# The Docks Expo

## Planning for Power at a Marina – from Equipment to Layout to Costs

Chris Dolan

December 6, 2018

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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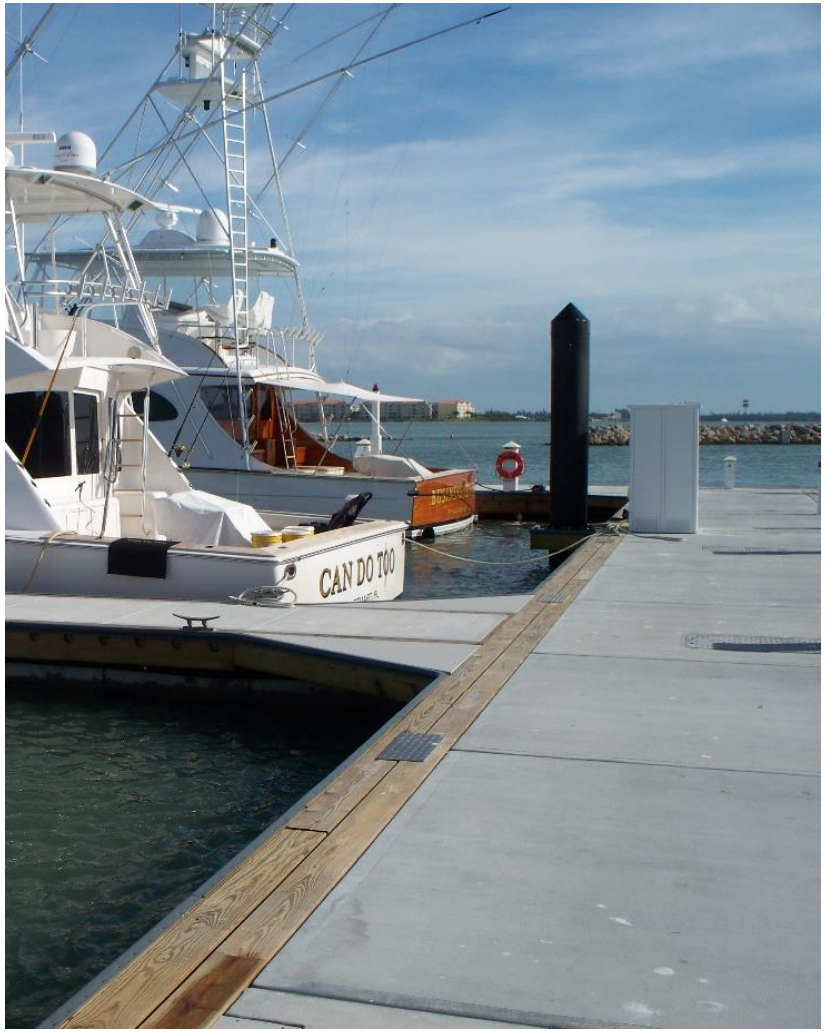
Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# Course Description




Whether you are undertaking a brand new electric installation or renovating existing electric there are considerations of what type of equipment you need, where it will be located, how it will be installed, costs and how long the work will take. This session will share what you need to know to provide the best service to your customers, while ensuring safety and cost efficiency in the overall electric project.

# Learning Objectives

At the end of the this course, participants will be able to:

1. Understand the basic operational components of a marina electrical system – what power do today's vessels require?

2. Understand the basics of designing a user-friendly marina electrical system – what amenities do today's customers require?

3. Understand the basics of providing a safe marina electrical system – how to identify potential hazards and understanding Electric Shock Drowning.

4. Understand the basics of providing a profitable marina electrical system – case study and cost analysis for various size slips.

# Basics of a Marina Electrical System

# Making a Design Operational and User-Friendly

- Three Basic Concerns:
  - Type of Boats?
  - Size of Boats?
  - Type of Boating Population?

# Why are Boat Type, Size, and Population Important?

- These factors will help determine receptacle selection.

# Boat Types:
# Power, Sail, or Mix?


- Powerboats typically use more power than sailboats.
- A mixture of vessels will require a mixture of receptacles.

# Boat Types:
# Exceptions to the Rules

- Of course there are always exceptions – houseboat, RV, floating building?

# Boat Sizes:
# Large, Small, or Mix

- Larger boats typically use more power than smaller boats.
- A wide range of sizes will require a wide range of receptacles or strategic pedestal placement.

# Boating Population:
# Age of Boats

- Modern vessels will often use more power than older vessels due to higher draw electronics.
- Older vessels may use equipment considered out-of-date.

# Boating Population: Transients

- Marinas with high transient populations may require a wider range of receptacle options to accommodate different size / types of vessels entering the facility.

# Boating Population: Megayachts

- Megayacht requirements vary by manufacturer and captain preferences. Providing a variety of receptacles and hardwire connections is beneficial for these vessels.

# Boating Population: Megayachts

- Megayacht requirements do not only apply to Power Vessels these days.

# Recommended Receptacle Configurations – NEMA:

| Boat Size | Minimum | Satisfactory | Preferred |
|---|---|---|---|
| 20’ & under | None | 1-20 Amp | 1-20 Amp |
| 21’ – 25’ | 1-30 Amp | 1-30 Amp | 1-30 Amp |
| 26’ – 30’ | 1-30 Amp | 1-30 Amp | 2-30 Amp |
| 31’ – 37’ | 1-30 Amp | 2-30 Amp | 2-30 Amp |
| 38’ – 45’ | 1-30 Amp | 2-30 Amp | 1-30 Amp & 1-50 Amp |
| 46’ – 50’ | 1-30 Amp | 1-30 Amp & 1-50 Amp | 2-50 Amp |
| 51’ – 60’ | 2-30 Amp or 1-50 Amp | 2-50 Amp | 2-50 Amp |
| 61’ – 70’ | 2-50 Amp | 2-50 Amp | 1-50 Amp & 1-100 Amp |
| 71’ – 80’ | 2-50 Amp | 1-50 Amp & 1-100 Amp | 2-100 Amp |
| 80’ & up | 1-100 Amp | 1-50 Amp & 1-100 Amp | 1-100 Amp Single Phase 1-100 Amp Three Phase |

# Recommended Receptacle Configurations – Megayachts:

| Boat Size | Minimum | Preferred |
|---|---|---|
| 70’ – 80’ | (2) 50A 120/240V | (1) 100A 120/240V<br>(2) 50A 120/240V |
| 80’ – 100’ | (2) 50A 120/240V<br>(2) 100A 120/240V | (2) 100A 120/240V<br>(2) 100A 120/208V |
| 100’ – 150’ | (2) 100A 120/240V<br>(2) 100A 120/208V | (2) 100A 120/208V<br>(2) 100A 480V |
| 150’ – 200’ | (2) 100A 120/208V<br>(2) 100A 480V | (2) 100A 480V<br>(1) 200A 480V |
| 200’ + | (2) 100A 480V<br>(1) 200A 480V | (2) 100A 480V<br>(2) 200A 480V |

# Notes for Selecting Receptacles:

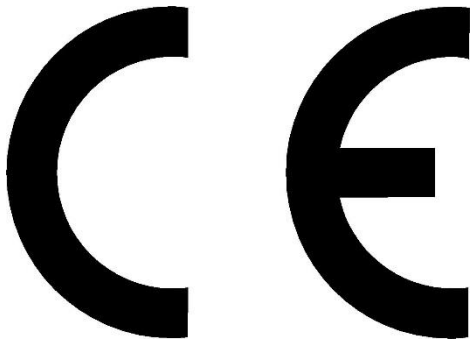
1. For sailboats use the minimum column.
2. For houseboats and fishing boats use the preferred column.
3. For a mix of sail & power pleasure craft use the satisfactory column.
4. The voltage rating for most 20 amp and 30 amp receptacles is 120V. *Straight blade 20 amp receptacles must be GFCI protected.*
5. The voltage rating for most 50 amp receptacles is 120/240V.
6. The voltage ratings for 100 or 200A amp, 4 wire receptacles are 120/240V or 480V.
7. The voltage ratings for 100 amp or 200A, 5 wire receptacle are 120/208V or 277/480V.
8. The 100 amp receptacles are IEC Pin & Sleeve configuration. 30 amp and 50 amp receptacles are twist-lock, while *most* 20 amp receptacles will be straight blade GFCIs.

# IMPORTANT NOTE – Avoid Using Adapters

- Most “Y-Adapter” cord sets are not listed products and do not provide the proper circuit protection for a safe electrical connection.

# Listed Products
# What to Look for:







- Listed products go through stringent tests to ensure products meet certain safety guidelines.

# Adapters and Splitters – Examples of Potential Danger:

50A 120/240V

30A 125V receptacle is now capable of drawing up to 40A without tripping a breaker

30A 125V receptacle is now capable of drawing up to 40A without tripping a breaker

- A typical circuit breaker trips at 80%. A 50A circuit breaker will allow 40A of electricity to pass through to 30A receptacles. This is DANGEROUS.

# Cords Sets and Splitters – Examples of Potential Danger:

- Overloading or overheating a receptacle can lead to melting, burning, arching, and potential fire.

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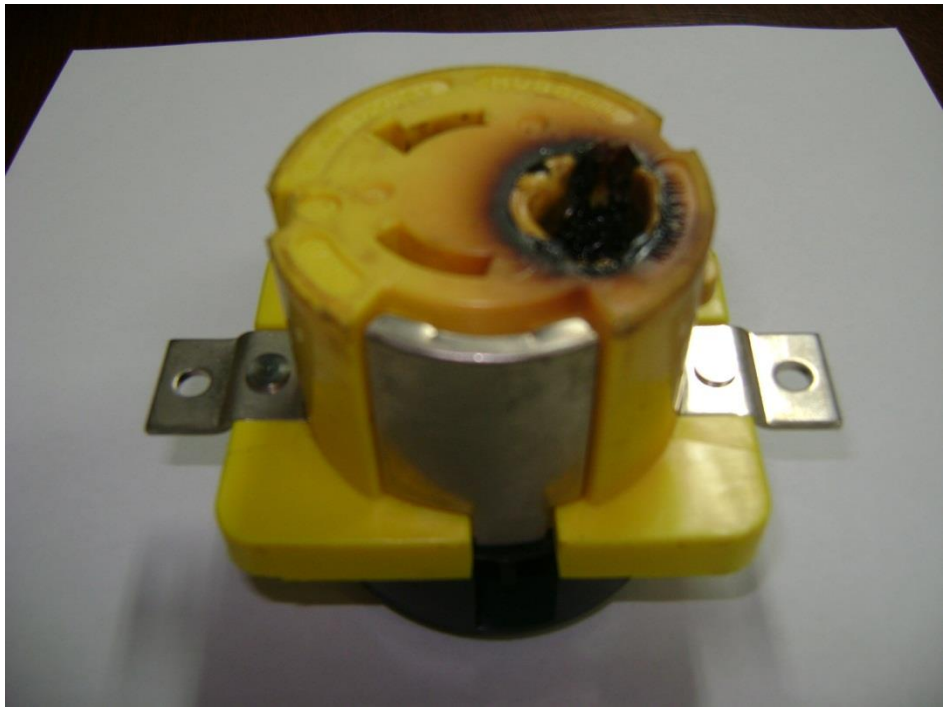

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# Safety, Maintenance, and Electric Shock Drowning:

# Ground-Fault Regulation and Requirements:

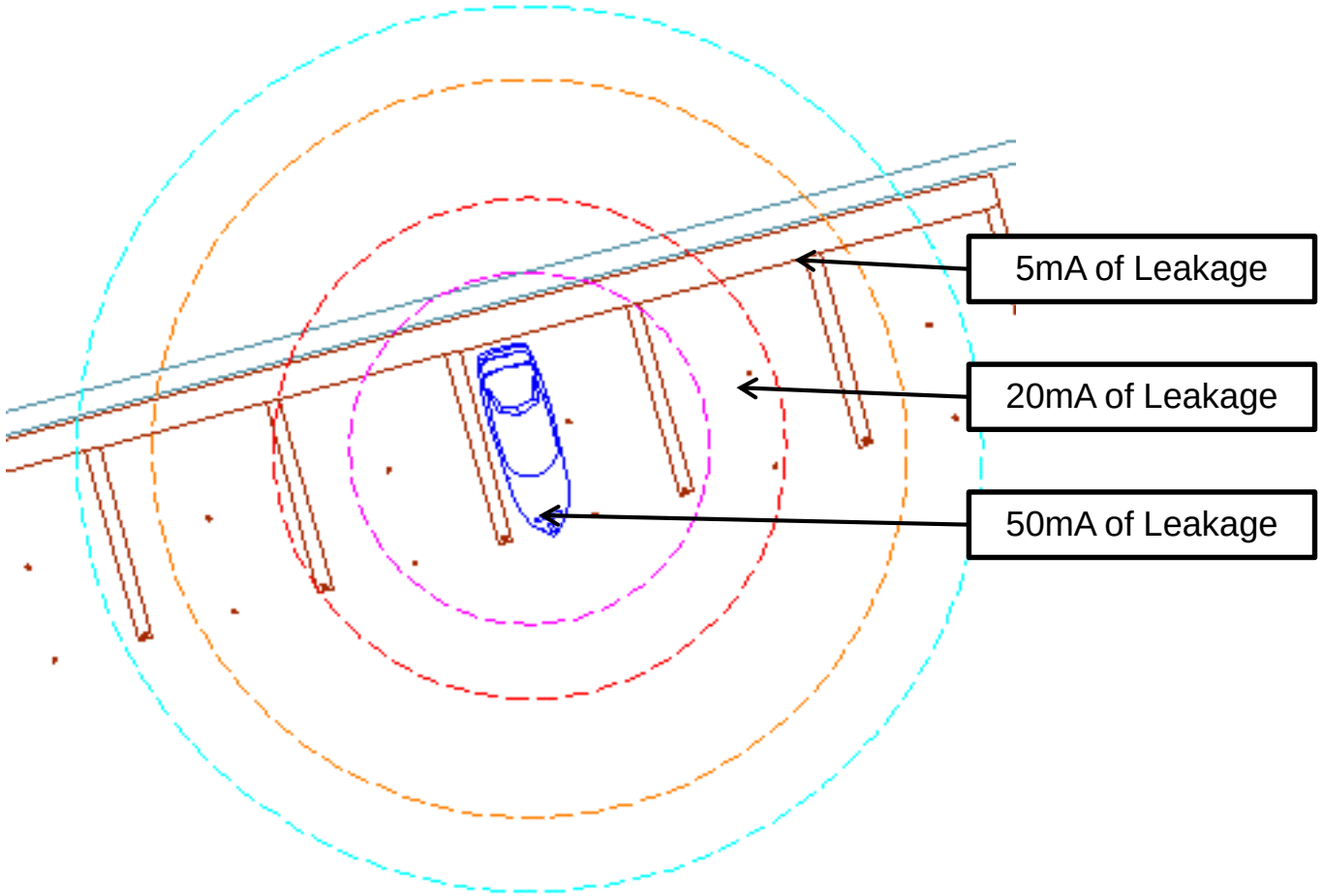
# In-Water Hazards and Electric Shock Drowning:

- Electric Shock Drowning occurs when faulty wiring on a boat or in a marina causes underwater metals to become energized.
- Examples of underwater metals that could become energized
  - Boat props, dock frames, ladders, etc…
- This creates an electrical field in the water
- The magnitude and intensity of the electrical field is determined by how much current is being leaked into the water.

# Electric Shock Drowning:

- A swimmer enters the electrical field and completes the electrical circuit to ground.
- The swimmer becomes a target for the electrical current leakage because the human body is a better conductor of electricity than fresh water
- ***Fresh water is close to 70 times more resistive than salt water***. This makes electric current leakage in fresh water marinas a major concern.
- Depending on the amount of current in the water and a swimmers location relative to the electrical field, a person may experience effects ranging from a slight tingle, to complete loss of muscle control, to ventricular fibrillation.

# Underwater Electrical Field:



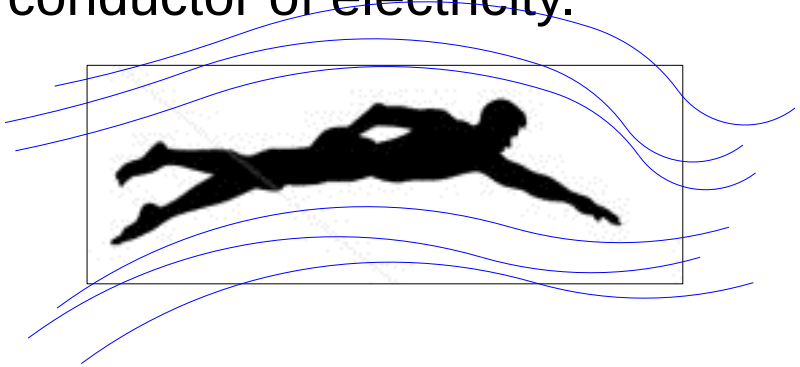
# Electric Shock Medical Facts (Freshwater Environment):

| Current | Effects |
|---|---|
| 1 mA to 8 mA | Tingle, sensation of shock, not painful, muscle control not lost |
| 8 mA to 15 mA | Painful shock, muscle control not lost |
| 15 mA to 20 mA | Pain shock, muscle control is lost, paralysis / inability to swim occurs, labored breathing |
| 50 mA to 100 mA | Ventricular Fibrillation possible |
| 100 mA to 200 mA | Ventricular Fibrillation occurs |
| 200+ mA | Burn marks may appear, chest muscles clamp heart |

- Current
- not Voltage
- Light Bulb
    - 100 mA

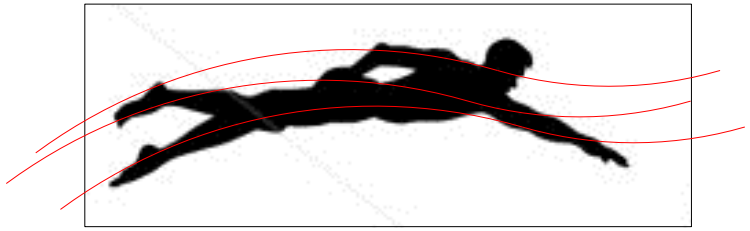
# Path of Least Resistance:

- Electricity will always look to return to its power source through the path of least resistance.  Salt is a great conductor of electricity.



