QUARTERMASTER YACHT CLUB – Tech Talk Introduction

WELCOME to QYC Tech Talks!

- A Tech Talk is…
  - An exchange of information, ideas and experience
  - More dialogue than "teaching"
  - A little structure
- We encourage…
  - Listening, learning & contributing
  - Discussion and debate
  - Questions
- Our next Tech Talk is:
  - During the 2018 – 2019 Season

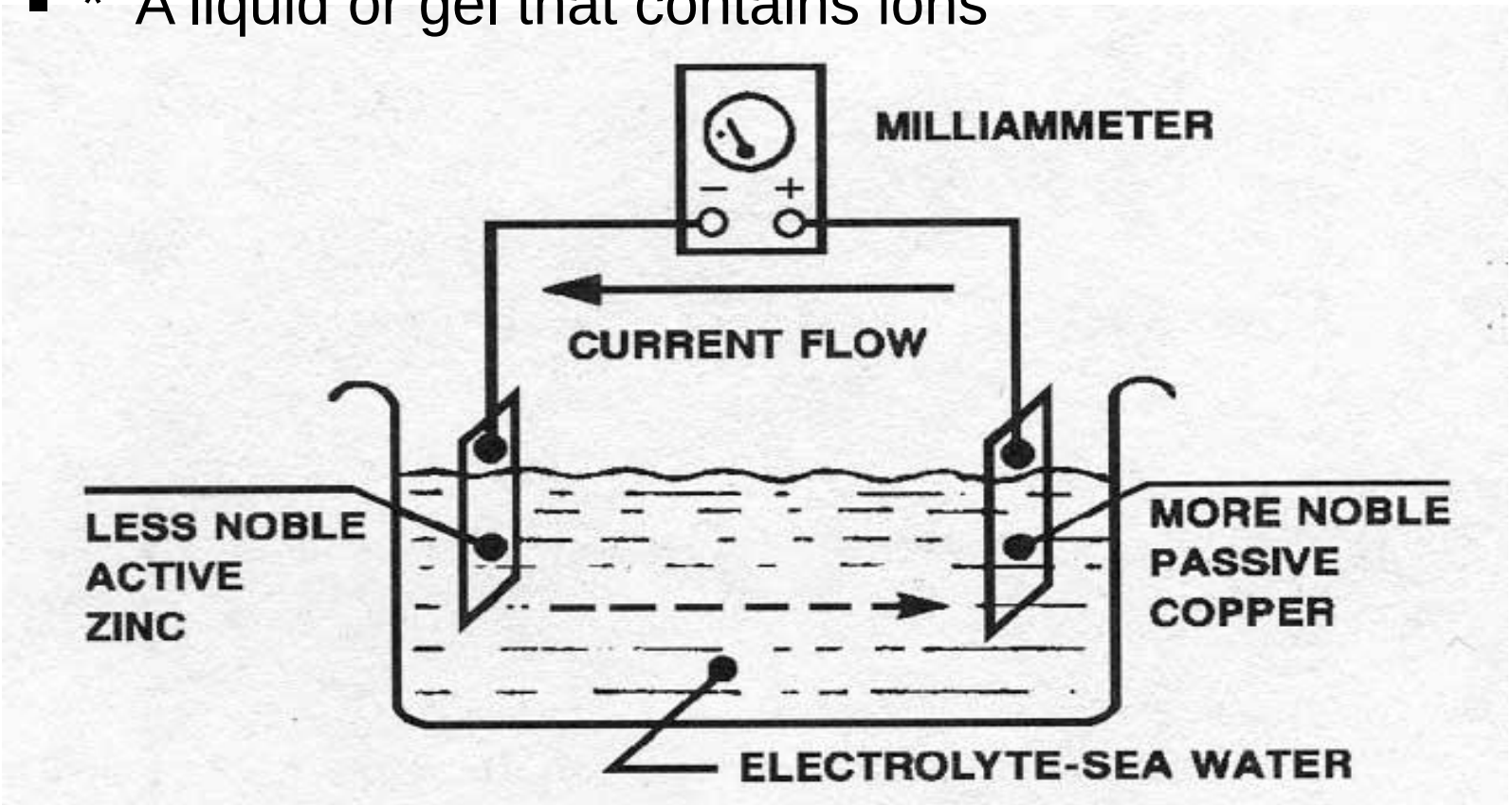
Together, to Learn From Each Other

Corrosion & Electrical Safety Overview

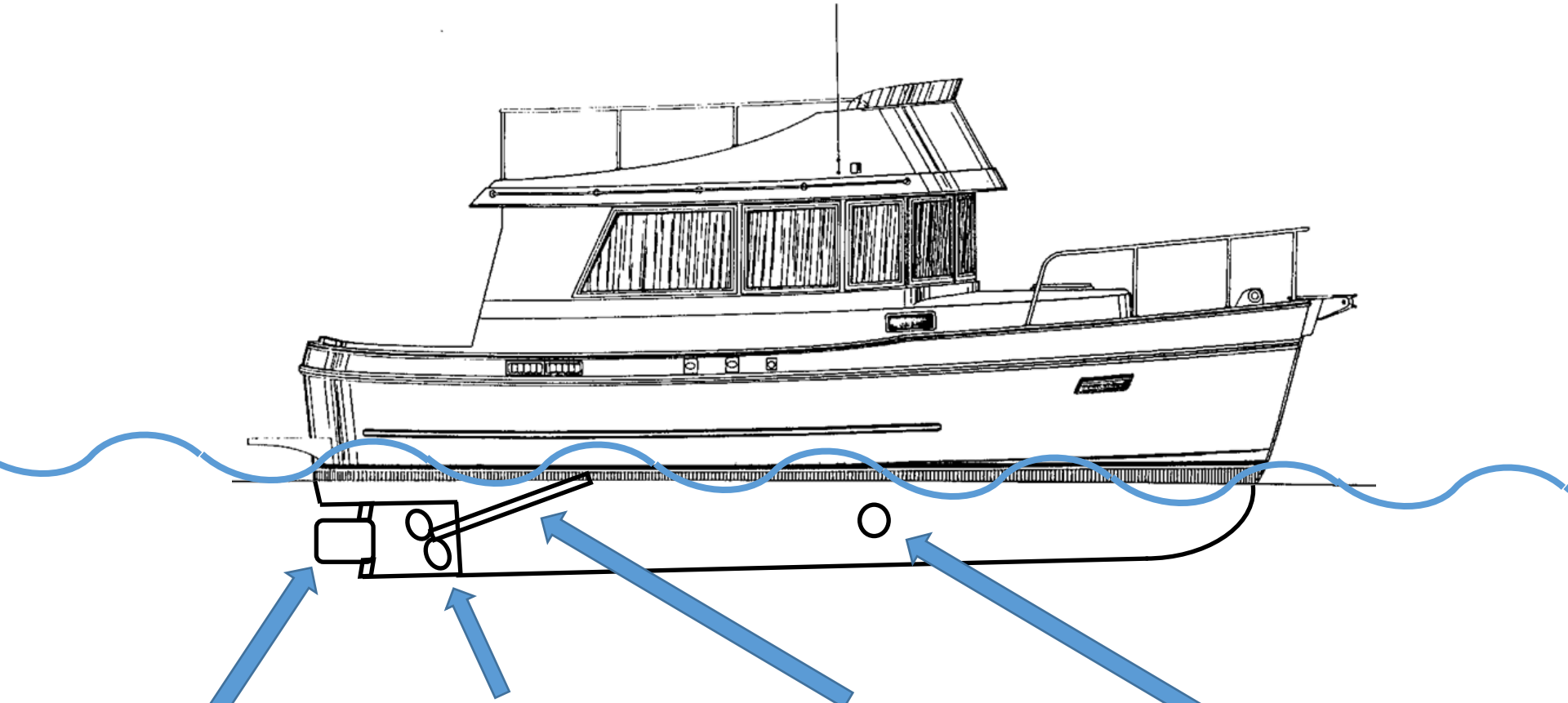
