Page 110-143

Lesson 4: Electrical Hazards—Other Preventive Measures

Lesson Focus

This lesson focuses on the following topics:

- Grounding
- Power Tool Requirements
- Clues that Electrical Hazards Exist
- Locking Out and Tagging Out of Circuits
- Safety-Related Work Practices
- Examples of the Infeasibility to De-Energize
- Preventing Electrical Hazards—Personal Protective Equipment (PPE)
- Training
- Batteries and Battery Charging

Grounding

Grounding creates a low-resistance path from a tool to the earth to disperse unwanted current.

When a short or lightning occurs, energy flows to the ground, helping protect you from electrical shock, injury, and death.

Hazard–Improper Grounding

Tools plugged into improperly grounded circuits may become energized. There also may be occurrences of broken wires or plugs on the extension cord.

Control–Ground Tools and Equipment

The following should be taken into consideration when working with tools and equipment:

- Properly ground power supply systems, electrical circuits, and electrical equipment.
- Frequently inspect electrical systems to ensure that the path to ground is continuous.
- Inspect electrical equipment before use.
- Don’t remove ground prongs from tools or extension cords.
- Do not use tools or extension cords with missing or damaged ground plugs.

- Ground exposed metal parts of equipment.

Control–Using a Ground-Fault Circuit Interrupter (GFCI)

A GFCI performs the following functions:

- Helps to protect you from shock.
- Detects differences in current as small as 4 mA between the amounts of electricity flowing into a circuit compared to the amount flowing out of the circuit.
- Shuts off electricity in 1/40th of a second if a ground fault is detected.

Control–Assured Equipment Grounding Conductor Program (AEGCP)

An employer must use *either ground fault circuit interrupters* or an assured equipment grounding conductor to protect employees on construction sites.

The AEGCP on construction sites must cover:

- All cord sets.
- Receptacles not part of a building or structure.
- Equipment connected by plug and cord available for use by the employer.

Program requirements include:

- Specific procedures adopted by the employer (in writing and available for inspection).
- A competent person designated by the employer to implement the program.
- Daily visual inspection for damage of equipment and cords connected by cords and plugs before use.

Click "More About" for more Information:

Hazard–Overloaded Circuits

Too many devices plugged into a circuit can result in heated wires and possibly fire.

Wire insulation melting can cause arcing and fire in the area where the overload exists, even inside a wall.

Control—Electrical Protective Devices

Electrical protective devices are designed to automatically open a circuit if excess current from overload or ground-fault is detected, resulting in the shutting off of electricity.

Electrical protective devices include GFCIs, fuses, and circuit breakers.

Ground-Fault Circuit Interrupter (GFCI): A device for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Fuses: (Over 600 volts, nominal) Overcurrent protective devices with a circuit opening fusible part that is heated and severed by the passage of overcurrent through that part. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. A fuse may or may not be the complete device necessary to connect it into an electrical circuit.

Circuit Breakers:

(a) (600 volts nominal, or less) Devices designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

(b) (Over 600 volts, nominal) Switching devices capable of making, carrying, and breaking currents under normal circuit conditions, and also capable of making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Power Tool Requirements

Power tools must:

- Be grounded through a 3-wire cord with one wire going to ground OR be double insulated; OR
- Be double-insulated or be powered by a low-voltage isolation transformer; OR
- Be powered by a properly designed and self-contained battery power unit.

Tool Safety Tips

The following are some safety tips to consider when using tools:

- Use gloves and appropriate footwear when using tools and when safe and appropriate to do so.
- Store tools in a dry place when not in use.
- Don't use tools in wet/damp conditions unless they are designed for this purpose.
- Keep working areas well lit.
- Ensure that tools and cords do not create a tripping hazard.
- Don't carry a tool by the cord.

- Don't yank the cord to disconnect the tool from the electrical source.
- Keep cords away from heat, oil and sharp edges.
- Disconnect tools when not in use and when changing accessories such as, blades and bits.
- Remove damaged tools from use.

More Information: Avoid accidental starting. Do not hold fingers on the power switch or button while carrying a plugged-in tool or while tagging damaged tools.

Preventing Electrical Hazards-Tools

The following measures should be taken to prevent electrical hazards associated with the use of tools:

- Inspect tools before use.
- Use the right tool correctly.
- Protect your tools from damage.
- Use double insulated tools when appropriate.

Temporary Lights

Temporary lights should be protected from contact and damage, and they should not be suspended by cords unless designed to do so.

Clues that Electrical Hazards Exist

The following are some clues that can help you in determining whether an electrical hazard exists:

- When there are tripped circuit breakers or blown fuses.
- When tools, wires, cords, connections, or junction boxes are warm to the touch.
- When a GFCI shuts off a circuit.
- When there is a worn or frayed insulation around a wire or a connection.

More Information: If a GFCI trips while you are using a power tool, there is a problem. Don't keep resetting the GFCI and continue to work. You must evaluate the "clue" and decide what action should be taken to control the hazard.

Locking Out and Tagging Out of Circuits

The following steps must be performed when locking out and tagging out circuits:

- Apply locks to the power source after de-energizing.
- Verify circuit is de-energized by testing with known functioning meters.

- Tag deactivated controls and power sources.
- Tag de-energized equipment and circuits at all points where they can be energized.
- Tags must identify equipment or circuits being worked on.

Safety-Related Work Practices

To protect workers from electrical shock:

- Use barriers and guards to prevent passage through areas of exposed energized equipment.
- Pre-plan work, post hazard warnings, and use protective measures.
- Keep working spaces and walkways clear of cords.
- Use special insulated tools when working on fuses with energized terminals.
- Don't use worn or frayed cords and cables.
- Don't fasten extension cords with staples, hang the cords from nails, or suspend the cords using wire.

More Information:

1. Employers must not allow employees to work near live parts of electrical circuits, unless the employees are protected by one of the following means:
   - De-energizing and grounding the parts.
   - Guarding the part by insulation.
   - Any other effective and approved means.
2. In work areas where the exact location of underground electrical power lines is unknown, employees using jack hammers, bars, or other hand tools that may contact the lines must be protected by insulating gloves, aprons, or other protective clothing that will provide equivalent electrical protection.
3. Flexible cords must be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.
4. Equipment or circuits that are de-energized must be rendered inoperative and must have appropriate locks and tags attached at all points where the equipment or circuits could be energized.