Salt Water Environment

Electricity is “transported” around the swimmer by the salt



Fresh Water Environment

The swimmer is the path of least resistance due to the salt content of the human body

# Signs of Electric Shock Drowning or Potential ESD:

- Often leaves no bodily clues to suggest anything but “simple drowning” due to alcohol intoxication or heart attack.
  - No signs of burning due to the victim being submerged in water – no signs of electrocution.
  - Often classified as electrical shock due to “evidence of great distress, multiple deaths…”
- Signs of a Potential Problem:
  - Tingling sensation reported by anyone swimming in the marina.
  - Excessive damage to metal boat parts in the water – props, etc…

# Electric Shock Hazards on the Boat:

- Often occurs when boaters are using corded power tools while on the boat.
- Essentially a boater touches a live piece of metal that has been energized due to a ground fault.
- Faulty or damaged wiring, often caused by “weekend electricians” creates a high potential for electric shock conditions.  All work on boats should be performed by certified electricians.
- Water build-up created by faulty bilge pumps and even high-humidity condensation can create wet and dangerous conditions if equipment on the boat is not properly grounded.

# Electric Shock Hazards on the Boat:


- The use of adapters, which turn shore power receptacles into straight-blade receptacles, is common in every marina.
- Using these eliminates all ground-fault protection required for straight-blade equipment.
- We recommend a 20A GFCI receptacles in every power pedestal.

# Maintenance of Electrical Wiring and Equipment:

- NFPA 303.5.20:
- “An **inspection** of all electrical wiring, **ground connections**, conduit, hangers, supports, connections, outlets, appliances, devices, and portable cables installed or used in a marina, boatyard, boat basin, or similar establishment shall be made at regular intervals to ensure a complete inspection **at least annually**.”
- **“The inspection required in 5.20.1 shall include a test of the ground integrity and polarity.”**
- “The use of grounding-type portable electrical equipment that is not properly and adequately grounded” shall be identified and removed from use or repaired.

# National Electrical Code 555.3 – Ground-Fault Protection:

- 2014 National Electrical Code
- "The main **overcurrent protective device** that feeds the marina shall have ground fault protection not exceeding ***100mA***. Ground-fault protection of each individual circuit breaker or feeder circuit shall be permitted as a suitable alternative."
- **Overcurrent protection device** – the device that disrupts power to a circuit or piece of electrical equipment in the event of an electrical problem. Examples include circuit breakers and fuses. Circuit breakers are the most common form of ground-fault protection devices.

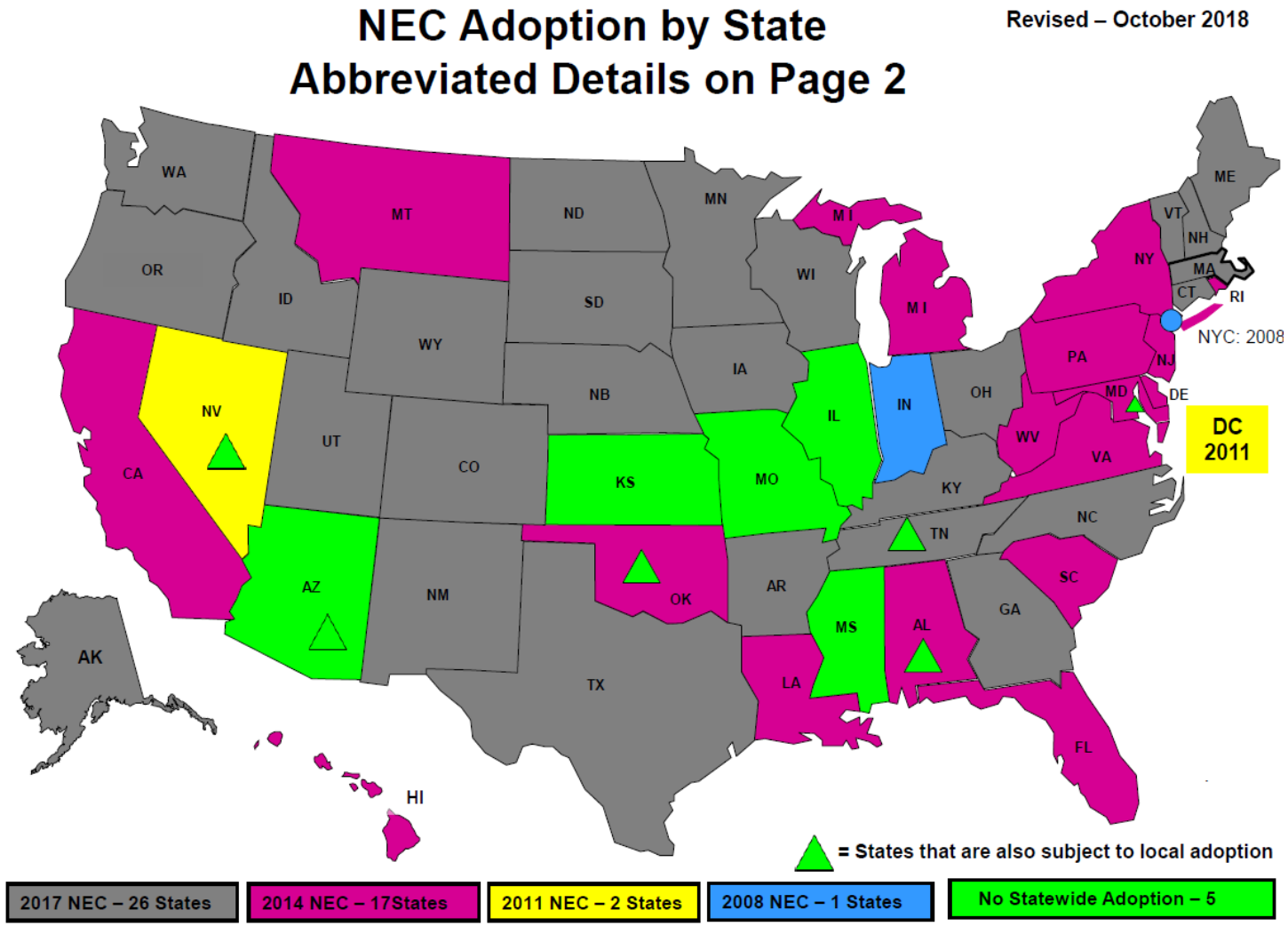
# National Electrical Code 555.3 – Ground-Fault Protection:

- ***NEW 2017 National Electrical Code***
- The main overcurrent protective device that feeds the marina shall have ground fault protection not exceeding ***30mA***. Ground-fault protection of each individual circuit breaker or feeder circuit shall be permitted as a suitable alternative.”

# NEC 553
# Floating Buildings:

- The same code applies for floating buildings such as ship stores, bathrooms, and restaurants.

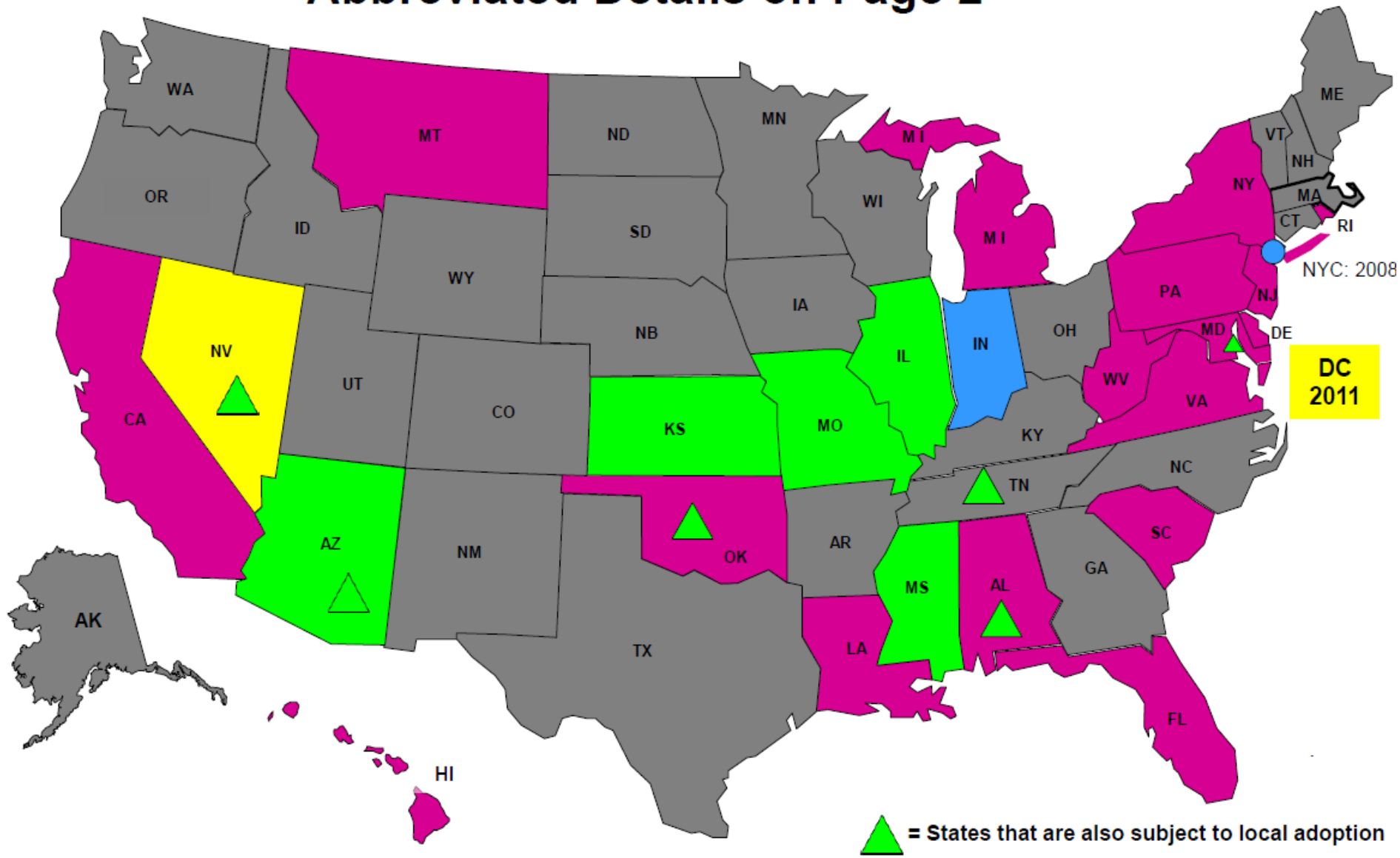
# Know Your Code:




States adopt versions of the National Electrical Code at different times. Make sure your constructions plans adhere to the codes your state (or municipality) have adopted.

# NEC Adoption by State
## Abbreviated Details on Page 2

Revised – October 2018




Note: Earlier editions of the NEC may be enforced in states with no statewide adoption or that are subject to local adoption.

| State | Adoption | Implementation | |
|---|---|---|---|
| Alabama | 7/1/16 | See Adoption Report | |
| Alaska | 5/9/18 | 5/9/18 | |
| Arizona | Local Adoption | See Adoption Report | |
| Arkansas | 9/19/17 | 1/1/18 | |
| California | January 2016 | 1/1/17 | |
| Colorado | 3/1/17 | 7/1/17 | |
| Connecticut | 7/25/18 | 10/1/18 | |
| Delaware | 3/11/16 | 3/11/16 | |
| Florida | 6/13/17 | 12/31/17 | |
| Georgia | 11/15/17 | 1/1/18 | |
| Hawaii | 2/14/17 | 3/27/17 | |
| Idaho | 7/1/17 | 7/1/17 | |
| Illinois | Local Adoption | See Adoption Report | |
| Indiana | August 2009 | 9/26/09 | |
| Iowa | 11/3/17 | 1/1/18 | |
| Kansas | Local Adoption | See Adoption Report | |
| Kentucky | 8/22/18 | 1/1/2019 | |
| Louisiana | 12/12/17 | 2/1/18 | |
| Maine | 11/6/17 | 11/6/17 | |
| Maryland | See Adoption Report | Local | State |
| Massachusetts | 12/1/16 | 1/1/17 | |
| Michigan | 4/23/15 | 6/3/15 | |
| Minnesota | 6/1/17 | 7/1/17 | |
| Mississippi | Local Adoption | See Adoption Report | |
| Missouri | Local Adoption | See Adoption Report | |

| State | Adoption | Implementation | |
|---|---|---|---|
| Montana | 10/23/14 | 10/23/14 | |
| Nebraska | 5/1/17 | 8/1/17 | |
| Nevada | 7/1/13 | Local | Majority |
| New Hampshire | 3/1/17 | 1/1/18 | |
| New Jersey | 9/21/15 | 3/21/16 | |
| New Mexico | 11/15/17 | 2/1/18 | |
| New York | 3/9/16 | 4/6/16 | Ex: NYC |
| North Carolina | 12/12/17 | 6/12/18 | |
| North Dakota | 3/14/17 | 7/1/17 | |
| Ohio | 5/26/17 | 11/1/17 | |
| Oklahoma | 6/8/15 | 11/1/15 | |
| Oregon | 10/1/17 | 10/1/17 | |
| Pennsylvania | 5/1/18 | 10/1/18 | |
| Rhode Island | 7/2/14 | 8/1/14 | |
| South Carolina | 8/26/15 | 7/1/16 | |
| South Dakota | 5/4/17 | 7/1/17 | |
| Tennessee | 3/19/18 | 10/1/18 | |
| Texas | 9/15/17 | 9/15/17 | |
| Utah | 5/8/17 | 7/1/18 | |
| Vermont | 10/1/17 | 10/1/17 | |
| Virginia | 4/30/18 | 9/4/18 | |
| Washington | 7/1/17 | 7/1/17 | |
| West Virginia | 3/11/16 | 8/1/16 | |
| Wisconsin | 4/1/18 | 8/1/2018 | |
| Wyoming | 2/1/17 | 7/1/17 | |

# Important Note on NEC Adoption / Implementation:

- Compliance with the most up to date NEC and NFPA codes are only required for new construction or modification that changes the fit, form, or function of a marina.
  - Basic maintenance – changing a light bulb, receptacle, or circuit breaker does not require drastic upgrades to the entire electrical system.
- Some states or municipalities are requiring immediate compliance.  Most are not.  Check with the local AHJ for code requirements.

# TIA to NEC 555.3 Effective April 30, 2018:

- TIA (Tentative Interim Amendment)

"555.3 **Ground-Fault Protection**. For other than floating buildings covered by 553.4, ground-fault protection for docking facilities shall be provided in accordance with (A) and (B).

**(A) Feeder and Branch Circuit Conductors.** Feeder and branch circuit conductors that are installed on docking facilities shall be provided with ground-fault protection set to open at currents exceeding 30 mA. Coordination with downstream ground-fault protection shall be permitted at the feeder overcurrent protective device.

# TIA to NEC 555.3 Effective April 30, 2018:

- TIA (Tentative Interim Amendment) – cont.

**(B) Receptacles Providing Shore Power.** In lieu of the requirement of 210.8, receptacles installed in accordance with 555.19(A) shall be permitted to have ground-fault protection set to open at currents not exceeding 30 mA.”

# NEC 555.24
# Required Signage:

"555.24 Signage. Permanent safety signs shall be installed to give notice of electrical shock hazard risks to persons using or swimming near a boat docks or marina and shall comply with all of the following:

(2) The signs shall be clearly visible from all approaches to a marina or boatyard facility.

(3) The signs shall state 'WARNING – POTENTIAL SHOCK HAZARD – ELECTRICAL CURRENTS MAY BE PRESENT IN WATER.'"

# NEC 555.24
# Required Signage:

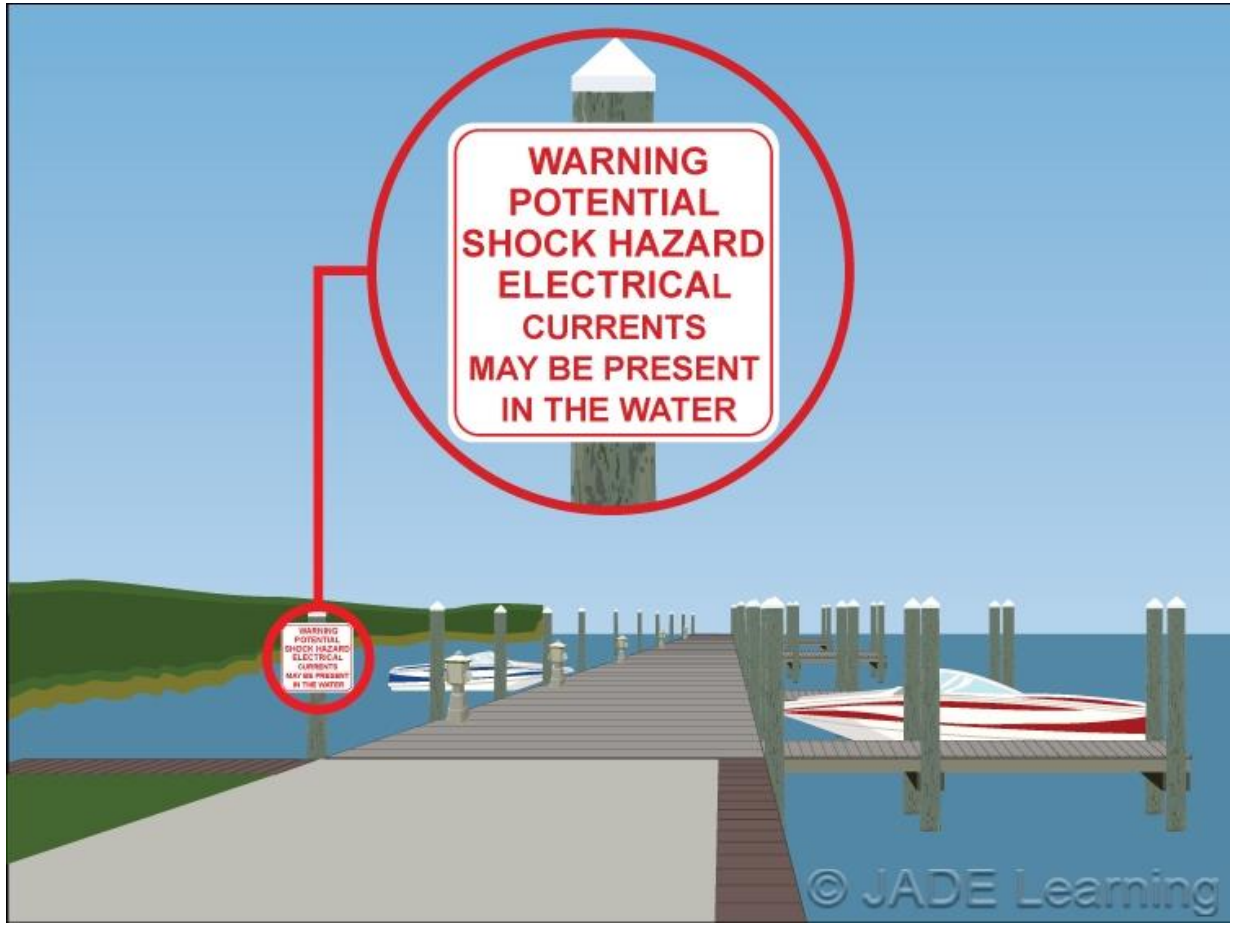



Photo from JADELearning (www.jadelearning.com)

# General Electrical Safety Rules:



- Do not allow swimming in your marina.
- Post signs prohibiting swimming in the marina.

