Electrical Task Analysis Document

Conduit Installation, Wire Pulling, and Termination

CPWR THE CENTER FOR CONSTRUCTION RESEARCH AND TRAINING

What is this document for?

This document contains task-specific conditions and recommendations compiled from onsite observations and interviews with electrical workers and industry practitioners. It addresses safety and health hazards as well as production challenges associated with the task. This document can be used for training, hazard analysis, and pre-task planning. This information was gathered from new construction projects including a data center, a multi-use office building, a commercial distribution warehouse, and a gas-insulated substation, as well as retrofit projects including a public museum and an office building.

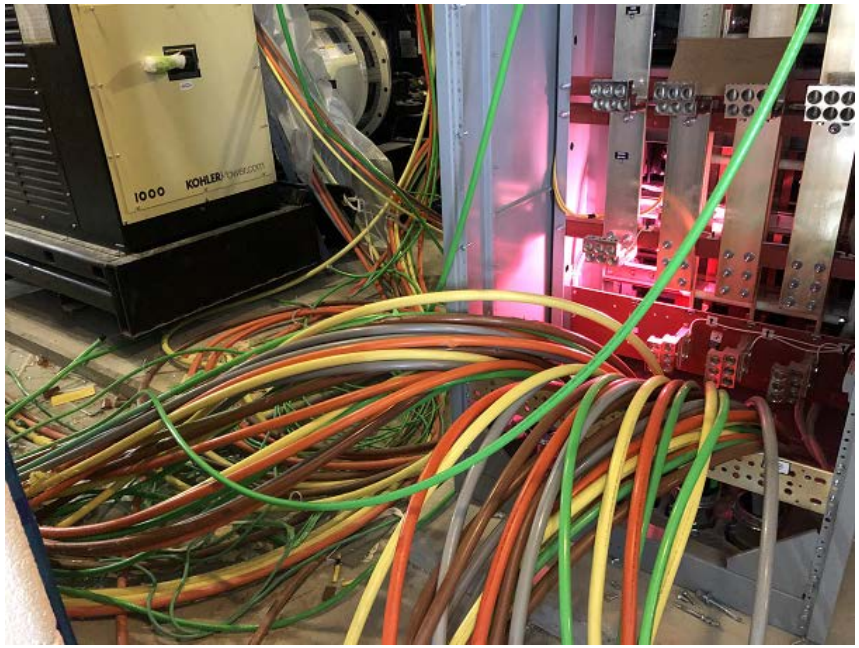
Task Description:

Conduit installation, wire pulling, and termination are interdependent tasks that must be carried out in a specific sequence to ensure the safety and functionality of the electrical system. They typically involve the following:

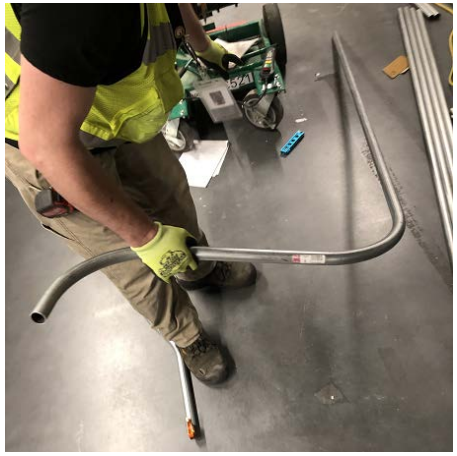
- **Conduit Installation** is the process of installing conduit pipes overhead, along the walls, or underground. It involves measuring, cutting, and bending conduit pipes to certain angles specific to a job layout. Equipment for this task may include manual/hydraulic benders and ladders/lift equipment. It also involves planning pathways for conduit runs from the main power source and connecting into junction boxes and electrical equipment.
- **Wire Pulling** is the process of pulling electrical wire through conduit. It involves tying a “head” or “nose” on the end of the wire and then attaching it to an adequately rated nylon/polyester cord or string (a.k.a. “mule tape”) that is either pushed through the conduit or sucked through using a shop vacuum. The nylon/polyester cord or string is then used to guide the wire inside and through the length of conduit. Wire pulling can be physically demanding, especially when the wire is heavy or there are multiple bends in the conduit.
- **Termination** is the process of terminating wires, which involves cutting, stripping, and fastening lugs or crimps on the ends of wires or cables to prepare them for a secured connection. Terminations can be within junction boxes, electrical panels, main electrical switchgear, or any other electrical equipment. Before beginning work, circuits must be identified and marked to verify that each one is terminated in the correct location. Mechanical tools such as cable strippers provide a safe way to strip the insulation from the end of the wire before terminating.

