ASSESSMENT OF HAZARDOUS VOLTAGE/CURRENT IN MARINAS, BOATYARDS AND FLOATING BUILDINGS

ACTIVITY SUMMARY

PREPARED BY C. GRANT, FPRF
6 NOVEMBER 2014

This is an Activity Summary for the research project on "Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings", and has been prepared in accordance with the Fire Protection Research Foundation (FPRF) "Research Foundation Policies for the Conduct of Research Projects" (available from the FPRF at www.nfpa.org/foundation).

The final report for this project is titled "Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings", and was authored by American Boat & Yacht Council Inc. This effort was funded by the following project sponsors: Attwood Marine; Eaton Corporation; Hubbell; Intertek; Leviton Manufacturing Company; NEMA Electrical Connector Section; and Underwriters Laboratories. The Fire Protection Research Foundation appreciates the guidance provided by the Project Technical Panelists, and all others that contributed to this research effort.

The following documents are included as part of this Activity Summary:

Attachment	Description	# of pages
A	Project Technical Panel Roster	1
B	Project Summary	2
C	Minutes of the Project Technical Panel Meeting on 14/Feb/2014	2
D	Minutes of the Project Technical Panel Meeting on 14/Mar/2014	2
E	Minutes of the Project Technical Panel Meeting on 24/Sep/2014	3
F	Panel Comments on Final Report	3
G	Contractor Responses on Panel Comments	4

THE FIRE PROTECTION RESEARCH FOUNDATION

Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings

PROJECT CONTACTS

Last Updated: 2 April 2014

Project Technical Panel

Ken Bush, Office of MD State Fire Marshal & Marina TC Chair (MD)	Phone: 410-822-7609 Email: Kenneth.bush@maryland.gov
Donny Cook, Shelby County & IAEI (AL)	Phone: 205-620-6650 x523 Email: dcook@shelbyal.com
Bill Drake, Power Products, LLC (CA)	Phone: 262-293-0605 Email: bill.drake@powerprodllc.com
Mark Earley, NFPA (MA)	Phone: 617-984-7400 Email: mwearley@nfpa.org
Michael Johnston, NECA & NEC TCC Chair (MD)	Phone: 301-215-4521 Email: mj@necanet.org
Carl Lynch, Reedy Creek Improvement District (FL)	Phone: 407-828-2047 Email: clynch@rcid.org
John McDevitt, Motorcraft TC Chair (PA)	Phone: 610-220-5619 Email: jmcdevittcaptain@aol.com
David Rifkin, Quality Marine Services LLC (FL)	Phone: 904-382-7868 Email: qualitymarinesvcs@comcast.net
Larry Russell, NFPA (MA)	Phone: 617-984-7499 Email: lrussell@NFPA.org

Project Sponsors

Paul Brazis, Underwriters Laboratories (IL)	Phone: Email: Paul.Brazis@ul.com
Steve Campolo, Leviton Manufacturing Co. (NY)	Phone: Email: scampolo@leviton.com
John Caskey, NEMA Electrical Connector Section (VA)	Phone: 703-841-3233 Email: John.Caskey@nema.org
Bill Fiske, Intertek (NY)	Phone: 607-758-6286 Email: bill.fiske@intertek.com
John Goodsell, Hubbell (CT)	Phone: 203-257-6870 Email: jgoodsel@hubbell.com
Robert Tate, Attwood Marine (MI)	Phone: Email: Robert.Tate@attwoodmarine.com
Christopher Walker, Eaton Corp. (PA)	Phone: 412-893-3793 Email: chrisgwalker@eaton.com

Other Project Contacts

John Adey, ABYC Foundation (MD)	Phone: 410-990-4460, x-117 Email: jadey@abycinc.org
Casey Grant, Fire Protection Research Foundation (MA)	Office: 617-984-7284; Cell: 617-594-1159 Email: cgrant@nfpa.org

THE FIRE PROTECTION RESEARCH FOUNDATION

Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings

PROJECT SUMMARY

18 December 2013

Background: The safety of electrical equipment installed and used in the vicinity of marinas, boatyards and floating buildings is a challenge. This typically requires designing, installing, operating and maintaining electrical equipment that balances inherently safe levels of equipment operation against nuisance interruptions of the applicable electrical infrastructure.

