ARCHITECTURE | MECHANICAL | **ELECTRICAL** | CIVIL | TECHNOLOGY

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Protecting Campus Staff and the Public from Underground Electrical Hazards

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SESSION OVERVIEW

University campuses have a great deal of underground electrical wiring.

The electrical systems must be properly designed, built, and maintained to remain safe and usable.

This session describes lessons learned on how to obtain safe, long-lasting underground electrical systems, and how to keep them safe for public use during their lifespan.

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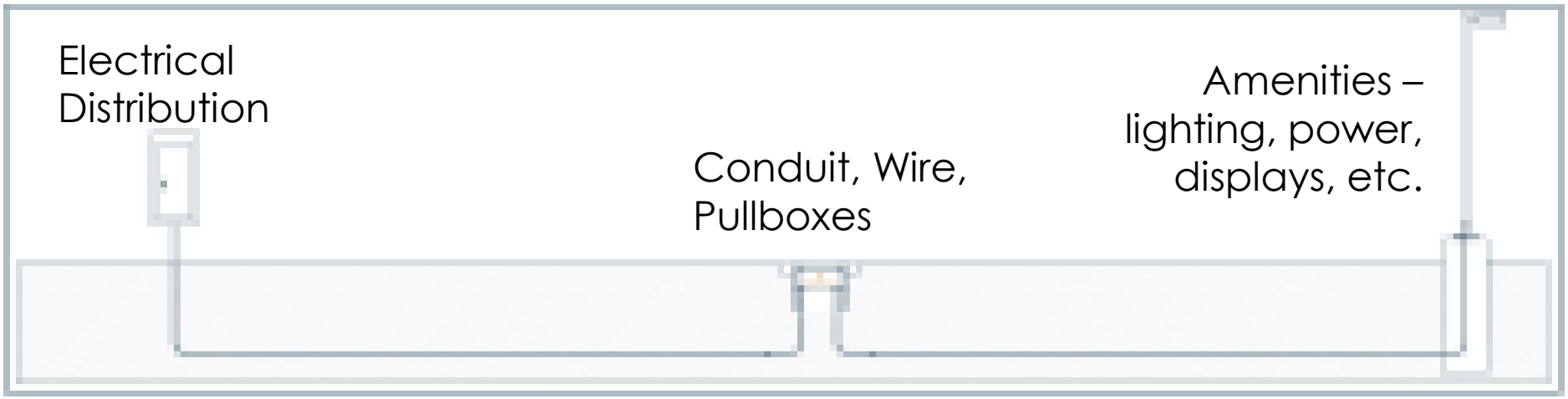
GLHN performed curb-to-curb electrical safety improvements at 26 municipal parks between 2009 and 2013.

The lessons learned are applicable to any public environment with underground electrical systems.

SESSION GOAL



Best practices for material selection

Best practices for design & installation

Best practices for testing & maintenance

IN THE BEGINNING, THERE WAS…

The National Electrical Code (NFPA 70):
"Adopted in all 50 states, the NEC is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards."

- NFPA

Underwriters Laboratories (UL):
"Dedicated to promoting safe living and working environments, UL helps safeguard people, products and places in important ways, facilitating trade and providing peace of mind."

