Installation of Resilient Electrical Systems

Bruce Lesikar
National Onsite Wastewater Recycling Association
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Acknowledgements

- Presenter: Bruce Lesikar, Ph.D., P.E.
- The materials presented are the opinions of the author and not an official representation of NOWRA.

- What is the purpose of the discussion in this presentation?
- Authorization to perform electrical work? NO!!!
- Jurisdiction over electrical work performed? NO!!!
- Qualifications of individual performing electrical work? Yes.
  - Discussion to enhance knowledge, skills and abilities associated with electrical components

Learning objectives

Upon completion of this presentation, participants should be able to:

1. Identify the working environment for electrical components of an OWTS as a Class 1, Division 1 (gasses) hazardous area
2. Recognize electrical conduit as a connection between the OWTS and a facility
3. Understand that insurance and bonding agency can deny coverage when the root cause of an incident is not following accepted practices
4. List the source of the National Electrical Code as the National Fire Protection Association
5. Identify accepted wiring practices for electrical components

Overview

- Professionalism in electrical practices protects people and property
- Electrical wiring considerations
- Electrical disconnect outside control panel
- Electrical disconnect weatherproof and lockable
- Wiring connections in riser – hazardous environment rated
- Electrical junction boxes not buried
- Gas and water seal in panels and conduit
- Separate high and low voltage wiring
- Flood hazard area considerations

Definitions

- Resilient – ability to rebound, including design and construction practices to facilitate rebounding to “shocks” to the system.
- Resilience - rebounding from or adjust easily to adversity or change; ability to recover from adverse conditions (harsh environment, temperature effects, corrosivity, wetness) or to adjust processes in response to peak loading events or changing waste streams.
- Premises – the land and buildings located on the user’s side of the point of demarcation between the communications service provider and the user.

Definitions

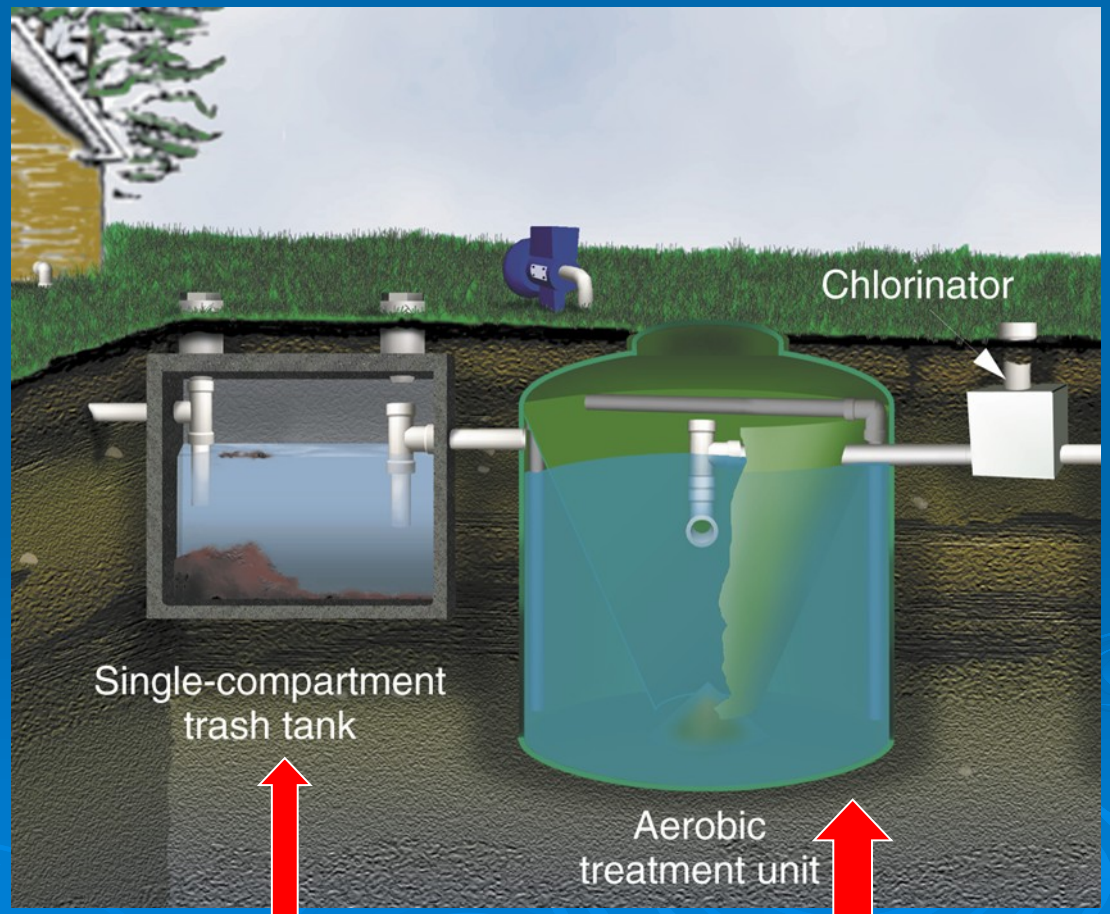
- Authorization – official permission, approval, or the legal right to perform work or provide a service.
- Jurisdiction – 1. the power or right to exercise authority; 2. the limits or boundary within which authority may be exercised.
- Qualification – knowledge, skill, abilities, or certification that establish an individual's competency to perform a specific job, task, or service.
- Demarcation point – 1. real or imaginary boundary that separates two different areas, groups or conditions; 2. Physical location where the communications service provider's network ends and the user's private network begins; 3. Physical location where an OWTS service provider's authorization to perform work begins.

National Electrical Code

- Source: National Fire Protection Association
- Jurisdiction over electrical work on premises.
- Limits the risk of fires due to improper selection, installation and operation of electrical systems.
- Establishes accepted practices for specification, installation, operation and protection of electrical devices and components
- Establishes ratings for electrical devices
- Establishes requirements for working with electrical components
- Establishes classifications for hazardous areas

Hazardous area classification

- Class 1, Division 1 (gasses)
- An area in which an explosive mixture is likely to occur in normal operation
- Anaerobic digestion in tanks have the potential to generate methane gas
- Corrosive environment due to gas formation



Electrical professionals

- Perform electrical activities that are authorized and within your qualifications
- Identify the demarcation point in your local area
- Remain technically competent regarding electrical components
- Understand the inherent risk associated with electrical systems
- Limit the risk associated with performing electrical work
- Recognize the risk to human safety and property damage due to improper electrical systems
- Deviations from accepted practices can result in loss of insurance or bonding coverage
  - Insurance companies perform a root cause analysis on claims
  - Insurance companies can deny coverage on claims with an identified failure to follow accepted practices – electrical code is an accepted practice

Demarcation point: electrical receptacle

- An electrical receptacle facilitates disconnection of power – demarcation point
- Electrician is authorized to install and repair the receptacle
- The cord plug is removed from the receptacle by the service provider. Service provider authorized to work on components after plug.
- Piggy-back plug float switch is control method for a pumping system



Demarcation point: disconnect

- A disconnect is defined as the point of demarcation
- Supply side of disconnect is authority of electrician
- Load side of disconnect is authority of service provider



OWTS guidelines

- Reference the National Electrical Code for guidelines for the protection of electrical devices and components as well as installation practices
- Pumping systems and treatment systems utilize electricity as energy to perform work within the processes
- Guidelines protect the equipment and people interacting with the equipment

Electrical wiring considerations

- Connections shall be in approved junction boxes.
- All electrical components should have an electrical disconnect within direct vision from the place where the electrical device is being serviced.
- Electrical disconnects should be weatherproof (approved for outdoor use) and have maintenance lockout provisions.