This electrical equipment is typically subjected to harsh environmental conditions that can result in deterioration and other long term maintenance concerns. Reports in the mainstream media of drowning in the vicinity of marinas, boatyards and floating buildings has raised question on possible shock hazards from nearby electrical equipment, and thus credible data is needed that clarifies the problem and provides guidance towards the most appropriate mitigation measures.

Research Goal: The goal of this project is to identify and summarize available information that clarifies the problem of hazardous voltage/current in marinas, boatyards and floating buildings, and to develop a mitigation strategy to address identified hazards.

Affected NFPA Documents: This project is directly applicable to NFPA 70, *National Electrical Code®* (2011 edition), Articles 553: *Floating Buildings* and Article 555: *Marinas and Boatyards*. It is also applicable to NFPA 303, *Fire Protection Standard for Marinas and Boatyards* (2011 edition), Chapter 5: *Electrical Wiring and Equipment*.

Project Tasks: Following the establishment of a Project Technical Panel of subject matter experts (in accordance with Foundation Policies) who will provide guidance during the study, the Foundation will seek a project contractor to conduct the study in accordance with the following tasks:

1) **Task 1: Review of Literature and Data Collection.** Conduct a comprehensive review of the literature and available data that addresses shock hazards in marinas, boatyards and floating buildings. This should have a primary focus on electrical leakage related issues, and have less emphasis on physiological issues. This should include the following based on addressing electrical shock hazards (in fixed installations influenced by water and related environmental conditions):

a) Review of published literature;
b) Identification and summation of systematic data collection studies (if any); and
c) Summation of documented case studies of noteworthy related incidents.

2) **Task 2: Identification of Available Technology.** Identify and categorize all known technological approaches used for addressing and handling electrical leakage concerns. Include a review of all related but different applications (to marinas, boatyards and floating buildings) yet different, such as the approaches taken in large commercial harbors/ports, permanently installed swimming pools, etc… Identify the performance characteristics of each approach, and the operational challenges of these characteristics (e.g., corrosion, temperature extremes, moisture, etc).
3) **Task 3: Technology Assessment.** Provide a full comparative assessment of all the positive and negative qualities of each identified technological approach. Consider all characteristics against the operational challenges.
4) **Task 4: Recommended Approach.** Analyze all information obtained and on the basis of an engineering evaluation provide recommendations for the optimum technological approach.
5) **Task 5: Final Report.** Generate a final report and disseminate this information to the applicable code making groups.

Implementation: This research program will be conducted under the auspices of the Fire Protection Research Foundation in accordance with Foundation Policies and will be guided by a Project Technical Panel who will provide input to the project, recommend contractor selection, review periodic reports of progress and research results, and review the final project report. The Panel will meet by teleconference periodically to review deliverables, provide input and assistance.

Schedule and Costs:

Literature Review & Data Collection:	Three Months after project initiation
Draft Final Report:	Five Months after project initiation
Final Report:	Six Months after project initiation

THE FIRE PROTECTION RESEARCH FOUNDATION

Assessment of Hazardous Voltage/Current
in Marinas, Boatyards and Floating Buildings

MEETING MINUTES

PROJECT TECHNICAL PANEL MEETING

CONFERENCE CALL

FRIDAY, 14 FEBRUARY 2014; 3:00 PM

1) Call to Order and Attendees. The meeting was called to order at 3:00 pm by Casey Grant of the Fire Protection Research Foundation. The following were in attendance:

- Ken Bush (Office of MD State Fire Marshal & Marina TC Chair)
- Steve Campolo, (Leviton Manufacturing Co.);
- Donny Cook (Shelby County & IAEI);
- Mark Earley (NFPA NEC Staff Liaison);
- Bill Fiske (Intertek);
- John Goodsell (Hubbell);
- Paul Orr (NEMA);
- Larry Russell (NFPA Marina Staff Liaison);
- Chris Walker (Eaton Corp); and
- Casey Grant (FPRF).

For reference, the updated Panel Roster is included herein as Attachment A, and the Project Summary is included as Attachment B. It was noted that several individuals were already recused from this conference call to avoid any possible perceived conflict of interest.

2) Introduction / Preliminaries. Casey Grant provided a brief overview of Fire Protection Research Foundation and the following re-cap of the Foundation Policies and Procedures (circulated earlier):

- In accordance with the Policies, the role of the Panel is advisory in nature and intended to provide guidance back to the contractor.
- The Panel will oversee the technical conduct of the project including recommendation of the contractor, progress reviews, and reviews of reports and other deliverables.
- Project sponsors (where applicable) are including as non-voting members of the Panel and are included in all discussions.
- Foundation makes the final decision on choosing the project contractor based on the Panel feedback.