- What makes a battery / Anodic table
- Types of marine corrosion
  - Galvanic
  - Stray Current
  - Crevice
- Marine wiring basics
- Marine electrical safety
  - You and your boat
  - Electro-shock drowning

What Makes a Battery?

- Two different metals
- Electrolyte* solution
  - * A liquid or gel that contains ions



Your Boat is a Battery!



Steel Rudder

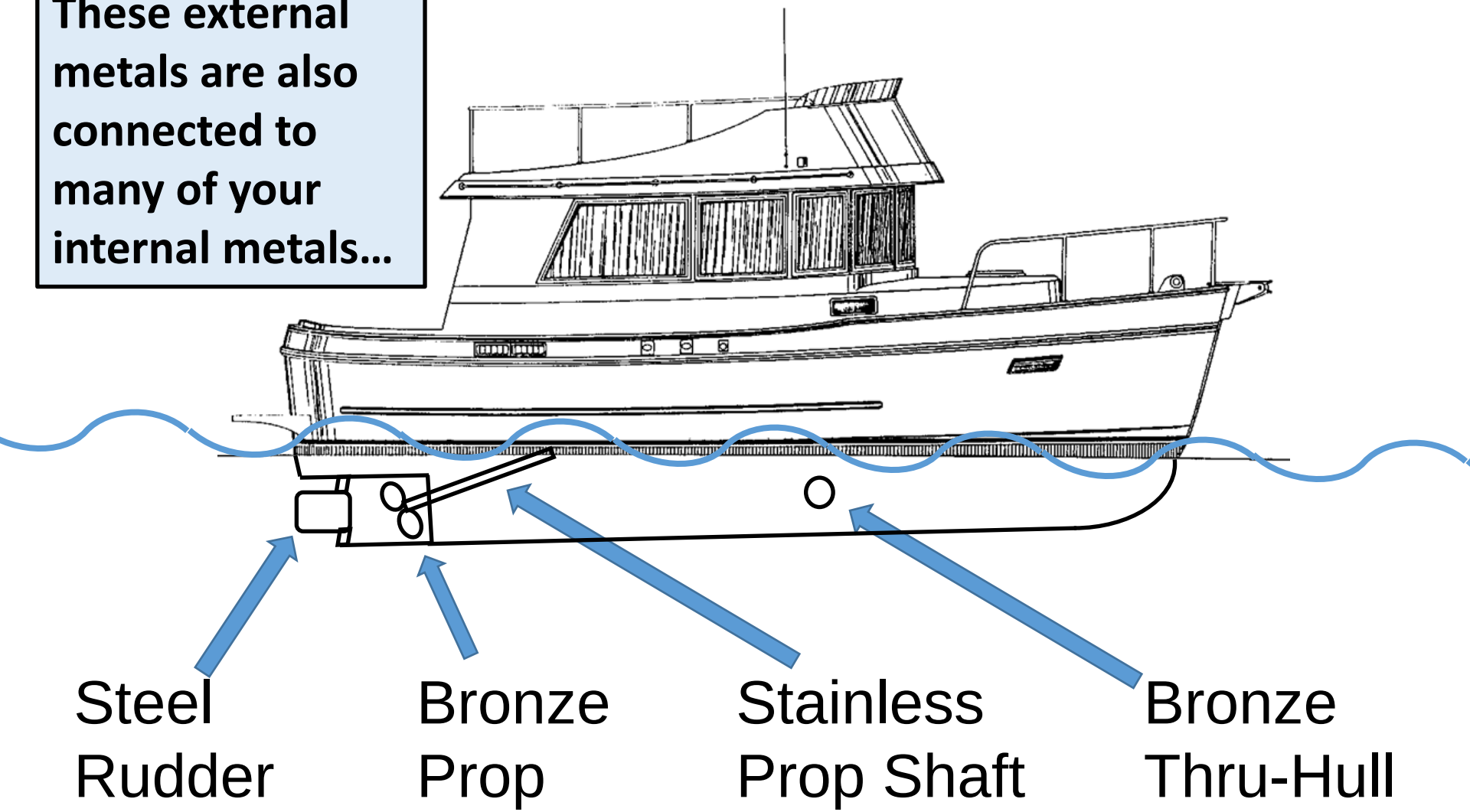
Bronze Prop

Stainless Prop Shaft

Bronze Thru-Hull

Your Boat is a Battery!