- UL

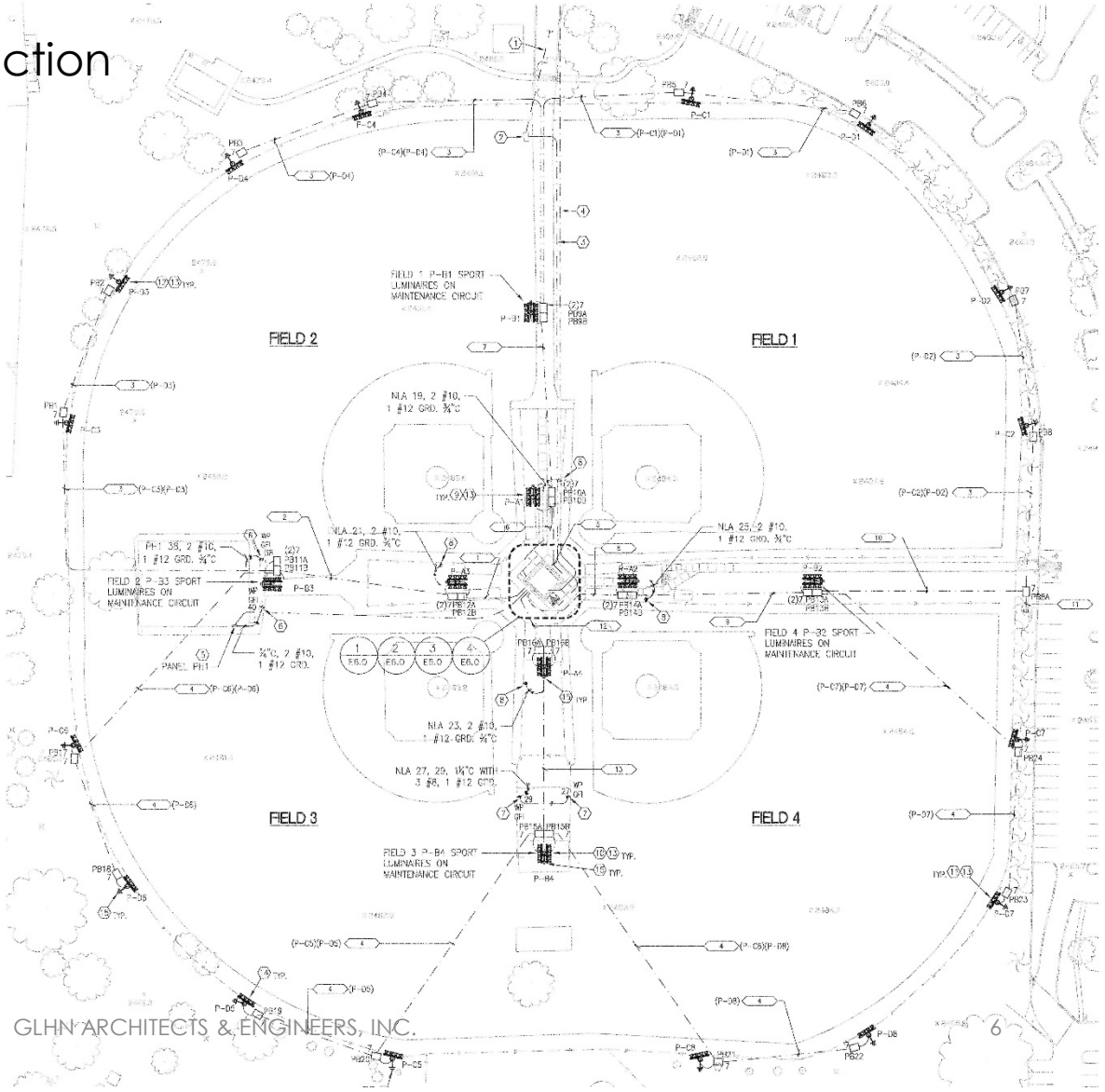
THE NEC AND UL ARE APPLIED BY…

- Authorities Having Jurisdiction
- Project Managers
- Professional Engineers
- Plans Examiners
- Contractors
- Inspectors

Procurement, design, and construction might occupy 3 – 12 months.

The lighting & electrical systems are yours for decades.

Systems have useful lifespans of 20-30 years.



WHAT CAN GO WRONG?

-Time

WHAT CAN GO WRONG?

-Time

WHAT CAN GO WRONG?

-Time

WHAT CAN GO WRONG?

-Water

WHAT CAN GO WRONG?

-Water

WHAT CAN GO WRONG?

-People

WHAT CAN GO WRONG?

-Dogs

WHAT CAN GO WRONG?

-Installation
& Maintenance

WHAT CAN GO WRONG?

-Users

WHAT CAN GO WRONG?

-Burrowing Animals

WHAT CAN GO WRONG?