Disclaimer: Development of this document was supported with funding from a cooperative agreement between CPWR - The Center for Construction Research and Training (#U60 OH009762) and the National Institute for Occupational Safety and Health (NIOSH). CPWR provides this document at no cost to the user. Please note that this document is not intended as legal advice and is not for the purposes of complying with any federal, state, or local standard or regulation. Content in this document has been developed by CPWR and does not necessarily represent the official views of NIOSH.

Table of Contents

CONDITIONS	RECOMMENDATIONS
Handling cables and wires in tight spaces in awkward positions: • Installing cables and wires at ground level in awkward positions can increase the risk of ergonomic injuries and lacerations during wire stripping. Additionally, the inherent bend in wires when taken directly off the reel can make handling and pulling them through conduit more difficult. • The restricted space around switchgear may require manual bending and shaping of heavy cables if mechanical benders will not fit, further elevating the risk of ergonomic injuries. 	• Don appropriate hand and arm PPE • Increase the frequency of breaks • Rotate workers if feasible • Stretch and flex • Unbend the wire using available hard surfaces and tools • Hand-held cable strippers • Mechanical wire and cable feeder • Powered wire-stripping machine • Wire dispensing cart

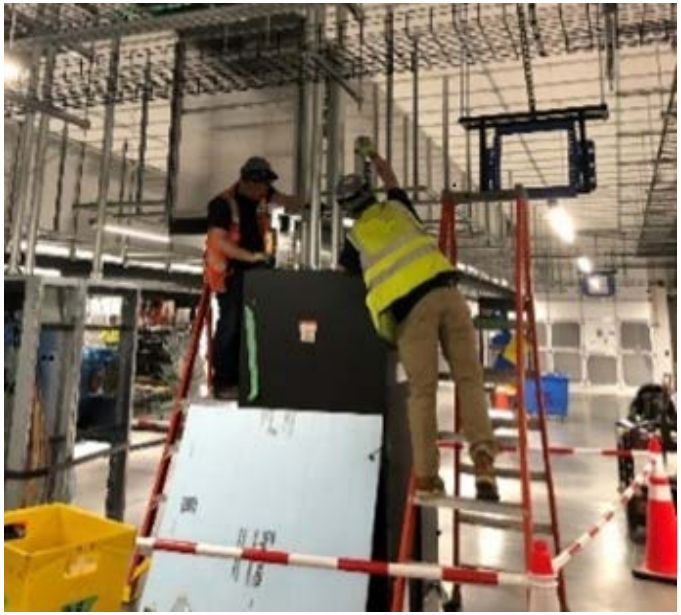
CONDITIONS	RECOMMENDATIONS
Calculating bends and angles in conduit: Bends and angles in conduit must be measured before beginning the wire pull to make sure they do not cumulatively exceed 360° degrees. 	• If bends exceed 360° degrees, reconfigure the conduit or shorten the pull distance • Building Information Modeling (BIM)
Measuring and calculating conduit length: Taking measurements and performing calculations to size and cut pipes.	• Consult blueprint to determine shortest path • Update as-built portion of blueprint to reflect changes • Gardner Bender ERB-UG Ugly's Electrical Reference Book

CONDITIONS	RECOMMENDATIONS
Determining orientation of conduits for offsets: Conduit offsets require measuring and figuring out bend orientations (e.g., left vs. right) to align pipes correctly. This requires precision to avoid errors and rework. 	• Building Information Modeling (BIM)
Remembering previously installed circuits and conduits: Sometimes workers are required to perform out-of-sequence work. As a result, workers may need to remember circuits and conduits installed months earlier. This can increase the likelihood of errors. 	• Provide project documents in physical and electronic format • Update blueprint as-builts • Building Information Modeling (BIM)

CONDITIONS	RECOMMENDATIONS
Checking "dog legs" on uneven floor surface: Checking pipes for "dog legs," or crooked offset bends, requires an even surface. When the floor is not level, it is more time-consuming to check and fix the pipes, which can lead to work disruptions and worker fatigue. 	• Designate leveled areas to test pipes • Implement an effective quality assurance/quality control (QA/QC) process upfront to avoid sending defective materials to work zones (e.g., pre-straightened pipes) • Provide transportable leveled 5x10 board to test roll pipes • Provide a 3-foot leveler
Damaged conduit: When pipes are dropped and damaged during delivery, it can result in work disruption (e.g., checking for "dog legs") and rework.	• Designate workers to perform QA/QC upfront to avoid sending defective materials to work zones
Obstructions in conduit pathway: Drywall that is installed out of sequence can obstruct the conduit pathway. Before wire pulling can begin, the conduit must be reconfigured or the drywall must be removed, leading to rework and delays.	• Involve all work crews in Pre-Task Planning (PTP)/Job Hazard Analysis (JHA) meetings • Building Information Modeling (BIM) • Pre-Task Planning (PTP) Guidelines and Resources for Construction