As appropriate, the employer shall ensure that all wiring components and utilization equipment in specific hazardous locations are maintained in a dust-tight, dust-ignition-proof, or explosion-proof condition. There shall be no loose or missing screws, gaskets, threaded connections, seals, or other impairments to a tight condition.

Avoiding Wet Conditions

The following are important points to consider in avoiding wet conditions:

- If you touch a live wire or other electrical component while standing in even a small puddle of water you may get a shock.
- Damaged insulation, equipment, or tools can expose you to live electrical parts.
- Improperly grounded metal switch plates and ceiling lights are especially hazardous in wet conditions.
- Wet clothing, high humidity, and perspiration increase your chances of being electrocuted.

Energized Work

Working on or Near Live parts

Energized work must be put into an electrically safe work condition or the reasons for not doing so must be properly documented and justified.

To justify energized work, an employer must demonstrate that de-energizing introduces additional or increased hazards, or is infeasible due to equipment design or operational limitations.

Work on circuits with voltages less than 50 volts may be performed in an energized state if a proper assessment has been completed and there is no increased exposure to electrical burns or explosion risks due to arcs.

Examples of Increased or Additional Hazards (Justification to Work on Energized Circuits Over 50 Volts)

- Interruption of life support equipment
- Deactivation of emergency alarm systems
- Shutdown of hazardous location ventilation equipment

Examples of the Infeasibility to De-Energize

- Performing diagnostics and testing during startup or troubleshooting that can only be done in an energized state
- Work on circuits that are part or a continuous process that would otherwise require the entire process to be shut down

Energized Electrical Work Permit

If justification for energized work is demonstrated, then the work can be performed only after proper completion of a written permit.

Elements of an Energized Electrical Work Permit include the following:

- Description and location of the circuit and the equipment involved
- Justification for energized work
- List of the safe work practices to be applied
- Results of a shock risk assessment
- Determination of the shock protection boundaries as noted in NFPA 70E
- Results of an arc flash analysis
- Required PPE
- Means used to restrict entry of qualified personnel into the work area
- Completion of a job briefing, including a discussion of job specific hazards
- Authorized and signed energized work approval

Exemptions to a Work Permit

Work that is performed on or near live parts by qualified persons and related to tasks such as testing, troubleshooting, and voltage measuring may not require an energized electrical work permit as long as the appropriate safe work practices and required PPE are used.

NFPA 70E Compliments OSHA Regulations

In lieu of detailed specifications, OSHA recognizes, and in some cases refers to, industry consensus standards such as the National Fire Protection Association's (NFPA) 70E as a tool for assisting with regulatory compliance. A copy of NFPA 70E is considered by many to be a critical addition to every employer's safety library.

The National Fire Protection Association provides free access to read and review their standards, including 70E. This service allows users to view the standards after registering with the association. This access is available on the website.

Purchasing or accessing this standard is critical a full and complete understanding of the definitions, work practices, controls, documentation, and equipment necessary to provide for a safe work site and to ensure compliance with the applicable OSHA standards.

The following definitions are used by the NFPA in defining the type and nature of protective measures to be taken at varying locations. It is highly recommended that you access NFPA 70E to ensure you have all of the information necessary.

Approach Boundaries to Energized Parts

Arc Flash Boundary: In those activities or conditions where the hazard of an arc flash is present, the arc flash boundary is that distance from the source that an exposed individual could receive second degree burns. In other words, the individual is potentially in harm's way.

Limited Approach Boundary: In those activities or conditions where the hazard of an electrical shock is presented by energized electrical components, this is the distance at which exposure to a shock is possible.

Restricted Approach Boundary: This is the distance at which there is a heightened possibility of electrical shock from energized electrical components, due to a combination of existing conditions, personnel movement, and proximity.

> **Note:** Any personnel working on energized parts must have training on the requirements of NFPA 70E. Please complete the additional training program on this code prior to working on energized parts.
>
> Detailed information regarding the application of the boundaries can be found in NFPA 70E. Appendix C, Section 1.2.3 of this standard provides an excellent graphical representation of the boundaries which may be useful for training and enforcement activities.

Preventing Electrical Hazards—Personal Protective Equipment (PPE)

When it is necessary to handle or come close to wires with a potentially live electrical charge, it is essential to use proper insulating personal protective equipment (PPE) to help protect employees from coming into contact with the hazardous electrical energy.

The following measures can provide protection from electrical hazards:

- Proper foot protection
- Rubber insulating gloves, hoods, sleeves, matting, and blankets
- Hard hat (insulated—nonconductive)

Safety Shoes and Boots

Safety shoes and boots should be nonconductive and should protect your feet from completing an electrical circuit to ground. Safety shoes can help protect against open circuits of up to 600 volts in dry conditions. These shoes should be used with other insulating equipment and in connection with active precautions to reduce or eliminate the potential for providing a path for hazardous electrical energy.

Hard Hats

Specific types of hard hats are needed when performing electrical work.

A "Class E" electrical/utility type hard hat protects against falling objects and high-voltage shock and burns.

Note: Wearing a hard hat provides protection for your head of up to 20,000 volts.

Basis for Determining Personal Protective Equipment for Work within a Flash Protection Boundary

When it is determined that work must be performed within an Arc Flash Boundary, a flash hazard analysis must determine, and the employer must document, the incident energy exposure of the worker in cal/cm^2.

Type of PPE for Arc Flash Protection

Flame-resistant (FR) clothing and PPE must be used by anyone crossing any part of her or his body into the Arc Flash Boundary as based on the incident energy calculation.

Training

Employees working with electric equipment must be trained in safe work practices, including:

- De-energizing electric equipment before inspecting or repairing.
- Using cords, cables, and electric tools that are in good repair.
- Lockout / tagout recognition and procedures.
- Using appropriate protective equipment.

De-Energizing Electrical Equipment

Accidental or unexpected starting of electrical equipment can cause injury or death. Before any inspections or repairs are made, the current must be turned off at the source and this location locked in the "OFF" position. Additionally, the switch or controls of the

machine, or other equipment being locked out of service, must be tagged securely to show which equipment or circuits are being worked on.