These external metals are also connected to many of your internal metals…



Battery Demo

QUARTERMASTER YACHT CLUB – Anodic Index Table

Metal	Index (V)
Most Cathodic	
Gold, solid and plated, Gold-platinum alloy	−0.00
Rhodium plated on silver-plated copper	−0.05
Silver, solid or plated; monel metal. High nickel-copper alloys	−0.15
Nickel, solid or plated, titanium an s alloys, Monel	−0.30
Copper, solid or plated; low brasses or bronzes; silver solder; German silvery high copper-nickel alloys; nickel-chromium alloys	−0.35
Brass and bronzes	−0.40
High brasses and bronzes	−0.45
18% chromium type corrosion-resistant steels	−0.50
Chromium plated; tin plated; 12% chromium type corrosion-resistant steels	−0.60
Tin-plate; tin-lead solder	−0.65
Lead, solid or plated; high lead alloys	−0.70
2000 series wrought aluminum	−0.75
Iron, wrought, gray or malleable, plain carbon and low alloy steels	−0.85
Aluminum, wrought alloys other than 2000 series aluminum, cast alloys of the silicon type	−0.90
Aluminum, cast alloys other than silicon type, cadmium, plated and chromate	−0.95
Hot-dip-zinc plate; galvanized steel	−1.20
Zinc, wrought; zinc-base die-casting alloys; zinc plated	−1.25
Magnesium & magnesium-base alloys, cast or wrought	−1.75
Beryllium	−1.85
Most Anodic	

Allowable voltage differences:

Harsh Environments
- Up to 0.15V between metals

Indoor Environments
- Up to 0.25V between metals

Controlled Environments (temp / humidity)
- Up to 0.50V between metals

Bronze to Stainless: < 0.20

Bronze to Aluminum: < 0.55

Bronze to Steel: < 0.80

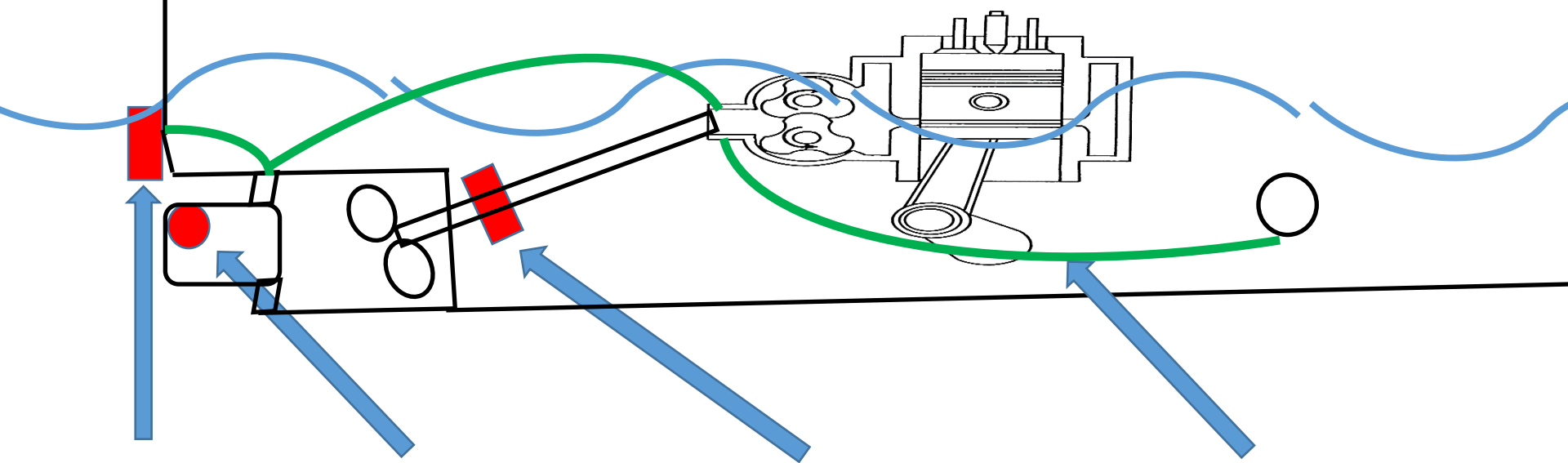
Aluminum to Stainless: < 0.45

Aluminum to Steel: < 0.70

Your Boat as a Battery = Galvanic Corrosion

- Cause: Different metals in electrolyte
- Attributes: Relatively slow
- To avoid: You can't
  - You can introduce sacrificial anodes
- Cautionary notes:
  - Metal based lubricants
  - Metal based bottom paints

Your Bonding System + Sacrificial Anodes



Stern Anode

Rudder Anode

Prop Shaft Anode

Bonding Wire*

The Bonding System connects all underwater metal components to a sacrificial anode – and to your on-board electrical ground system