# General Electrical Safety Rules:

- Set aside a window of time where people can work on boats in the water when the electricity will be turned off.
- Post dates and / or times.
- Inform customers and workers no power will be available on the docks.
  - Customers need to be aware their power will be turned off during these “working windows.”
  - Contractors will need to be aware that no electricity will be available for power tools.
- All electrical work on the marina and vessels should be performed by qualified electricians.
  - Document all work

# General Electrical Safety Rules:

- Electrical work should only be completed by certified electricians.
  - Marina work should comply with all NEC and NFPA codes.
  - Routine maintenance and inspections should be performed at least annually per NFPA 5.20 “Maintenance of Electrical Wiring and Equipment.”
    - Document inspections and maintenance for liability purposes.
  - Boat owners should have all electrical work completed by ABYC certified electricians.
    - Boat owners should also document inspections and maintenance for liability purposes.

# Equipment and Protection to Comply with 555.3:

- **<u>Examination Points</u>**
  - Protection Equipment
  - Protection Locations
    - Code Compliance?
    - Protection of Human Life?
    - Effects of Outage
    - Costs
    - “Retrofitability”
    - Other Pros / Cons

# Available Equipment:



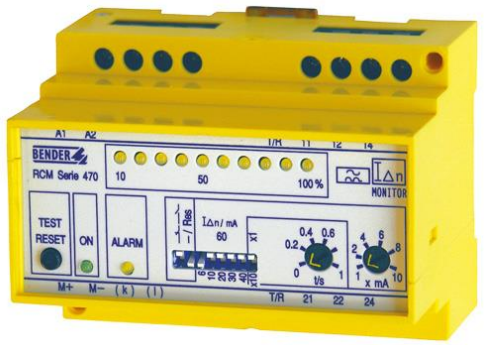
# Ground-Fault Monitoring:

- Install a ground fault monitoring system in the marina.
- Usually consist of a control module and current transformer(s).
- Wires are run through the current transformer(s) and the electrical cycle is measured.
- Multiple models
  - Single Source Monitoring
    - One monitor for one major power source
  - Multiple Source Monitoring
    - One monitor for multiple power sources

# Single-Source Ground-Fault Monitors:


| Design Characteristic | Effect of Monitoring Method |
|---|---|
| Cost | Low – Single CT units are relatively inexpensive and can be added to existing equipment. |
| Leakage Grouping Effect | High – more devices monitored by a single CT produce a high likelihood of leakage grouping. |
| Ease of Detecting the Cause or Causes of Leakage Sources | Difficult – pinpointing the device or devices producing the leakage can be problematic due to the number of devices on one monitor |

# Multi-Source Ground-Fault Monitors:




| Design Characteristic | Effect of Monitoring Method |
|---|---|
| Cost | High – Multiple CT units can be expensive due to the number of CTs required for monitoring. |
| Leakage Grouping Effect | Low - each circuit is monitored by a single CT. Fewer vessels monitored on one CT limits the grouping effect. |
| Ease of Detecting the Cause or Causes of Leakage Sources | Easy – if an alarm is triggered, the piece of equipment it is monitoring is experiencing a problem. |

# Ground-Fault Circuit Breakers:


- Installing ground fault circuit breakers in all pedestals can be expensive and lead to "**customer renovations**."
- **Customer renovations** – customers frustrated by circuit breakers that constantly trip bypass protection devices.
  - It is important to educate boat owners of the potential hazards associated with work performed by untrained professionals.
- **Nuisance tripping** – common phrase used by customers to deflect blame for faulty boat wiring and / or repairs.
  - If a circuit breaker is in good working condition and trips, there is a problem present.

# Ground-Fault Circuit Breakers:

- Different Types of Ground Fault Circuit Breakers
  - 5mA or 6mA – People Protection
  - 30mA – Equipment Protection
- REMINDER: Most Currently Adopted NEC Codes require 30mA protection within the electrical system for all new installations.
- REMINDER: 15mA can cause serious injury

| Current | Effects |
|---|---|
| 15 mA to 20 mA | Pain shock, muscle control is lost, paralysis / inability to swim occurs, labored breathing |

# Ground-Fault Circuit Breaker Manufacturer's Warning:

**Table 7.7: QO-GFI Circuit Breakers**

| Ampere Rating◆ (A) | Qwik-Gard Circuit Breakers With Ground Fault Circuit Interrupter | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1P 120 Vac | | | | 2P Common Trip 120/240 Vac | | 3P Common Trip 208Y/120 Vac | |
| | 10 k AIR | | 22 k AIR | | 10 k AIR | | 10 k AIR | |
| | 1 Space Required | | 1 Space Required | | 2 Spaces Required | | 3 Spaces Required | |
| | Cat. No. | $ Price | Cat. No. | $ Price | Cat. No. | $ Price | Cat. No. | $ Price |
| 15 | QO115GFI | 233. | QO115VHGFI | 482. | QO215GFI | 413. | QO315GFI | 791. |
| 20 | QO120GFI | 233. | QO120VHGFI | 482. | QO220GFI | 413. | QO320GFI | 791. |
| 25 | QO125GFI | 233. | QO125VHGFI | 482. | QO225GFI | 413. | — | — |
| 30 | QO130GFI | 233. | QO130VHGFI | 482. | QO230GFI | 413. | QO330GFI | 791. |
| 40 | — | — | — | — | QO240GFI | 413. | QO340GFI | 791. |
| 50 | — | — | — | — | QO250GFI | 413. | QO350GFI | 791. |
| 60 | — | — | — | — | QO260GFI★ | 413. | — | — |

**QO-EPD/EPE**

QO-EPD/EPE circuit breakers provide overload and short circuit protection combined with Class B ground fault protection. They are designed to provide ground fault protection of equipment at a 30 milliampere level (EPD) or 100 milliamp level (EPE). They are not designed to protect people from electrical shock.

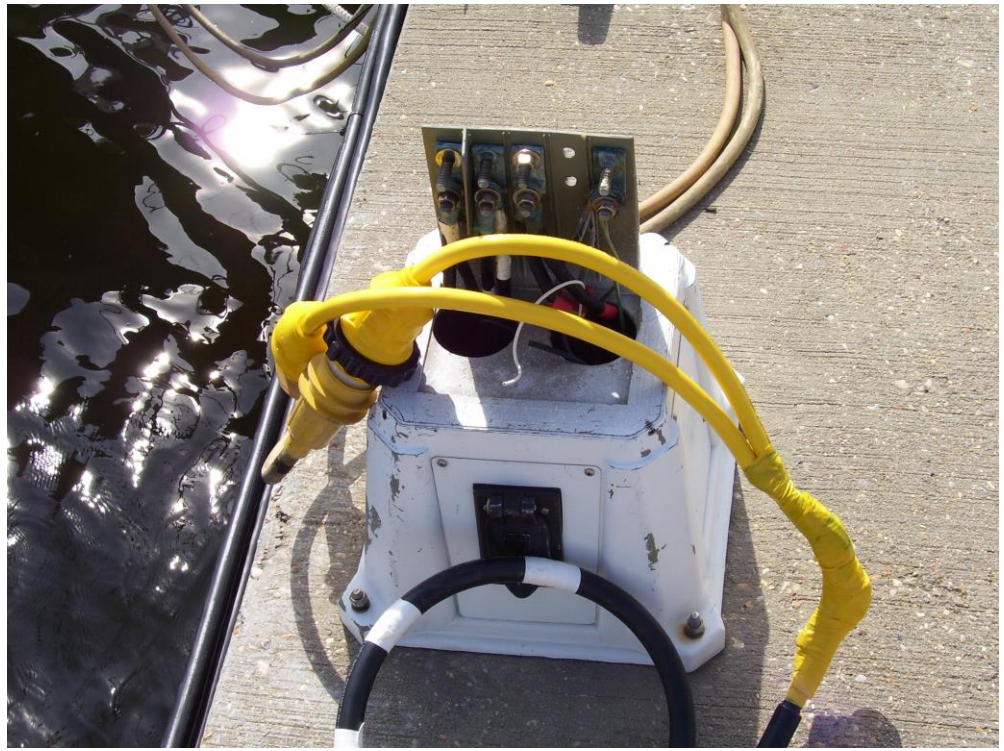
Personnel Protection Protects Humans From Electrical Shock Hazards.

Equipment Protection Protects Equipment From Harmful Leakage Current.

**PRODUCT IDENTIFICATION TABLE**

| TEST BUTTON COLOR | CORRESPONDING GROUND FAULT CALIBRATION | TYPE OF PROTECTION |
|---|---|---|
| WHITE | 5mA | PERSONNEL |
| RED | 10mA | EQUIPMENT |
| AMBER | 30mA | EQUIPMENT |

# “Customer Renovations”

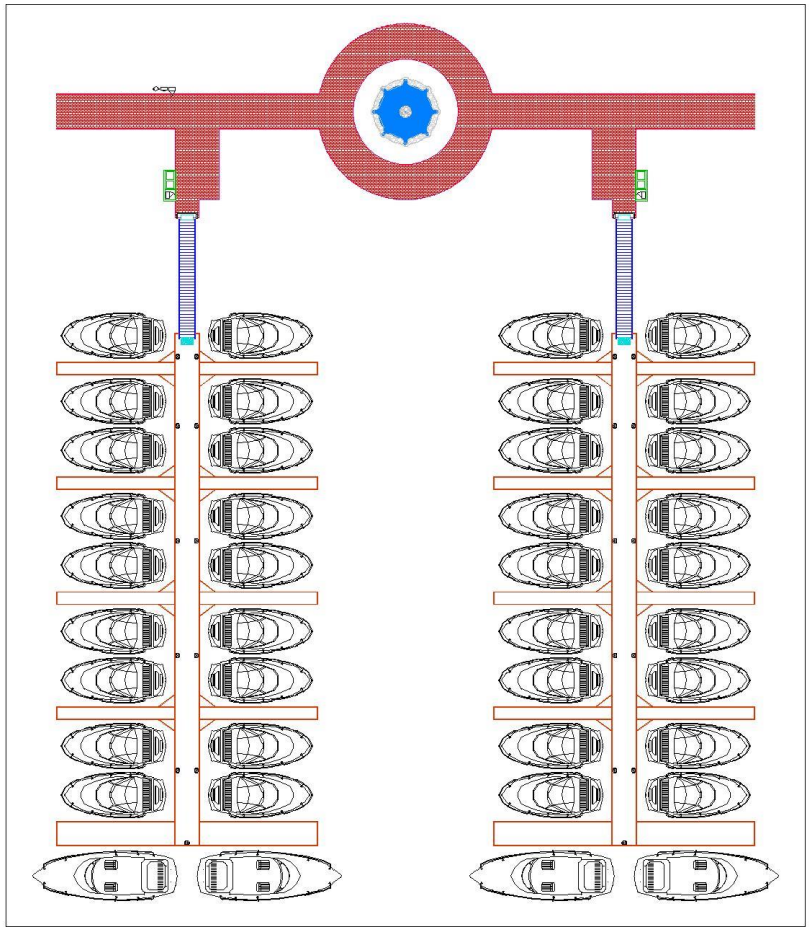


# Meter-Based Monitors:


| Design Characteristic | Effect of Monitoring Method |
|---|---|
| Cost | Moderate to High – depending on the number of pedestals being monitored. |
| Leakage Grouping Effect | Non-existent – each boat is monitored by a single CT. One vessel monitored by one monitor eliminates grouping effect. |
| Ease of Detecting the Cause or Causes of Leakage Sources | Easy – if an alarm is triggered, the boat being monitored is experiencing a problem. |

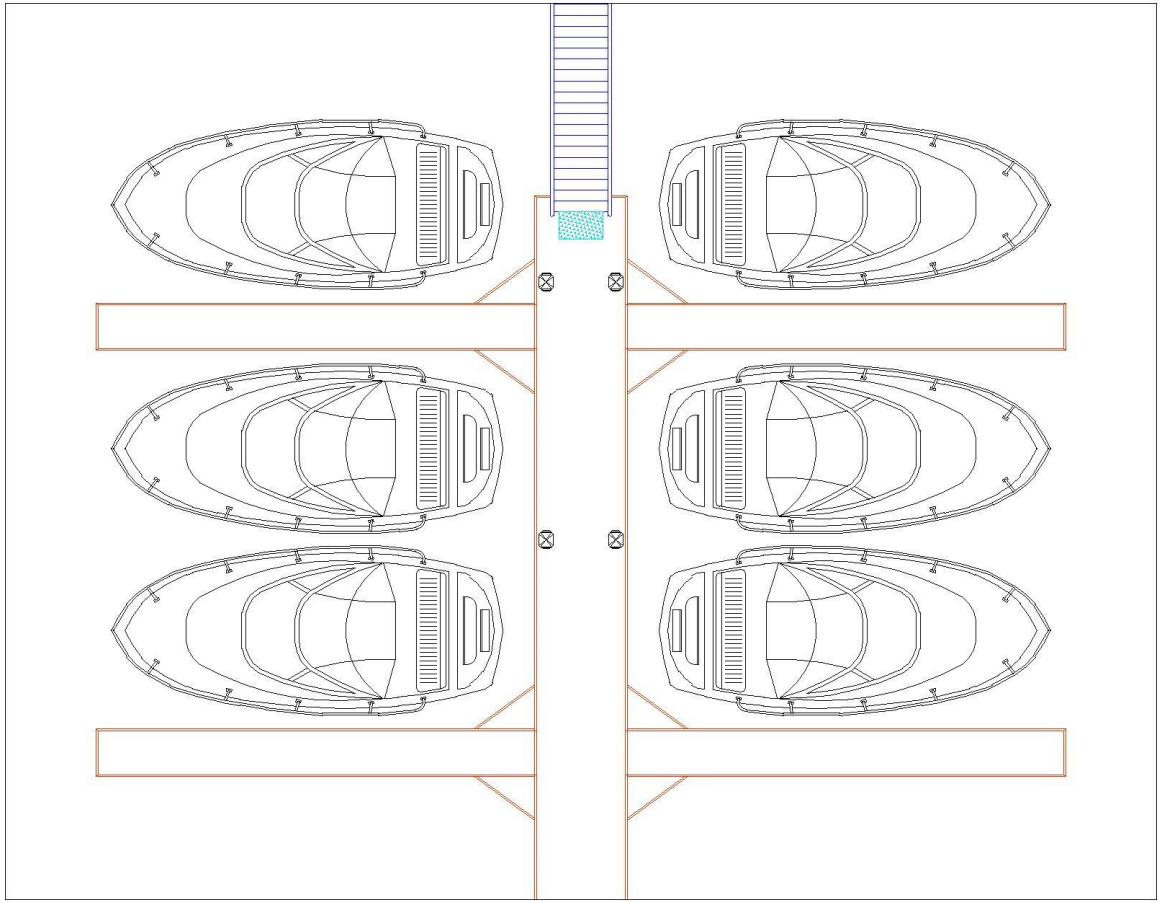
# Protection Locations – Case Study

# Case Study
# Dock Layout

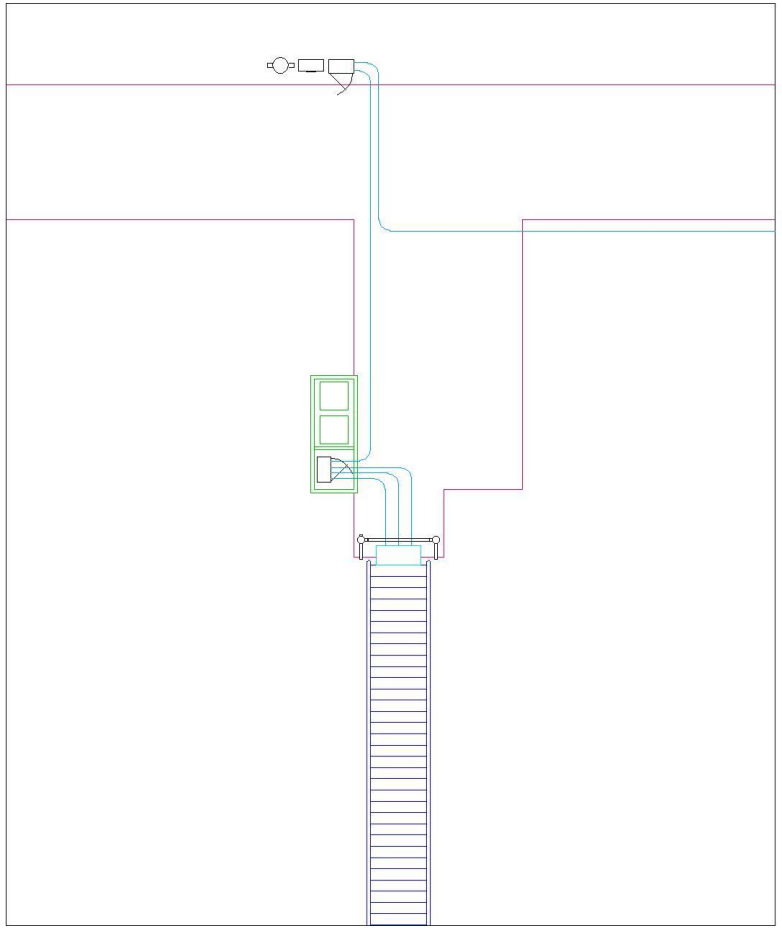


- **<u>Design Criteria</u>**
  - Two Docks
  - 20 Slips Per Dock
  - Power at Head of Each Dock
  - Power Pedestals
  - Multiple Pedestals per Circuit