- All reports are authored by the contractor.
- Once completed, all Foundation reports are made publically available.
- Project results and interim reports should not be issued prior to the completion of the final report without Foundation approval.

With regard to the meeting agenda, Casey pointed out that the primary purpose of this teleconference is to obtain a recommendation from the Panel to assist with the contractor selection for the project.

3) Review of Proposal(s) Submitted in Response to RFP. A summary of the RFP process was provided by FPRF staff and it was mentioned that the average number of proposals received in response to an RFP is typically around half dozen. In this case nine proposals were received. It was clarified that the proposals should be evaluated against one another as well as making sure that the top selection was responsive to the RFP. After further review and discussion, it was unanimously agreed the recommendation from the panel should be ABYC Foundation as the selected contractor. This was also confirmed as being responsive to the RFP.

4) Next Steps. The next steps will be for FPRF staff to notify the contractor and to hold a conference call in the coming weeks for the Panel to review a detailed work plan provided by the contractor. Casey Grant will make these arrangements, and this will be done soon knowing that the timetable for conducting the project will commence on or about 1 March 2014. Staff will provide the necessary call-in details and other applicable information at a later date.

5) Adjournment. Panel members were thanked for their participation, and the meeting adjourned at 3:40 pm.

(Meeting Summary by C. Grant, 24/February/2014)

Attachments

Attachment	Description	No. of Pages
A	Project Panel Roster	1
B	Project Summary	2

THE FIRE PROTECTION RESEARCH FOUNDATION

Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings

MEETING MINUTES

PROJECT TECHNICAL PANEL MEETING

CONFERENCE CALL

FRIDAY, 14 MARCH 2014; 11:00 AM

1) Call to Order and Attendees. The meeting was called to order at 11:00 am by Casey Grant of the Fire Protection Research Foundation. The following were in attendance:

John Adey (ABYC Foundation);
Richard Blackmon (ABYC Foundation);
Steve Campolo (Leviton Manufacturing);
Donny Cook (Shelby county & IAEI);
David Dini (UL);
Mark Earley (NFPA);
Bill Fiske (Intertek);
John Goodsell (Hubbell);
Carl Lynch (Reedy Creek Improvement District);
John McDevitt (Motorcraft TC Chair);
Paul Orr (NEMA Electrical Connector Section);
Kevin Ritz (ABYC Foundation);
David Rivkin (Quality Marine Services);
Robert Tate (Atwood Marine);
Christopher Walker (Eaton Corp); and
Casey Grant (FPRF).

For reference, the latest updated Panel Roster is included herein as Attachment A, and the latest Project Summary is included as Attachment B.

2) Introduction / Preliminaries. Casey Grant clarified that the agenda for the meeting is to review the project scope, tasks, timetable, and other pertinent project details. This is the Panel's opportunity to clarify direction on any details within the current project scope (per RFP and Project Summary), to provide emphasis on any details within the scope, and to capture feedback on any open questions. It was clarified that the role of the Panel is to provide guidance back to the contractor as he and his research team proceeds with the project, in accordance with the Foundation policies. Panel members were also reminded that at the conclusion of the project the final report will be posted and openly available.

3) Review of Project Details. John Adey led a review of the project using slides, and these are included herein as Attachment C. Discussion by the group resulted in the following comments and observations:

- The project start date is 1/March/2014.
- Both salt and fresh water applications will be addressed.
- The draft final reports is targeted for 150 days.
- An interim report will be circulated after tasks 1 & 2.
- The ABYC Foundation is providing in-kind support for this project.
- The Research Foundation will post the Project Summary on their website under "Current Projects".
- When the project is completed the ABYC Foundation will consider providing a webinar.
- The Electrical Safety Research Advisory Committee is planning to meet in Las Vegas on Sunday 8 June 2014, and a brief update on the project will be provided at that time.

4) Next Steps. The research team will proceed to address the project tasks and keep staff and the Panel updated as needed. At this time there is not a need to schedule a panel conference call until progress is achieved and substantial materials are developed. Thus, Staff will monitor progress and keep the Panel updated on the need for the next conference call, which will likely be in the summer of 2014.

5) Adjournment. Panel members were thanked for their participation, and the meeting adjourned at 12:00 pm Noon.