* Bonding wire resistance recommended less than one ohm

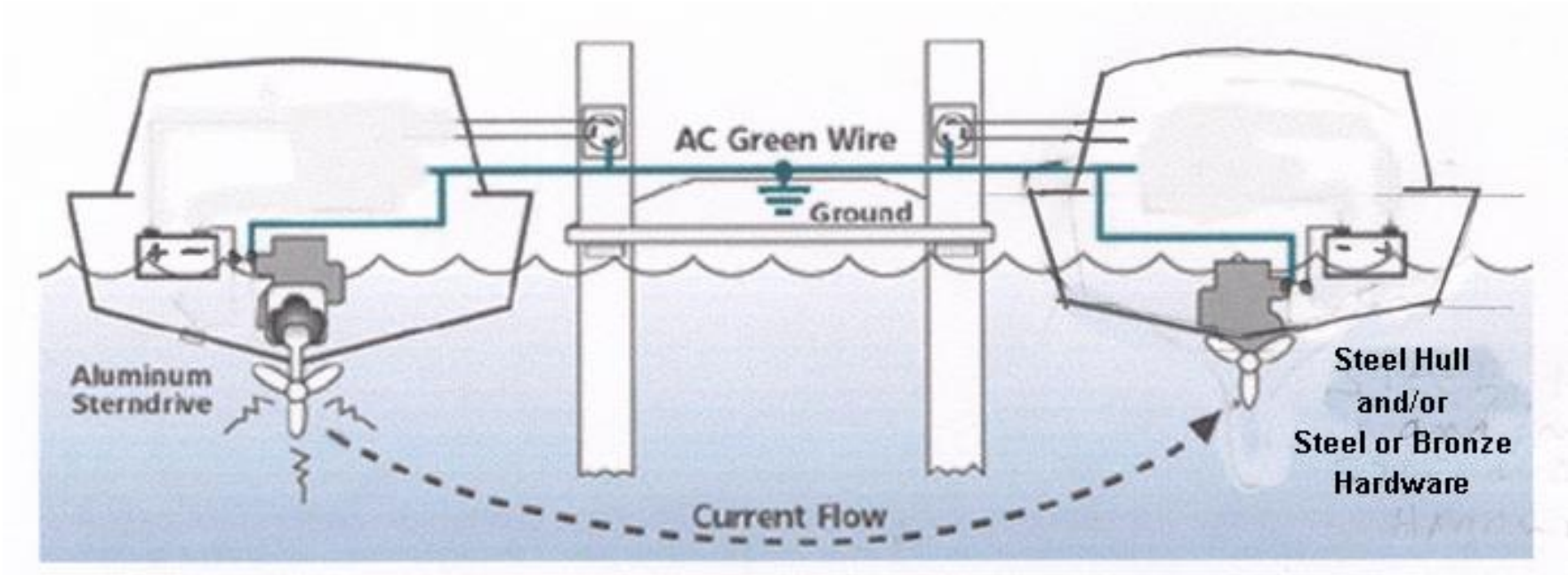
Other Bonding System Considerations

- Bonding to avoid static electricity buildup on fuel tanks, fuel filler hoses, fuel inlets, etc

- Calder, and others, suggest not bonding any "electrically isolated metal fittings"
  - To assure through hulls and other immersed metals are not electrically bonded to a lightning protection system, and
  - To avoid the multi-boat stray current corrosion problem cited below

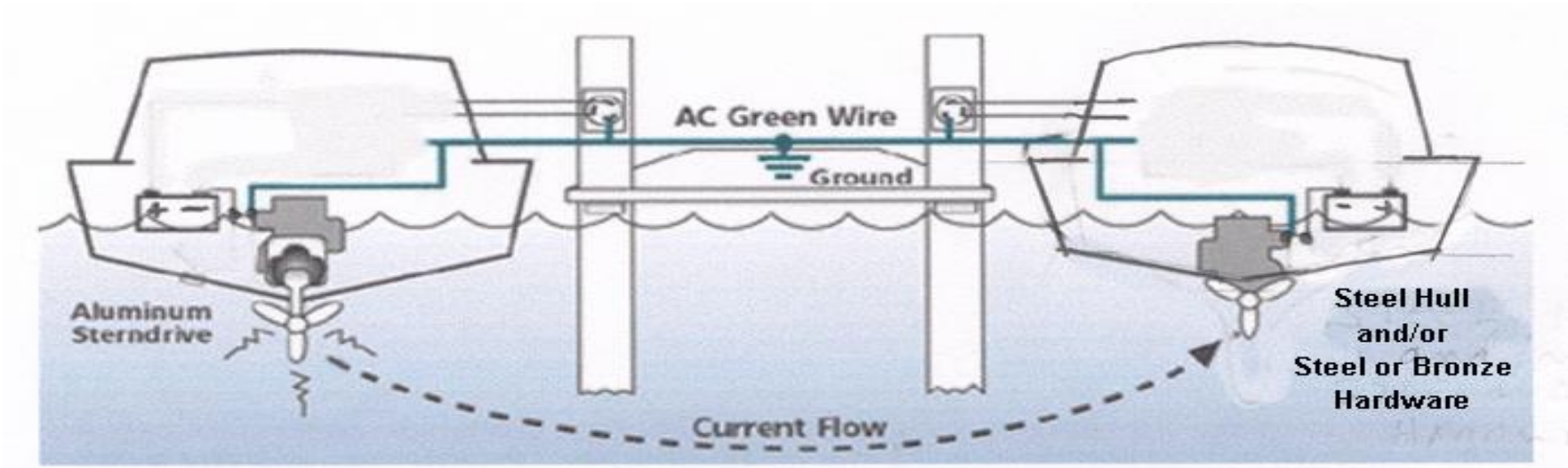
Galvanic Corrosion between Boats

- Cause: Different metals in electrolyte
- Attributes: Relatively slow
- To avoid: Galvanic Isolator / Isolation Transformer
  - Stops DC current in your AC grounding wire



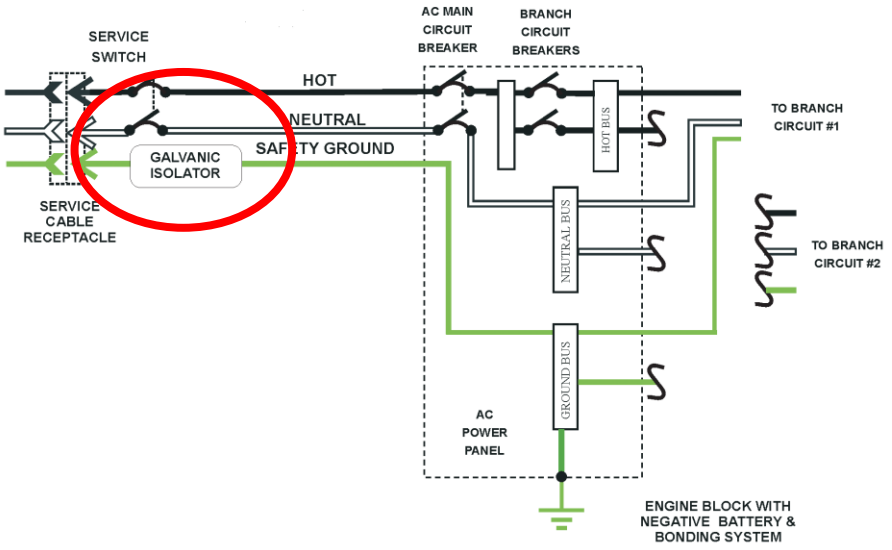
Galvanic Corrosion between Boats

- Cut the AC grounding wire?
  - Stops galvanic corrosion current flow
  - **Not** compliant with ABYC standards
  - **Only** if install AC ground fault circuit interrupters to protect **EVERY** AC device on the boat