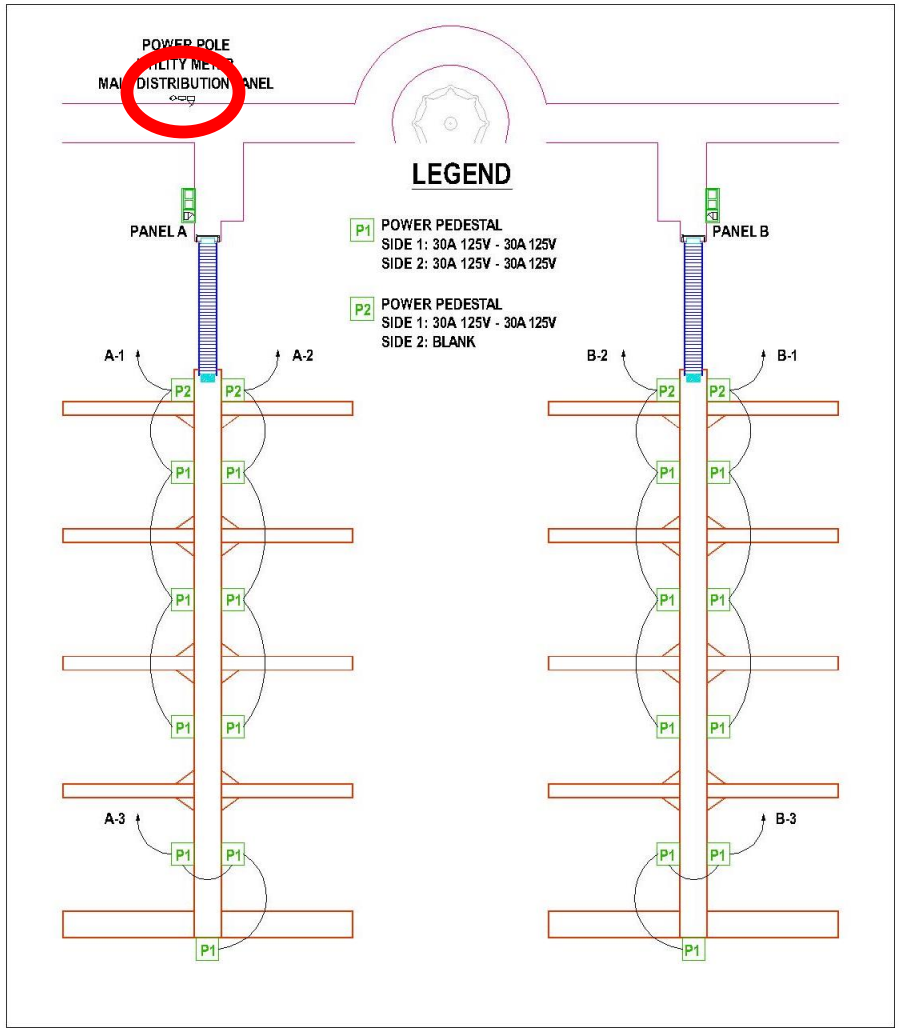
# Case Study
# Dock Layout / Distribution Gear



# Case Study
# Dock Layout / Distribution Gear



# Protection at the Utility Entrance – Main Power Source




- Circuit breaker protection (using a ground fault monitor) can be located where the incoming power enters the facility from the utility company.
- While this is a very economical solution, it may be difficult to pinpoint the exact cause or causes of the current leakage.

# Protection at the Utility Entrance – Main Power Source

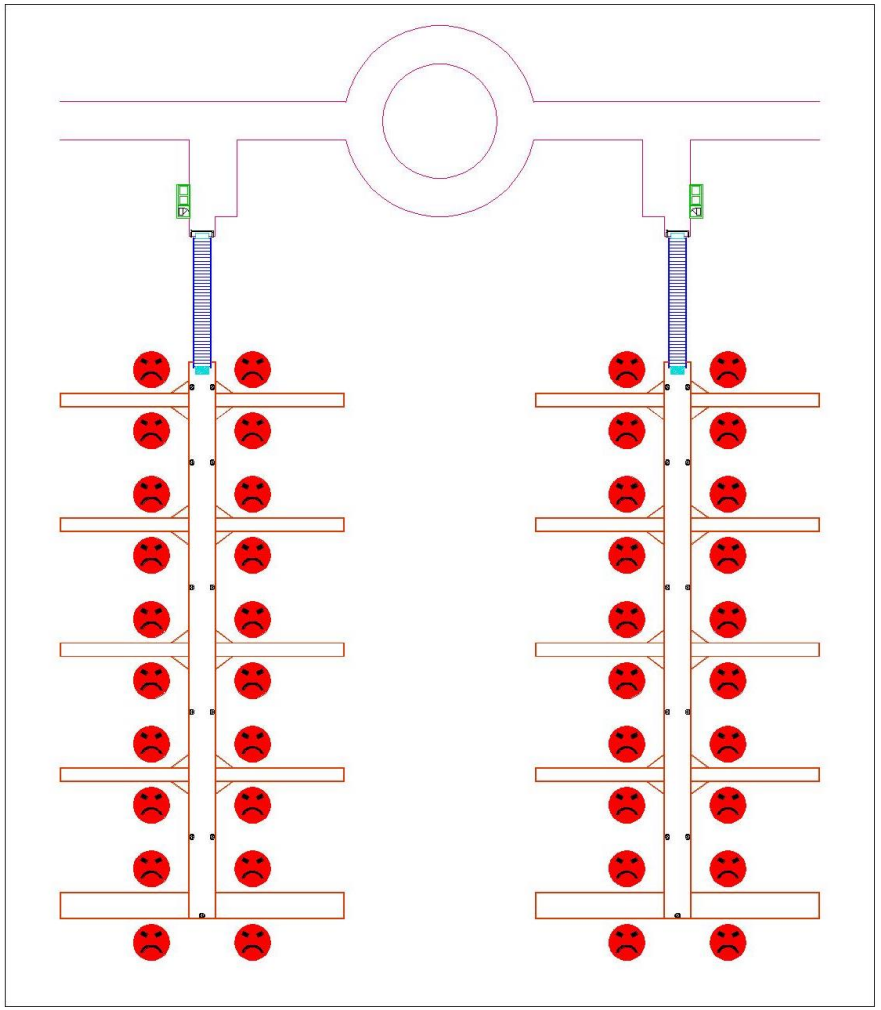
# Protection at the Utility Entrance – Main Power Source

| Location |
| --- |
| Utility Entrance or Main Power Source |

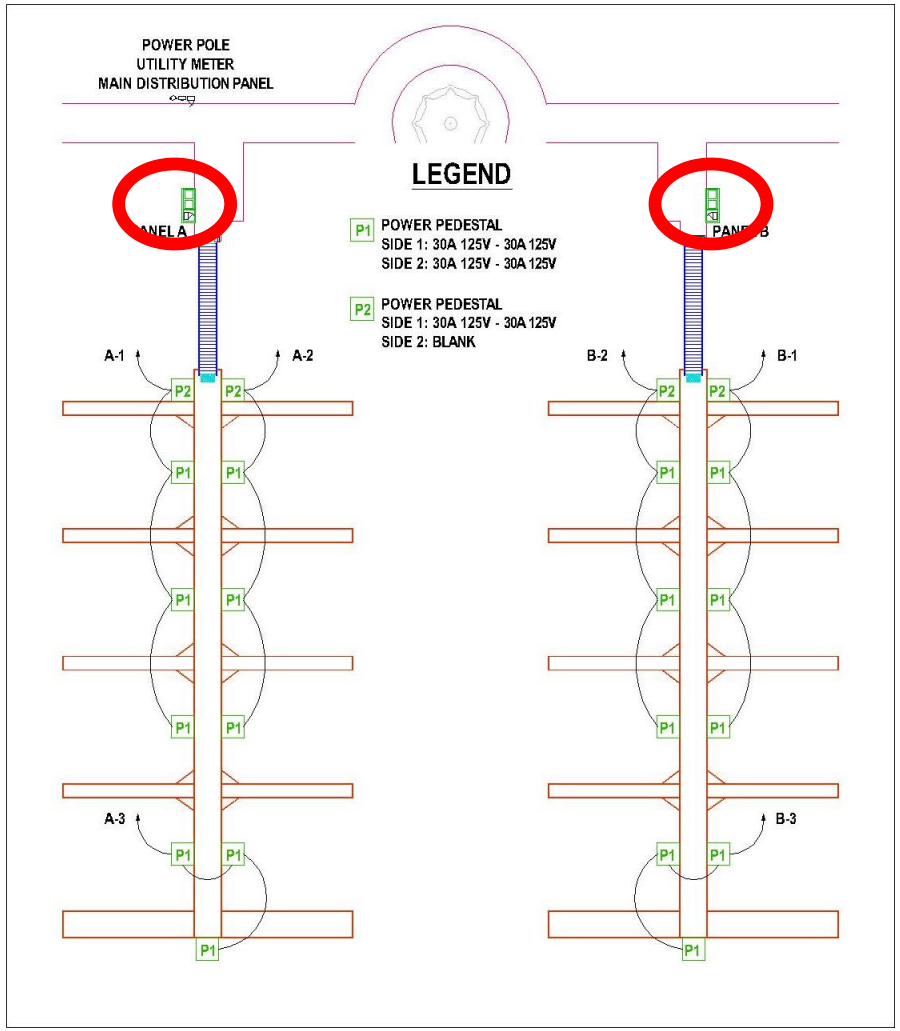
| Method |
| --- |
| Ground-Fault Monitor tied to Shunt-Trip Circuit Breaker |

| Outage % |
| --- |
| 100% (40 of 40 slips) |

| Approximate Cost |
| --- |
| $50 / slip |

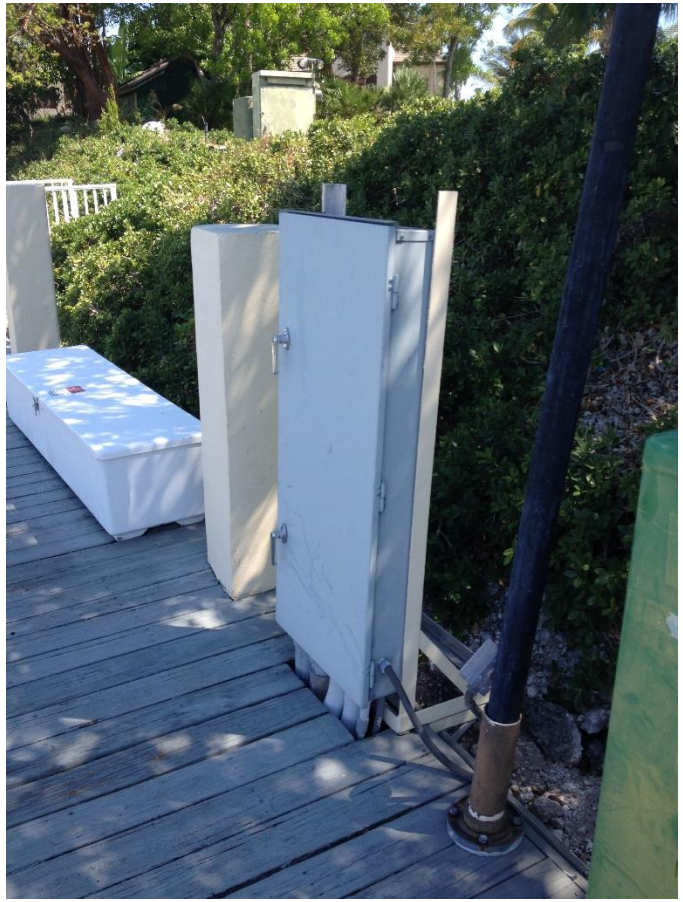


# Protection at the Main Breaker or Feeder of Each Dock




- Circuit breaker protection can be located at the head (or on the main circuit breaker) feeding each dock within a disconnect or distribution panel. Usually requires a ground fault monitor to reach an acceptable 30mA or 100mA threshold.
- Identifying the cause or causes of the leakage depends on how the system is wired.

# Protection at the Main Breaker or Feeder of Each Dock

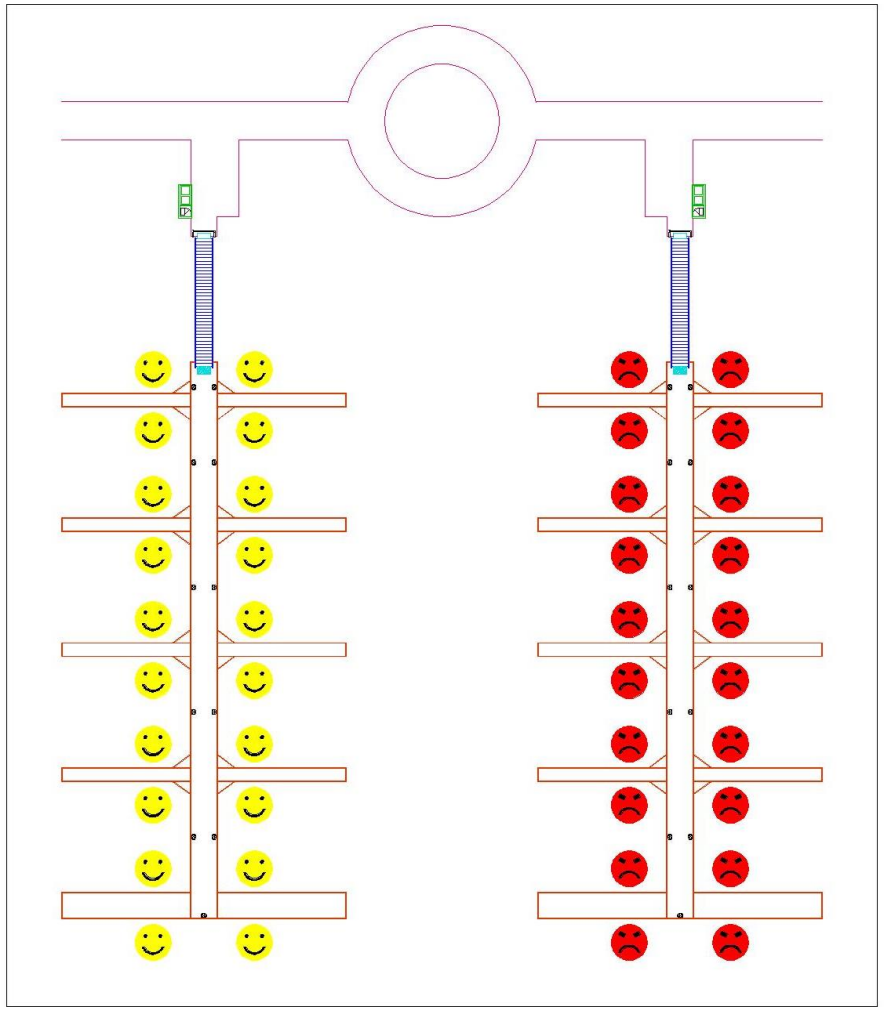
# Protection at the Main Breaker or Feeder of Each Dock

| Location |
| --- |
| Main Feeder for Each Dock in MDP |

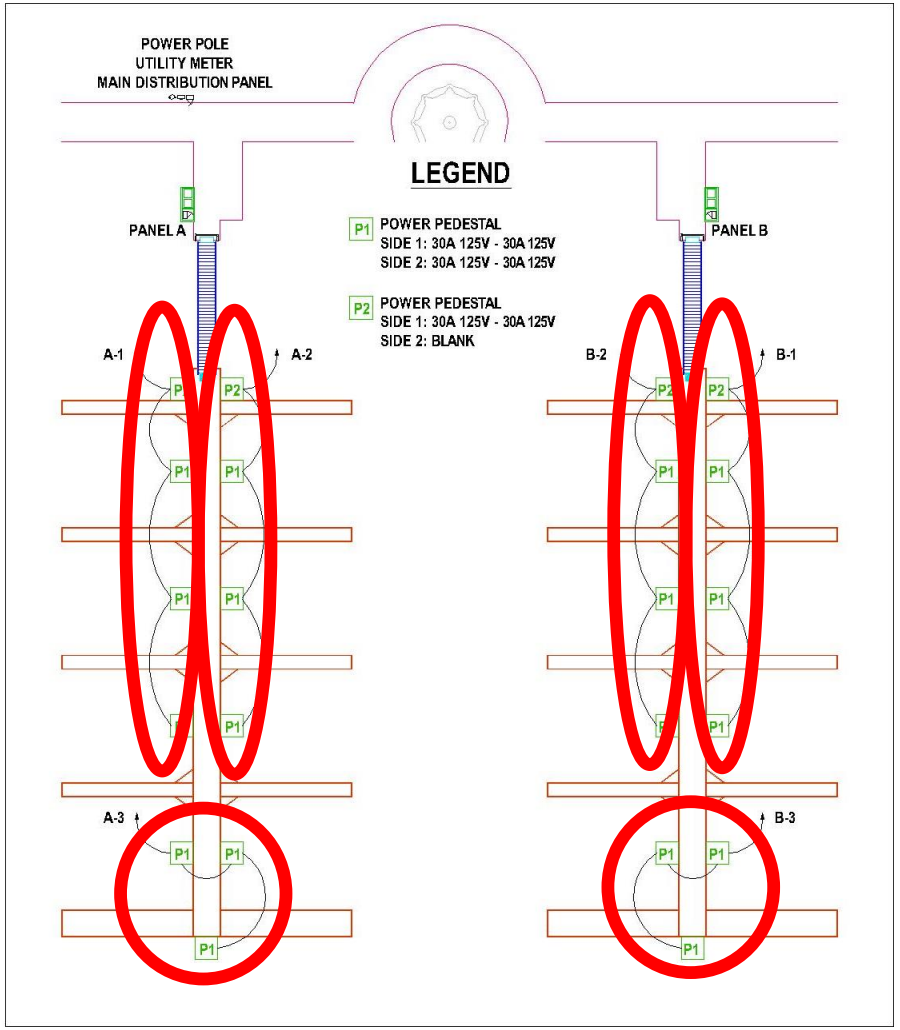
| Method |
| --- |
| Multi-CT Ground-Fault Monitor tied to Shunt-Trip Circuit Breakers |

| Outage % |
| --- |
| 50% (20 of 40 slips) |

| Approximate Cost |
| --- |
| $80 / slip |



# Protection at Each Circuit on the Dock




- Circuit breaker protection can be located on each circuit on the dock within a distribution panel or through a ground fault monitoring system with shunt trip circuit breakers.
- While this is a more costly solution, it is relatively easy to identify the cause or causes of the leakage.