(Meeting Summary by C. Grant, 31/March/2014)

Attachments

Attachment	Description	No. of Pages
A	Project Panel Roster	1
B	Project Summary	2
C	PowerPoint Slides Summarizing the Project	2

THE FIRE PROTECTION RESEARCH FOUNDATION

Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings

MEETING MINUTES

PROJECT TECHNICAL PANEL MEETING

CONFERENCE CALL

WEDNESDAY, 24 SEPTEMBER 2014; 1:30 PM – 2:50 PM

1) Call to Order and Attendees. The meeting was called to order at 1:30 pm by Casey Grant of the Fire Protection Research Foundation. The following were in attendance:

John Adey (ABYC Foundation);
Paul Brazis (Underwriters Laboratories);
Ken Bush (Office of MD State Fire Marshal & Chair of NFPA TC on Marinas);
Steve Campolo (Leviton Manufacturing);
Donny Cook (Shelby county & IAEI);
Bill Daley (CED Technologies);
Mark Earley (NFPA Staff Liaison for NEC);
Bill Fiske (Intertek);
John Goodsell (Hubbell);
Brian Goodwin (ABYC Foundation);
Michael Johnston (NECA and NEC TCC Chair);
Ryan Kelly (CED Technologies);
Carl Lynch (Reedy Creek Improvement District);
Mark Noest (Leviton);
David Rifkin (Quality Marine Services);
Larry Russell, NFPA Staff Liaison for NFPA 302 and 303);
Robert Tate (Atwood Marine);
Christopher Walker (Eaton Corp);
Matt Wienold (ABYC Foundation); and
Casey Grant (FPRF).

2) Meeting Purpose and Agenda. For reference, the latest updated Panel roster is included herein as Attachment A. The purpose of the meeting (and meeting agenda) was indicated to provide a status update of the project and to clarify next steps. At this time we are approaching the end of this 6 month project, which has been funded

through a consortia of sponsors. Casey reminded the panel that their role is to provide advisory support to the project contractor and provide appropriate guidance.

<u>3) Review of Overall Project Status.</u> The research team from ABYC Foundation (led by John Adey) provided a review of the overall project status, using slides included herein as Attachment B. The following key points were provided:

- Have been focusing on dockside electrical faults (e.g., faulty installation, lack of maintenance, aging, etc.).
- A new observation is "phantom neutral current", which is assumed to be a by-product of the electrical delivery system.
- The approach that is evolving is to consider three possible options:
  - Warning system;
  - Ground fault breaker assembly, which would be strictly focused on difference of current (a.k.a., imbalance of current); and
  - Neutral blocker
- The trip levels are a key issue, and include the following considerations:
  - 30 mA maximum is suggested to align with other requirements (e.g., ABYC, ISO);
  - NEC Article 555.3 presently has 100 mA;
  - Residential already at 5 mA, though understandably a different application; and
  - Clarification needed if more enforcement is a possible option
- Each possible solution is being generically evaluated, with a rating criteria and score that will consider multiple factors (e.g., location, availability, etc.).
- An important consideration will be the differences in salt water versus fresh water installations, both in terms of the rigors of the exposure to equipment as well as the shock hazard.
  - Salt water may benefit from "warning" as well as a trip.
  - Brackish water needs special consideration, and will likely default to worse case.
- Another key consideration will be new versus existing installations, and to clarify if solutions will be able to address both needs.
- The draft recommendations, at this time, are:
  - 30 mA breaker at each pedestal;
  - 30 mA breaker at head of each dock or per XX slips;
  - Alarm in normally occupied location (e.g., dock master's office), possibly salt water only; and
  - Possible addition of a neutral blocker for the above

<u>4) Discussion of Project.</u> Based on the review of Project Status, the following observations and comments were provided by panel members during this project overview:

- The scope of this project is not limited to only technology-based solutions, and therefore non-technological options can also be included such as signage.
- Consider recommendations for signage (e.g., "stay out of the water").
- For the evaluation of each solution, make sure to remain generic and not to openly identify specific products
- Consider recommendations for possible solutions on-board boats.
- False alarm trips are a concern since nuisance trips will handicap widespread embracement of this approach.
- False alarm trips might also include the potential for liability, since a false trip that causes loss of power to a bilge pump can result in direct property loss.
- Anxious to review final draft report to prepare for possible NEC proposals.