Employees should be trained in, and familiar with, the safety-related work practices that pertain to their respective job assignments.

A De-Energizing or Lockout / Tag out Program requires the following:

- Application of locks to all power sources, including all potential sources of electrical energy, after each source has been de-energized.
- Application of a tag on each de-energized control identifying who has locked the control out, and instructing others to not unlock or re-energize the control.
- Proper training for all workers involved in or potentially impacted by the de-energization of the equipment. Included in this training should be the following groups of employees:
    - **Authorized employees**—those who lock out and/or tag out machines or equipment in order to perform maintenance or servicing
    - **Affected employees**—those whose job requires them to use or operate equipment or machines being maintained or serviced
    - **All other employees**—who work or operate in areas where lockout/tagout procedures are used

Batteries and Battery Charging

Batteries of the unsealed type shall be located in enclosures with outside vents or in well-ventilated rooms and shall be arranged so as to prevent the escape of fumes, gases, or electrolyte spray into other areas.

Following are the parts of Section 1926.441(a) and (b).

Click on the highlighted parts of Section 1926.441(a) and (b) to learn more.
1926.441(a)(2): Ventilation shall be provided to ensure diffusion of the gases from the battery and to prevent the accumulation of an explosive mixture.

1926.441(a)(3): Racks and trays shall be substantial and shall be treated to make them resistant to the electrolyte.

1926.441(a)(4): Floors shall be of acid resistant construction unless protected from acid accumulations.

1926.441(a)(5): Face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries.

1926.441(a)(6): Facilities for quick drenching of the eyes and body shall be provided within 25 feet (7.62 m) of battery handling areas.

1926.441(a)(7): Facilities shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

1926.441(b): Charging*

1926.441(b)(1): Battery charging installations shall be located in areas designated for that purpose.

1926.441(b)(2): Charging apparatus shall be protected from damage by trucks.

1926.441(b)(3): When batteries are being charged, the vent caps shall be kept in place to avoid electrolyte spray. Vent caps shall be maintained in functioning condition.

*Section title is not clickable.

Lesson Summary

Wearing a proper hard hat can provide protection for your head of up to 20,000 volts, and safety shoes can protect against open circuits of up to 600 volts in dry conditions. Safety shoes should be used with other insulating equipment and in connection with active precautions to reduce or eliminate the potential for providing a path for hazardous electrical energy.

Live parts to which an employee may be exposed must be de-energized before the employees work on or near them, unless the employer provides proper justification to demonstrate that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations.

Lesson 5: Struck by Hazards

Lesson Focus

This lesson focuses on the following topics:

- What is the Struck-By Hazard?
- Danger from Heavy Vehicles
- Danger from Falling or Flying Objects
- Danger from Constructing Masonry Walls

What is the Struck-By Hazard?

According to the U.S. Department of Labor Occupational Safety and Health Administration, being struck by objects is a leading cause of construction-related deaths. Only falls rank higher and is the number one cause of death in the construction industry. OSHA estimates that 75 percent of struck-by fatalities involve heavy equipment like trucks or cranes. The number of workers that die as a result of being struck by a vehicle was at a seven-year high in 1998.

Safety and health programs must include ways to limit or eliminate the many ways struck-by accidents can occur because one of the major causes of construction-related deaths is from being struck by objects.

Typically, struck-by accidents are associated with:

- Vehicles
- Falling or flying objects
- Masonry walls

The Danger from Heavy Vehicles

Danger

If vehicular safety practices are not followed at a work site, workers are at risk of being pinned (caught) in between construction vehicles and walls or stationary surfaces, struck by swinging equipment, crushed beneath overturned vehicles, or many other similar accidents. When working near a public roadway, workers are additionally exposed to being struck by trucks, cars, or other vehicles.

Improper operation of heavy vehicles poses a life-threatening danger to construction workers. Always follow safe practices to minimize injuries and save lives.

Important engineering controls include:

- Always install, use, and maintain vehicle back-up alarms.
- Station flaggers behind vehicles that have obstructed rear views.
- Keep non-essential workers away from areas of vehicle use.
- Keep workers away from temporary overhead activities.
- Place barriers and warning signs around hazardous operations and public roadways.

Seat Belts

The use of seatbelts during use of construction equipment or other motor vehicle must be made mandatory to reduce the effects of a crash. Research shows that the use of a seat belt reduces the risk of a fatal injury by 45% to front seat occupants of a car and 60% by light truck occupants.

Workers must wear seat belts in all vehicles that are equipped with seat belts. In the event of an accident, workers can be struck by the frame of the cab. Roll-over accidents can cause tools or material into the operator.

Avoiding Vehicle-Related Injuries

There are many ways to protect workers from being struck by objects and equipment.

Two important general rules to follow are:

- **Never** put yourself between moving or fixed objects.
- **Always** wear bright, highly visible clothing when working near equipment and vehicles.

Internal Traffic Control Plans for Work Zones

Using an internal traffic control plan (ITCP) for work zones is the best practice for construction site vehicle safety. The ITCP can be utilized by the project manager as a communication and coordination tool to control the movement of construction workers, vehicles, and equipment in the activity area.

ITCP's are intended to promote the safety of the roadway and to prevent caught in or struck by accidents to workers or others in the area. Some considerations for having an internal traffic control plan are:

- Internal signage denoting the activity area
- Specific protocols and procedures for construction vehicle ingress/egress

- Movement of traffic within the activity area
- Designated areas that prohibit workers that are on foot
- Communication protocol between all parties on the construction site.

Portable LED Tower Lighting

It is important for nighttime work zones to have proper lighting that will improve visibility for all the work activities within that area. High-efficiency light emitting diodes (LED) floodlights that are mounted on portable trailers or on moving equipment are very helpful and, in some cases, considered required equipment. LED Tower lights are lightweight and can be mounted between 14 and 15 feet high with a directional aim to the work area.

The use of LED lighting will provide low maintenance and durable lighting of good quality for the work area. This type of lighting will also reduce glare, helping avoid any spillover or struck by/caught in accidents. This type of portable set up can be labor-intensive therefore, it is best to use it for short-term project like lane or road closure.