-Ants

BEST PRACTICES – MATERIAL SELECTION

Buy unitized electrical equipment
- field-replaceable parts
- separation of power and controls
- easier to secure

BEST PRACTICES – MATERIAL SELECTION

Pullboxes

- eliminate all you can
- use polymer concrete pullboxes instead of concrete pullboxes
- use one concrete vault instead of a number of pullboxes

BEST PRACTICES – MATERIAL SELECTION

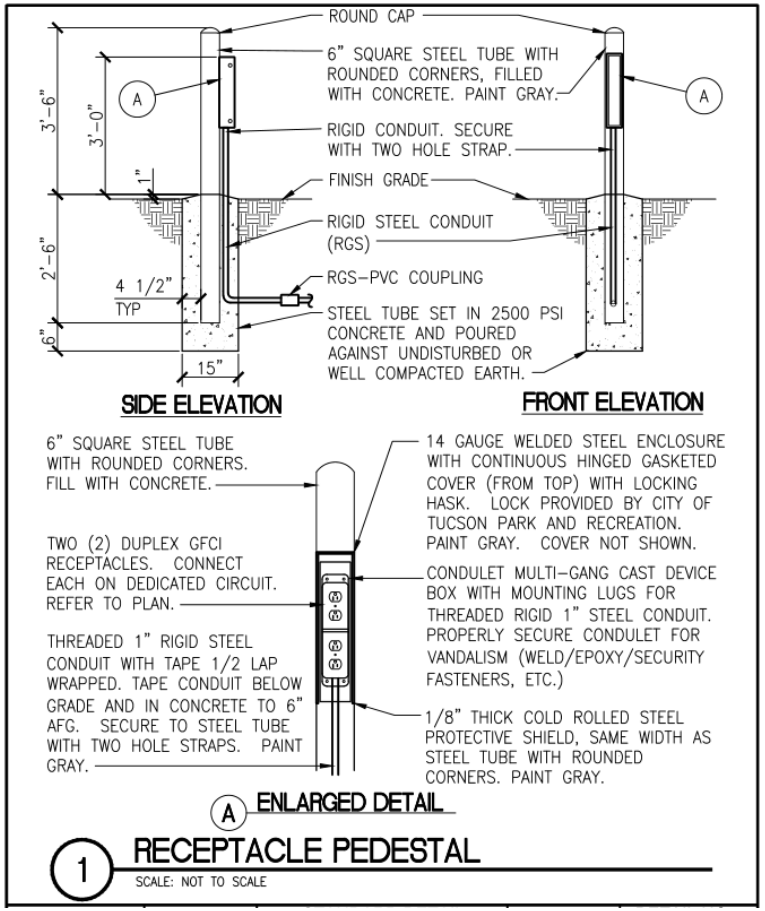
Wire

- XHHW instead of THHN/THWN; ants like XHHW less
- submersible splices instead of twist-on connectors or split bolts