<u>5) Next Steps.</u> The project will continue to address the various tasks for the project and finalize the draft final project report. There is a sense of urgency among some members to complete this effort prior to the upcoming 7/Nov/2014 NEC Proposal Closing Date, with the intent of providing at least a couple of weeks for interested panel members and others to submit applicable code changes to the NEC if they deemed it appropriate. The research team indicated they expect the draft final report to be finalized by 10/Oct, and will get it to the Panel as soon as

possible after that date. The draft final report will be circulated for review to the Panel members and the report and project will be finalized at that time.

6) Adjournment. Panel members were thanked for their participation, and the meeting adjourned at 2:50 pm.

(Meeting Summary by C. Grant, 31/March/2014)

Attachments

Attachment	Description	No. of Pages
A	Project Panel Roster	1
B	PowerPoint Slides Summarizing the Project	2

Summary of Comments from FPRF Panel
Assessment of Hazardous Voltage/Current in Marina's, Boatyards and Floating Buildings

Carl Lynch

First of all, I feel the report is very well done and provides great information, especially regarding realistic considerations such as usability and availability. I am somewhat concerned, however, regarding our last group discussion as it relates to stray neutral to ground currents. It was mentioned that stray neutral to ground currents presented a shock hazard even after a sense and trip device had been actuated. That concerned me during our discussion, but it appears according to page twelve of the report that stray neutral to ground currents do not pose a significant threat to swimmers. If that is in fact the case, then neutral blockers would not be a crucial part of the protection system. If that is not the case, however, then I feel that aspect of the study needs to be revisited.

David Rifkin

Here are some observations and considerations regarding the draft report. A few specific comments are also provided at the end.

The study eliminated consideration for protecting marina wiring for 2 reasons. First, it claims that only 10% of accidents/injuries (that they studied) occurred as a result of dock electrical problems. Our accident list shows that more accidents and injuries occurred from faults in dock wiring than faults from boats. Second it reports that the referenced USCG study only covered faults on boats, not docks. While this is true, it's also true that an energized dock ladder would behave identically to an energized stern drive or hull fitting on a boat. Based this type of similarity, I don't think a complete separate study is necessary in order to make recommendations about protecting dock wiring systems.

Keep in mind that the NFPA paragraph 555.3 (introduced in the 2011 NEC and what prompted the study) applies to marinas and boatyards. The boats themselves are just "appliances" which plug into the service. ABYC is on the forefront of electrical safety on the boat side of things by including ground fault protection for boats in their electrical standard. Limiting the study to the pedestal approach (point of boat service) limits the value of the study to marina operators, designers and installers. The pedestal approach was chosen because it represents the best way for operators to manage electrical faults from boats connected to the electrical service.

Second, there is another overall strategy that was not considered in the study. This strategy can be used to protect the entire marina while still allowing for effective management of electrical faults on boats. This strategy is used today in all hospitals and is included in the NEC 517.17 (health care facilities). It uses a "selective tripping" strategy, which would be perfect for the marina environment as well. A single boat fault wouldn't cause the main feeders to trip, but a fault between the main panel and the pedestal would still trip secure power to the affected area. Keep in mind that the majority of accidents/injuries occurs due to faults on the dock side of things.

The best overall approach would be to have the pedestal protection (as is analyzed in the study) along with protection on the feeders and main breakers. This would provide protection to all electrical wiring supplying boats and docks in the marina. Yes it would cost more than just pedestal protection, but the purpose of the study was to evaluate all the technology and strategies available. The marina builder or operator should be able to use the study to help them decide the manner in which they want to meet the standards. The study did not address or "score" this higher level of protection in the evaluation.

One reason for this omission may be a misnomer or misunderstanding as stated in the report. It implies that the NEC already requires ground fault protection on the main protection devices. In fact, it also allows solely using branch feeder or pedestal protection as an alternative. 555.3 quoted below for quick reference:

In my opinion, information on the limitations discussed above should be provided for the end users in the report, perhaps as a disclaimer or in the introduction. They should be aware that there are other strategies not covered by the study which can enhance electrical safety in marinas and boatyards. Operators and installers should not be led by the study to not consider protecting the whole marina electrical system. They should be made aware that the study was 2 limited to protecting only receptacles and the boats thereto attached (e.g. the study only covers the individual branch circuit as mentioned in paragraph 555.3 of the NEC).