CONDITIONS	RECOMMENDATIONS
Installing conduit in tight spaces: Working on ladders in tight spaces can result in awkward body postures, raising the risk of ergonomic injury.	• Adopt a "ladders last" approach: only use ladders when scaffolding, aerial lifts, portable stairs, or pulleys are not available or feasible. • Use manageable prefabricated components if feasible • LEANSAFE® ladder • Proper ladder selection
Drilling in tight spaces and hot conditions at a data center: The core driller needed to drill holes in a 6-foot concrete wall by the ceiling weighs 150 pounds and must be raised into a very tight space on a scissor lift, causing worker fatigue and raising the risk of injury. Additionally, if the work area is unfinished and narrow with little ventilation, workers may be at risk of heat illness, especially during the summertime. This can be exacerbated by heat coming through the holes from the adjacent server room.	• Increase the frequency of breaks • Provide portable fans • Rotate workers if feasible • Cooling clothing and personal protective equipment • Heat illness prevention resources • Heat stress program • Real-time physiological monitoring for heat strain in workers

CONDITIONS	RECOMMENDATIONS
Adding on to an existing installation: • If a substantial chiller pipe obstructs the pathway between two conduit sets meant to connect two buildings, it requires an offset that does not damage the chiller pipe. This can cause work delays. • If the conduit's pathway to the switchgear is blocked by other components, workers must take multiple measurements for bends and then reconfigure conduit before wire pulling can commence, resulting in rework and delays. 	• Coordinate with affected trades working in the area • Involve all work crews in PTP/JHA meetings • Use a unified communication platform to coordinate information among all stakeholders • Building Information Modeling (BIM) • Pre-Task Planning (PTP) Guidelines and Resources for Construction

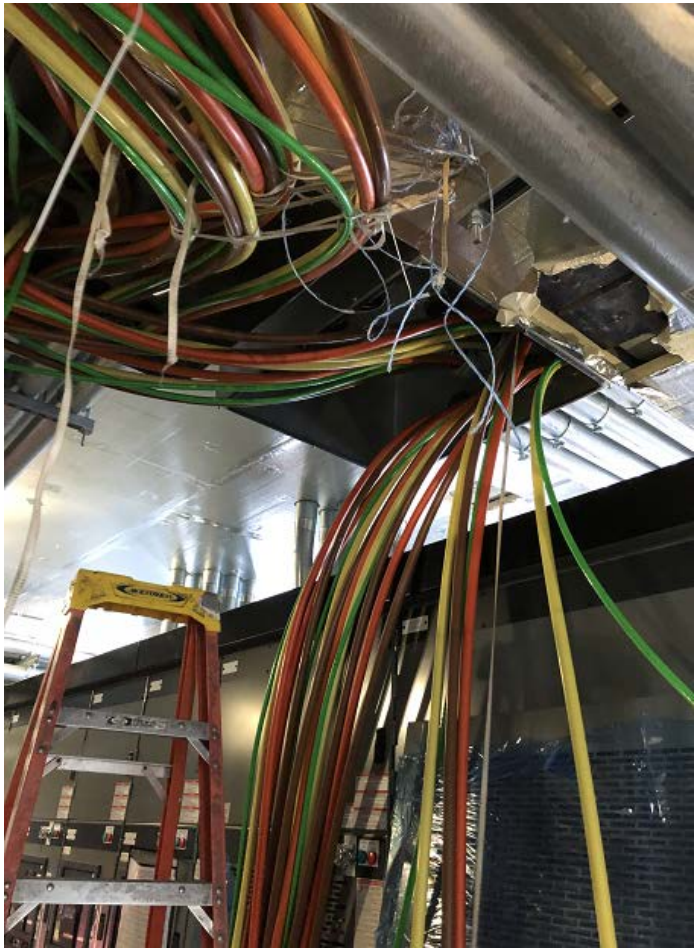
CONDITIONS	RECOMMENDATIONS
Fixing pipes installed incorrectly by other workers: Pipes installed incorrectly by other workers must be fixed while avoiding damage to other components, which can lead to work delays and worker fatigue (e.g., switching out an installed pipe that is too short). 	• Involve all work crews in PTP/JHA meetings • Building Information Modeling (BIM) • Pre-Task Planning (PTP) Guidelines and Resources for Construction • Last Planner® System; Last Planner® System Workbook
Incorrect installation of receptacle boxes: If the wrong size receptacle box is installed in the wrong location, it can lead to delays and rework.	• Communicate field installation conditions with engineers • Keep track of modified installation on one-line diagrams • Mark and color-code different locations for different sizes