Electrical tools

- Multi-meter modes
  - Voltage
  - Continuity
  - Amperage
- Auto voltage detection
  - Detect AC and DC current

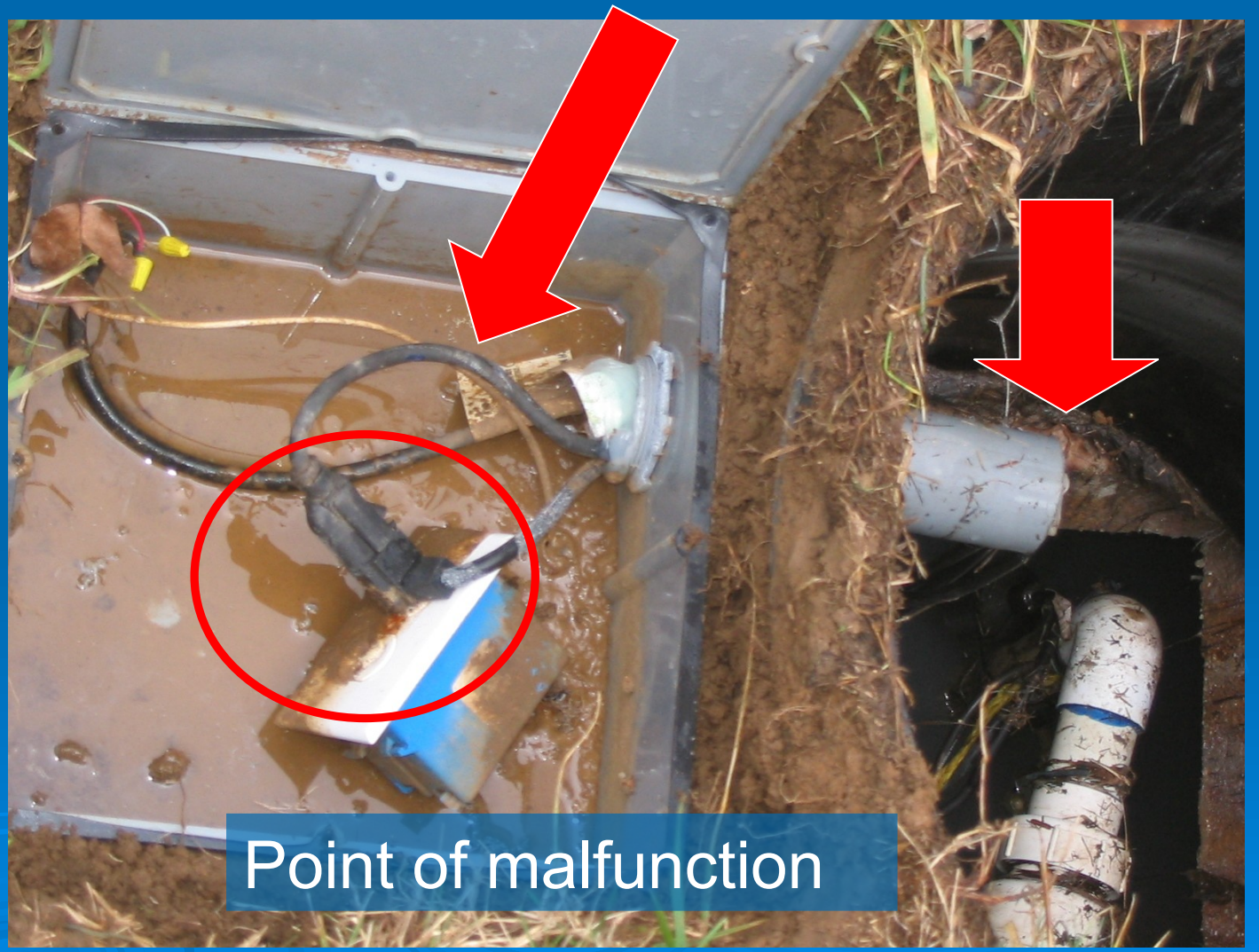


Key considerations

- Wire - appropriate for use
- Wiring in conduit
  - Rigid PVC conduit
  - Gray color coding
  - Conduit terminates in main panel or subpanel
  - Burial depth
- Stop gas and liquid movement
  - Gas- and liquid-tight seal
  - Air gap
  - Solid wire
- Junction boxes for wiring connections
  - Junction boxes at grade
  - Wiring connections inside riser – hazardous environment
  - Wiring pull boxes in riser
- Electrical disconnect
  - View of panel being serviced
  - Approved for outdoor use
  - Lockable feature
  - Non-fused – amperage - motor rating
- UL listing

What is the problem?

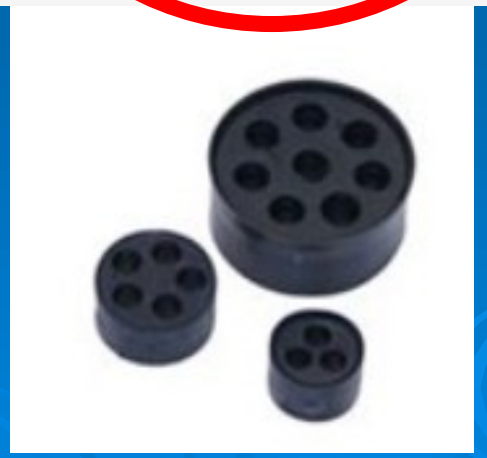
- Water and electricity mixes!!
- Junction box buried
- Liquid in insulated box is energized
- Electrical circuit remains energized
- Non-liquid tight connectors
- No gas- and liquid-tight seals on conduit and wiring



Connector – cord grip

- Electrical cable gland
- Serve multiple purposes
  - Waterproofing
  - Gas seal
  - Strain relief – support wiring
- Metallic cable glands -
  - Stainless steel - YES
  - Aluminum - NO
- Nonmetallic cable glands – corrosive environment rated