# Protection at Each Circuit on the Dock

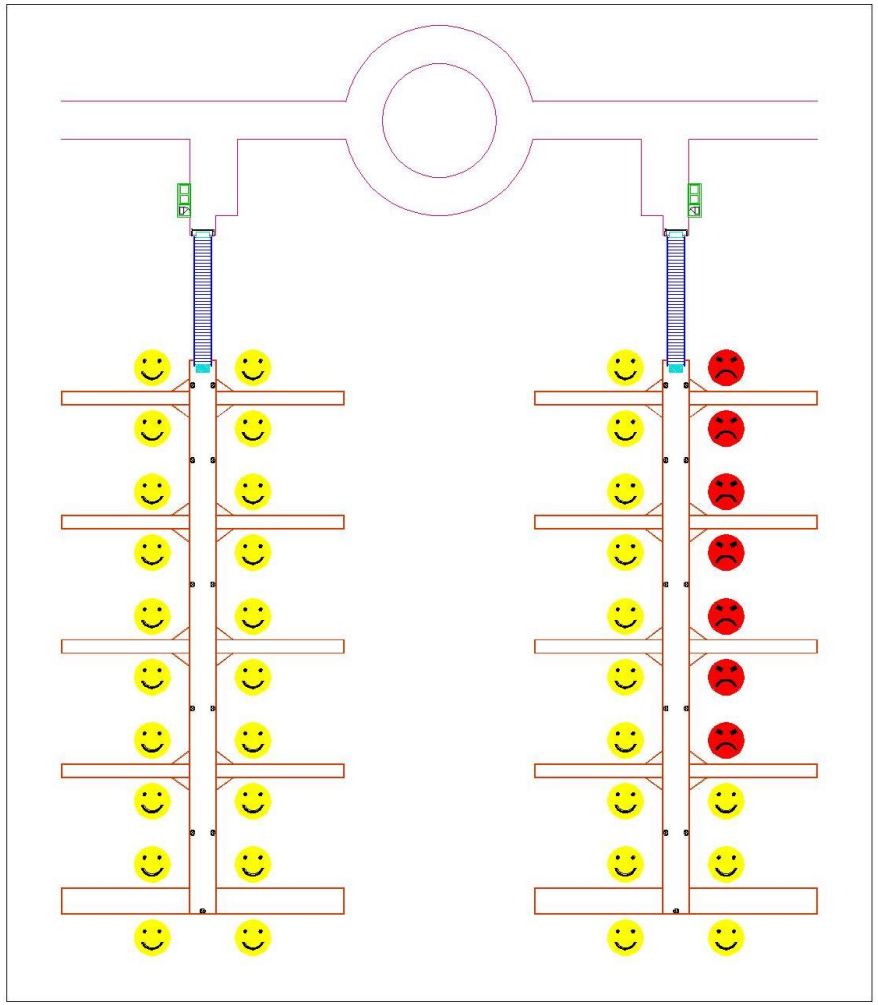
# Protection at Each Circuit on the Dock

| Location |
| --- |
| Each Circuit Breaker for Each Panel on the Dock |

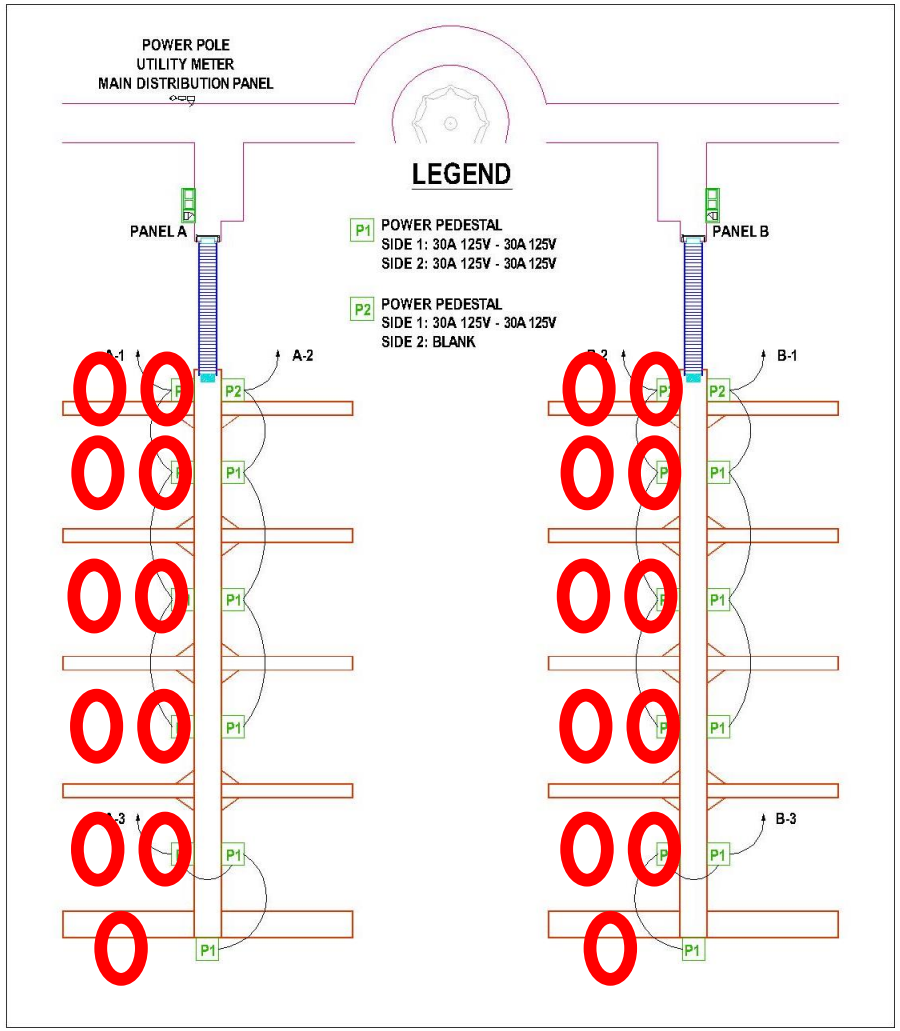
| Method |
| --- |
| Multi-CT Ground-Fault Monitor tied to Shunt-Trip Circuit Breakers |

| Outage % |
| --- |
| 15% (7 of 40 slips) |

| Approximate Cost |
| --- |
| $295 / slip |

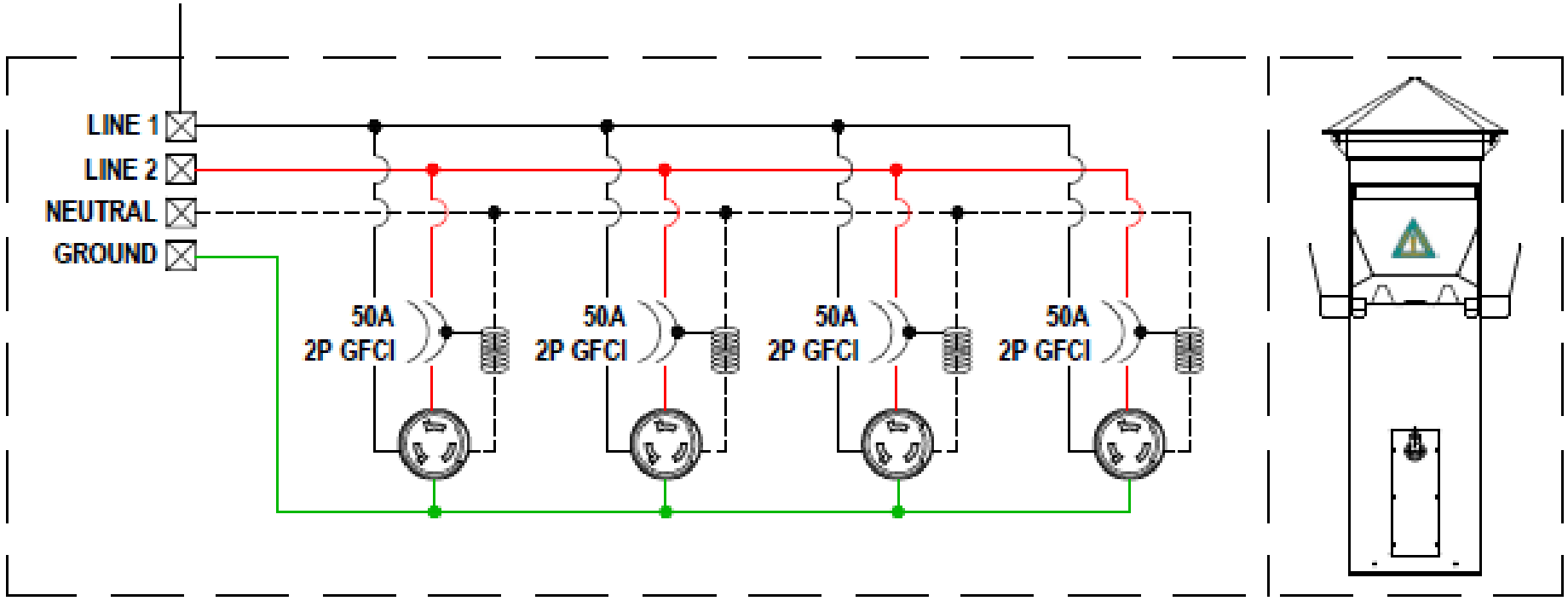


# Protection for Each Receptacle at Slip Level




- Circuit breaker protection can be located at the head (or on the main circuit breaker) feeding each dock within a disconnect or distribution panel. Usually requires a ground fault monitor to reach an acceptable threshold.
- Identifying the cause or causes of the leakage depends on how the system is wired.

# Protection for Each Receptacle at Slip Level



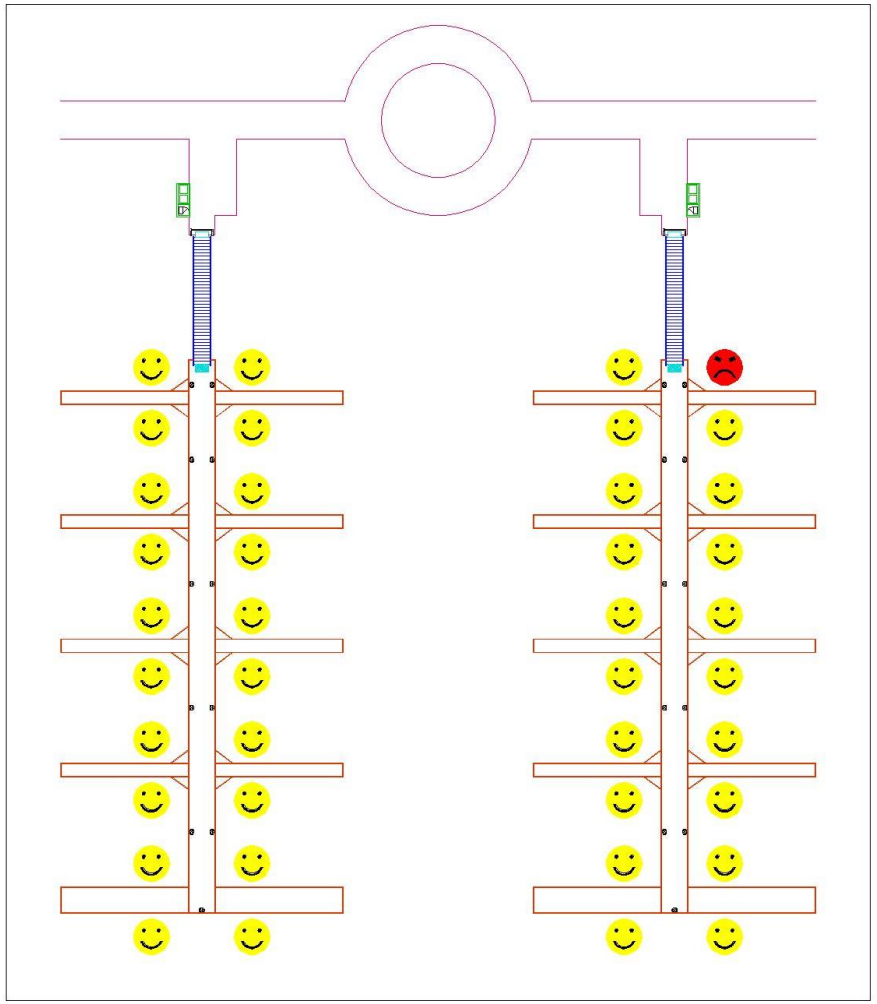
# Protection for Each Receptacle at Slip Level

| Location |
| --- |
| Each Circuit Breaker in Each Power Pedestal |

| Method |
| --- |
| Ground-Fault Circuit Breakers or Monitors w/ Shunt-Trip Breakers |

| Outage % |
| --- |
| 2.5% (1 of 40 slips) |

| Approximate Cost |
| --- |
| $325 - $520 / slip |



# Protection for Each Receptacle at Slip Level

**$325 People Protection (5 or 6mA)**

**$520 Equipment Protection (30mA)**

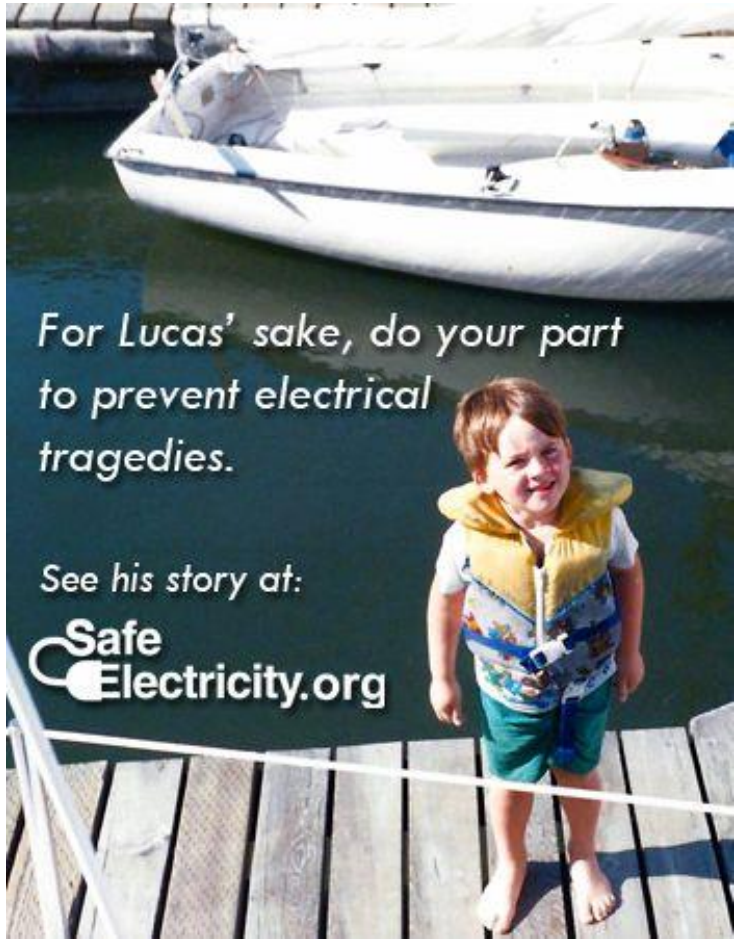
| Current | Effects |
|---|---|
| 15 mA to 20 mA | Pain shock, muscle control is lost, paralysis / inability to swim occurs, labored breathing |

# Portable Ground-Fault Check Units




- Allow marina owners and operators to check and identify problem boats / boaters prior to plugging into the marina electrical system.