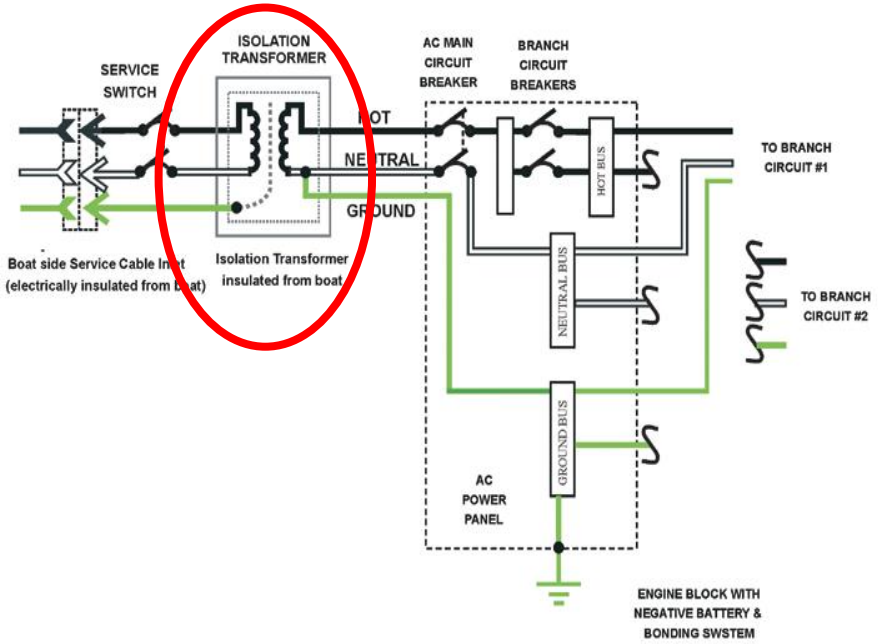


Galvanic Corrosion between Boats

Galvanic Isolator or Isolation Transformer – ABYC approved way to stop multi-boat galvanic corrosion

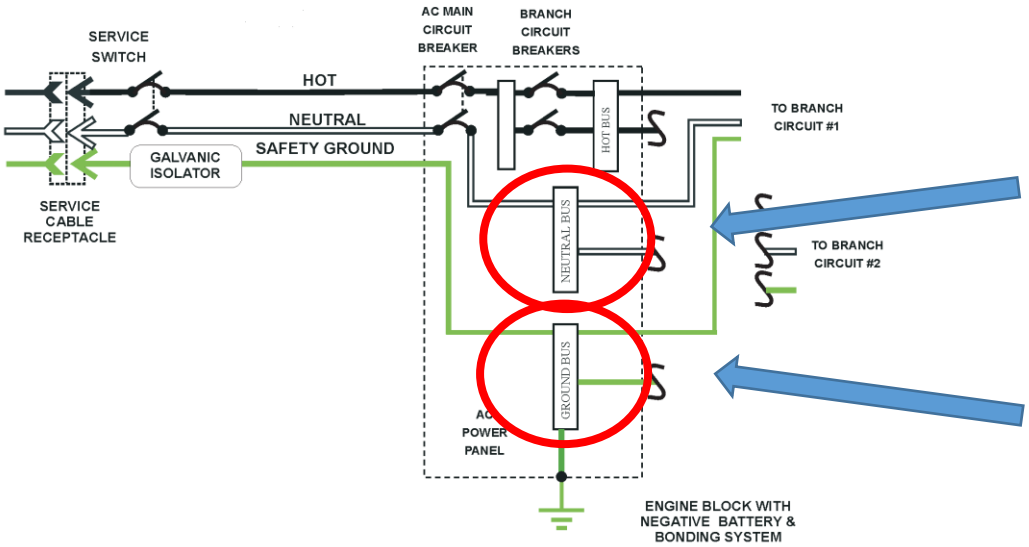


Galvanic Isolator



Isolation Transformer

Boat Wiring vs Home Wiring



AC Neutral (White)

AC Grounding (Green)

Boat: Separated

Home: Connected

ABYC: Neutral and Grounding wire never connected except at the source of power

- On shore, at an Isolation Transformer or at an Inverter
- Non-marine AC appliances – AC Grounding wire must not be connected to AC Neutral wire – Stray AC current source