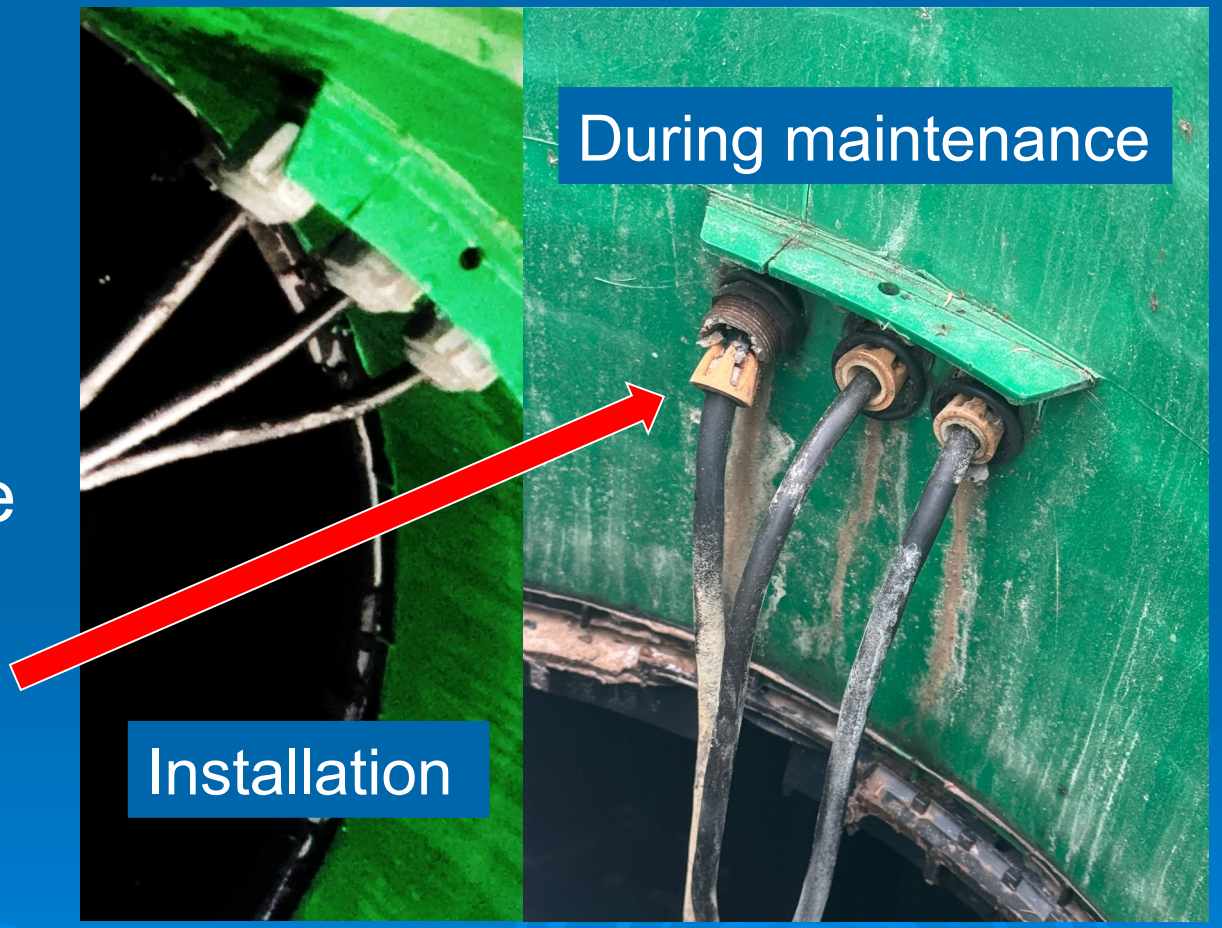




Plastic and polymer must be suitable for corrosive environment – It dissolves!!!

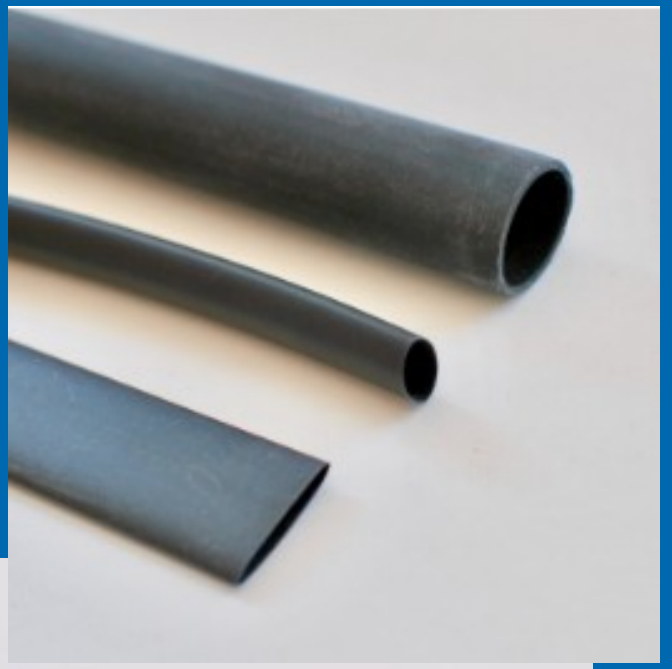
Gas seal: cable gland strain relief

- Stainless steel strain relief is recommended
- Gases in treatment system characterized as a corrosive environment
  - Anaerobic tanks – highly corrosive
  - Aerobic tanks – less corrosive
- Aluminum and some plastic parts dissolve
- Resulting in a non-sealed conduit



Connectors - heat shrink

- Electrical connectors
  - Wet environment rating
  - Not dust environment rating
- Gas- and water-tight connections
- Heat shrink butt connectors
- Heat shrink tubing
- Heat source used to shrink tubing connections
- Connections in pump tank – hazardous environment





Connectors – Epoxy encapsulated

- Sealing of connectors to prevent moisture and gas movement
- Epoxy filled tube
- Place connections plus SOOW cord into epoxy
- Permanent connection: All wires must be cut to replace components
- Extra wire length:
  - Facilitate cutting all connections and sealing when replacing components
  - Work outside riser with components



Wire

- Correct wire for the application
- No Romex!!!!
  - Nonmetallic building wire
- Stranded wire – conduit to convey water and gases (seal jacket)
- Solid wire – jacket bonded to wire – stops water and gas movement
  - 10 gauge – 30 amps
  - 12 gauge – 20 amps
  - XHHW coating
- Service cord cabling (SOOW)



Wire coating designation - 2026 code

- ***310.10(C) Wet Locations.*** *Insulated conductors and cables used in wet locations shall comply with one of the following:*
  1) *Be moisture-impervious metal-sheathed*
  2) *Be types MTW, RHW, RHW-2, TW, THW, THW-2, THHW, THWN, THWN-2, XHHW, XHHW-2, XHWN, XHWN-2 or ZW*
  3) *Be of a type listed for use in wet locations*