CONDITIONS	RECOMMENDATIONS
Poor accessibility of mechanical tools/equipment: Poor accessibility of mechanical tools or equipment can raise the risk of ergonomic injury (e.g., if the mechanical bender is on the other side of a large building, workers must manually bend and shape pipes at their current location).	• Optimize access and distance to mechanical pipe bender • Last Planner® System; Last Planner® System Workbook
Inadequate pipe bending equipment: If equipment is worn out or uncalibrated, it can cause "dog legs" and lead to work disruption and delays (e.g., Cyclone Bender). 	• Ensure equipment is in good working condition • Follow a calibration maintenance schedule • Use manageable prefabricated components if feasible

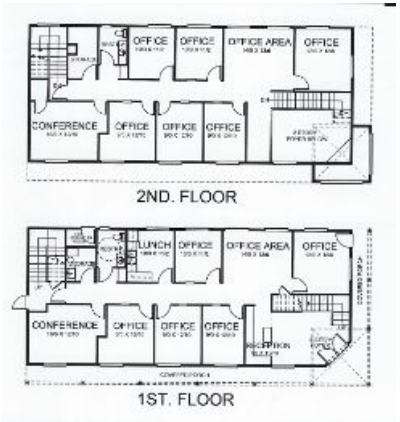
CONDITIONS	RECOMMENDATIONS
Removing concentric knockouts: Removing the correct-sized concentric knockout from metal ductwork requires precision and concentration. Any error can result in the pipe not fitting. 	• Allocate sufficient time for task • Knockout sets
Repetitive lifting and installing heavy pipes overhead: Repetitively lifting heavy rigid pipes and holding them overhead for installation can lead to fatigue, raising the risk of ergonomic injuries.	• Create a pulley system (e.g., tie a rope to the pipe and hang it over something stable to pull it up) • Use a two-person approach to lifting and carrying material • Portable manual hoist and puller • Best Built Plans for safe material handling

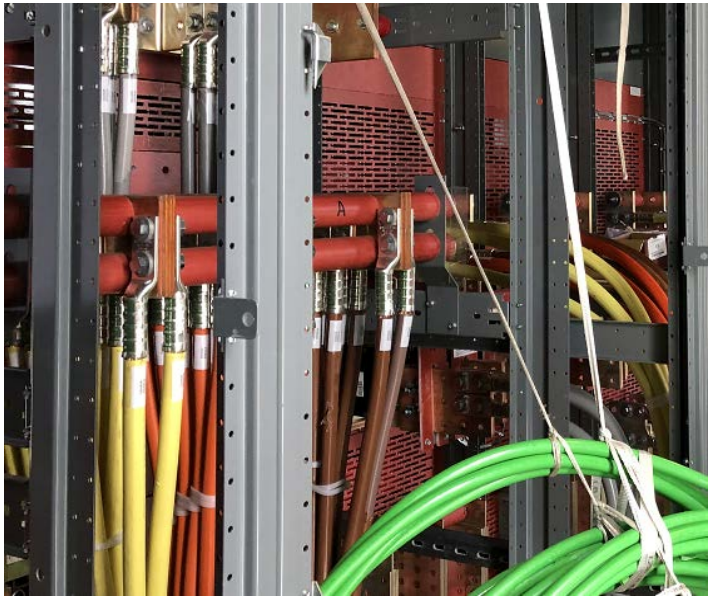
CONDITIONS	RECOMMENDATIONS
Lifting and moving heavy electrical materials: Lifting and moving heavy electrical material including large boxes onto equipment carts, as well as lifting heavy pipes, pipe bundles, and struts, can raise the risk of ergonomic injuries.	• Use a two-person approach to lifting and carrying material • Best Built Plans for safe material handling • Handtruck with mechanical lift platform • Pipe dolly • Powered hand truck • Self-propelled platform truck
Heavy/bulky prefabricated components: Lifting and installing heavy and bulky prefabricated components, especially around existing installations, can be physically challenging and can raise the risk of ergonomic injuries.	• Coordinate with prefabrication shop to reduce the size and weight of prefabricated components • Stick build where feasible • Use a two-person approach to lifting and carrying material • Best Built Plans for safe material handling • Portable manual hoist and puller • Skate dolly • Powered hand truck • Handtruck with mechanical lift platform • Duct lift

CONDITIONS	RECOMMENDATIONS
Handling heavy cables and wire reels: Manually lifting and handling heavy cables and wire reels can lead to exhaustion and raise the risk of ergonomic injuries. 	• Use a two-person approach to lifting and carrying material • Best Built Plans for safe material handling • Cable reel transporter system • Jack stand • Mechanical wire and cable feeder • Mechanical wire and cable puller (tugger)