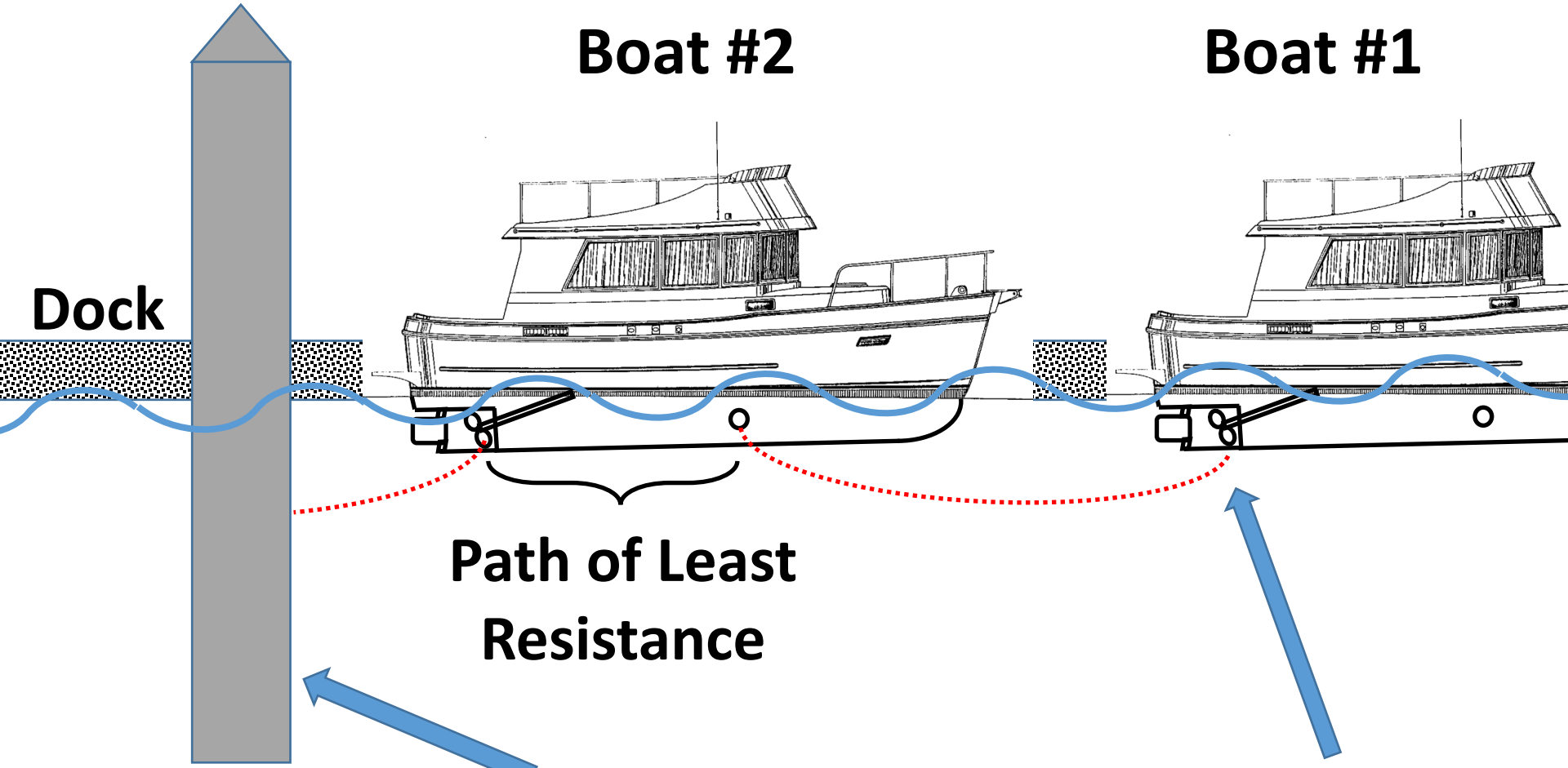
Stray Current Corrosion

- Cause: When metal with an electrical current flowing into it is immersed in water that is grounded – like any lake, river or ocean.
- Attributes: Relatively slow (AC) to **very** fast (DC)
- To detect: Regular maintenance testing of your AC and DC electrical systems.
- To avoid: Investigate and fix if system test fails.

Stray Current Corrosion

- Other stray current avoidance practices:
  - Always use marine grade wiring
  - Keep wiring out of bilge water
  - Butt connectors with heat shrink and adhesive
  - No wire nuts! No wing nuts! No Solder joints!
  - Clean AC and DC ground system connections
  - Keep AC Neutral separate from AC Grounding

Multi-Boat Stray Current Corrosion

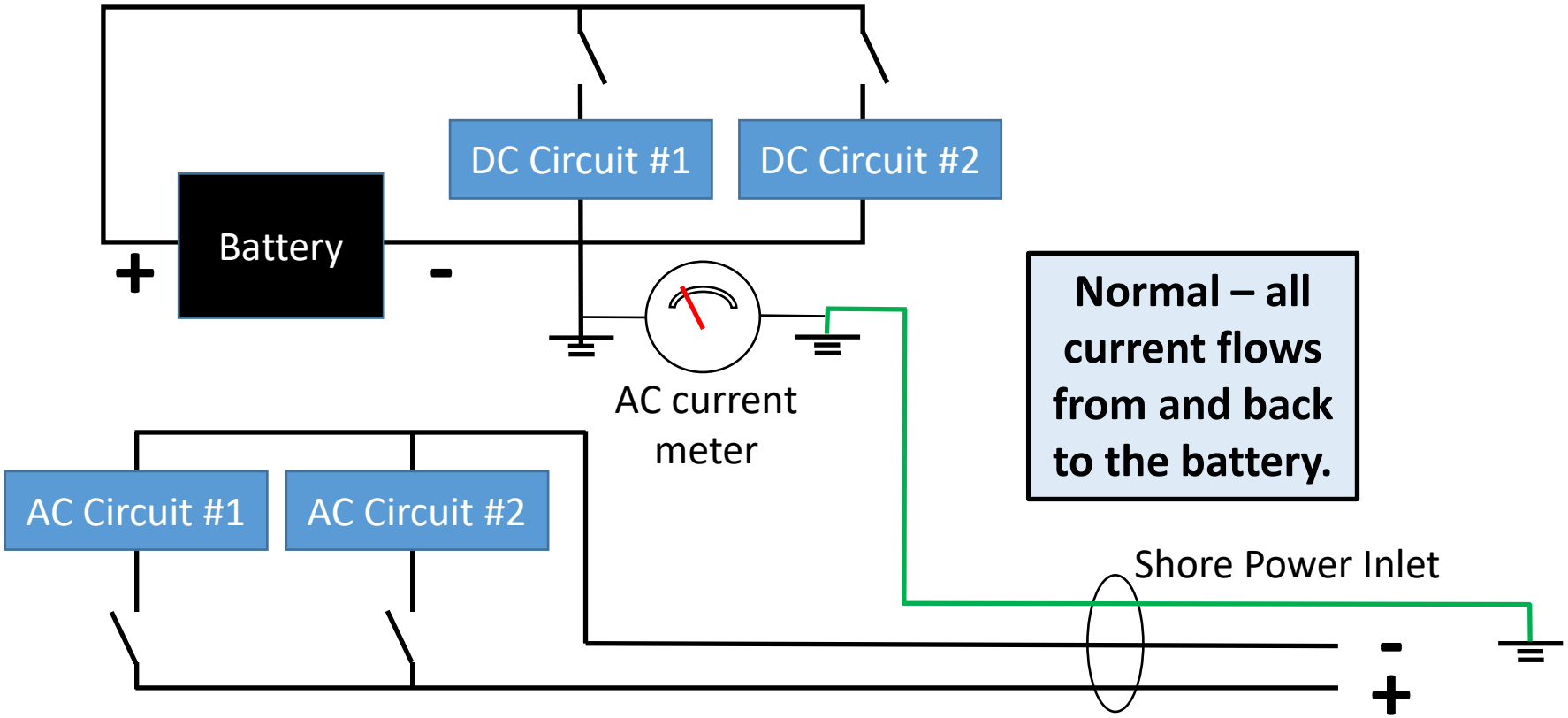


Sources of Stray Current Corrosion

- In either DC or AC systems:
  - A short in your boat's wiring system
    - Eg: poorly insulated wire in the bilge
  - Chafed insulation leaking current to ground
  - An improperly wired electrical accessory
- AC motor winding insulation breakdown