Road Closure Program

Construction projects must be analyzed to determine any prior road closures before setting up of construction activities. The city or county where the road closure will occur would have to conduct a cost benefit analysis to determine its impact on the surrounding area. Some of considerations that will be made during this cost-benefit analysis will be traffic volumes, duration of the project, and the length of the detour that will be required. Another consideration will be provisions that need to be made for residents and businesses that are affected by the road closure. The possibility of closing the road prior to the construction activities will eliminate any chances of struck by vehicle hazards for the workers as well as general public.

Lane Closure Policy/Map

There are some states that have adopted lane closure policies based on traffic mapping. Traffic mapping informs traffic engineers what areas are prone to more traffic during various times of a day or on a specific day of the week as compared to other areas. Understanding the flow of traffic pattern of the community will lead to effective work lane closure policies. For instance, Colorado DOT (CDOT) has identified six distinct regions that have their own unique lane closure policies. CDOT will publish Lane closure maps and spreadsheets for works to engineers and contractors. This program has helped the

Colorado Department of transportation to plan more effective enclosures based on the specific needs of the region.

Working around Other Vehicular Traffic

When working in an area that is exposed to vehicular traffic it is important to be aware of struck-by accidents.

This section will focus on the hazard of controlling traffic and how to control the worksite to avoid any injuries to workers. There are a few areas of concern when controlling traffic due to construction activities, these include but are not limited to:

- Maintenance of Traffic Basics
- Traffic Control Devices
- Flagger Procedures

The Federal Highway Administration (FHWA) has a Federal guidance for traffic control devices known as the Manual on Uniform Traffic Control Devices (MUTCD). In the MUTCD, the instruction is to use signs and channelizing devices to warn and direct traffic to the open lanes. Communication with the traveling public starts in the advance warning area. This is where the MOT designer will set up channeling devices and warning size based on:

1. The build of the road:
    a. Two-lane/Two way Roads
    b. Multilane road
2. Where the work is located:
    a. Shoulder
    b. Travel lane
    c. Median
3. Speed limit of the travel lane

Traffic Control Devices

The use of traffic control devices is crucial to the maintenance of traffic operations. This traffic device that is placed in the road must:

- **Fulfill a need**- A channelizing is needed to guide and direct traffic and pedestrians to the safest traveling path. These devices are helpful in

creating barriers and boundaries on a temporary basis. It also helps in training the drivers regarding what is expected of them on the road.

- **Command attention**- Both drivers and pedestrians must look at the channeling devices. These are generally made from a retro reflective material, have a warning light, or a ballast and will warn and alert drivers of hazards created by construction and maintenance activities in or near the roadways. Any disregard for the channeling devices or signs can increase the likelihood of a struck by accident.
- **Convey a clear and simple meaning**- The traffic control engineer must choose an appropriate traffic control device that gives a clear meaning to the drivers. No channeling device or message should cause an accident due to its design.
- **Command respect**- Both drivers and pedestrians must obey and respond to the road signs, channeling devices, or traffic personnel. Everything that the MOT operator does must be communicated through authority.

Traffic Control Signage

The use of temporary traffic control devices and signage can greatly reduce traffic related hazards. These signs come in three categories:

- **Warning:** Warning signs have a basic shape, usually diamond, to denote a hazard ahead. Sometimes the signs are orange with black legend or yellow with black legend.
- **Regulatory**: Regulatory signs are legal obligation which, if broken, can result in a traffic citation. This obligation is denoted on the sign that is usually in a rectangular design with a white background and black legend. However, there are some regulatory signs with unique shapes such as the eight sided stop sign.
- **Guidance:** Guidance signs are generally rectangular in shape in basic white on green colors. However, signs indicating construction activity ahead may be black on orange.

In addition to using signs, channeling devices must also be used to control traffic. The function of any channeling device is to help guide and direct the pedestrians, cyclist, or motorist to the safest way to proceed past the construction area. Additionally, these channeling devices will provide warnings of hazards which were created by the construction activities.

Channeling devices consist of the following:

- Traffic Cone
- Tubular marker
- Drums
- Vertical panels
- Type I barricades
- Type II barricades
- Type III barricades
- Longitudinal Channelization Devices (LCD)
- Arrow boards
- Portable Changeable Message Sign (PCMS)
- Radar Display Speed Unit
- Portable Regulatory Sign
- Truck/Trailer Mounted Attenuators (TMA's)
- Temporary Lane Separators
- Painted or Raised Pavement Markers
- Temporary Signals

Purpose of the Traffic Control Device

Each temporary traffic control device has its own purpose and use. The person who is creating the maintenance of a traffic plan must be aware of the several other conditions prior to the choice of channeling devices.

MOT sites are set up into 4 distinct areas:

1. **Advanced Warning Areas** - Used as the first indication to the motorist that there is upcoming construction work in the roadway or shoulder. In the advanced warning area the signs will be of:
    a. Road Work
    b. Men at Work
    c. Lane Closed or Flagger Ahead
    d. Workers Ahead

2. **Transition Area** - Used to channel the motorist to the open travel lane.
3. **Activity Area** - This section will have the buffer space for motorist to get back into the travel way, if they go through the MOT towards the work space.
4. **Termination Area** - Used to channel the traffic back into the usual travel lanes.

The first part of every traffic control zone is to warn the vehicles of the change that is about to take place. The disruption of the driver's pattern is a hazardous latent condition that could result in a struck by incident. The signs that are posted leading into the construction zone all the way to the end of the construction zone must be uniform in design and expectations.