- What do the letter designations mean in a wire rating
  - T = thermoplastic insulation
  - X = Cross-linked polymer (XLPE) insul.
  - R = Rubber insulation
  - N = Nylon jacket/insulation
  - H = 75°C temperature rating
  - HH = 90°C temperature rating
  - W = Water resistant
  - O = oil-resistant
  - OO = oil-resistant jacket/insulation
  - M = constant service
  - 2 = High temperature rating

Cable cord ratings

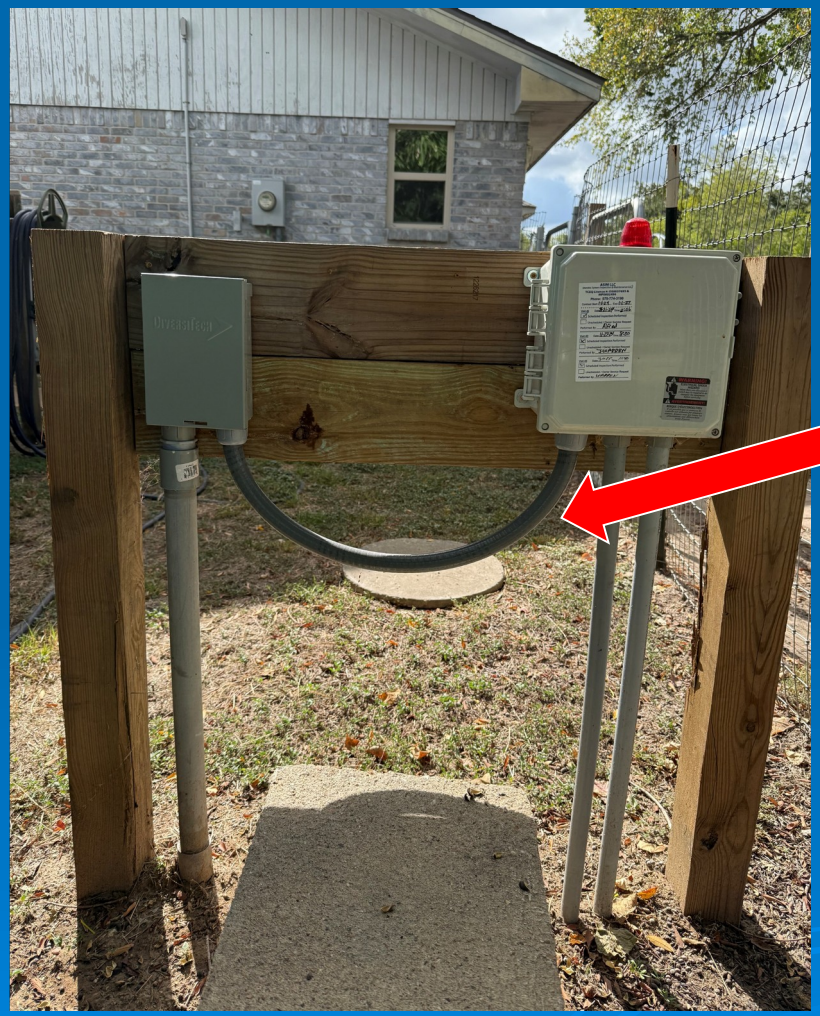
- **"S"** means service cord category. A service cord is a portable power cable meant for heavy duty service or light-duty service, 600 Volt rated.
- **"J"** means junior service cable with a voltage rating of 300 volt
- **"O"** means that the cable has an oil-resistant outer jacket, but not the oil-resistant insulation.
- **"OO"** indicates that the cable has an oil-resistant insulation and an oil-resistant jacket.
- **"T"** means that the type of insulation used in a portable power cord is thermoplastic.
- **"W"** indicates weather and water resistance. This includes resistance to all environmental impacts, including sunlight, ozone, moisture, and many others.

Service cord and wires

- Chemical compatibility
- Service cord
  - Corrosive environment is compatible (OK) for cord coating
  - High chlorine disinfection concentration degrades cord
  - Do not drip chlorine solution on to service cord
- Wire and wire coating
  - Corrosive environment can degrade wire and wire coating – wet environment rating
- Best to keep wires covered
  - Heat shrink tubing and butt connectors
  - Epoxy sealant



Nonmetallic flexible conduit

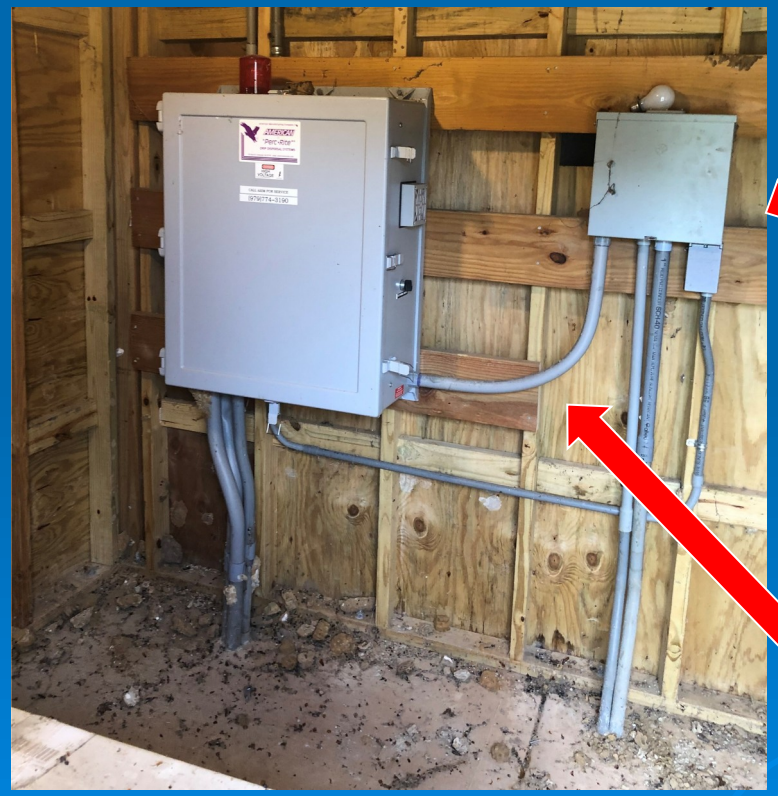


- NEC Article 362
- Flexible PVC tubing; commonly called car flex
- NEC requires support (356.30) on lengths greater than six (6) feet
- Rigid conduit support (352.30(B))
  - ½ to 1 inch - three feet
  - 1-1/4 to 2 inch – five feet