BEST PRACTICES – MATERIAL SELECTION

Receptacles

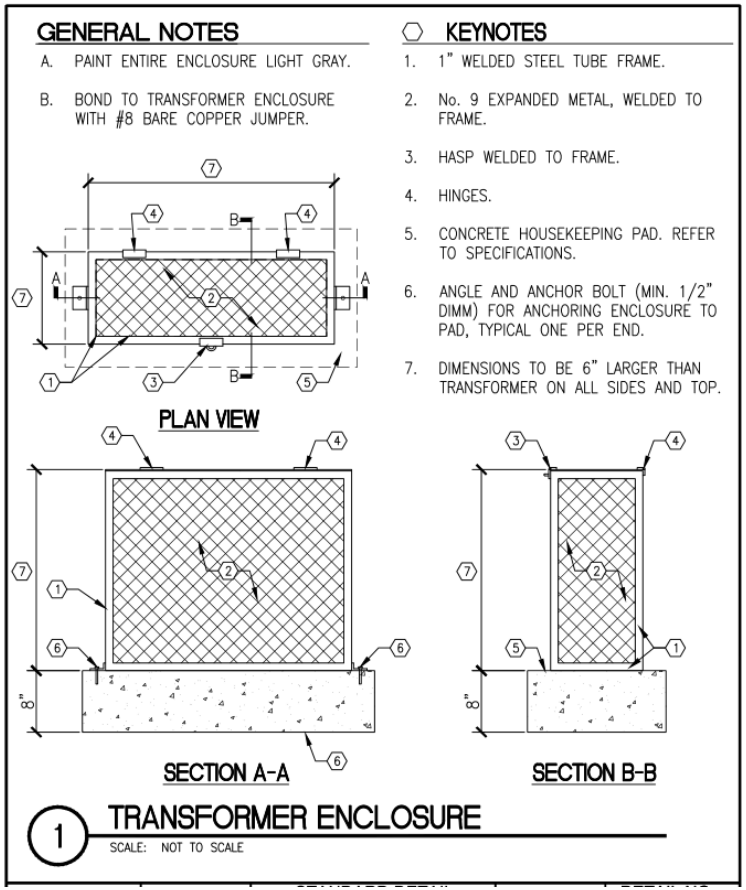
- Use steel pedestals with steel covers



BEST PRACTICES – MATERIAL SELECTION

Outdoor Transformers

- Put them in cages



BEST PRACTICES – DESIGN & INSTALLATION

Curb – to – Curb Electrical Evaluations

Joint effort between staff electrician, engineer, and contractor

Particularly important for older campuses with years of small repairs

Begins with institutional knowledge

Visual observation
- Code violations
- Listing violations
- Condition concerns

Recommendations for repair
- Immediate shutdown
- Prioritized actions

BEST PRACTICES – DESIGN & INSTALLATION

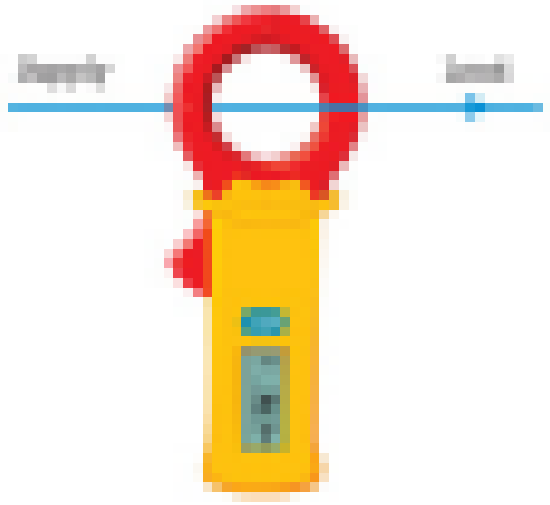
Current Leakage Testing

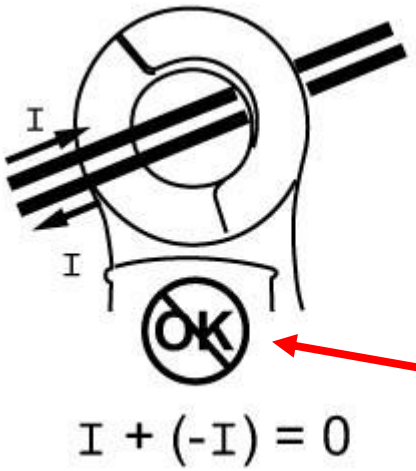
Tests for electrical current that isn't going where it should go.

The most common example is the 15 & 20A GFCI receptacle. UL has established the Standard for Ground-Fault Circuit Interrupters, which sets the receptacle's trip value at 6mA (0.006A).

GFCI receptacles power off when they detect that current is flowing along an unintended path, such as through water or a person.

CURRENT LEAKAGE TESTING





I + (-I) = 0

This is OK – it's exactly what we want to do !!!

CURRENT LEAKAGE TESTING

Clamp-on current testers –

- cost $400 - $600
- used by a Qualified Person
- good for smaller wire sizes

Fluke
360

Amprobe
AC50A

CURRENT LEAKAGE TESTING

Key Lessons Learned

GLHN helped test hundreds of branch circuits at municipal parks. Approximately 50% of the circuits failed, showing current leakage 6mA or greater.

We found that passing or failing the 6mA test was not dependent on circuit age.

Approximately 90% of circuits that tested greater than 6mA of leakage current had a found defect!

This test is beyond Code, or UL, or NETA requirements.

We believe this test to be valid for existing electrical systems as a maintenance procedure, and for new electrical systems as an acceptance procedure.