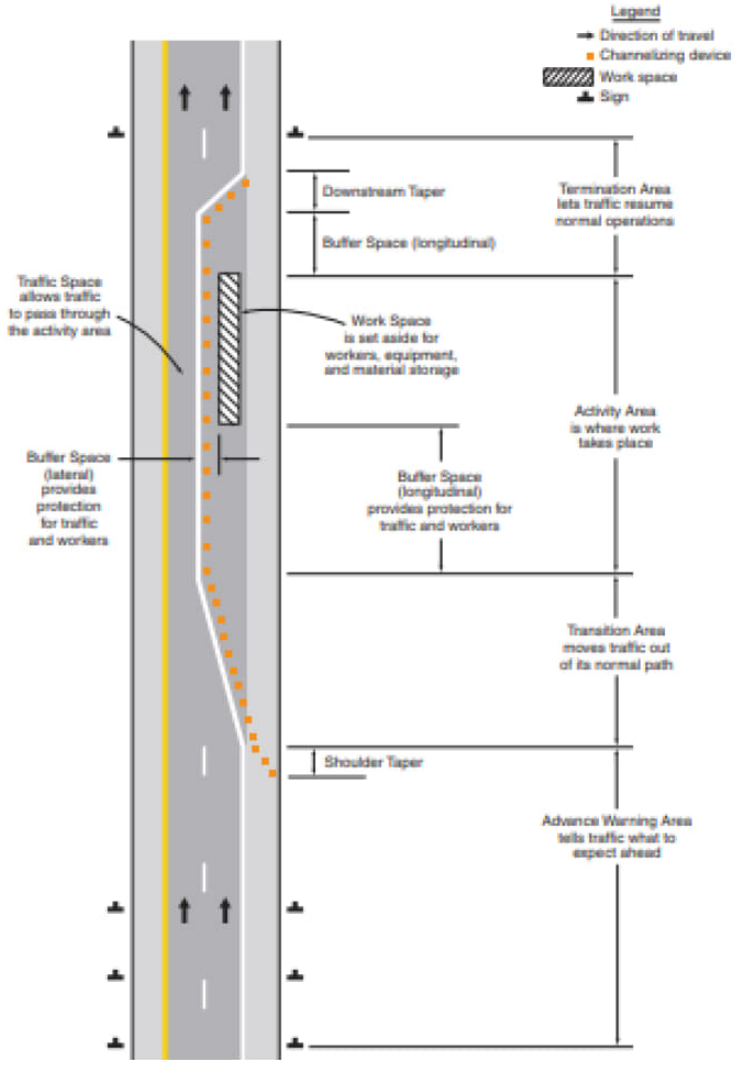
The channeling devices are placed in a pattern that begins in the advanced warning area so that when the cones are parallel to the work area they have been angled back. This angling of the channeling devices is referred to as the taper.

The taper length and the spacing between each column is subsided through a calculation of the posted speed limit. As the speed of the vehicles increase, the amount of taper length and buffer space is created prior to the activity area.

At the activity area, the channeling devices are placed adjacent to the traveled way to keep the traffic out and work as warning devices for the workers. Some construction zones will have the barricades as an engineering control to avoid the struck-by accidents. Workers are the most at risk from public vehicle activities.

It is also important to keep the buffer space area free from equipment or staging material, to give the wayward driver an opportunity to swerve back into their own lane. If there is any material in that Transition Area, then the driver can have a collision in the MOT zone.

Figure 6C-1. Component Parts of a Temporary Traffic Control Zone



Flagger Safety

All workers who are designing or maintaining the MOT for a construction zone must be trained for their responsibilities. The flaggers play a very important part in the protection of the workers. Each flagger must have the knowledge of proper techniques and requirements for controlling the traffic.

The ultimate control of public safety lies within the communications made by the flagger. The flagger must understand how to maneuver the traffic along the channeling devices; give guidance to the pedestrian, cyclist, and motorist.

The first priority of the flaggers is first to protect themselves, the personnel on the construction site, the drivers and the pedestrians. In all cases, the flagger must leave an escape route for themselves in case someone disregards a warning sign. The flagger must warn the crew of the potential danger. In some cases the flagger will be the primary person to obtain vehicle information and driver description.

The flagger must also be visible to oncoming traffic therefore proper high visibility apparel must be worn during flagging operations. It is important that the flaggers remain alert and stay off the path of any approaching vehicle.

Flagger Responsibilities

It is important for the flagger to never turn his back to traffic or perform any other activity while flagging. The basic rules of conduct which the flaggers must all adhere to are:

- Stay alert to the needs of the emergency vehicles cruise
- Report a car if they refuse to obey instructions
- To cover or remove flagger signs when no flagging operations are present
- Never mingle with the work crew, traveling public, or people
- Do not lean against any vehicle

It's also imperative for the lead flagger to have communication with all other flaggers. This communication can be two-way radios or hand signals, whichever is more appropriate for the situation. The flaggers must also be equipped with a stop/slow paddle and an illuminated flagging station during nighttime operations.

In order to get a vehicle to stop, the flagger must present the stop side of the paddle and with a raised hand palm out. To proceed, the flagger will rotate the stop/slow paddle to the slow indication and deliberately and slowly waive the drivers through the work zone.

If there's a driver who is going faster than the posted speed limit, then it is the responsibility of the flagger to slow him/her down. The procedure to slow down the driver involves showing the slow side of the paddle to the driver while indicating him/her to slow down by slowly raising and lowering the palm of the hand.

In case of emergency, when the flagger is not equipped with a stop/slow paddle, they can use a flag for immediate MOT usage. During nighttime operations it is also

necessary for the flagger to have a flashlight, lantern or the lighted signals that display a red warning light.

The flags are 24 x 24" and are used by qualified flagger to control the traffic. To stop traffic the flagger should hold their hands straight out with the flag facing downwards and the other hand extended with the palm facing the driver. Both hand gestures should be shoulder height for maximum visibility.

When it's time for the flagger to release traffic, they will put the flag to their side to wave the traffic through by rotating their bodies as they motion with their non-flag bearing arm.

To slow the traffic, the flagger must slowly raise and lower the flag from their side to shoulder height. This will signal the driver that they are going too fast and need to adjust their speed through the works zone.

Safety Controls

Additional safe practices are:

- Use manufacturer-approved safety restraints unless the vehicle is not designed for them.
- Never allow workers to drive equipment in reverse without an alarm or flagger.
- Enforce a limited access zone before dumping or lowering buckets.
- Properly turn off and block all equipment, including accessories.
- Set parking brakes and use chock wheels if parked on an incline.
- Install cab shields on hauling vehicles to protect against struck by and rollover injuries.
- Never exceed the vehicle's rated lift capacity or carry unauthorized personnel.
- Use signs, barricades, and flaggers to protect workers near roadways.
- Use proper lighting and reflective clothing/vests at night.

