Marina Shock Hazard Research Planning Workshop

PROCEEDINGS

HELD:

13 August 2015 in Baltimore, Maryland

PREPARED BY:

Casey C. Grant, P.E.

Fire Protection Research Foundation

Quincy, Massachusetts USA

RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

FIRE PROTECTION RESEARCH FOUNDATION

ONE BATTERMARCH PARK | QUINCY, MASSACHUSETTS, USA 02169-7471

E-MAIL: FOUNDATION@NFPA.ORG | WEB: WWW.NFPA.ORG/FOUNDATION

EXECUTIVE SUMMARY

These are the proceedings of a research planning session (a.k.a. workshop) to address "*Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings*". Reports in the mainstream media of Electric Shock Drowning (ESD), which can directly electrocute a swimmer in the water or cause a level of paralysis that ultimately results in drowning, is a concern in the vicinity of marinas, boatyards and floating buildings. How best to address this concern is the focus of this workshop.

The general desire by safety professionals to address this topic is not lacking, but rather the solution approaches are not obvious due to the technical and regulatory complexities that make this application particularly challenging. For example, electrical equipment in these applications are typically subjected to harsh conditions that can accelerate equipment degradation over time, and solution approaches are exacerbated due to factors such as different regulatory/enforcement realms for motorcraft versus marinas versus the shore-based infrastructure. The goal of the workshop is to address and clarify the research priorities for electrical applications involving marinas, boatyards and floating buildings.

The summary observations of these proceedings are organized into proposed solution approaches that are categorized as: (i) technical; (ii) awareness; and (iii) regulatory. These solution approaches are intended to provide useful information for directing future resources to efforts for preventing the occurrence of ESD events and mitigating their severity if they do occur.

ACKNOWLEDGEMENTS

The workshop has been made possible through support from the following:

Attwood Marine
Eaton Corporation
Hubbell
Intertek
Leviton Manufacturing Company
NEMA Electrical Connector Section
Underwriters Laboratories

This workshop summary report has been prepared by Casey Grant, Executive Director for the Fire Protection Research Foundation. The information contained herein is based on the input of numerous professionals and subject-matter-experts. While considerable effort has been taken to accurately document this input, the final interpretation of the information contained herein resides with the report author.

Photographs included in this report and not in PowerPoint slides were taken by Casey Grant, FPRF

About the Fire Protection Research Foundation

The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission. All NFPA codes and standards can be viewed online for free. NFPA's membership totals more than 65,000 individuals around the world.

Keywords: electric shock drowning, ESD, electricity, voltage current, marinas, boatyards, floating buildings, motorcraft, national electrical code, NEC, NFPA 70, NFPA 302, NFPA 303, research planning

TABLE OF CONTENTS

Executive Summary ii
Acknowledgements iii
Table of Contents iv
1. Background and Overview 1
2. Discussion on Needs 5
3. Summary Observations 9
Annex A: Workshop Participants and Attendees 13
Annex B: Workshop PowerPoint Slides: Overview 15
Annex C: Workshop PowerPoint Slides: NEC Implications 19
Annex D: Code Fund Request Form 27

1) BACKGROUND AND OVERVIEW

These are the proceedings of a research planning session (a.k.a. workshop) to address "*Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings*". This workshop was conducted on Thursday 13 August 2015, and held at the BWI Airport Marriott, 1743 West Nursery Road, Linthicum, Maryland.

Reports in the mainstream media of drowning in the vicinity of marinas, boatyards and floating buildings have raised questions on possible shock hazards from nearby electrical equipment. Of particular concern are incidents suspected of involving Electric Shock Drowning (ESD), which can directly electrocute a swimmer in the water or cause a level of paralysis that ultimately results in drowning. It is often difficult to link ESD to an incident due to multiple reasons, such as the transient nature of some electrical sources (e.g., from a boat, that relocates). Addressing this and related concerns are the primary focus of this workshop.

The safety of electrical equipment is a challenge when installed and used in the vicinity of marinas, boatyards and floating buildings. 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. Initial and on-going inspections as well as code enforcement likewise face special challenges due to factors such as the transitory existence of motorcraft and ultimate responsibility for the source of stray current from interconnected electrical equipment. The general desire by safety professionals to address this topic is not lacking, but rather the solution approaches are not obvious due to the technical and regulatory complexities that make this application particularly challenging.