CONDITIONS	RECOMMENDATIONS
Errors in selecting the right wire: When there are varying sizes and lengths of wire, selecting and cutting the right type and size and making sure wires match can be challenging. Incorrect selection can result in rework and time and cost overrun. 	• Label wires based on the colors in the drawings using a wire marker to indicate the feed source • Use manufactured cable lengths that meet installation specifications. This reduces the likelihood of human error in cutting the wrong length of wire • Gardner Bender TrueTape measuring tape

CONDITIONS	RECOMMENDATIONS
Interpreting wiring diagram: Interpreting and remembering the wiring diagram and differentiating between different circuits can require concentration and advanced planning, especially when measurements provided are not always accurate and consistent.	• Gather all needed tools and materials, as well as a paper or electronic copy of the wiring diagram, at the work location before starting work • Maintain all equipment wiring diagrams for reference
Planning wire route: • Choosing an appropriate wire route while avoiding edges, hot boards, and obstacles. • Keeping wire routes uniform in identical spaces (e.g., data halls in data centers).	• Building Information Modeling (BIM) • Last Planner® System; Last Planner® System Workbook
Wire layout and preparation impacted by other trades: Wires may be laid out in specific sequences before the task begins. Other crews working in the same area may inadvertently step on or shift the wires, resulting in work delays.	• Barricade off the area surrounding the wires • Involve all work crews in PTP/JHA meetings • Building Information Modeling (BIM) • Last Planner® System; Last Planner® System Workbook • Pre-Task Planning (PTP) Guidelines and Resources for Construction
Inefficient wire route: Project planning documents may lay wires out in overcomplicated back-and-forth patterns rather than along the shortest, most efficient route. If this occurs, it results in the unnecessary use of extra wire and creates additional friction on the wire, making it more difficult to pull.	• Coordinate between engineering and field personnel to develop shortest wire path for improved efficiency and cost savings • Communicate alternative paths with the owner's representatives

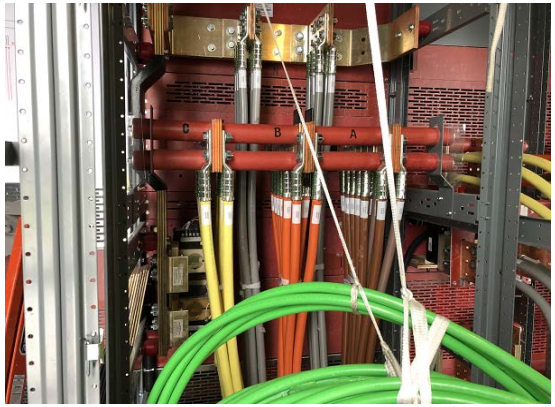
CONDITIONS	RECOMMENDATIONS
Remembering layout across multiple floors: Remembering the layout of electrical components and wiring pathways on different floors of a multi-level project is difficult when floors are not uniform.  	• Label wires using color-coded wire markers to indicate the feed source • Always have the most current edition of blueprints and examine each floor's layout
Manually preparing wire for pulling: Pulling the wire off the reel, stripping it, and tying a "nose" on the end to be pulled can raise the risk of ergonomic injuries and lacerations. 	• Don appropriate hand and arm PPE • Cable pulling grip kit • Hand-held cable strippers • Mesh pull grip • Pre-installed wire pulling heads • Pulling grip • Wire pulling device

CONDITIONS	RECOMMENDATIONS
Running wires to the correct unit: Running the right set of wires to the right unit without damaging the circuit can require concentration and advanced planning. 	• Arrange tools, materials, and project documents in an easily accessible location • Consult the latest revision of the blueprints • Walk the whole wire route from start to finish before beginning work to ensure equipment is properly labeled
Wiring larger junction boxes: Figuring out which wire to connect to each circuit can require planning and memorization, especially when working on larger junction boxes.	• Ensure that current revisions of blueprints are available • Gather all needed tools and materials, as well as a paper or electronic copy of the wiring diagram, at the work location before starting work • Label wires using color-coded wire markers to indicate the feed source • Mark and color-code circuits and box locations on the floor before work begins

