument shall be verified before and after an absence of voltage test is performed.

Personal Protective Equipment

All insulating PPE must be inspected before each day's use and immediately following any incident that can reasonably be suspected of having caused damage. Insulating gloves shall be given an air test, along with the inspection.

Maximum test intervals for rubber insulating personal protective equipment shall include:

- Blankets-before first issue/every 12 months thereafter
- Gloves-before first issue and every 6 months
- Sleevers before first issue and every 12 months
- Covers and line hose shall be testing if insulating value is suspect.

Energized Electrical Work Permit

Work on energized electrical conductors or circuit parts that are not placed in an electrically safe work condition shall be considered energized electrical work and shall be performed by written permit only.

Lighting

Employees shall not enter spaces containing electrical hazards unless illumination is provided that enables the employees to perform the work safely. Where lack of illumination or an obstruction precludes observation of the work to be performed employees shall not perform any task within the Limited Approach Boundary of energized electrical conductors or circuit parts operating at 50 volts or more or where an electrical hazard exists.

LOCKOUT/TAGOUT-FORMS OF HAZARDOUS ENERGY (Reference Lockout/Tagout Program in Manual)

There are many different types of machinery and equipment used by the company. Energy comes in many forms and can exist in two states, active and stored. Machinery and equipment used by the company are identified on the master equipment list and discussed individually in the Energy Control Shutdown Forms section of this program. The following are different forms of hazardous energy:

- Electrical
- Compressed Air (Pneumatic)
- Petroleum Fuels (Fuel Lines)
- Gravity (Suspended Components)
- Hydraulic
- Tension
- Chemical
- Thermal (Surface Temperature)

LOCKOUT/TAGOUT-AUTHORIZED EMPLOYEE (Reference Lockout/Tagout Program in Manual)

The only employees authorized to lock or tag machinery and equipment and remove their locks and tags are personnel who have had specific lockout/tagout training and are authorized by the company. Authorized employees have received information and training on energy sources and stored energy with machinery and equipment used by the company. Machinery and equipment will not be energized without the consent of an authorized employee. Unauthorized removal of locks or tags will be grounds for disciplinary action and/or grounds for termination.

LOCKOUT/TAGOUT-AFFECTED EMPLOYEES (Reference Lockout/Tagout Program in Manual)

Affected employees are individuals who cannot use machines or equipment for production due to lockout/tagout devices. If the machine, which you frequently use, is to be locked-out for maintenance or repair you will be verbally notified. You will also be notified if you typically use the products of the affected machine (such as materials cut to specific lengths). This will allow you to make other arrangements for obtaining the materials you need to do your work and/or do projects that do not require the affected machine. Do not attempt to restart any machinery or equipment that is locked or tagged. When the machinery or equipment is ready for production the lockout/tagout supervisor will notify affected employees. Do not attempt to remove any energy-isolating device.

Individual positions for authorized and affected employees will be identified by the employers prior to any LOTO process taking place.

ELECTRICAL PROTECTIVE DEVICES

As a power source, electricity can create conditions almost certain to result in bodily harm, property damage, or both. It is important for workers to understand the hazards involved when they are working around electrical power tools, maintaining electrical equipment, or installing equipment for electrical operation. The electrical protective devices include fuses, circuit breakers, and ground-fault circuit-interrupters (GFCIs).

- Fuses - A fuse is an electrical device that opens a circuit when the current flowing through it exceeds the rating of the fuse. The "heart" of a fuse is a special metal strip (or wire) designed to melt and blow out when its rated amperage is exceeded.

- Circuit Breaker - Circuit breakers provide protection for equipment and conductors from excessive current without the inconvenience of changing fuses. Circuit breakers trip (open the circuit) when the current flow is excessive.

- Ground-Fault Circuit-Interrupter - A ground-fault circuit-interrupter is <u>not</u> an over-current device. A GFCI is used to open a circuit if the current flowing to the load does not return by the prescribed route. The GFCI is designed to limit electric shock to a current-and time-duration value below that which can produce serious injury.

All equipment grounding conductors shall be tested for continuity & shall be electrically continuous. Each receptacle & attachment cap or plug shall be tested for correct attachment of the equipment grounding conductors.

The equipment grounding conductor shall be connected to its proper terminal:
(1) Before each use.
(2) Before equipment is returned to service following any repairs
(3) Before equipment is used such as when a cord has been run over.
(4) At intervals not to exceed 3 months,
(5) Cord sets & receptacles which are fixed & not exposed to damage shall be tested at intervals not exceeding 6 months.