# Why Is This Important?




# Signs of Potential Problems

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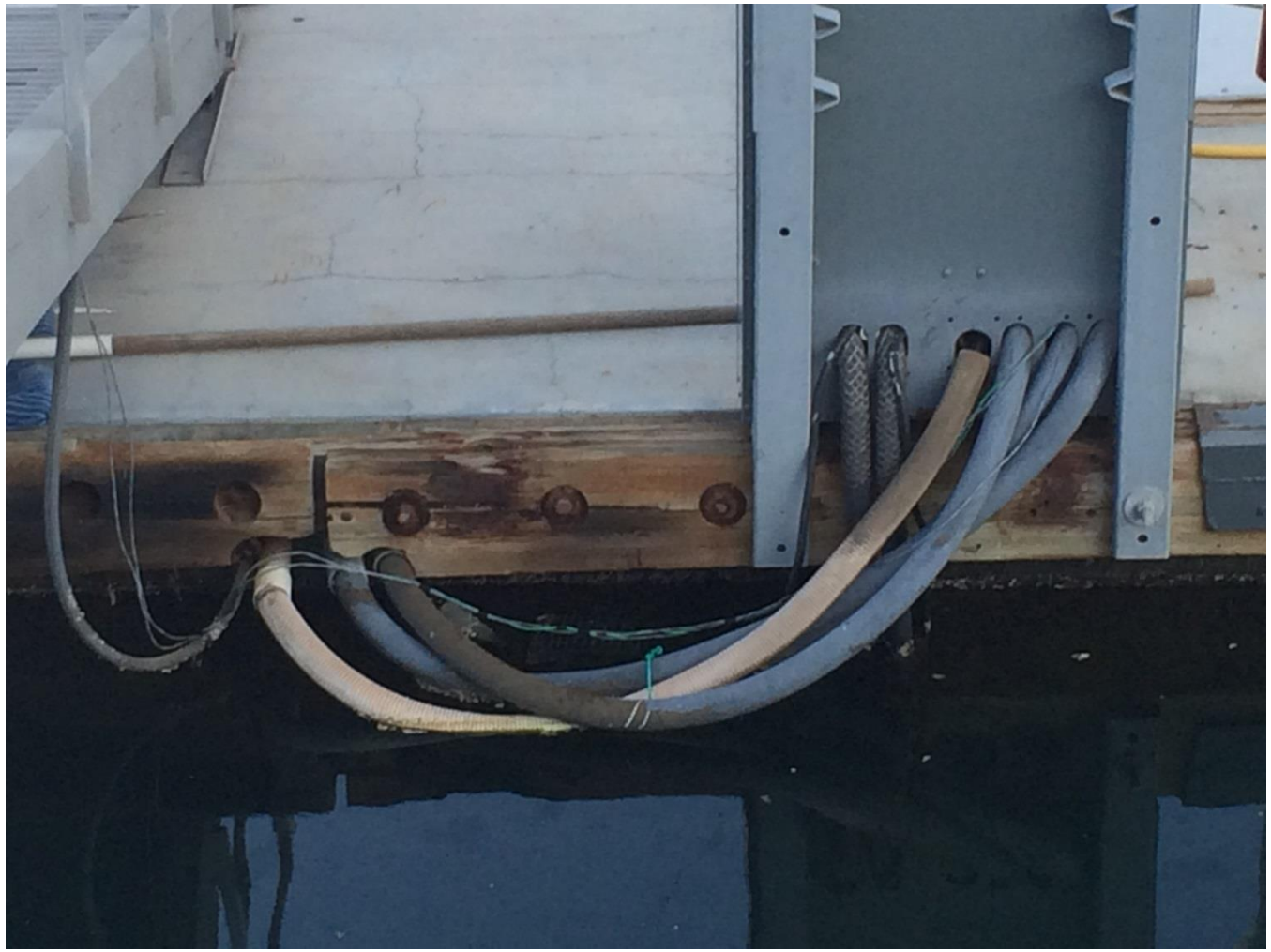

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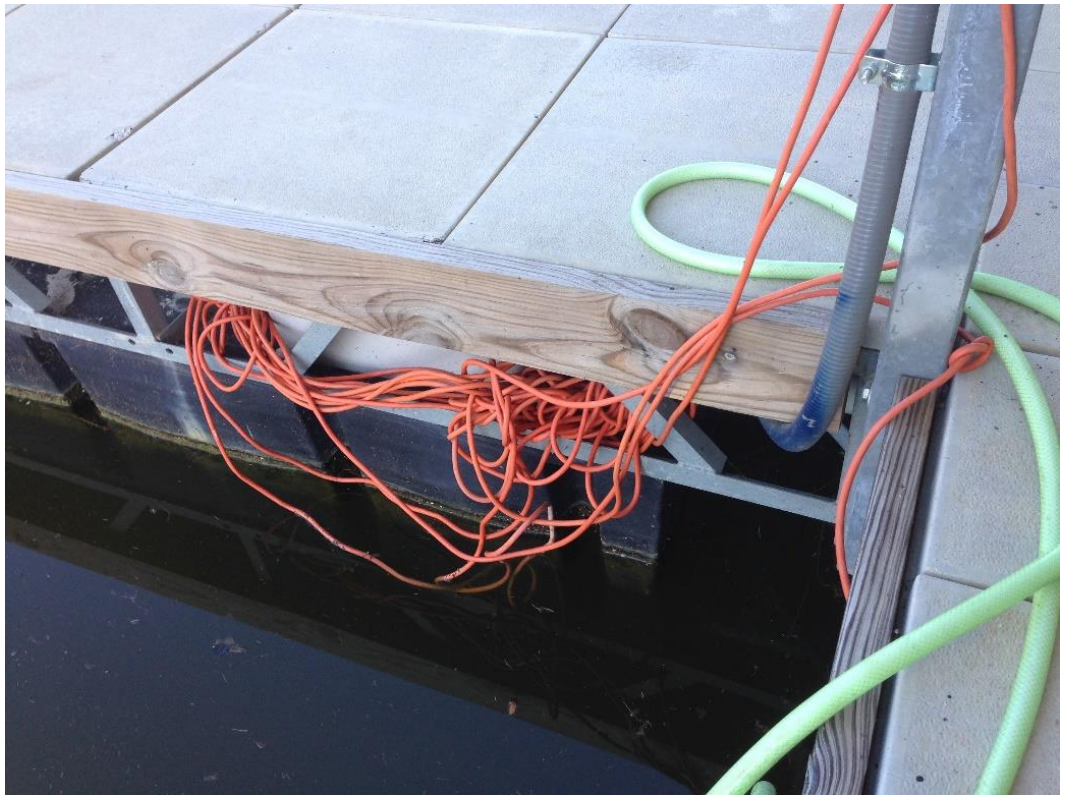

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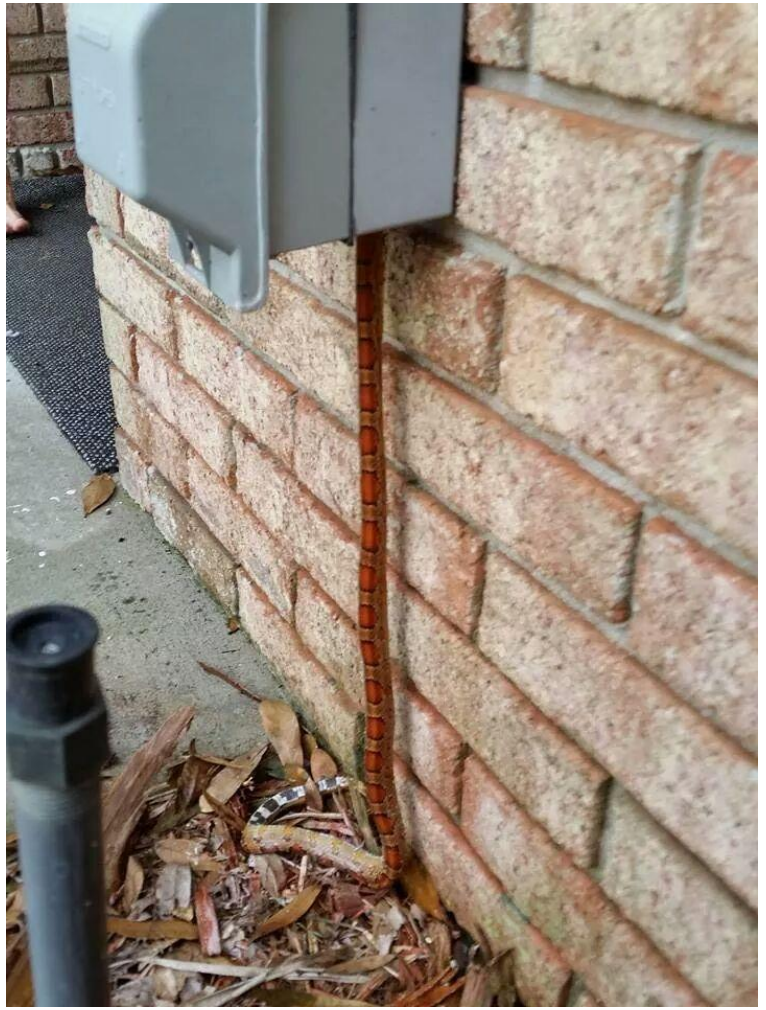


# Signs of Potential Problems

# Signs of Potential Problems

# NFPA 303.5.20 – Annual Maintenance

# NFPA 303.5.20 – Annual Maintenance

- "An **inspection** of all electrical wiring, **ground connections**, conduit, hangers, supports, connections, outlets, appliances, devices, and portable cables installed or used in a marina, boatyard, boat basin, or similar establishment shall be made at regular intervals to ensure a complete inspection **at least annually**."

# NFPA 303.5.20 – Annual Maintenance

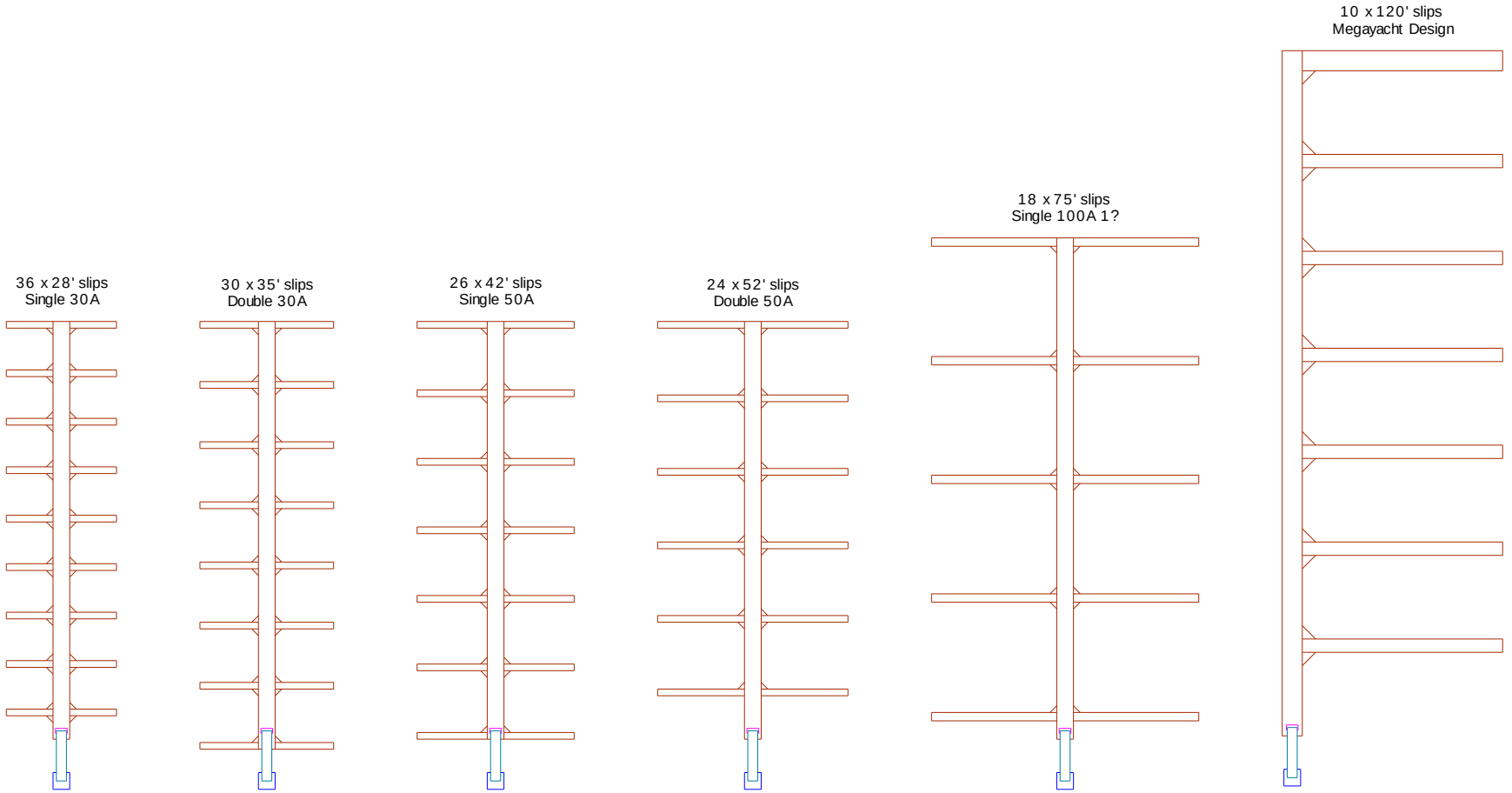
- **“The inspection required in 5.20.1 shall include a test of the ground integrity and polarity.”**
- “The use of grounding-type portable electrical equipment that is not properly and adequately grounded” shall be identified and removed from use or repaired.

# Estimated Upgrading Cost Analysis By Slip Size

# Cost Analysis Based on Receptacle Configuration

- Single 30A slip
- Double 30A slip
- Single 50A slip
- Double 50A slip
- 100A Single Phase slip
- Megayacht slip

# Cost Analysis of a Marina Electrical Design



# Design Assumptions

- Shore power is being supplied by power pedestals – polycarbonate construction
- Distribution equipment (panels, transformers, and disconnects) are housed in stainless steel enclosures
- THWN designs include PVC conduit (schedule 80)
- Power sources are located within 10’ of a 30’ access ramp
- Each slip monitored by an electronic meter (10% deduction)
- Diversity levels are set using NEC 555.12
- Wire lengths include a 7.5% adder for bending radius to pedestal connections and dock movement

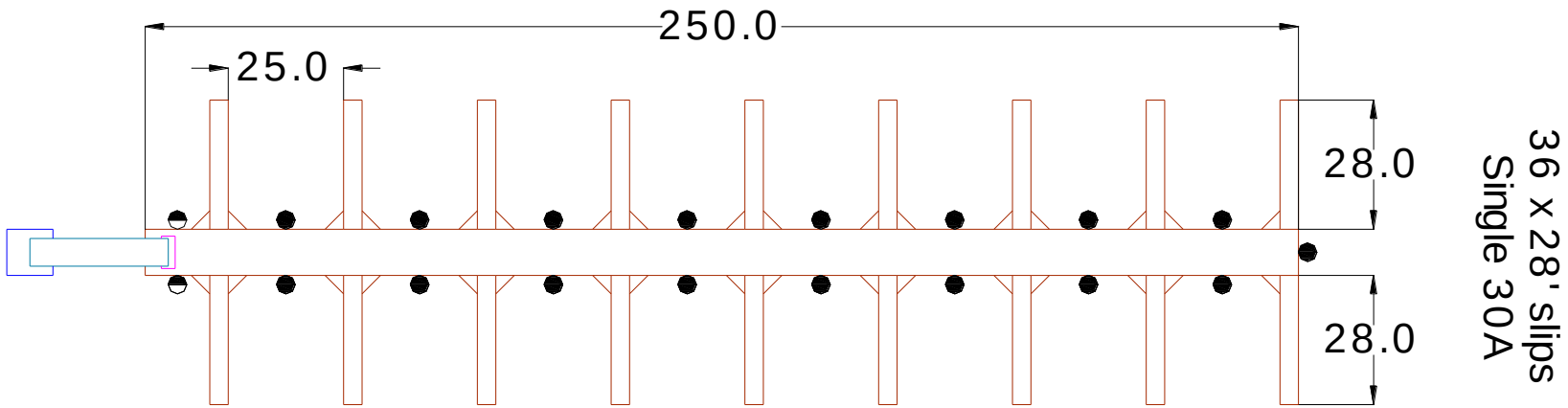
# Design Assumptions (cont.)

- Circuits are designed to a 3% voltage drop for branch circuits
- Feeder calculations (panel to transformer) are designed to a 2% voltage drop

# Cost Factors

- What is being included in the total cost per slip?
  - Cost of Power Pedestal
  - Cost of Electrical Wire / Cable
  - Cost of Distribution Equipment
    - Transformer
    - Panel
    - Disconnect
  - Cost of Conduit for THWN (Building Wire)
- Not Included – Labor, Communications, and Water

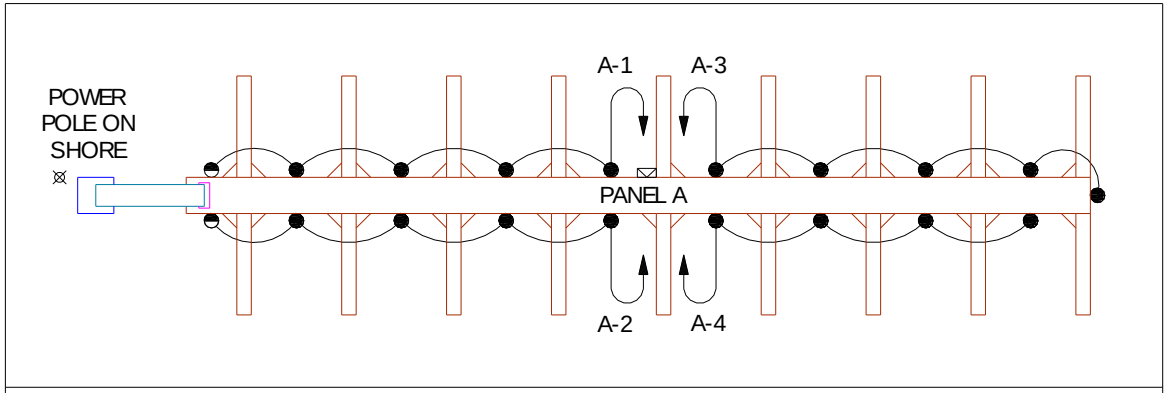
# Single 30A Slip
# (Up to Approximately 32')



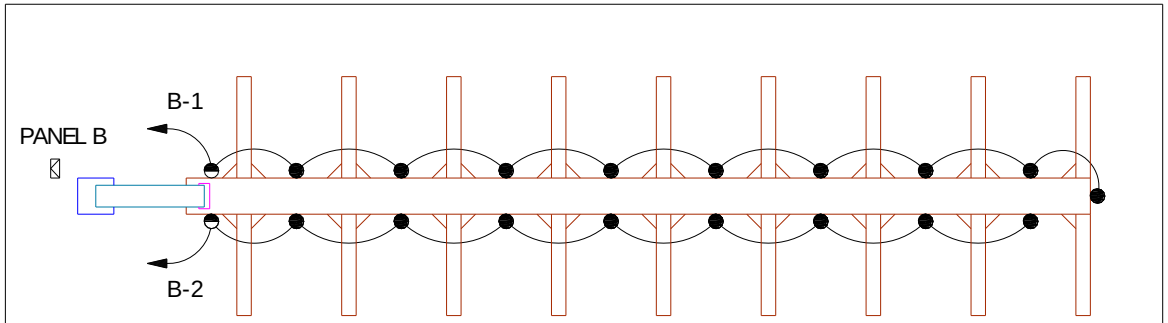

●= Power Pedestal 30 / 30

◓= Power Pedestal 30 / -

# Single 30A Slip
# (Up to Approximately 32')




SINGLE 30A PER SLIP DESIGN - DISTRIBUTION PANEL ON DOCK




SINGLE 30A PER SLIP DESIGN - DISTRIBUTION PANEL ON SHORE

| Distribution Panel |
| --- |
| 300A Main Lug Only – 120/240V |

| Transformer |
| --- |
| 75KVA 480V to 120/240V |

| Fused Disconnect |
| --- |
| 150A – 480V |

# Single 30A Slip
# (Up to Approximately 32’)

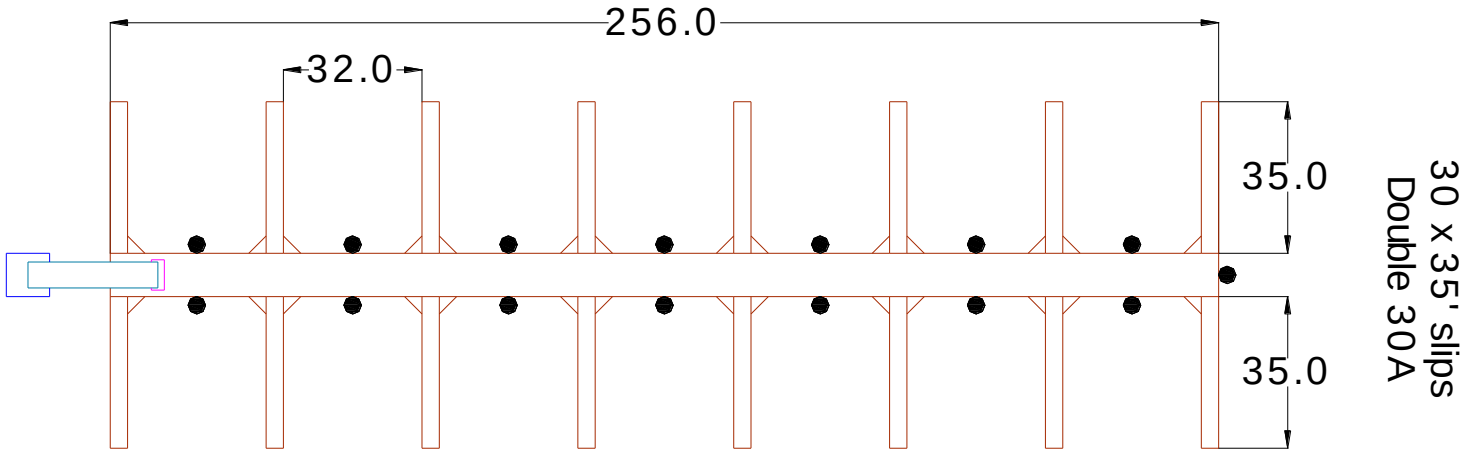
| THWN in Conduit – Panel on Dock | |
|---|---|
| Dist. Equipment | $26,375.00 |
| Wire w/ Conduit | $11,000.00 |
| Pedestals | $22,895.00 |
| Cost per Slip | $1,675.00 |

| THWN in Conduit – Panel on Shore | |
|---|---|
| Dist. Equipment | $26,200.00 |
| Wire w/ Conduit | $10,300.00 |
| Pedestals | $22,895.00 |
| Cost per Slip | $1,650.00 |