CONDITIONS	RECOMMENDATIONS
Wire separates during pull: When mule tape separates from the main wire during a pull, it can lead to an increased risk of injuries and rework.	• Use cable tension calculator to determine tensile strength needed for the wire pull activity • Mesh pull grip • Pulling grip • Pulling grip kit • Wire pulling device
Working with copper wire: Forming and pulling thick, rigid copper wires can raise the risk of ergonomic injuries, especially when repeated multiple times in a single shift.	• Assign a team of at least three people to push wire and two people to pull • To counteract the natural bend of wire taken directly from a reel, use tools or other hard surfaces to straighten the wire before fishing it through • Hickey • Mechanical wire and cable feeder • Mechanical wire and cable puller (tugger) • Ratchet cable bender
Prolonged heavy wire pulling: Pulling heavy wires for multiple days in a row can be physically demanding and can raise the risk of ergonomic injuries.	• Wire pulling coordination: the person feeding the wire should communicate regularly with the person pulling to keep the wire tension consistent (e.g., keep an even flow, try to match up with the person on the other end). Using walkie-talkies for communication is recommended. • Rotate crews to less strenuous tasks • Mechanical wire and cable feeder • Mechanical wire and cable puller (tugger) • Puller attachment for cordless drill

CONDITIONS	RECOMMENDATIONS
Pulling wire in crowded ceilings: Pulling wires in crowded ceilings around tight angles and multiple existing components can lead to awkward work positions. It can also make it difficult to move and see around you.	• Mechanical wire and cable puller (tugger) • Proper ladder selection • Pulling sheaves
Tuggers that won't fit in tight spaces: When mechanical tuggers will not fit in a tight workspace, wire must be pulled manually with mule tape. This can result in work delays and raises the risk of fatigue and ergonomic injuries.	• Wire pulling coordination**:** the person feeding the wire should communicate regularly with the person pulling to keep the wire tension consistent (e.g., keep an even flow, try to match up with the person on the other end). Using walkie-talkies for communication is recommended. • Puller attachment for cordless drill • Pulling sheaves
Manual wire pulling over long distances: Manually pulling wire over long distances can be physically demanding and can raise the risk of ergonomic injuries (e.g., when tugging #4 wire as far as 800 feet).	• Mechanical wire and cable feeder • Mechanical wire and cable puller (tugger) • Puller attachment for cordless drill • Pulling sheaves
Feeding wire improperly: Improper feeding angle or tension while feeding the wire can result in wire pullers' overexertion, raising the risk of ergonomic injury.	• Mechanical wire and cable puller (tugger) • Pulling sheaves

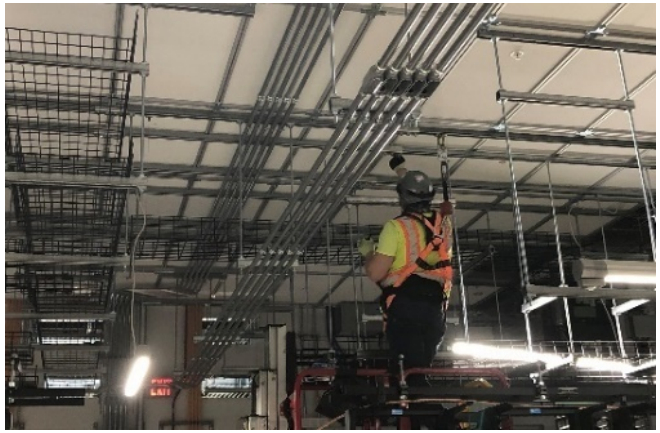
CONDITIONS	RECOMMENDATIONS
Feeding wires between floors: Feeding wire through AC units to the floor below can require bending and awkward postures, which can raise the risk of ergonomic injuries. 	• Use knee pads • Use back support systems • Use manageable prefabricated components if feasible • Work in pairs to assist in feeding and pulling
Missing wire labels: Wire label stickers may fall off due to environmental humidity, which can result in work delays due to additional required circuit tracing and consultation with wire pullers.	• Conduct daily PTP/JHA with crews at beginning of work shift • Label conduit in case the wire label falls off • Use nylon wire markers with wrap-around features • Pre-Task Planning (PTP) Guidelines and Resources for Construction
Wire pulling left incomplete: Wiring that should have been installed and pulled during prior phases of work may be missing. If this happens, workers must stop terminations, find the right size of missing wire, and pull it through.	• Involve all work crews in PTP/JHA meetings • Last Planner® System; Last Planner® System Workbook • Pre-Task Planning (PTP) Guidelines and Resources for Construction

CONDITIONS	RECOMMENDATIONS
Scanning barcodes for tracing purposes: Barcodes may be applied to each component/module so that workers can easily scan them and see what's inside during the next phase of work. Remembering to perform the initial scan that links the barcode with information on what's inside can be difficult to remember while simultaneously working with multiple wires and circuits. 	• Designate a supervisor to double-check barcodes after the task is complete • Provide a checklist to ensure all steps of the task are performed
Terminating multiple wires: Terminating multiple wires can require gathering, processing, and memorizing information, which carries a high risk of errors. 	• Keep a comprehensive log of all terminations • When workers switch from a less complicated task to a more complicated one, provide a brief refresher and consider providing a checklist