Testing for Stray DC Current – USPS

- Disconnect DC Negative bus bar and AC Grounding bus bar from the engine and insert AC current meter between the two grounding wires.
- Set meter to DC amps, turn DC batter switch “on”. Reading < 1mA.
- Activate each circuit individually. All readings < 1mA.



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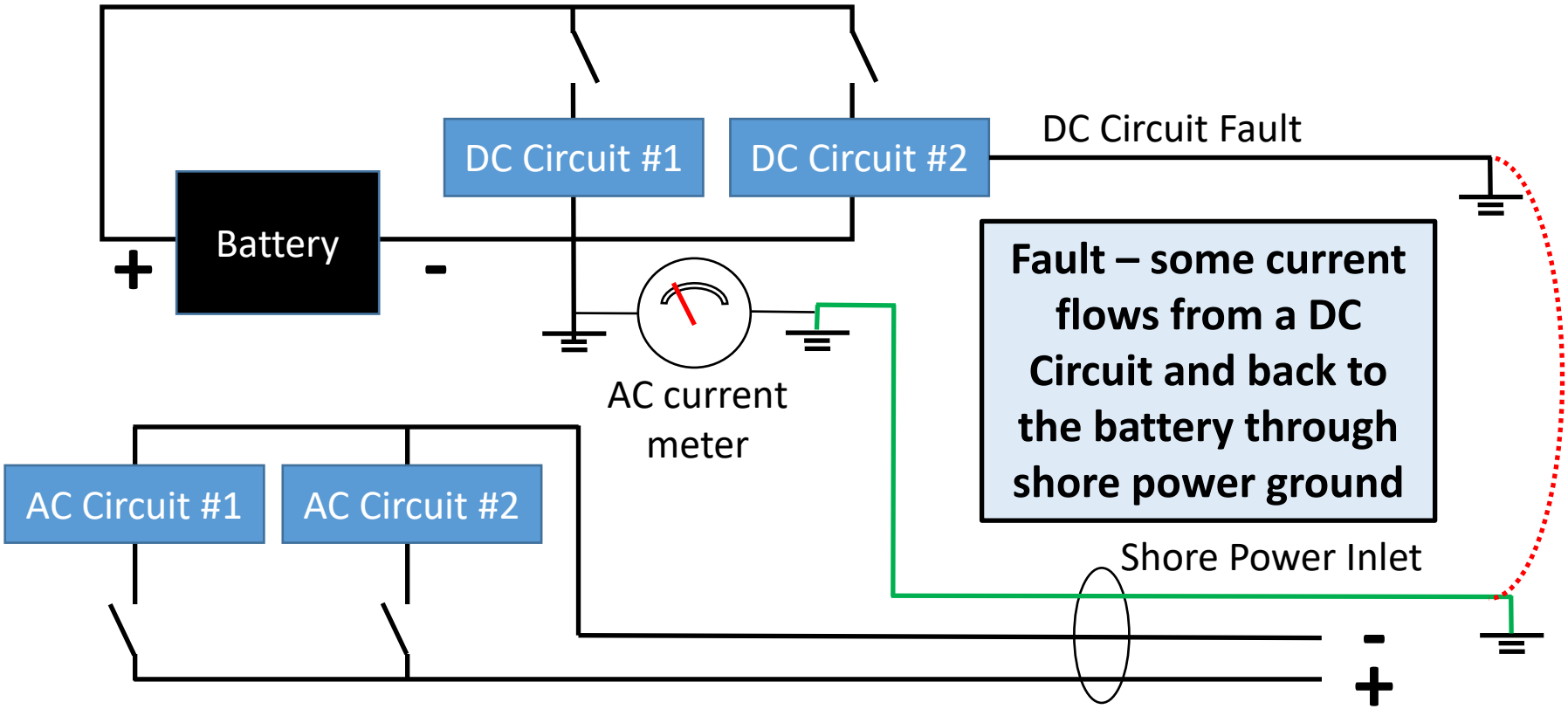


Testing for Stray AC Current

- USPS: use the same method as above (not sure)
- Prefer AC Clamp Meter test
  - All current in should come out
    - Zero reading expected
    - >0.1A = Not OK in fresh water
  - AC reading = leakage current
  - Activate all boat AC circuits

Testing for Stray Current in Standing Rigging

- Clamp meter test any piece of standing rigging
  - Either AC or DC meter settings
- Clamp meter test the VHF cable to the mast-top antenna
- Clamp meter test the wire bundle leading to and from the mast
  - Should get zero reading