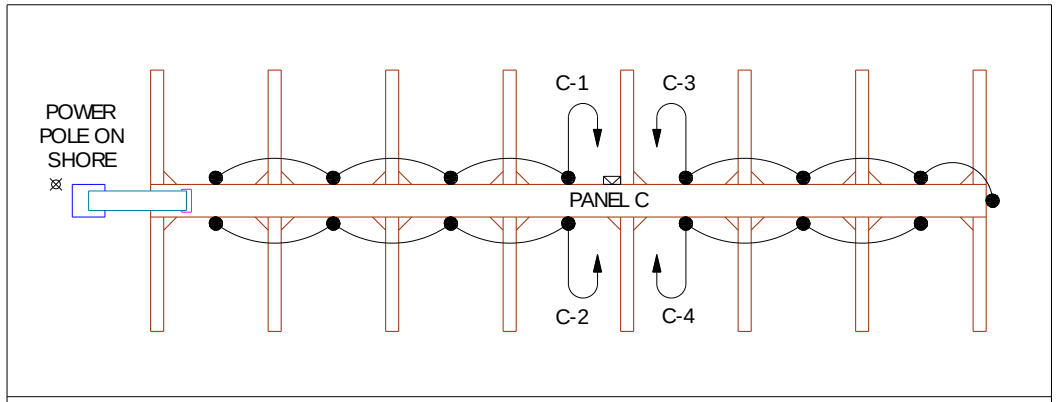
| “G” Cable – Panel on Dock | |
|---|---|
| Dist. Equipment | $26,375.00 |
| Wire | $12,900.00 |
| Pedestals | $22,895.00 |
| Cost per Slip | $1,725.00 |

| “G” Cable – Panel on Shore | |
|---|---|
| Dist. Equipment | $26,200.00 |
| Wire | $16,125.00 |
| Pedestals | $22,895.00 |
| Cost per Slip | $1,810.00 |

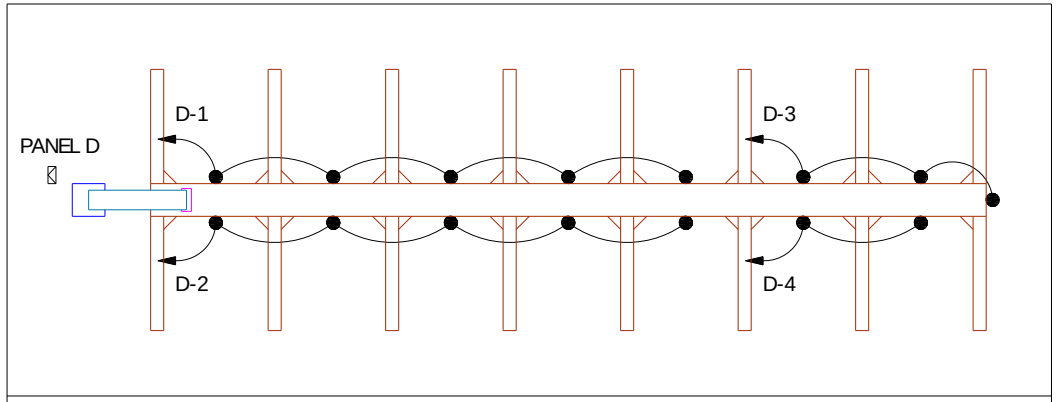
# Double 30A Slip
# (Up to Approximately 42’-45’)



# Double 30A Slip
# (Up to Approximately 42’-45’)




DOUBLE 30A PER SLIP DESIGN - DISTRIBUTION PANEL ON DOCK




DOUBLE 30A PER SLIP DESIGN - DISTRIBUTION PANEL ON SHORE

| Distribution Panel |
| --- |
| 400A Main Lug Only – 120/240V |

| Transformer |
| --- |
| 100KVA 480V to 120/240V |

| Fused Disconnect |
| --- |
| 200A – 480V |

# Double 30A Slip
# (Up to Approximately 42’-45’)

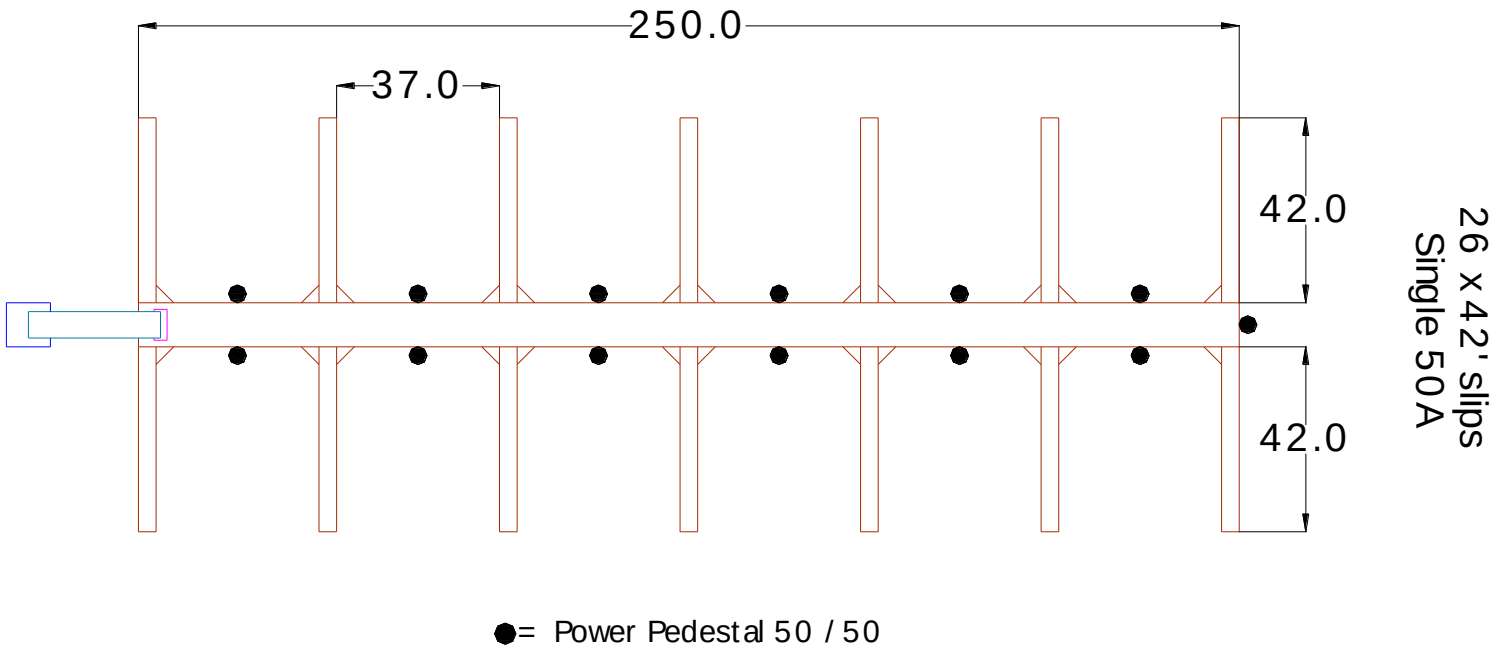
| THWN in Conduit – Panel on Dock | |
|---|---|
| Dist. Equipment | $27,750.00 |
| Wire w/ Conduit | $11,600.00 |
| Pedestals | $21,850.00 |
| Cost per Slip | $2,040.00 |

| THWN in Conduit – Panel on Shore | |
|---|---|
| Dist. Equipment | $19,059.50 |
| Wire w/ Conduit | $9,050.00 |
| Pedestals | $21,850.00 |
| Cost per Slip | $1,665.00 |

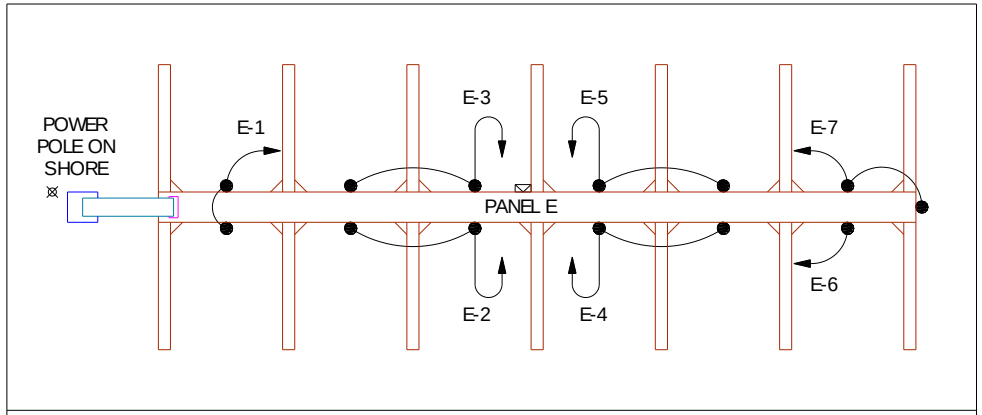
| “G” Cable – Panel on Dock | |
|---|---|
| Dist. Equipment | $27,750.00 |
| Wire | $10,600.00 |
| Pedestals | $21,850.00 |
| Cost per Slip | $2,005.00 |

| “G” Cable – Panel on Shore | |
|---|---|
| Dist. Equipment | $19,059.50 |
| Wire | $15,385.00 |
| Pedestals | $21,850.00 |
| Cost per Slip | $1,875.00 |

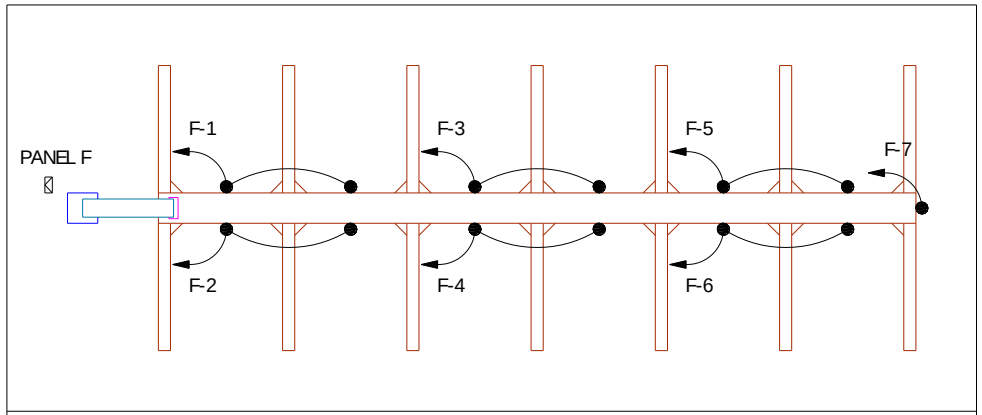
# Single 50A Slip
# (Up to Approximately 50')



# Single 50A Slip
# (Up to Approximately 50’)




SINGLE 50A PER SLIP DESIGN - DISTRIBUTION PANEL ON DOCK




SINGLE 50A PER SLIP DESIGN - DISTRIBUTION PANEL ON SHORE

| Distribution Panel |
| --- |
| 1000A Main Circuit Breaker – 120/240V |

| Transformer |
| --- |
| 250KVA 480V to 120/240V |

| Fused Disconnect |
| --- |
| 500A – 480V |

# Single 50A Slip
# (Up to Approximately 50’)

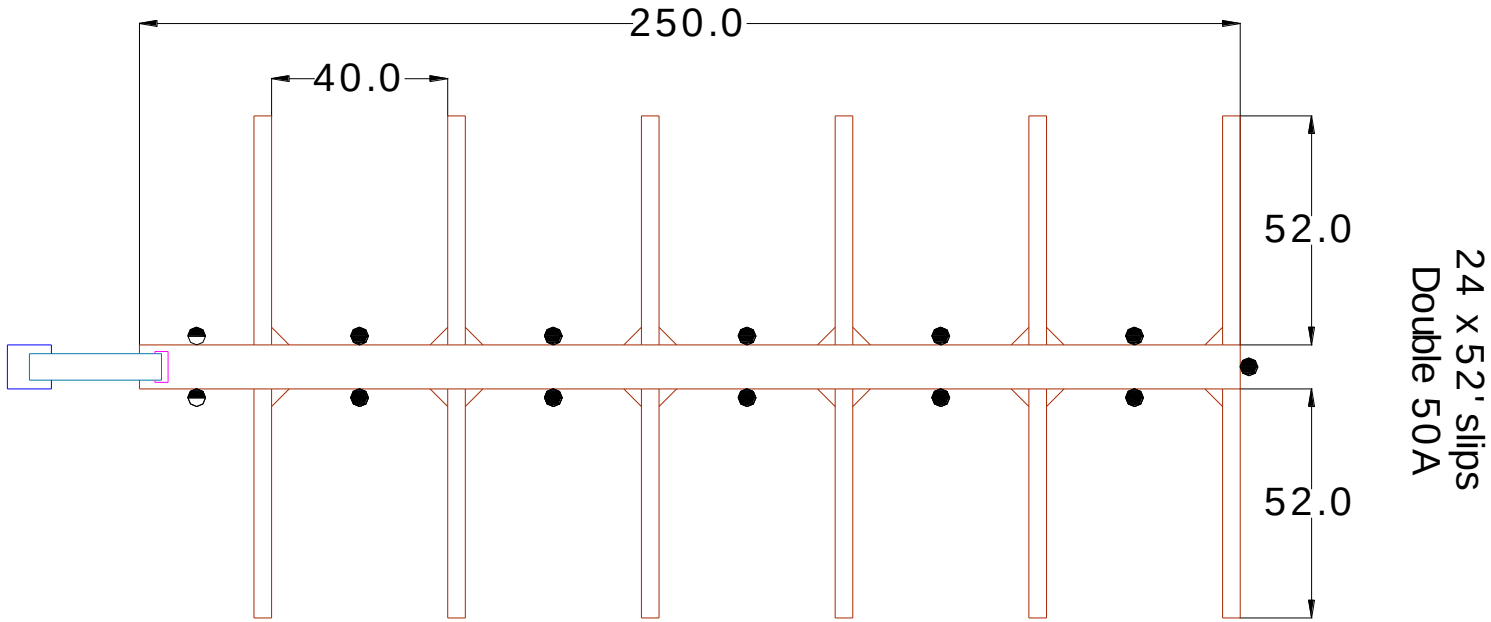
| THWN in Conduit – Panel on Dock | |
|---|---|
| Dist. Equipment | $28,036.00 |
| Wire w/ Conduit | $19,078.00 |
| Pedestals | $19,050.00 |
| Cost per Slip | $2,545.00 |

| THWN in Conduit – Panel on Shore | |
|---|---|
| Dist. Equipment | $28,036.00 |
| Wire w/ Conduit | $19,231.00 |
| Pedestals | $19,050.00 |
| Cost per Slip | $2,550.00 |

| “G” Cable – Panel on Dock | |
|---|---|
| Dist. Equipment | $28,036.00 |
| Wire | $17,252.00 |
| Pedestals | $19,050.00 |
| Cost per Slip | $2,475.00 |

| “G” Cable – Panel on Shore | |
|---|---|
| Dist. Equipment | $28,036.00 |
| Wire | $23,065.00 |
| Pedestals | $19,050.00 |
| Cost per Slip | $2,700.00 |

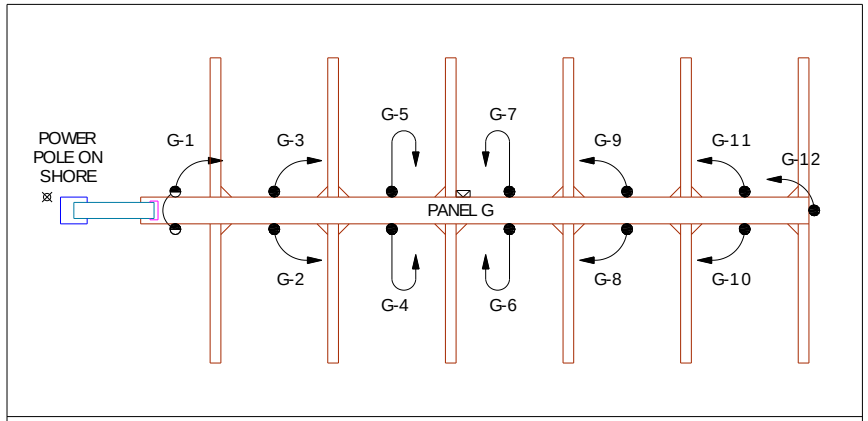
# Double 50A Slip
# (Up to Approximately 70')