NOT APPROVED IN ALL JURISDICTIONS

Electrical Disconnect & Flexible Conduit

Electrical inside building: disconnect outside panel, flexible conduit



Disconnect

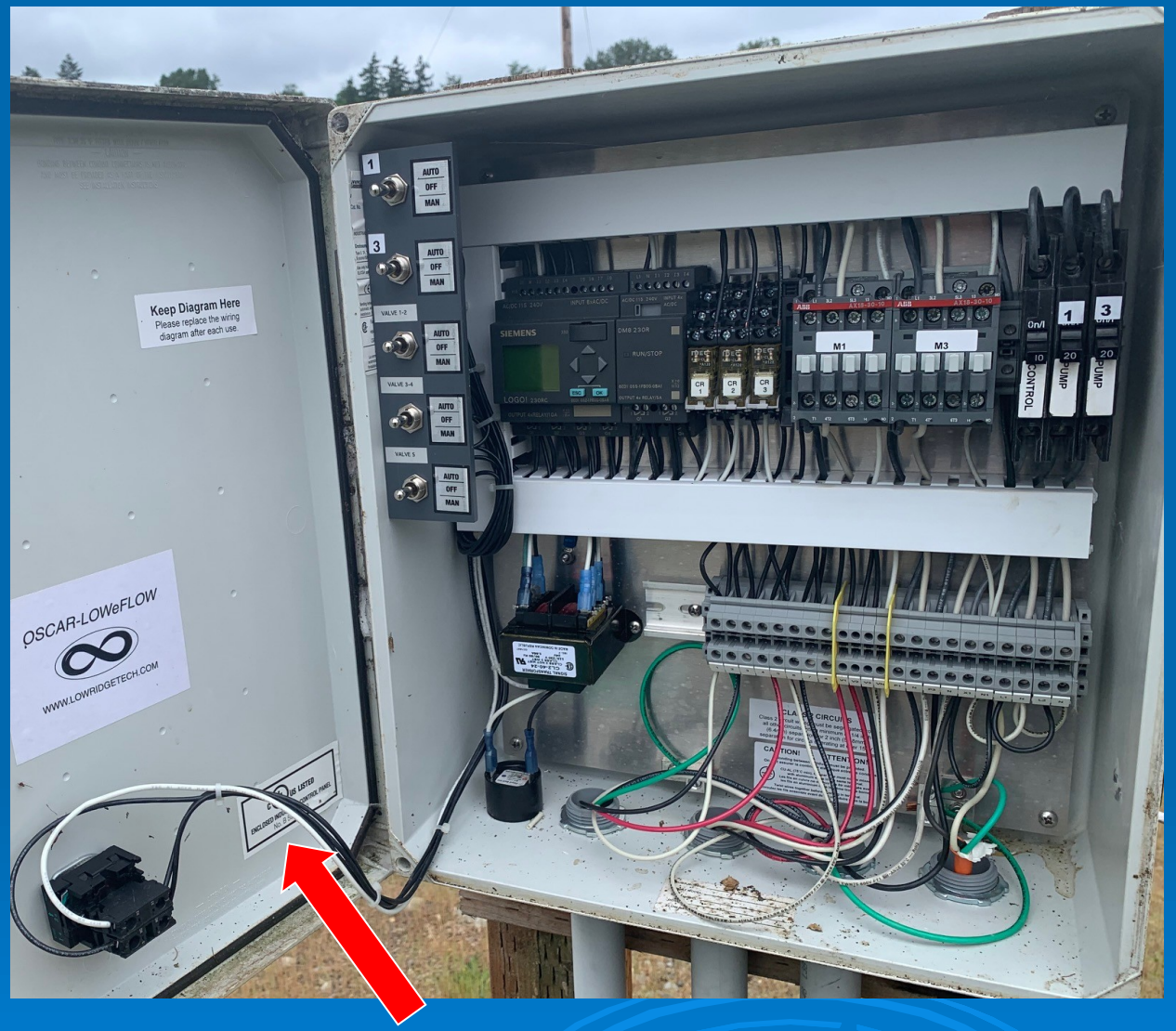
Flexible conduit

House electrical panels: OSSF panel, flexible conduit between panels



Control panel

- Duplex controls
- Three breakers
  - Pump 1
  - Pump 2
  - Controls
- Three separate circuits to panel with second circuit breaker in panel
  - Challenge for troubleshooting
  - Main panel breaker should have greater amperage rating



UL listing label

Control panels – watertightness

- All penetrations through bottom
- NEMA rating of panel is subject to penetrations
- Seal penetration of the enclosure – outside of conduit entering control panel
- Seal inside of conduit for wire entry – gas and water from tank