CONDITIONS	RECOMMENDATIONS
Working around energized components (hot work): Working near energized components (a.k.a. hot work) requires proper Lockout/Tagout (LOTO) and testing to ensure equipment is in an electrically safe working condition.	• Appoint a designated person in charge of Lockout/Tagout (LOTO) • LOTO per company policy • Use a Comprehensive Outage Plan • Use retractable tape barriers to block off area • Use warning signage or light signals to inform other workers of current location • Absence of voltage tester • Insulating blankets
Miscommunicating Lockout/Tagout (LOTO) schedule: Workers may need to wait an unknown amount of time for other contractors to complete LOTO to ensure gear is safe to work on, which can lead to work delays. 	• Appoint a designated person in charge of Lockout/Tagout (LOTO) • Hold weekly LOTO coordination meetings • Involve all work crews in PTP/JHA meetings • Pre-Task Planning (PTP) Guidelines and Resources for Construction

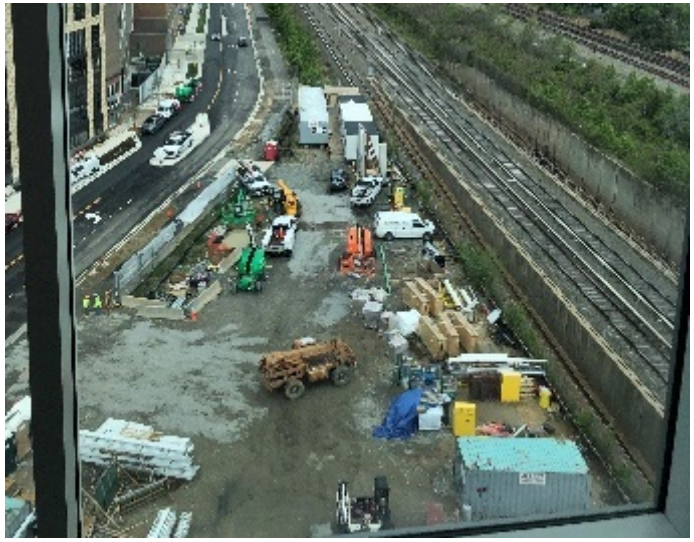
CONDITIONS	RECOMMENDATIONS
Repetitive climbing and prolonged standing on ladders: Climbing and standing on ladders for extended periods of time can increase fatigue and raise the risk of falls due to loss of balance.	• Adopt a "ladders last" approach: only use ladders when scaffolding, aerial lifts, portable stairs, or pulleys are not available or feasible. • Use platform ladders or alternative ladders appropriate for the task • Increase the frequency of breaks • Rotate workers if feasible • Mobile elevating work platforms (MEWP) • Portable lift platforms • Proper ladder selection
Lack of variety in ladder selection: Lack of variety in ladder type and size to accommodate task requirements and worker body size can result in worker discomfort as well as loss of balance. 	• Adopt a "ladders last" approach: only use ladders when scaffolding, aerial lifts, portable stairs, or pulleys are not available or feasible. • Mobile elevating work platforms (MEWP) • Portable lift platforms • Ladder safety base system • Ladder safety mobile application • Proper ladder selection

CONDITIONS	RECOMMENDATIONS
Climbing ladders in tight spaces: Climbing ladders in tight spaces where scissor lifts will not fit (e.g., network rooms in data centers) can cause worker fatigue and raise the risk of ergonomic injuries.	• Portable lift platform • Proper ladder selection • Tripod ladder
Working around fragile, unmovable objects: Working in close proximity to fragile, unmovable objects can require advanced planning and constant monitoring (e.g., priceless historical artifacts in a museum renovation project). It may lead to working in awkward postures or using less efficient equipment and work processes. This can cause work disruptions.	• Conduct daily PTP/JHA with crew at beginning of work shift • Request that client install protection over fragile, unmovable objects • Pre-Task Planning (PTP) Guidelines and Resources for Construction • Tool lanyards, connection and anchorage points
Being aware of surroundings while using a boom lift: Being aware of other equipment, installations, and workers in high traffic areas while working on a boom lift requires increased operator awareness to avoid incidents. Operators also need to watch out for their own personal safety (e.g., avoid bumping into overhead obstacles).	• Ensure boom lift has audible warning sounds during movement • Use warning signage or light signals to inform other workers of current location • Use barricades to block off high-traffic area, if feasible • Schedule time slots for mobile equipment use • Have designated spotters on the worksite • Overhead protection accessory for boom lift
Boom lift allocation: Boom lifts may be assigned to individual people rather than to work areas. If this occurs, boom lifts must be moved and switched out every time the shift changes, increasing worker exposure to struck-by hazards.	• Assign equipment to specific work areas based on task • Only allow properly trained, authorized individuals to operate boom lift