For those choosing to only use pedestal-level protection, the study presents valuable guidance on the equipment available. Those considering a "whole marina approach" will have to look elsewhere for similar detailed equipment information for this protection strategy. It's very important that they understand that pedestal protection is not the only strategy to consider.

A few other comments below, along with those above, were provided to ABYC earlier in the week for consideration.

1. In the overview (page 1) it states that the human body has a much higher salinity than freshwater. Would be more precise to say that the body has a much lower resistance than freshwater. Most of the body's resistance is from the skin which is normally not associated with salinity in a liquid sense.

2. Overview (page 2) states that current theory suggests a 100ms trip. Can you provide a source for this trip level? Trip levels for protection are usually based on magnitude of current. For example, GFCI max trip time for a 30ma fault is about 0.6 seconds.

3. Overview (page 3) states that ABYC expects to prevent at least 95% of ESD incidents (with the 30ma trip). Since we don't know much about the levels of currents actually involved in most of the accidents, where did the 95% number come from? We do have data from the study, and this data suggest that it would take over 100ma to potentially get into lethal gradient area. Not necessarily disagreeing but was wondering what the basis for "95%" is.

4. On page 9 it states that "GFCIs are fail safe because they are powered by the circuit they protect". Actually they are powered by the circuit that supplies power to the GFCI, and not from the circuit they protect (which is downstream of the GFCI). GFCIs can fail but still supply power. Standards recently changed to require a failed self-test to trip the device (this was being debated and not sure when the exact language of the current standard has evolved to...).

5. On page 9 it states that GFCIs have variable response time up to 2 seconds. Actually it's up near 6.5 seconds for currents in the 5-6ma range. GFCI trip curve attached below.

Paul Brazis

As was requested by your email on October 14th, we are supplying comments regarding the ABYC draft report, “Assessment of Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings”. I would like to share feedback on behalf of myself and several of my colleagues at UL. This letter is a compilation of that feedback to the ABYC report.

The report suggests a fault trip threshold of 30 mA, which is indirectly based on a US Coast Guard (USCG) study which shows that a swimmer is exposed to only a fraction of the total fault current. This 30 mA threshold would be lower than the 100 mA threshold that is currently in Section 555 of the 2014 National Electrical Code (NEC), and therefore any reduction in this threshold is expected to be in support of public safety. However, evidence is lacking in whether this 30 mA limit is sufficient, and under what conditions such protection may be effective (the authors of the report state “95% effective” with no supporting evidence given) The introduction of a 30 mA protection requirement may cause confusion among different parts of the Code; for example, the current code language in 555.3 is distinctly different from 555.19(B)(1) in that 555.3 is ground fault protection while 555.19(B)(1) is Ground Fault Circuit Interrupter (GFCI) Protection for Personnel. It would be crucial to have included an analysis on how such confusion should be addressed by the NEC and manufacturers, and what impact enforcement of a 30 mA threshold may have on public safety and marina operations.

A large portion of the report is devoted to a grading methodology to evaluate several potential ground fault protection technologies that may or may not be available on the market. This evaluation masks the name and most details for these technologies, and assesses them with a largely subjective numbering system. It is unclear of the value of this analysis since the reader is unable to identify potential solutions that can be applied to mitigating electric shock drowning. Coupled with the conclusions in the report, it is not clear what action should or can be taken in response to this report.

In summary, the ABYC report is lacking in quantitative evidence or scientific analysis. The report lacks explicit citations to claims, with any scientific claims appearing to come from a single source (the USCG report). The analysis of technologies appears to be subjective. In our opinion it is unclear from this report what actions should be taken by industry or the NEC Code Making Panel 19 to address the serious safety issue of electrical shock in marinas.

Ken Bush

I have reviewed the reports from ABYC regarding in-water shock hazards and have no further comments at this time.

Comment Summary Form

Assessment of Hazardous Voltage/Current in Marina's, Boatyards and Floating Buildings