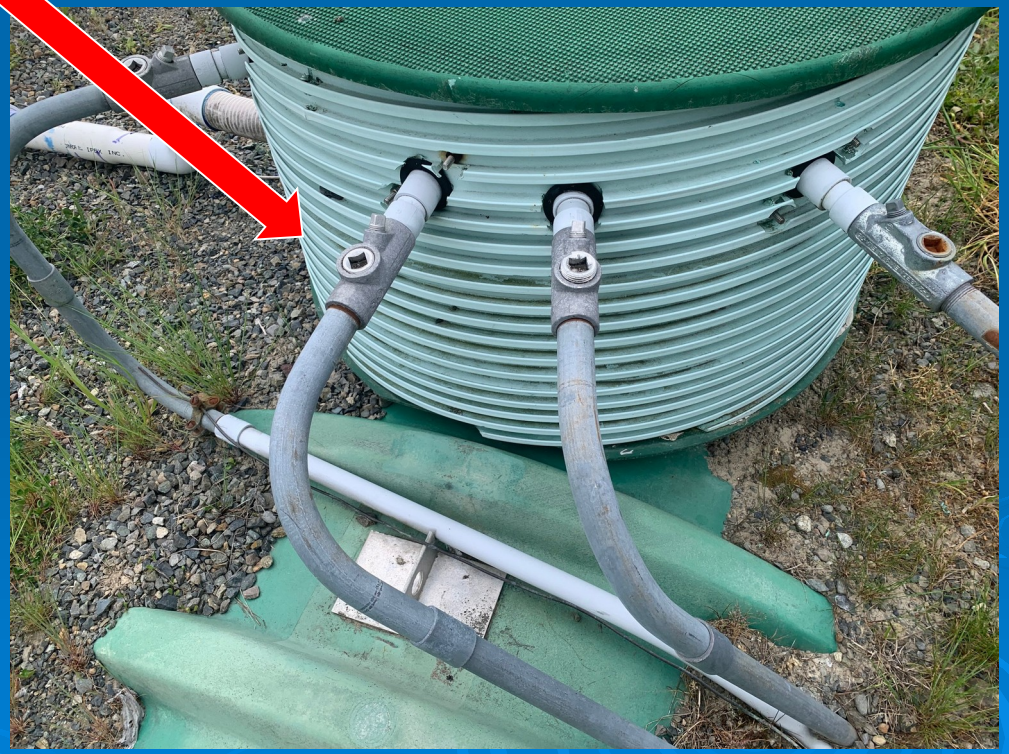
Rust on components

Gas seal in conduit – both ends

Gas seal as conduit enter panel or cable tray-raceway



Gas seal as conduit enters tank riser



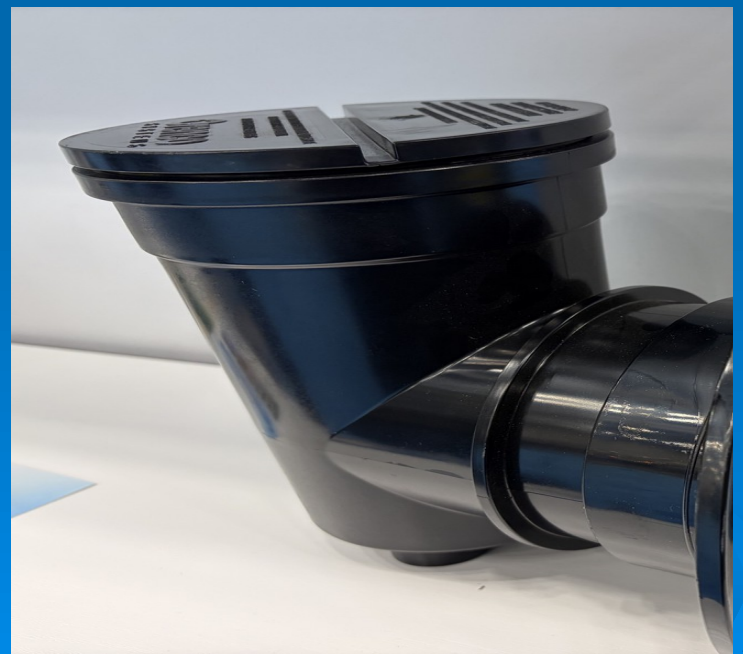
Gas seal: cable gland



- Pull boxes inside riser
- Separate pull boxes for high and low voltage wiring
- Extra cable for removing float trees
- Cable management would help

Riser access ports

- Molded fitting with cable glands
- Access at ground surface for connections
- Conduit on bottom to control panel

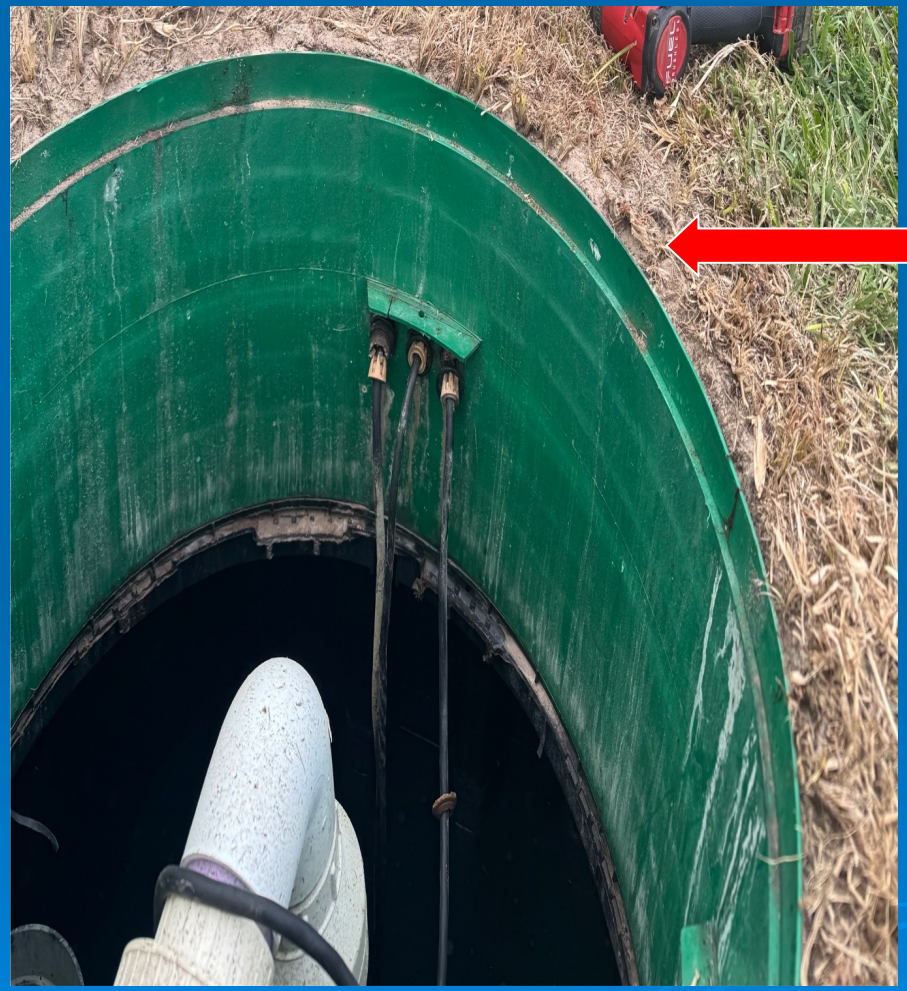




Minimum cover (burial depth) of conduit

- PVC conduit burial depth, NEC Article 300.7(A), up to 1000 Volts
- Residential: 20 amp & 120 VAC or less with GFCI, 12 inches deep
- Others: 18 inches deep
- Driveways & parking lots: 24 inches
- Restrictions - tank surfaces
  - Lesser depth across tank lid to riser
  - Double 90-degree bends to elevate conduit from trench to tank lid
- Maximum bends – 360 degrees 352.24(B); 270 degrees is easier