Tests performed as required by this program shall be recorded as to the identity of each receptacle, cord set, & cord & plug connected equipment that passed the test and shall indicate the last date tested or interval for which is was tested. This record shall be kept by means of logs, color coding, or other effective means & shall be maintained until replaced by a more current record. These records shall be made available at the job site for inspection by the Assistant Secretary & any affected employees

ASSURED EQUIPMENT GROUNDING CONDUCTOR PROGRAM

This assured equipment grounding conductor program is to be used on sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. The employer shall designate one or more competent persons (as defined in 1926.32(f)) to implement this program.

Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other effective means and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

GROUNDING & BONDING

Grounding must be taken into account wherever electrical current flows. It can never be stressed too strongly that proper grounding and bonding must be correctly applied if the system, the equipment, and the people that come in contact with them are to be protected.

Effective grounding means that the path to ground: (1) is permanent and continuous, and (2) has ample current-carrying capacity to conduct safely any currents liable to be imposed on it, and (3) has impedance sufficiently low to limit the potential above ground and to facilitate the operation of the over-current devices in the circuit.

Effective bonding means that the electrical continuity of the grounding circuit is assured by proper connections between service raceways, service cable armor, all service equipment enclosures containing service entrance conductors, and any conduit or armor that forms part of the grounding conductor to the service raceway.

Proper grounding requires connecting all of the enclosures (equipment housings, boxes, conduit, etc.) *together, and back to the service entrance enclosure*. This is accomplished by means of the green wire in the cord.

Ladder Usage: Step Ladders

Great care should be taken in the selection of the proper size and design of the ladder for the use intended. Never use metal ladders as they are considered as electrical conductors. Their use around electrical circuits of any type, or places where they may come in contact with such circuits, is not recommended. Metal ladders should be marked with signs reading "CAUITON: DO NOT USE AROUND ELECTRICAL EQUIPMENT"

- Step ladders shall have non-conductive side rails.
- Stepladders sometimes referred to as "A" frame ladders, must have positive locking spreaders that will be fully spread and locked when the ladder is in use.
- Stepladders will not be used as straight ladders. They should be of sufficient height to preclude the necessity of employees using the top two steps of the ladder.

- Employees will not be allowed to work from the top two steps of a stepladder.

- Stepladders shall be firm and well constructed. Special care shall be taken when setting any ladder on grating. Often the feet of a stepladder can slip through the grating causing the ladder to fall.

- Stepladders shall be tied off or a worker shall hold the ladder when the user is 6 feet or more above the floor.

FIXED EQUIPMENT

Exposed non-current carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

- If within 8 feet vertically or 5 feet horizontally of ground or grounded metal objects and subject to employee contact.

- If located in a wet or damp location and not isolated.

- If in electrical contact with metal.

- If in a hazardous (classified) location.

CONFINED SPACE WITH ELECTRICAL HAZARDS (Reference Confined Space Program in Manual)

In potentially explosive or flammable atmosphere, non-sparking tools and portable vapor-proof electric light not exceeding 12 volts must be used. Smoking, open flames, and cutting or welding will be prohibited. Personal protective equipment (PPE), such as coveralls, impervious gloves, boots, face and eye protection, must be used are required by the nature of the operation to be performed. Protective shields, protective barriers or insulating materials as necessary shall be provided.

ELECTRICAL SAFETY QUIZ

Company: _____

Name: _____ Date: _____

1. All personnel must inspect and test each cord set, electric tool, piece of electrical equipment and receptacle: (1).) before first use, (2.) before equipment is returned to service following repairs, and (3.) before equipment is used after any incident that can be reasonably suspected to have caused damage. True False

2. List two primary hazards associated with electricity and its use:
   a._____
   b._____

3. The effects of electric shock on the human body depend on several factors. The major factors are:

   1. Current and Voltage 2. Resistance
   3. Path through a body 4. Duration of shock True False

4 A fuse is an electrical device that opens a circuit when the current flowing through it exceeds the rating of the fuse. The "heart" of a fuse is a special metal strip (or wire) designed to melt and *blow out* when its rated amperage is exceeded. True False

5. Circuit breakers provide protection for equipment and conductors from excessive current without the inconvenience of changing fuses. Circuit breakers *trip* (open the circuit) when the current flow is excessive. True False

6. *Effective grounding* means that the path to ground: (1) is permanent and continuous, and (2) has ample current-carrying capacity to conduct safely any currents liable to be imposed on it, and (3) has impedance sufficiently low to limit the potential above ground to facilitate the operation of the over-current devices in the circuit. True False

7. *Effective bonding* means that the electrical continuity of the grounding circuit is assured by proper connections between service raceways, service cable armor, all service equipment enclosures containing service entrance conductors, and any conduit or armor that forms part of the grounding conductor to the service raceway. True False

Instructor:_____