CURRENT LEAKAGE TESTING

Key Points

Testing is done on energized circuits

Performed by a qualified person

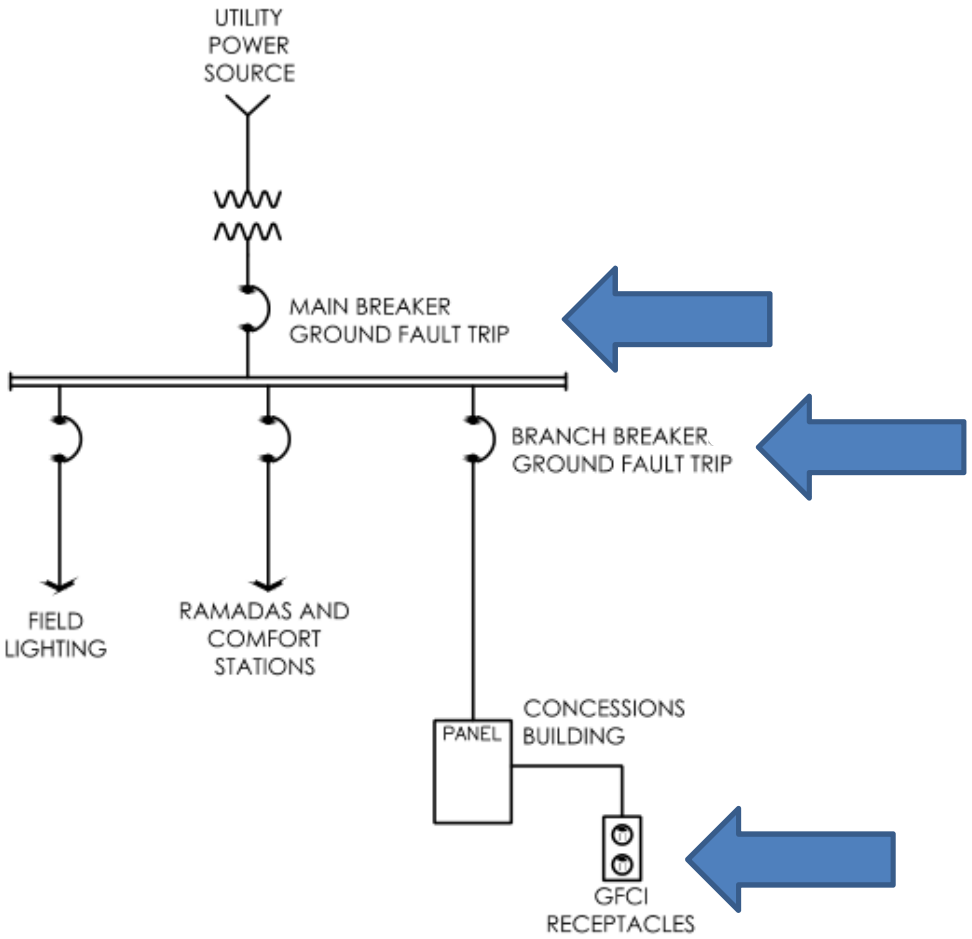
Be careful to isolate the conductors of one single circuit

Test at the beginning of the circuit, and work downstream
- panel to pullbox
- pullbox to pullbox
- pullbox to load

Results may vary slightly for any and no reason
- hold of the meter
- temperature and humidity

CURRENT LEAKAGE PROTECTION

Tiered Ground Fault Protection



Notes

GFCI receptacles cost $20

Ground Fault Circuit Breakers cost $100's more than standard breakers

A standard circuit breaker only monitors how much current is going down the wire to the load

A ground fault current circuit breaker cares about how much current goes out, and how much comes back

CURRENT LEAKAGE PROTECTION

Experience with End-Users

Based on GLHN's experience in Tucson…

May reject test results that suggest problems with their equipment

May have multiple or damaged power strips, or cast-off equipment

May reset tripped GFCI receptacles without investigation, or will bypass them with extension cords to non-GFCI receptacles

May self-perform their own electrical work

BEST PRACTICES – DESIGN & INSTALLATION

Each circuit should have a dedicated conduit.

Specify minimum 24" high concrete pole bases along walking paths.

Specify current leakage testing at closeout, in addition to insulation resistance ("megger") testing.

Require AHJ inspections for all work - even 'like for like' work that doesn't require engineered drawings.

Photograph as-left conditions.

BEST PRACTICES – MAINTENANCE

Covered or corroding metal pole bases

Remove concrete

Sandblast

Epoxy paint

BEST PRACTICES – MAINTENANCE

Repeat current leakage tests on branch circuits every three years.