Name	Comment	Statement of Problem	Proposed Change	Action
David Rifkin	In the overview (page 1) it states that the human body has a much higher salinity than freshwater.	Most of the body's resistance is from the skin which is normally not associated with salinity in a liquid sense.	Would be more precise to say that the body has a much lower resistance than freshwater.	Accepted
David Rifkin	Overview (page 2) states that current theory suggests a 100ms trip	Can you provide a source for this trip level?	Trip levels for protection are usually based on magnitude of current. For example, GFCI max trip time for a 30ma fault is about 0.6 seconds.	Accepted
David Rifkin	Overview (page 3) states that ABYC expects to prevent at least 95% of ESD incidents (with the 30ma trip).	Since we don't know much about the levels of currents actually involved in most of the accidents, where did the 95% number come from?	We do have data from the study, and this data suggest that it would take over 100ma to potentially get into lethal gradient area. Not necessarily disagreeing but was wondering what the basis for "95%" is.	95% Removed, accepted.
David Rifkin	On page 9 it states that "GFCIs are fail safe" because they are powered by the circuit they protect".	Actually they are powered by the circuit that supplies power to the GFCI, and not from the circuit they protect (which is downstream of the GFCI).	GFCIs can fail but still supply power. Standards recently changed to require a failed self-test to trip the device (this was being debated and not sure when the exact language of the current standard has evolved to...).	Accepted, Statement removed
David Rifkin	On page 9 it states that GFCIs have variable response time up to 2 seconds		Actually it's up near 6.5 seconds for currents in the 5-6ma range.	Accepted in principle - Statement changed to the CT devices "researched".
David Rifkin	The study eliminated consideration for protecting marina wiring for 2 reasons.	*[See separate attachment with original comment submittal.]*	The best overall approach would be to have the pedestal protection (as is analyzed in the study) along with protection on the feeders and main breakers.	Rejected – The grantee believes that an additional study similar to the USCG study be done on the main feeder side to determine the parameters in which the device will be intended to perform and protect, prior to making a recommendation.
Carl Lynch	It was mentioned that stray neutral to ground currents presented a	It appears according to page twelve of the report that stray neutral to ground currents do not	If that is in fact the case, then neutral blockers would not	Accepted in Principle, the discussion on neutral blockers has been

Name	Comment	Statement of Problem	Proposed Change	Action
	shock hazard even after a sense and trip device had been actuated. That concerned me during our discussion	pose a significant threat to swimmers.	be a crucial part of the protection system. If that is not the case, however, then I feel that aspect of the study needs to be revisited.	removed. The concept ads no significant contribution to the goal of swimmer protection.
Paul Brazis	The report suggests a fault trip threshold of 30 mA, which is indirectly based on a US Coast Guard (USCG) study which shows that a swimmer is exposed to only a fraction of the total fault current. This 30 mA threshold would be lower than the 100 mA threshold that is currently in Section 555 of the 2014 National Electrical Code (NEC), and therefore any reduction in this threshold is expected to be in support of public safety.	Evidence is lacking in whether this 30 mA limit is sufficient, and under what conditions such protection may be effective (the authors of the report state "95% effective" with no supporting evidence given) The introduction of a 30 mA protection requirement may cause confusion among different parts of the Code; for example, the current code language in 555.3 is distinctly different from 555.19(B)(1) in that 555.3 is ground fault protection while 555.19(B)(1) is Ground Fault Circuit Interrupter (GFCI) Protection for Personnel. It would be crucial to have included an analysis on how such confusion should be addressed by the NEC and manufacturers, and what impact enforcement of a 30 mA threshold may have on public safety and marina operations.	*[See separate attachment with original comment submittal.]*	Rejected – 30mA protection is a proven concept in the EU market as well as on board boats in the US. The conclusion of the grant is such that the addition of 30mA protection at each pedestal in addition to an undetermined type of ground fault protection on the main feeder of a marina will result in a significant improvement in customer safety. A second research project must be undertaken to determine the type of protection needed on the main feeder. The group believes that this main feeder protection is necessary.
Paul Braziz	A large portion of the report is devoted to a grading methodology to evaluate several potential ground fault protection technologies that may or may not be available on the market. This evaluation masks the name and most details for these technologies, and assesses them with a largely subjective numbering system. It is unclear of the value of this analysis since the reader is unable to identify potential solutions that can be applied to mitigating electric shock drowning. Coupled with the conclusions in the report, it is not clear		In summary, the ABYC report is lacking in quantitative evidence or scientific analysis. The report lacks explicit citations to claims, with any scientific claims appearing to come from a single source (the USCG report). The analysis of technologies appears to be subjective. In our opinion it is unclear from this report what actions should be taken by industry or the NEC Code Making Panel 19 to address the serious safety issue of	ABYC is clearly recommending 30mA protection at the pedestal, as well as outlining further study needed for a recommendation on the marina main feeder.