Maintenance and Safety

Proper maintenance of vehicles and the surfaces on which they operate will eliminate many struck by injuries. Be sure to:

- Require workers to check equipment before each shift.
- Only drive vehicles/equipment on safely constructed and maintained surfaces.
- Every vehicle must have a working, properly maintained brake system.

Danger from Being Struck by Falling or Flying Objects

Danger

Workers are at risk from *falling* objects when they are required to work around cranes, scaffolds, overhead electrical line work, etc.

There is a danger from *flying* objects when using power tools, or during activities like pushing, pulling, or prying, that can cause objects to become airborne.

Flying/falling objects can also roll off rooftops, or be accidentally kicked off walkways, scaffold platforms, etc. if they are not properly constrained.

Depending on the situation, injuries from being struck by flying or falling objects range from minor ones like bruises to severe ones like concussions, blindness, and death.

Training

Loose debris left on a roof can easily be blown by a gust of wind which will carry it to the ground below where a worker could be standing. When working in this kind of an environment, accidents are inevitable. Workers must be trained to be careful and remain constantly on the lookout for such conditions, securing all materials in an appropriate manner.

Employers must educate their employees on how to prevent accidents and exposures. Employers have a responsibility under OSHA standards to educate and train their employees to recognize and avoid unsafe conditions that can lead to struck-by injuries.

Ways to Avoid Being Struck by Falling or Flying Objects

Workers can be struck by falling or flying objects or by materials that slide, collapse, or otherwise fall on them. To protect workers from these types of injuries, OSHA requires that employers:

- Require workers to use hardhats/helmets when appropriate.
- Train employees to stack materials to prevent sliding, falling, or collapsing .
- Install protective devices onsite, such as toe boards on elevated platforms and walkways.
- Install debris nets beneath overhead work.

Safety nets must be installed as close as practicable under the walking/working surface on which employees are working, but in no case more than 30 feet (9.1 m) below such

levels. When nets are used on bridges, the potential fall area from the walking/working surface to the net must be unobstructed.

Properly Use and Inspect Power Tools and Equipment

Before each use, inspect equipment and tools to ensure that they work properly. Loose parts can fly into the air and cause damage. Never allow workers to use powder actuated tools until they are properly trained on how to use and maintain them. A qualified person who is properly trained should inspect all equipment before use.

PPE for Power Tools and Equipment

Ensure that workers use all required PPE when operating power tools and equipment. Examples of required PPE include:

- Safety glasses and goggles
- Face shields
- Hardhats/helmets

Head Protection Equipment

Head injuries are generally caused by falling or flying objects, or by bumping the head against a fixed object. Head protectors in the form of protective hats can resist penetration and absorb the shock of a blow. The shell of the protective hat is hard enough to resist many blows and the suspension system keeps the shell away from the wearer's skull. Some protective hats can also protect against electrical shock.

Protective hats are made in the following types and classes:

- Type 1—Helmets with a full brim.
- Type 2—Brimless helmets with a peak extending forward from the crown.
- Class G—General service, limited voltage. Intended for protection against impact hazards. Used in mining, construction, and manufacturing.
- Class E—Utility service, high voltage. Used by electrical workers.
- Class C—Special service, no voltage protection. Designed for lightweight comfort and impact protection. Used where there is a possibility of bumping the head against a fixed object.

Compressed Air and Flying Objects

Compressed air is a productive tool when used correctly. If used incorrectly, it can launch unexpected and very dangerous objects into the air that can strike and injure unsuspecting workers.

Follow these steps when using compressed air to keep objects from flying. Be sure to:

- Limit compressed air pressure to safe level when cleaning floors, equipment, etc.
- Ensure equipment parts are fastened before cleaning.
- Always use appropriate guarding.
- Never use compressed air to clean clothing.

Nail Gun Safety

One of the most used power tools in the construction field is the nail gun. It is also responsible for an estimated 37,000 emergency room visits. A study of apprentice carpenters by OSHA states that:

- 2 out of 5 were injured using a nail gun during their 4 years of training.
- 1 out of 5 were injured twice.
- 1 out of 10 were injured three or more times.

Most of the injuries obtained from a nail gun accident involves hand and finger injuries that involve structural damage to tendons, joints, nerves, and bones.

Some serious injuries related to being struck-by a nail from a nail gun (nailer) are:

- Paralysis
- Blindness
- Brain damage
- Bone Fractures and
- Death

There are various types of specialized nailers such as for framing, roofing, and flooring. The framing nail guns are powerful pieces of equipment that fire larger nails. Framers are therefore even more at risk from the mishandling and misuse of nailers.

Workers who understand the trigger mechanism can greatly reduce the potential of injury. The trigger has two basic control mechanisms:

1. Finger trigger
2. Contact safety tip

These trigger mechanisms can be single discharge or multiple discharge when the controls are activated. The safest type of nail gun trigger is the one that only fires a nail when the controls are activated in a certain order. Nails cannot be fired in a bump fire mode but only through a single shot trigger, restricted trigger, or by a trigger fire mode.

Nail gun accidents can happen in a variety of manners with different types of triggers. Contact triggers can have a double fire discharge of a second unintended release. If a person has the activation trigger depressed and knows the safety contact, then the nailer will discharge and most likely cause an accident.

Nails can also penetrate lumber material and discharge into a person on the other side of the lumber. The nail can ricochet from hitting a wood knot, metal, or other hard surface and strike a nearby worker with the nail. If a worker is in the habit of gripping the nail gun by the trigger when traveling with the unit, it may lead to an accidental discharge of the nail gun.

Workers can get injured if a part of the nailer is not working properly or missing altogether. Each worker must check their tools before each shift and prior to each use. This will ensure that all tools and equipment are in proper working order with all safety features working properly.

When workers are working in an awkward position, it may be difficult for them to control the application or angle of the nailer. In some cases, the workers might use their body as a brace and put themselves in the line of fire.

Tips to Better Nail Gun Safety

The following tips will ensure proper handling of a nail gun:

1. Use the full sequential trigger nail gun for the safest trigger mechanism. This type of trigger reduces the risk of unintentional nail discharge or double fires. New workers should be restricted to using the full sequential trigger nail guns only until they are fully oriented with other trigger types.