Verify tightness of electrical connections every three years.

Operate circuit breakers every three years.

Install expanded-metal cages around ground-mounted stepdown transformers.

Modify sprinkler patterns so that electrical equipment isn't watered.

Remove abandoned wiring!

WHY DID WE DO ALL THIS?

SAFETY!

Campuses concentrate people, water, permanent amenities, and transient equipment.

Lighting and electrical systems have a finite lifetime: 20-30 years.

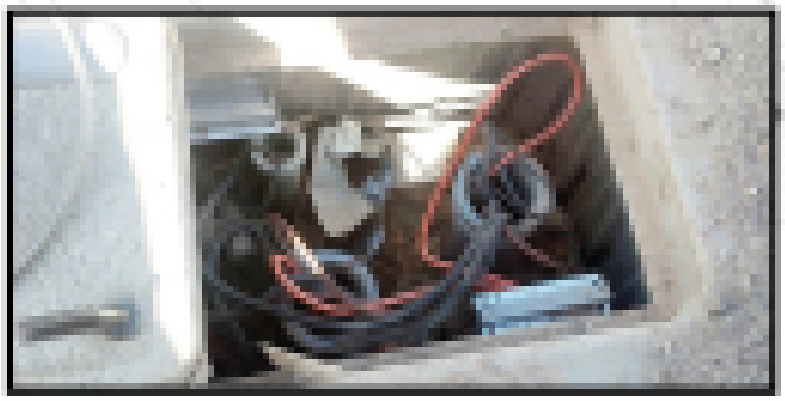
Properly designed, installed, and maintained underground electrical systems will give years of safe and trouble-free service.

ADDED FEATURE !

Copper Wire Theft

PREVENTING WIRE THEFT

- Pullbox lid security system
- Eliminate pullboxes
- Small vaults instead of pullboxes
- Aluminum wire rather than copper
- Locking pullboxes



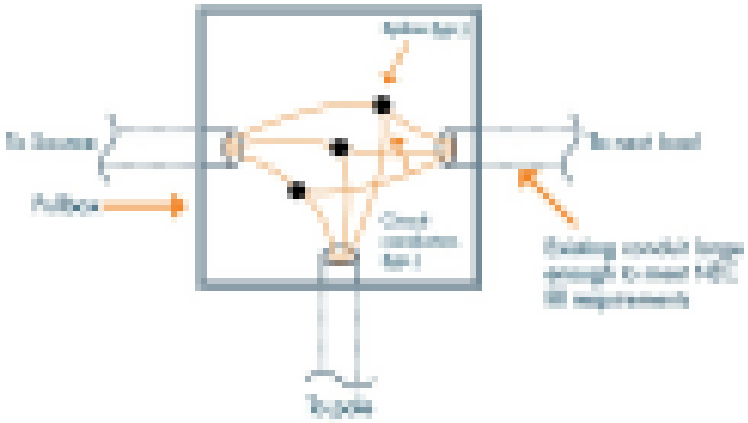
Pullbox lid security system

Locking pullbox

UNDERGROUND PULLBOX REMOVAL

PLAN VIEWS

EXISTING (if wire is not stolen)



SECTION VIEWS

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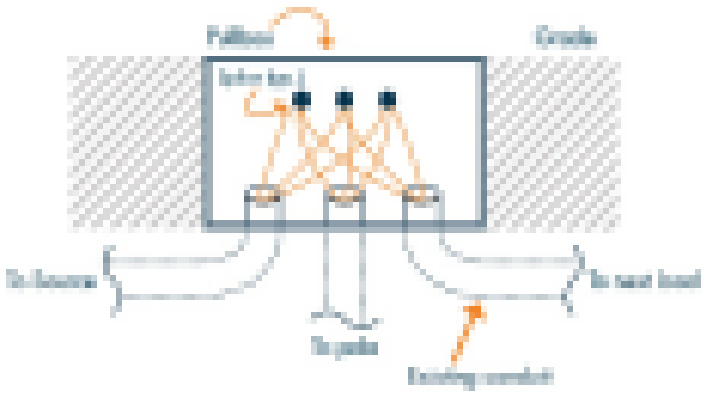