Name	Comment	Statement of Problem	Proposed Change	Action
	what action should or can be taken in response to this report.		electrical shock in marinas.	
Charlie Game	Foreword. “floating buildings has raised”	Editorial: Revise grammar	“floating buildings have raised”	Accepted
Charlie Game	Overview. “…United States Coast Guard Office of Boating Safety grant…	Should include date	Include date of grant	Accepted
Charlie Game	Overview Page 2 “…allow swimming in their facilities.”	Inconclusive statement	“…allow swimming or wading in their facilities.”	Rejected – The concept of “No Swimming” is clearly represented
Charlie Game	Overview Page 2 “…no recreational swimming…”	Do not limit this to "recreational" swimming. Those working or diving can also be at risk.	Remove “recreational”	Accepted
Charlie Game	Overview Page 2 “…a fault within 100 ms…”	"In water" testing is needed to validate this.		Accepted in principle – comment refers to the existing ABYC E-11 Standard for confirmation of the 100mA level.
Charlie Game	Overview Page 2 “…U. S. Coast Guard studies have shown…”	Cite the name and date of this study.		Accepted
Charlie Game	Overview Page 3 “…prevent at least 95% of ESD…”	How was this number determined?		Accepted in Principle – Percentage has been removed.
Charlie Game	Results Page 3 “…neutral blocker,…”	Are there any known applications of this system (in service) for ESD mitigation? The January, 2013 IEEE paper by Lambert and Patel ("Boat Dock Exposure Voltage Mitigation") focuses mainly on reduction or elimination of neutral to water voltage at docks and not on mitigation of ESD hazards from "leakage current" emanating from boats..		The concept of the neutral blocker has been removed, as it does not offer a significant improvement over the 30 mA solution suggested.
Charlie Game	Results Page 4 “…Based on testing…”	Has there been in water testing in an actual marina using a simulated swimmer and an actual 30 Ma GFCI ?		Yes – See the USCG grant titled In-Water shock Hazard Mitigation Strategies, 2008
Charlie Game	Results Page 4 “…and analysis…”	Where is test data?		The criteria for each device discussed was derived from manufacturers published data.
Charlie Game	Results Page 4 “…then neutral blockers were not deemed to be an effective stand-alone protective technology…”	Before completely discarding the work presented in the January 2013 IEEE paper, the concept of employing a simple isolation transformer to establish a separately derived source for each slip should be considered further. If this concept is adopted the neutral blocker, primary and secondary GFP breakers, by- pass		Neutral blockers were removed from the report

Name	Comment	Statement of Problem	Proposed Change	Action
		breakers and other "extraneous" components can be eliminated, thus leaving little else but the isolation transformer. These few remaining components, including the transformer, are currently "off the shelf" items. In fact, the isolation transformer shown in the IEEE paper is an item in wide spread use in the construction of vessels found in marinas of the size and scope anticipated to be covered by this Report. They are UL Marine Listed and fully encapsulated; this type of component is certain to have a longer life than electronics in the anticipated environment.		
Charlie Game	Environment "…humidity, rain, and salt spray?..."	lightning, line voltage surges, RF interference.		Rejected - These items were not included in the original scope of work. Applicable standards for these types of devices are understood to contain testing for these items. Only items unique to the marina environment were researched here.
Charlie Game	Regulatory and Standards: "Does the device literature advertise compliance with marina regulations or standards?	As GFCI's have long been recognized as "Life Safety Equipment", these devices for ESD protection should meet the requirements of UL 943 Ground Fault Circuit Interrupters.		See Table 1 of report.
Charlie Game	Results Summary page 12: "…They shined most…"	Editorial - Grammar	"They excelled most…"	Accepted
Charlie Game	Separate Sensor Ground Fault Monitors page 15 "…Fault current is provided on…"	Editorial - Grammar	"Fault current is indicated on…"	Accepted
Charlie Game	Conclusions page 16: "…the standard of safety is indeed met…"	Has there been in-water testing in an actual marina using a simulated swimmer and an actual 30 Ma GFCI? If so, where is the data?		Yes – See the USCG grant titled In-Water shock Hazard Mitigation Strategies, 2008. A similar study is proposed on the main feeder, which has not been done.
Charlie Game	Conclusions page 16: "…requires 100mA protection for the main marina feeder…"	This is an unrealistic requirement in that such a device in the appropriate frame size generally is not available with integral GFCI.		The conclusion indicates that some type of main feeder protection is necessary, a future study will have to indicate what that may be.