2. All workers that use nail guns must be trained on how to use the tool and its safety features. Hands on training is always the best form of training, so the worker can see how to use the equipment first hand. OSHA recommends the following training topics:
    a. How nail guns work and how triggers differ.
    b. Main causes of injuries – especially differences among types of triggers.
    c. Instructions provided in manufacturer tool manuals and where the manual is kept.
    d. Hands-on training with the actual nailers to be used on the job. This gives each employee an opportunity to handle the nailer and to get feedback on topics such as:
        i. How to load the nail gun
        ii. How to operate the air compressor
        iii. How to fire the nail gun
        iv. How to hold lumber during placement work
        v. How to recognize and approach ricochet-prone work surfaces
        vi. How to handle awkward position work (e.g., toe-nailing and work on ladders)
        vii. How best to handle special risks associated with contact and single actuation triggers such as nail gun recoil and double fires. For example, coach new employees on how to minimize double fires by allowing the nail gun to recoil rather than continuing to push against the gun after it fires.
        viii. What to do when a nail gun malfunctions.
    e. Training should also cover items covered in the following sections of the guidance, such as:
        - Company nail gun work procedures
        - Personal protective equipment
        - Injury reporting, and
        - First aid and medical treatment

3. Establish nail gun work procedures for workers that will include:
    a. Mandatory reviews of the tool operations and maintenance manual
    b. Have O & M manuals onsite for review
    c. Check tools and power source for proper operations and require broken or malfunctioning equipment to be taken out of service immediately
    d. Check lumber surfaces to ensure that there are not knots, nails, hangers, or anything that can impede the nail from going through the material.
    e. Keep hands at least 12 inches away from the point of impact of the nailer.
    f. Disconnect the compressed air when servicing, traveling or clearing a nail jam from the equipment
    g. Analyze the dangers of nail gun work and mitigate as many hazards as possible prior to working in the area.
4. Provide Personal Protective Equipment (PPE) such as hard hats, high impact eye protection, and hearing protection.
5. Encourage reporting and discussion of injuries and near misses to help workers learn how to identify hazards. Once the hazards have been identified, the prompt correction of the problem is needed.
6. Provide first aid and medical treatment for workers at the job location. Getting workers medical care as quickly as possible to limit the impact of the accident.

Roofing and Multi-Story Construction

Workers must always be aware that a tool, piece of building material, or equipment could accidentally fall from roofs or above-ground building levels. Ensure that workers:

- Use safety nets or other protective means when objects can fall on workers below.
- Use limited access zone guidelines to keep outsiders and non-essential workers from being struck.
- Install toe boards on scaffolds and walkways when appropriate.

PPE for Roofing and Multi-Story Construction

Always use PPE to protect the face and head when there is a chance of being struck by a falling or flying object at a construction site. During the workday, you can be struck by an unsecured falling roofer's hammer or by a piece of lumber that accidentally falls through a hole in the floor above your work area.

Examples of PPE to be used during building activities include:

- Hardhats
- Face shields
- Goggles

Working Around Cranes and Hoists

It is extremely hazardous to work underneath heavy equipment, especially when it is being operated. Heavy debris can fall from a swinging bucket. A crane can accidentally break something loose and send it flying. If hoists break during use, their loads can tumble down and strike workers. Work must not be performed beneath an elevated, unsecured load at any time.

Always follow these safe practices while working around cranes and hoists:

- Never allow employees to work underneath suspended loads.
- Barricade areas and post warning signs to keep non-essential employees and outsiders away from overhead equipment.
- Inspect cranes and hoists before each use to ensure components are in good working condition.
- Never exceed the lifting capacity of cranes and hoists.

Operating Cranes and Hoists

When operating cranes and hoists during construction work, always:

- Secure tools and building materials to keep them from falling or being pushed over.
- Barricade areas underneath operation and post warning signs.
- When using hoists for scaffold work, use toe boards, screens, or guardrails to keep materials and tools from falling.
- Use debris nets or other appropriate safeguards to intercept falling objects.

Danger from Constructing Masonry Walls

Danger

Because of the tremendous weight of a masonry wall or slab, if one collapses on a worker, it can cause permanent injury or death. Proper safeguards should be used and all jacks and equipment used to support and position such walls and slabs must be reliably maintained and kept failsafe.

Avoiding Struck-By Hazards Related to Masonry Construction

Only essential workers should be allowed near this type of operation. To enforce this, set up a limited access zone around operations. Additionally, be sure to:

- Have concrete structures checked by qualified persons before placing loads.
- Adequately shore or brace structures until they are permanently supported.
- Secure unrolled wire mesh so it cannot recoil.
- Never load a lifting device beyond its intended capacity.

Abrasive Wheels and Tools

Abrasive wheels and tools may throw off flying fragments creating a struck-by incident. Many incidents are due do the blade wheel fracturing and flying towards the worker. In a 2017 case, OSHA reported an employee of a freight trucking company was working on an abrasive grinding wheel. The wheel broke apart and struck the employee in the right eye creating a laceration.

This event lead to an OSHA inspection of the workplace where the organization was cited for a violation in the machine guarding standard for portable power tools. This citation was $11,408 to the employer on top of having an injured worker.

Most of the injuries from the angle grinders are in the head and face area. The high speed of disc when broken will cause disfiguring, permanent disabilities or even a fatality. The injuries occur for many reasons, such as, but not limited to:

- The wheel kicking back from the surface it is cutting. This usually will cause the blade to fly back on the operator.
- Blade cracks but the guard has been removed causing the blade to fly back and injure the operator.
- When the blade is not rated for the grinder, it will shatter causing a shrapnel that will create many foreign body embedment's or lacerations.
- Overhead use of the grinder is associated with fatal intracranial injuries.

Equip abrasive wheels with guards that:

- Cover the spindle end, nut, and flange projections.
- Maintain proper alignment with the wheel.
- Do not exceed the strength of the fastening.
- Guard so that a minimal amount of the wheel is exposed.

Inspecting Abrasive Wheels

Before mounting:

- Inspect closely for damage.
- Perform sound or ring test to ensure that the wheel is free from cracks and/or defects.

To test:

- Tap wheel gently with a light, non-metallic instrument.
- If the wheel sounds cracked or dead, do not use it because it could fly apart.