*Grounds not Shown

UNDERGROUND PULLBOX REMOVAL

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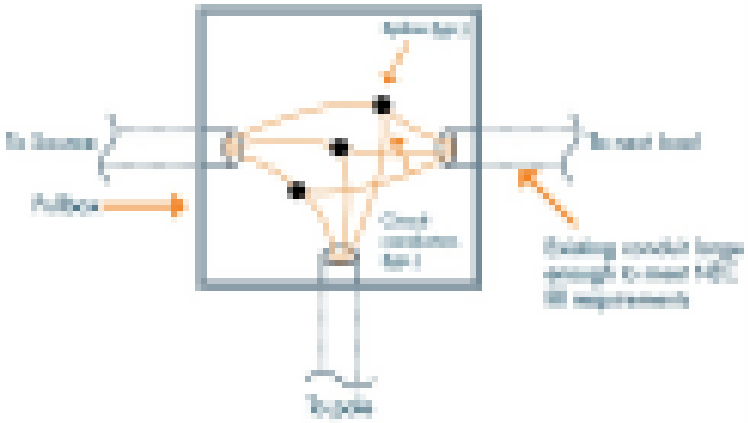

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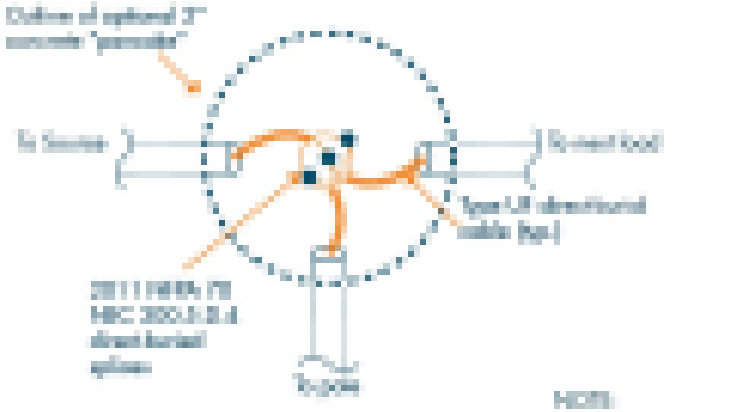

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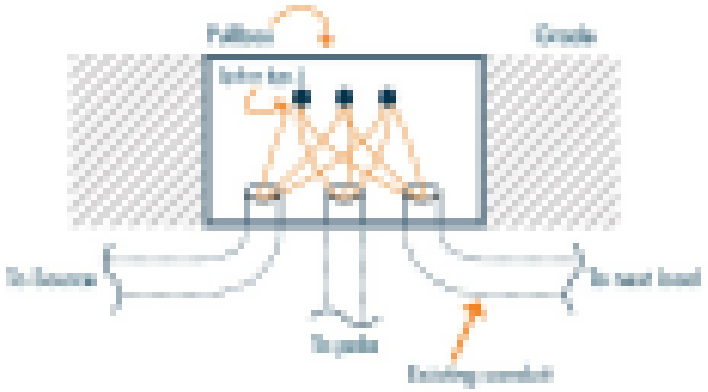

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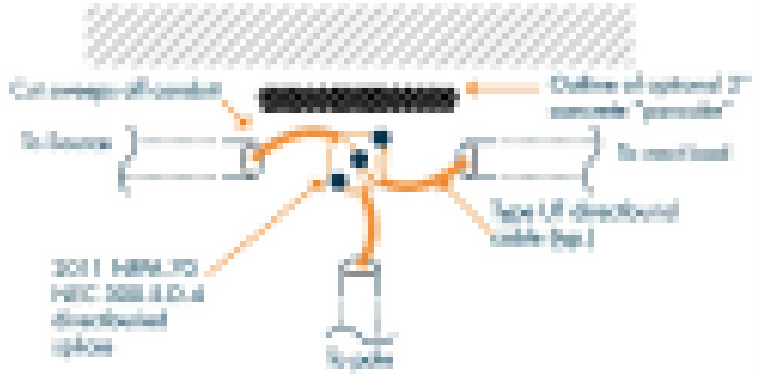

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THANK YOU!

Questions?

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