Junction box above grade



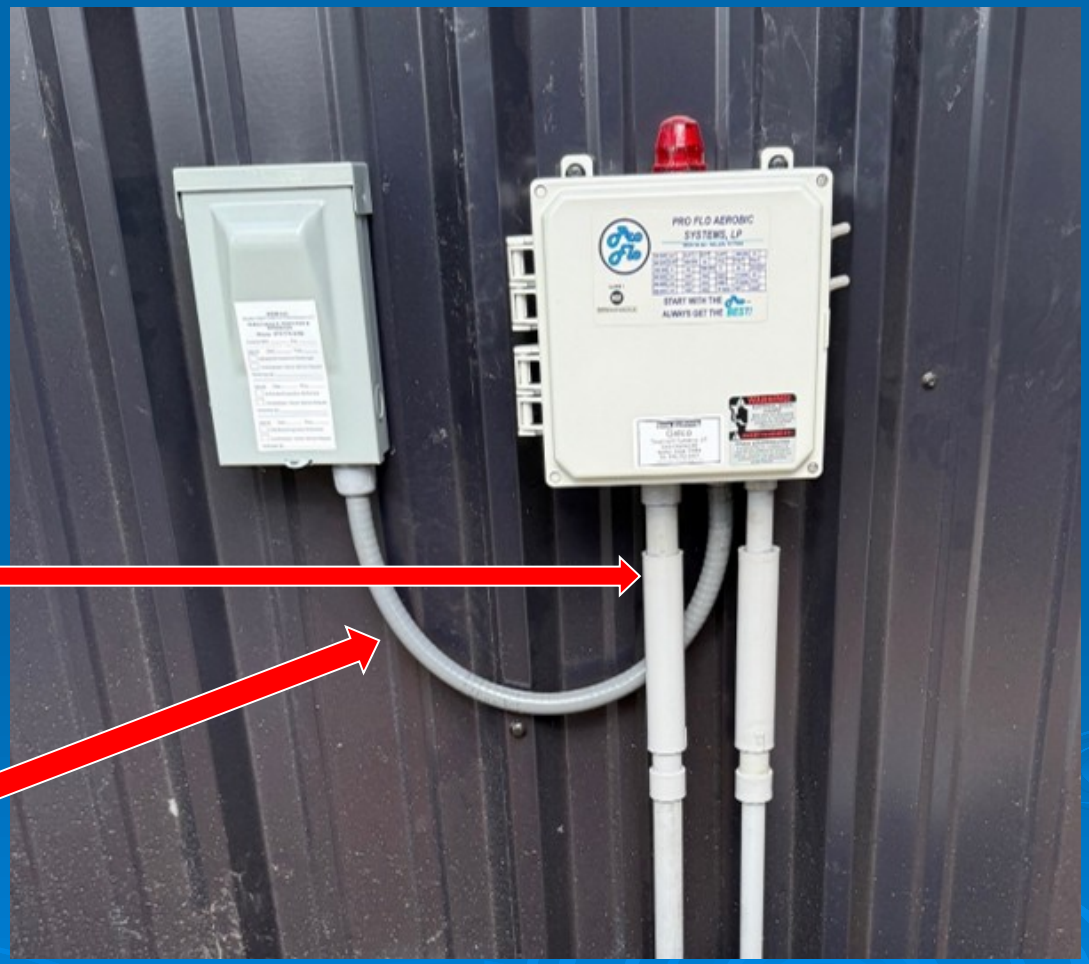
- Conduit exits riser to junction box
- Junction box above grade
- Panel in remote location

Protective concrete ring



Flexible connections

- Conduit movement
- Shrink-swell clay soils
- Settling following installation
- Flexible connections:
  - Expansion fitting – required in electrical code to serve as a flexible connection
  - Short length of flexible tubing



Electrical components

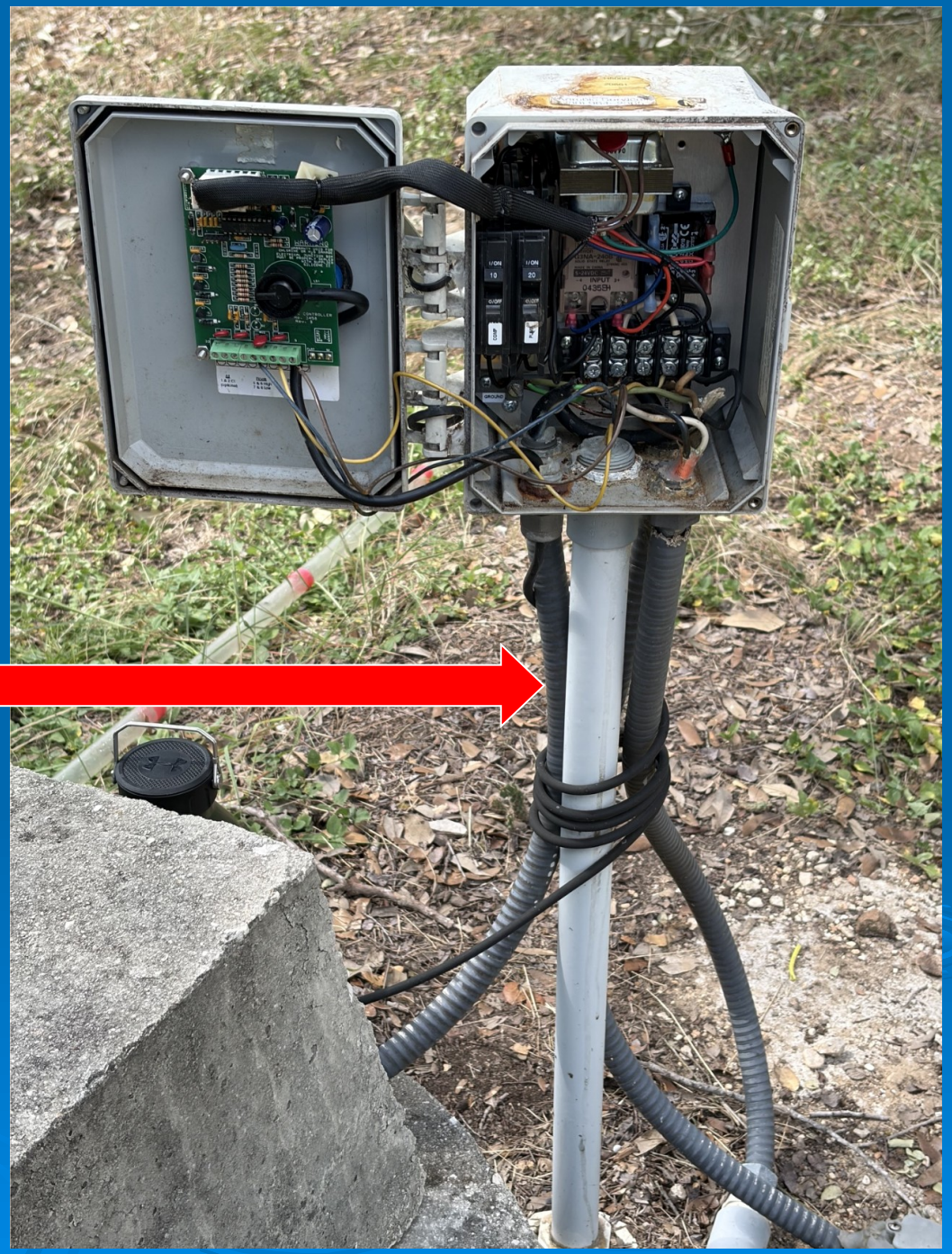
- Expansion fittings – rigid polyvinyl chloride conduit (PVC) NEC Article 352.44
- Required on all rigid conduit
- Conduit supports
  - Required every three feet



Panel support

- Enclosures with greater than 100 in^3 must have additional support, NEC Article 314.23(F)
- Support required in addition to the conduit.
- Metal or post support needed to carry weight of panel and limit risk of damage

NOTE: Installer to provide support structure for panel



Air gap

- External junction boxes
- Cable gland strain relief connectors on wires passing between junction boxes
- Double gas protection with air gap in wiring
- Pea gravel in base of box to assist with water drainage