CONDITIONS	RECOMMENDATIONS
Reaching installations when boom lift cannot fully extend: Boom lifts may be prevented from extending fully due to component crowding in the ceiling. As a result, workers may need to stand up on the second rung of the basket or lean out over it to access work, which can raise the risk of falls due to loss of balance. 	• Access deck accessory on scissor lift • Portable lift platform
Lack of secure tie-off points: A lack of pre-defined secure tie-off points can force the crew to find alternatives, causing work delays.	• Install permanent recessed anchor point systems • Mobile anchor system
Restrictive fall protection harnesses: Fall protection harnesses may restrict movement while working on a boom lift, which can lead to poor body postures and work disruption.	• Consult with fall protection manufacturer for adequate equipment selection • Don form-fitting fall protection harness based on employee size and ensure a snug fit before commencing work

CONDITIONS	RECOMMENDATIONS
Cluttered work area: Equipment left in the work area (e.g., multiple lifts and ladders) can obstruct movement, leading to work disruption and an increased risk of slips and trips.	• Involve all work crews in PTP/JHA meetings • Designate personnel to organize on a regular basis or at the end of the shift to prepare for the next day • Building Information Modeling (BIM) • Last Planner® System; Last Planner® System Workbook • Pre-Task Planning (PTP) Guidelines and Resources for Construction
Prolonged standing in the same spot: Standing in the same place for long periods of time can result in exhaustion and loss of balance.	• Move your feet regularly • Stretch and flex
Excessive dust: Excess dust and particulate dispersed by other nearby work crews can lead to airway irritation and respiratory diseases like silicosis.	• Local exhaust or dilution ventilation • Use tools equipped with HEPA filters per OSHA's Table 1 • Exposure Control Database • Respiratory protection program • Use an air-purifying respirator
Vendor errors: Despite providing the correct specifications to suppliers, the wrong size and length of wire may be delivered to the jobsite, leading to rework and delays.	• Implement an effective QA/QC process upfront to measure wire length and size upon material offloading and prior to pulling
Mismatch between project specifications and procured material: Difficulty procuring specific types of electrical panels may result in the delivery of panels with unexpected size and layout variations. As a result, panels may need to be moved and installed in places not originally indicated in project documents.	• Coordinate material specifications with members of supervision • Implement an effective QA/QC process upfront to avoid sending incorrect materials to work zones

CONDITIONS	RECOMMENDATIONS
Inaccurate drawings and errors in project documents: Sometimes project drawings do not provide sufficient details or provide incorrect information on conduit layout. In such cases, the electrical contractor needs to coordinate with the general contractor and submit a request for information, leading to work disruptions and delays.	• Mark circuit numbers on the conduit • Involve contractors during the design process • Review project documents during the pre-construction phase to avoid work interruptions • Building Information Modeling (BIM)
Outdated project documents: Not providing updated project documents in a timely manner can lead to rework and delays.	• Provide comprehensive information on the project's "big picture" to all workers – do not limit communication to the immediate task • Share information immediately and proactively when plans, prints, and other information is updated • Supervision should ensure during weekly meetings that revisions are up to date • Tailor each morning's PTP/JHA to actual site conditions • Pre-Task Planning (PTP) Guidelines and Resources for Construction
Conflict with other trades: If other trades enter the work area despite not being on the work schedule, it can disrupt planned electrical work and cause delays.	• Involve all work crews in PTP/JHA meetings • Pre-Task Planning (PTP) Guidelines and Resources for Construction
Materials delivered to wrong work zone: Materials delivered to an incorrect work zone can cause unnecessary searching and work delays.	• Label material with delivery location information prior to moving • RFID stickers

CONDITIONS	RECOMMENDATIONS
Inefficient material storage location: Materials may be stored in inconvenient locations far from the work zone (e.g., outside the building across a busy street). This can require workers to make frequent long-distance trips while carrying heavy items, which can result in frustration, work delays, and an increased risk of injuries. 	• Use material cages and stack material on the jobsite • Assign a coordinator to each work zone who can provide information, take material orders, and retrieve materials • Optimize the location of critical tools or equipment relative to workspaces to minimize hauling distance • Use a warehouse utility vehicle • Last Planner® System; Last Planner® System Workbook • Lean Construction principles including Just-in-Time inventory management system • Powered hand trucks • Self-propelled platform trucks

Use the QR code to access the electronic version of the document.