Keep in mind that this test is most accurate if the abrasive wheel is suspended and not held. By holding the wheel you could possibly alter the sound and giving off a false indicator of defects.

Abrasive Wheel Use

To prevent cracking:

- Fit the wheel on the spindle freely.
- Tighten the spindle nut enough to hold the wheel in place without distorting the flange.
- Let the tool come up to speed prior to grinding or cutting.
- Don't stand in front of the wheel as it comes up to full speed.
- Use eye and/or face protection while operating wheel.

Abrasive Wheel Work Rests

The following information applies to abrasive wheel work rests:

- Keep work rests not more than 1/8th inch from wheel surface, and tongue guards at the top of the wheel not more than 1/4 inch from wheel surface.
- This minimizes the chance of jamming the work between the wheel and the rest, which may cause the wheel to break.
- Don't adjust the wheel while it is rotating.

Additional safe operating tips for angle grinders is as follows:

- Use the correct disc size for the wheel's rpm.
- Remove cracked or chipped discs from service
- Stop using if vibration is very apparent
- Keep the guard in place
- Don't us an angle grinder above your head. Stand next to the plane of the cutting wheel.
- Always wear gloves, goggles, face-shields and hard hats when operating the equipment.

The Impact of an Accident on the Employer

Many accidents are considered to be thought of as expensive when considering lost time events. However, there are many more cost factors related to the accident that can be both direct or indirect cost of the accident. To evaluate the total cost of the accident you must combine both of these costs.

In order for the cost to be paid, the organization must use the profits of the company. All profits are derived after the operational cost of the company have been calculated. Accidents effect the organization's profitability, because the costs of the accidents must be paid from increased revenue. A company's profit margin is calculated by **Profit Margin=Total Profits/Total Sales**. The revenue required for funds to offset an injury are: **Revenue Required=Total Cost of Incident/Profit Margin**.

Additionally, the Business Roundtable publication, *Improving Construction Safety Performance*, published a study conducted by *Stanford University Department of Civil Engineering* which provides an indirect cost estimator for accidents as it relates to direct costs of an accident.

Direct Cost of an Accident

The direct costs of an accident are seen to be directly associated with the event and is easily quantifiable. Most direct costs are paid by the insurance company of the employer. An example some of these costs are:

- Physical therapy
- Medical expenses
- Repair fees for damaged equipment
- Increase in workers' compensation premium
- Continuation of pay
- Compensatory damages

Indirect Cost of an Accident

The indirect cost of an accident cost is not paid for through insurance and therefore is unrecoverable. While the direct costs are easy to be quantified, the indirect costs are often unseen or impossible to quantify. The relationship between direct cost and indirect cost is the indirect cost is greater than the direct cost for the company. Examples of indirect cost are:

- Wages paid to injured workers for absences not covered by Worker's Compensation;
- Lost high wages work stoppage associated with the worker injury;
- Over time due to the accident;
- Administrative costs and time spent by safety personnel, clerical workers, and other employees after the injury;
- Training for replacement worker;
- Lost productivity due to the work unit separation from the injury;
- New employee learning curve;
- Accommodation the injured employee within the organization:
- Clean up, prepare, replacement cost of damage material, machinery, and property.

The National Council Compensation Insurance, Inc. (NCCI) conducted statistics and data collected from insurance claims between policy periods 2011 through 2013. This data was incorporated by OSHA in the Safety Pays cost estimator for accidents. The NCCI manages the nation's largest database of workers compensation insurance information.

OSHA's program uses the *Business Roundtable* publication "**Improving Construction Safety Performance"** to calculate the indirect costs estimates and create the Safety Pays Cost Calculator, which are based on a study conducted by the Stanford University Department of Civil Engineering. According to this the indirect costs have a measurable relationship to the direct cost of accidents and the magnitude of indirect costs is inversely related to the severity of an accident.

The following chart will help understand the relationship between direct costs and indirect costs in a ratio that is used to calculate the total accident cost.

Direct Costs	Indirect Cost Ratio
$0-$2,999	4.5
$3000-$4,999	1.6
$5,000-$9,999	1.2
$10,000 or more	1.1

To use the cost estimate calculator, you need to know either the injury type or the workers' compensation, direct cost of an accident and the company's profit margin. However, if the profit margin is not known to the officer using the cost estimator then OSHA will give a default 3% profit margin for calculation of the direct and indirect costs relations to the additional sales needed to pay total cost of the accident.

In the example of this calculator, if you select an amputation from the entry type menu and give the company a profit margin of 10%, the calculator will give you the following information:

- Amputation: (1) Instance
- Direct Cost: $77,995
- Indirect Cost: $85,794
- Total Cost: $163,789

Additional Sales needed to recuperate cost (Indirect Cost): $857,945
Additional Sales needed to recuperate cost (Total Cost); $1,637,890

Therefore, this example illustrates that just one instance of an amputation through most likely an at-risk behavior has historically cost $77,995, with direct costs of $85,794 and indirect costs yielding a total injury cost of $163,789.

Organizations will have to use funds from the profits to cover both direct and indirect cost of the accident. However, up to $77,995 can be recoupable through workers' compensation; then sale must increase $2,859,816 to cover the indirect costs of the injury that cannot be reimbursed at a 3% profit margin.

Lesson Summary

There are many ways to protect workers from being struck by objects and equipment. Two important general rules to follow are:

- Never put anyone between moving or fixed objects.
- Always wear bright, highly visible clothing when working near equipment and vehicles.

Many struck-by accidents are associated with vehicles, falling or flying objects, and masonry walls. For example, workers are at risk from falling objects when they are required to work in the vicinity of cranes, scaffolds, and overhead electrical lines. There is also danger from flying objects when using power tools or during activities like pushing, pulling, or prying that can cause objects to become airborne.

Flying/falling objects can also roll off rooftops or be accidentally kicked off walkways or scaffold platforms if not properly constrained. Depending on the situation, injuries from being struck by flying or falling objects range from minor ones like bruises to severe ones like blindness or death. Because improper operation of heavy vehicles and equipment poses a life-threatening danger to construction workers, always follow safe practices to minimize injuries and save lives.

Revision #3
Created 2023-02-24 00:29:50 UTC by Nicole Blum
Updated 2023-02-24 00:34:04 UTC by Nicole Blum