High and low voltage wiring

- Control panels can use low voltage wiring for sensors
  - For example, 24-volt DC.
- Pull boxes inside riser to support connections
- Do not mix voltages in conduit
- Separate pull boxes
  - High voltage wiring
  - Low voltage wiring
- Note: use multi-meter with auto voltage reading (AC/DC)



High voltage wiring junction box

- Separate box for high voltage wires
- Gas seal in conduit to panel
- Cords from pump enters from riser
- Non-sealed wiring connectors
- Gas seal at conduit end in riser



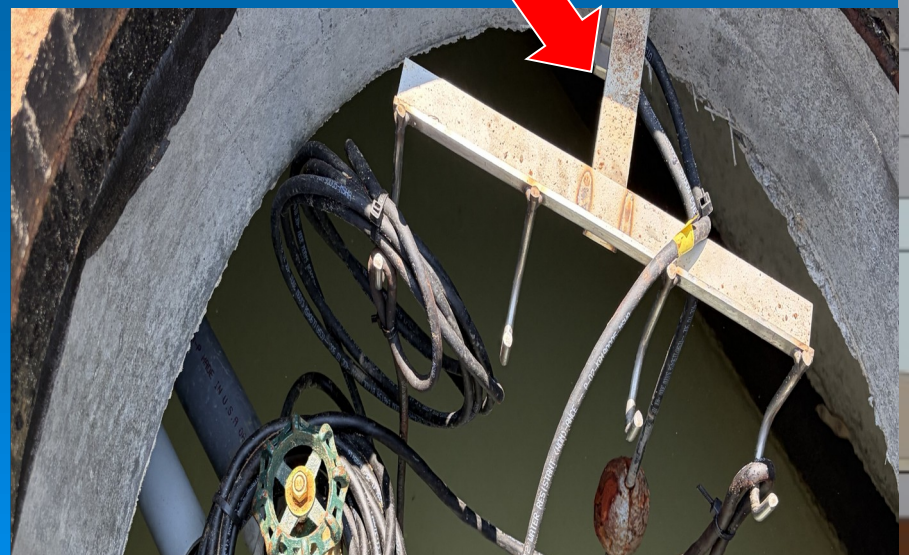
Low voltage wiring

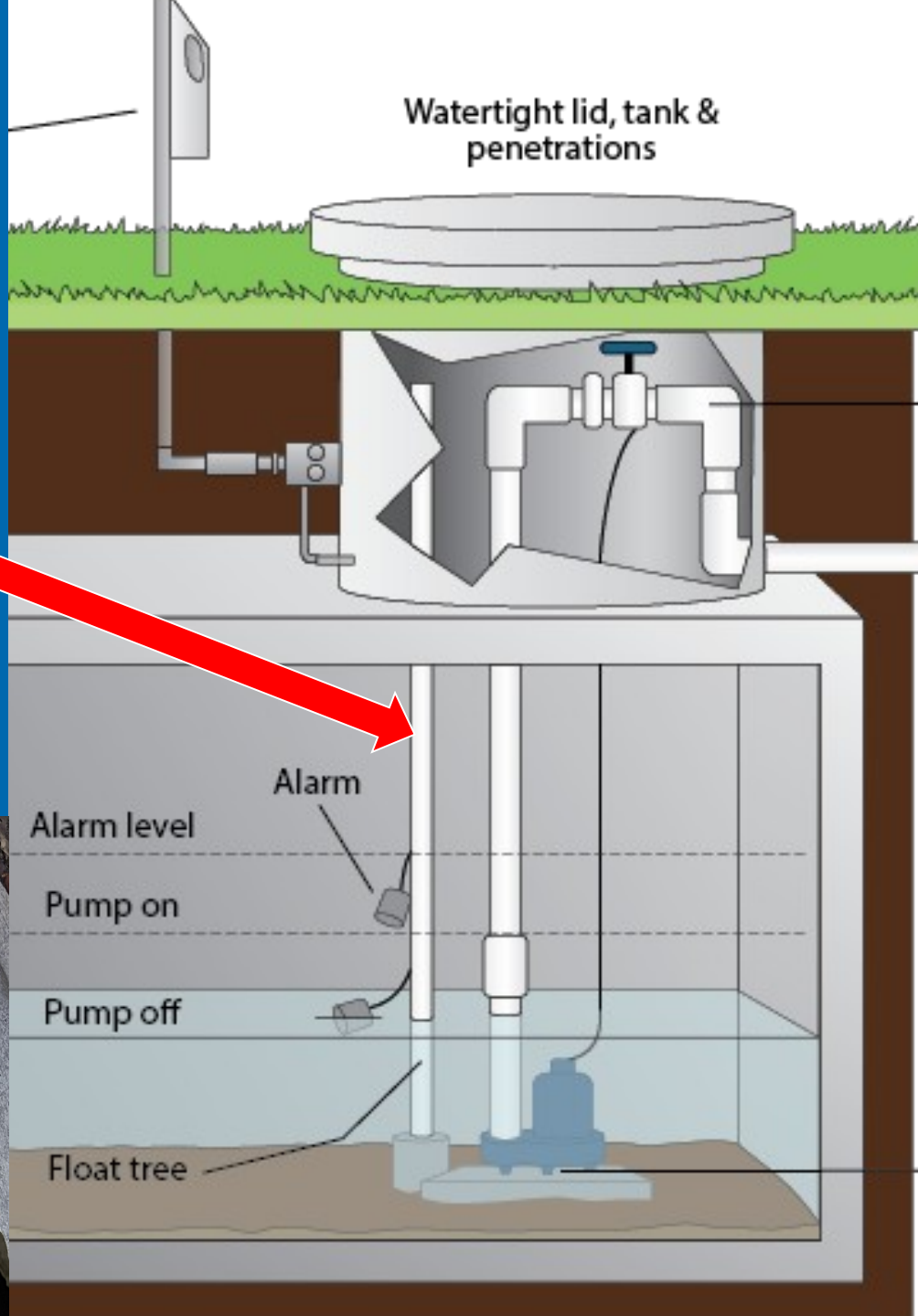
- Separate junction boxes for high and low voltage
- High voltage box
- Low voltage box
- Junction box outside of riser
- Label for wire colors on lid
- Conduit sealed with panel wires



Sensor supports

- Sensors on pump discharge vibrate – excessive component wear
- Float tree - snap tees with cable glands secure senor cable
- Sensor hanger – support sensors in riser





Flood hazard



- Non-buried components (e.g. alarms, junction boxes, and compressors) should be elevated above the 100-year flood elevation
- Platform constructed for electrical disconnection points
- Vent piping for tanks above flood elevation
- Note: main electrical service

Summary

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- Electrical wiring considerations
- Electrical disconnect outside control panel
- Electrical disconnect weatherproof and lockable
- Wiring connections in riser – hazardous environment rated
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Questions

Bruce Lesikar
lesikarb@yahoo.com