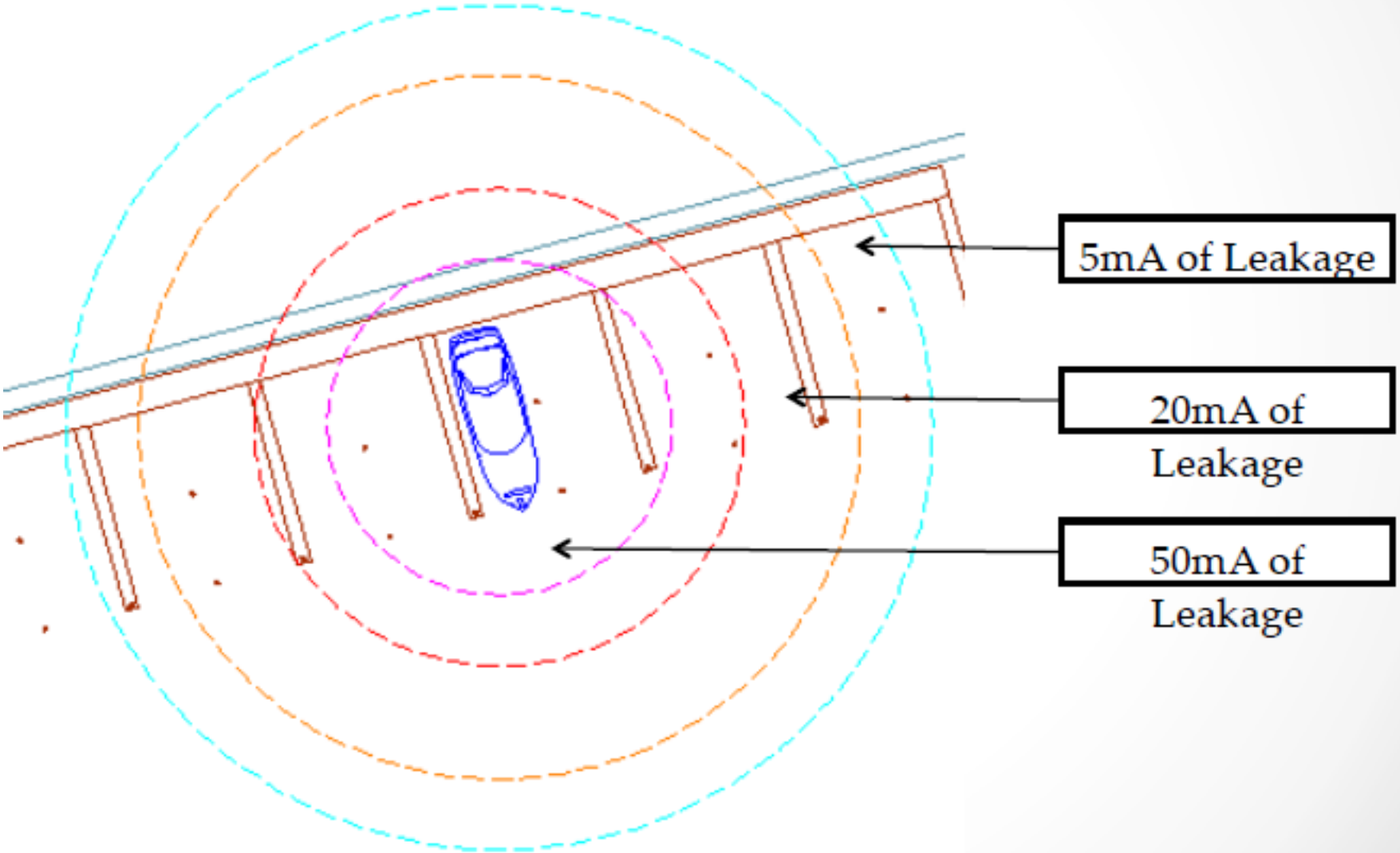
Testing for AC Stray Current

- USPS: use the same method as above (not sure)
- Prefer AC Clamp Meter test
  - All current in should come out
    - Zero reading expected

Why?

  - >0.1A = Not OK in fresh water
  - AC reading = leakage current
  - Activate all boat AC circuits

AC Stray Current & Electro-Shock Drowning



AC Stray Current & Electro-Shock Drowning

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

- Major concern in fresh water
  - Current will seek the lowest resistance path
  - Human body is lower resistance electrical path than fresh water
  - Human body is less conductive than salt water
  - Electro-Shock drowning nearly impossible in salt water, unless direct contact with current leak

Crevice Corrosion

- Crevices can form…
  - Under washers, dirt, gaskets
  - In crevices where moisture is trapped
- Especially relevant to stainless steel parts
  - Chain stays, buried “under deck”, are vulnerable
- Stainless requires oxygen for corrosion resistance
  - To maintain anti-corrosive chrome oxide layer

Electrical Safety - Fire

- Only 2.5% of Boat US insurance claims
  - One of the leading causes of boat loss
  - Fifth largest cost category – often total loss
- Top causes:
  - Off-boat sources
  - Old (>25 years) / chafed / faulty wiring
  - Improperly installed battery cables

  } Resistance = Heat = Fire
  - AC electrical components (AC, Microwave, etc)
  - Engine overheating (impeller / cooling water issues)
  - Old outboard engine voltage regulators

Electrical Safety – Fire – Best Practices

Electrical connectors and wiring odds and ends:

- Wing nuts are not good
- Nuts with lock washers are good
- Crimp connectors are good
  - Particularly with heat shrink and sealant
  - Wire nuts are no good
- Welding cable is no good – use marine stranded wire
- Tinned marine wire is good – the rest is no good – solid house wiring is no good
- Wire runs must be supported every 18 inches – why? – vibration
- Bilge pump wires – keep connectors out of the bilge water
- Good idea to inventory the entire electrical system
  - What fuses are where, get spares for at least critical equipment

Electrical Safety – Other Best Practices

- Inspect and clean electrical connections
  - Battery terminals and grounding terminals
- Running DC motors too long can cause heat = fire
  - DC bow thruster and anchor windlass motors
  - Run these motors when the engine is turning the alternator
- Your shore power cord
  - Plug it in BEFORE you turn the power on
  - Turn power off BEFORE you disconnect
  - Keep it out of the water, yes, even the cord
    - If the plug drops into salt water, rinse and dry with fresh water
  - Check cord heat while in operation, particularly in winter
  - Check burn marks around receptacle
  - Replace the electrical inlet fixture every 5 years

Corrosion & Electrical Safety – Summary

- Three types of corrosion
  - Galvanic – dissimilar metals – slow – sacrificial anodes
  - Stray Current – DC fast / AC slow – test / inspect / fix
  - Crevice – slow – cleaning & direct inspection

- Bonding systems and galvanic isolators or isolation transformers address most corrosion problems

- Proper wiring and inspection cure the rest
  - Perform AC and DC electrical system tests
  - If your boat leaks electricity – get it fixed

QUESTIONS?

References

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