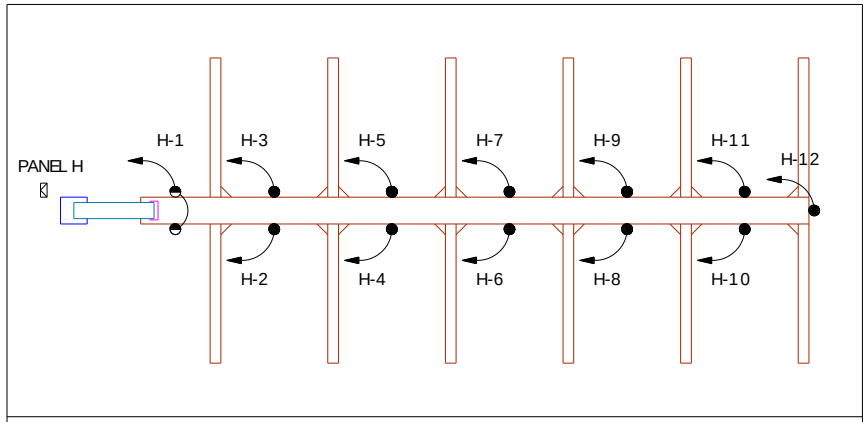

●= Power Pedestal 50-50 / 50-50

◓= Power Pedestal 50-50 / -

# Double 50A Slip
# (Up to Approximately 70’)




DOUBLE 50A PER SLIP DESIGN - DISTRIBUTION PANEL ON DOCK




DOUBLE 50A PER SLIP DESIGN - DISTRIBUTION PANEL ON SHORE

| Distribution Panel |
| --- |
| 1200A Main Circuit Breaker – 120/240V |

| Transformer |
| --- |
| 330KVA 480V to 120/240V |

| Fused Disconnect |
| --- |
| 600A – 480V |

# Double 50A Slip
# (Up to Approximately 70’)

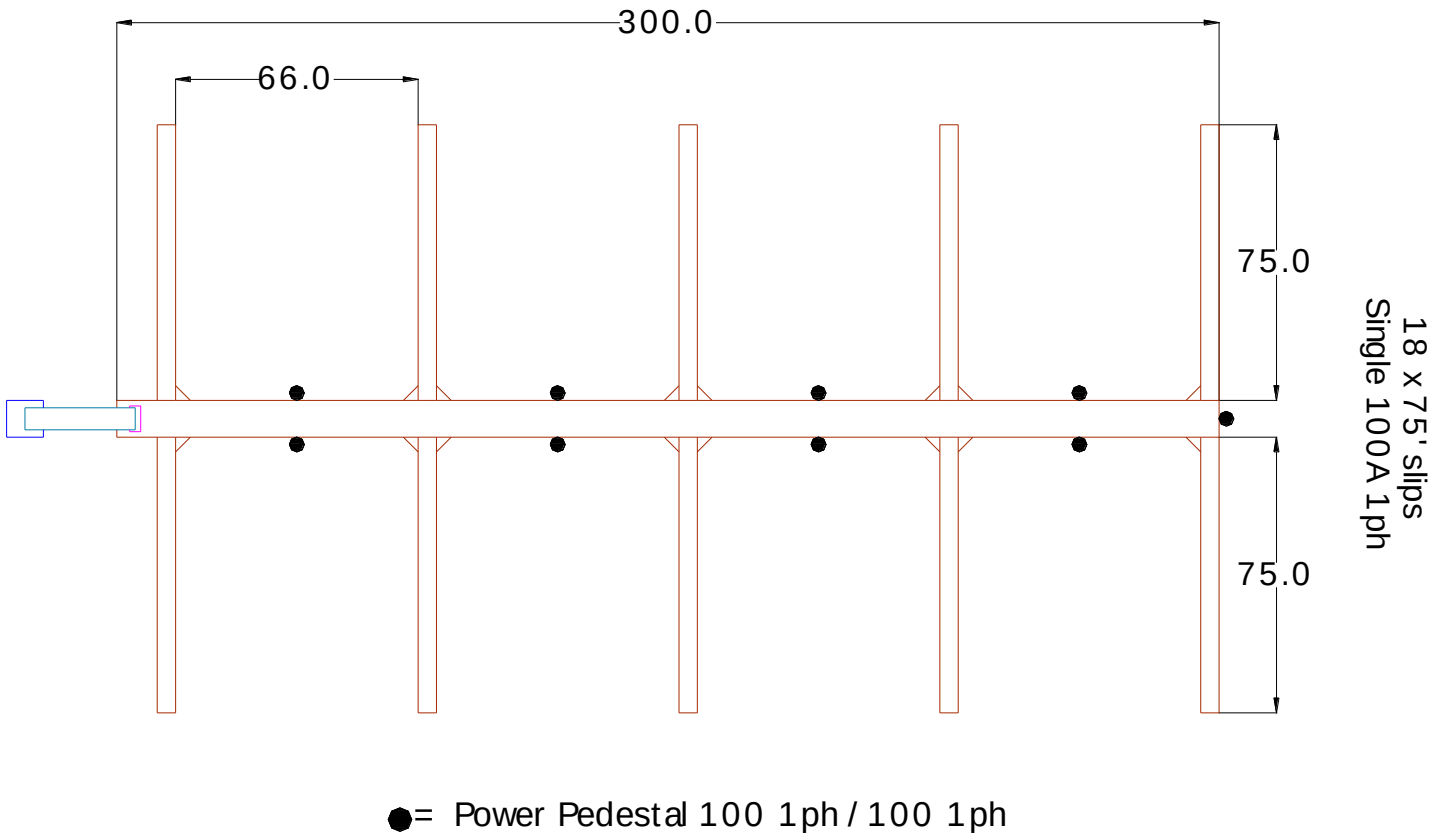
| THWN in Conduit – Panel on Dock | |
|---|---|
| Dist. Equipment | $32,605.00 |
| Wire w/ Conduit | $22,751.00 |
| Pedestals | $21,725.00 |
| Cost per Slip | $3,210.00 |

| THWN in Conduit – Panel on Shore | |
|---|---|
| Dist. Equipment | $32,605.00 |
| Wire w/ Conduit | $24,196.00 |
| Pedestals | $21,725.00 |
| Cost per Slip | $3,270.00 |

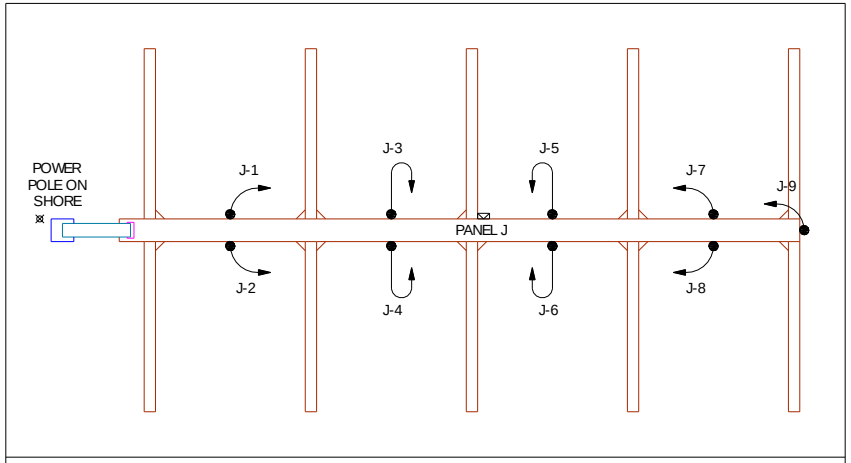
| “G” Cable – Panel on Dock | |
|---|---|
| Dist. Equipment | $32,605.00 |
| Wire | $25,106.00 |
| Pedestals | $21,725.00 |
| Cost per Slip | $3,310.00 |

| “G” Cable – Panel on Shore | |
|---|---|
| Dist. Equipment | $32,605.00 |
| Wire | $35,502.00 |
| Pedestals | $21,725.00 |
| Cost per Slip | $3,745.00 |

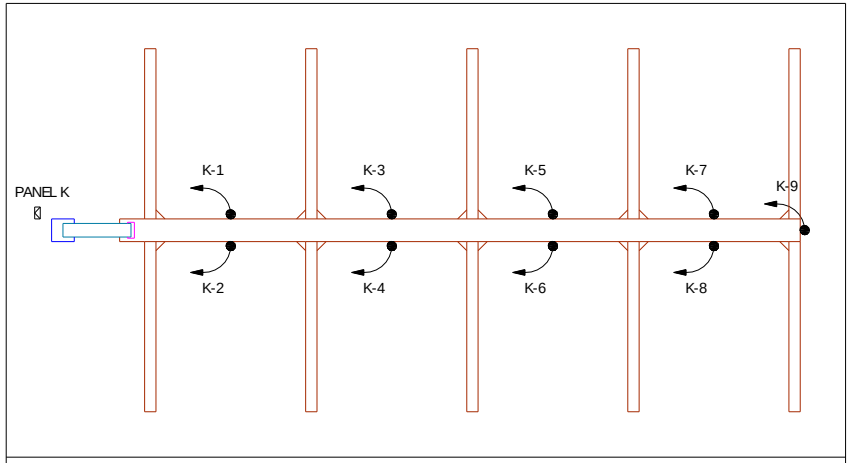
# Single 100A 120/240V Slip (Up to Approximately 85')



# Single 100A 120/240V Slip (Up to Approximately 85’)




SINGLE 100A 120/240V PER SLIP DESIGN - DISTRIBUTION PANEL ON DOCK




SINGLE 100A 120/240V PER SLIP DESIGN - DISTRIBUTION PANEL ON SHORE

| Distribution Panel |
| --- |
| 1200A Main Circuit Breaker – 120/240V |

| Transformer |
| --- |
| 330KVA 480V to 120/240V |

| Fused Disconnect |
| --- |
| 600A – 480V |

# Single 100A 120/240V Slip (Up to Approximately 85')

| THWN in Conduit – Panel on Dock | |
|---|---|
| Dist. Equipment | $32,398.75 |
| Wire w/ Conduit | $25,209.00 |
| Pedestals | $20,970.00 |
| Cost per Slip | $4,365.00 |

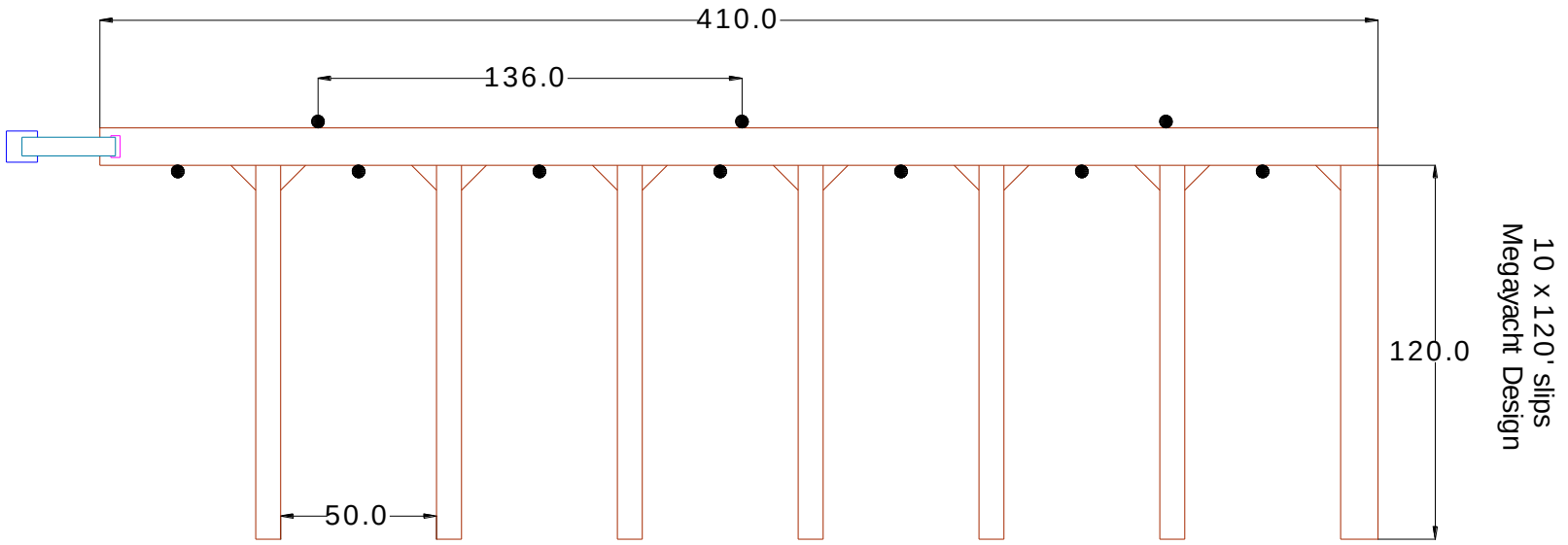
| THWN in Conduit – Panel on Shore | |
|---|---|
| Dist. Equipment | $32,398.75 |
| Wire w/ Conduit | $25,757.00 |
| Pedestals | $20,970.00 |
| Cost per Slip | $4,395.00 |

| "G" Cable – Panel on Dock | |
|---|---|
| Dist. Equipment | $32,398.75 |
| Wire | $27,558.00 |
| Pedestals | $20,970.00 |
| Cost per Slip | $4,495.00 |

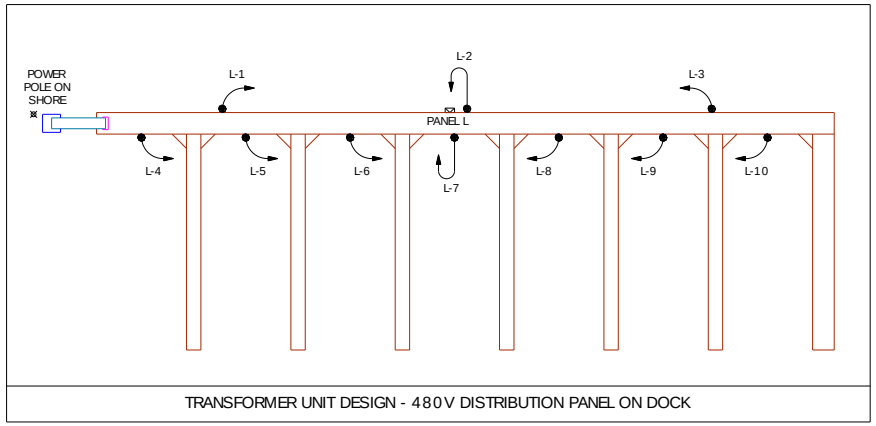
| "G" Cable – Panel on Shore | |
|---|---|
| Dist. Equipment | $32,398.75 |
| Wire | $36,029.00 |
| Pedestals | $20,970.00 |
| Cost per Slip | $4,965.00 |

# Megayacht Slips (Approximately 90+')

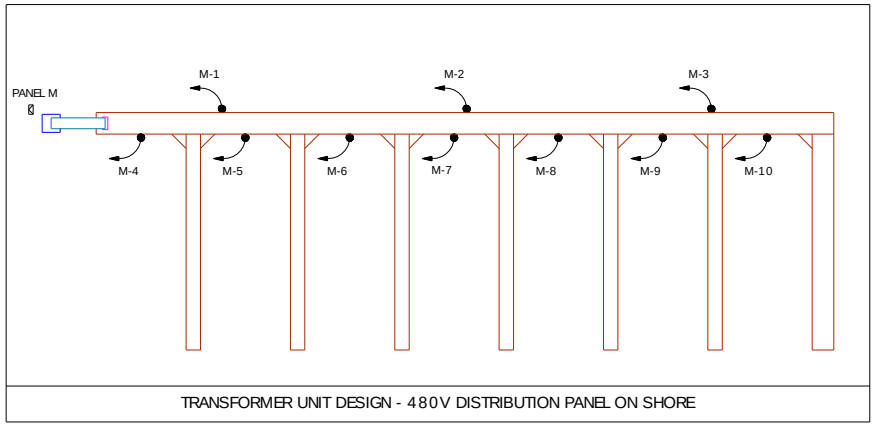
# Megayacht Slips (Approximately 90+')



# Megayacht Slips (Approximately 90+')




TRANSFORMER UNIT DESIGN - 480V DISTRIBUTION PANEL ON DOCK




TRANSFORMER UNIT DESIGN - 480V DISTRIBUTION PANEL ON SHORE

| Switchboard | Transformer | Fused Disconnect |
|---|---|---|
| 1600A Main Circuit Breaker – 480V | Utility Provided in most cases | Not Applicable |

# Megayacht Slips (Approximately 90+')

| THWN in Conduit – Switchboard on Dock | |
|---|---|
| Dist. Equipment | $49,500.00 |
| Wire w/ Conduit | $48,674.00 |
| Pedestals | $211,500.00 |
| Cost per Slip | $30,965 |

| THWN in Conduit – Switchboard on Shore | |
|---|---|
| Dist. Equipment | $49,500.00 |
| Wire w/ Conduit | $50,569.00 |
| Pedestals | $211,500.00 |
| Cost per Slip | $31,155 |

| "G" Cable – Switchboard on Dock | |
|---|---|
| Dist. Equipment | $49,500.00 |
| Wire | $54,899.00 |
| Pedestals | $211,500.00 |
| Cost per Slip | $31,590 |

| "G" Cable – Switchboard on Shore | |
|---|---|
| Dist. Equipment | $49,500.00 |
| Wire | $57,165.00 |
| Pedestals | $211,500.00 |
| Cost per Slip | $31,820 |

# Good References and Documents to Own

- NFPA 303 – Fire Protection Standards for Marinas and Boatyards – 2011 Edition
- National Electrical Code Handbook 2017 – Article 555 Marinas and Boatyards
- ACSE 50 – Planning and Design Guidelines for Small Craft Harbors
- American Boat and Yacht Council
- Electrical Safety Foundation Intl.
- ADA
- Local Electrical Authorities

Electrical Safety Foundation International (ESFI)
Tel 703-841-3229 | info@esfi.org

# AMI – Best Management Practices for Marina Electrical Safety

# Thank You

This concludes The American Institute of Architects
Continuing Education Systems Course

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Chris Dolan

Marina Electrical Equipment

(855) 258-3939 Office

(757) 869-4683 Cell

chrisdolan@marinaee.com