To simplify the overall topic from a high level, the problem is the following: there is dangerous electric current in the water. The possible sources of this stray current are: Marina; Motorcraft; or Infrastructure. Thus the ultimate question is: What is lacking in the present safety approaches and infrastructure?

Figure 1: Typical Electrical Installation at a Marina

The goal of the workshop is to address and clarify the research priorities for electrical applications involving marinas, boatyards and floating buildings. Solution approaches are identified and reviewed with the intent to provide useful information for directing future resources to efforts for preventing the occurrence of ESD events and mitigating their severity if they do occur. The summary observations of these proceedings are organized into solution approaches that involve issues in one of the following three groups:

(i) Technical;
(ii) Awareness; and
(iii) Regulatory.

<u>Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings</u>

(Focused research planning meeting to address the remaining priorities for this specific application)

1. Background and Overview of Hazardous Voltage/Current in Marinas, Boatyards And Floating Buildings (10:00 am – 12:00 noon)
    a. Overview of Electric Shock Drowning (ESD) and Hazardous Voltage/Current
    b. Review of FPRF Report
    c. Codes and Standards Update
2. Discussion on "Needs for Research and Mitigation Strategies" (12:00 noon – 2:30 pm)
    a. Identification of new and additional research topics
    b. Identification of new and additional mitigation strategies
    c. Clarify the focus on priority topics
    d. Review of Priorities
3. Summary, Observations and Next Steps (2:30pm – 3:00 pm)

Figure 2: Workshop Agenda

The agenda for the workshop is shown in Figure 2. Thirty individuals participated representing the following professional communities: electrical, fire protection and safety, marinas, and motorcraft (boating). A summary of all the workshop participants is included in Annex A. The overall workshop was facilitated by Casey Grant of the Fire Protection Research Foundation, supported by Donny Cook, Chair of the FPRF Electrical Safety Research Advisory Committee. This was led using PowerPoint slides that are included in Annex B and Annex C.

Several model codes and standards are directly applicable to this topic, and they are monitoring this activity in pursuit of enhancements and revisions that are intended to prevent ESD occurrences and/or mitigate their severity if they do occur. These model codes and standards are important regulatory tools, and the most applicable for this particular application are:

- ABYC E-11, AC & DC Electrical Systems on Boats
- IEEE National Electrical Safety Code® (NESC®)
- ICC International Fire Code®
- NFPA 1, Fire Code
- NFPA 70, National Electrical Code® (NEC®)
- NFPA 70B, Recommended Practice for Electrical Equipment Maintenance
- NFPA 302, Fire Protection Standard for Pleasure and Commercial Motorcraft
- NFPA 303, Fire Protection Standard for Marinas and Boatyards

In support of the workshop, multiple handouts of background information were circulated beforehand and made available at the meeting. These are summarized for purposes of reference and are:

- November 2014 Fire Protection Research Foundation report, "Assessment of Hazardous Voltage/Current in Marinas, Boatyards, and Floating Buildings" co-authored by John Adey with ABYC Foundation and Bill Daley & Ryan Kelly with CED Technologies.
- October 2008 ABYC report "In-Water Shock Hazard Mitigation Strategies" on electric shock drowning coauthored by David Rifkin and James Shafer.
- May 2015 article in NFPA Journal titled "Troubled Waters" by Ashley Smith.
- November 2011 article in Marine Dock Age titled "Hot Boats: What Marinas Need to Know About the Dangers" by John McDevitt.
- May 2013 article in BoatingMag.com titled: "Does Death Lurk Below?", by Mike Telleria.
- Examples of State Legislative Activity relating to Hazardous Voltage/Current at Marinas, Boatyards and Floating Buildings, in Arkansas, Kentucky, Tennessee, and West Virginia.
- Website dedicated to addressing ESD: Electric Shock Drowning Prevention Association

2) Discussion on Needs

As attention is given to the safe use of electrical equipment in and around water oriented applications, professionals in the safety arena have been quick to agree on the need to maintain focused attention on ESD and address its inherent concerns. Rather, the challenge is what solution approaches are realistic, effective and achievable. The complexities of this topic suggest that a single, simple solution approach is not realistic, and multiple synergistic approaches will be required to make meaningful progress.

The overall topic of hazardous voltage/current in water-based applications like marinas, boatyards and floating buildings was discussed by the workshop attendees. This revealed certain concepts and methodologies that have been identified and documented in this section. This is in support of the overall workshop goal to address and clarify the research priorities for electrical applications in these settings.

A key reason why this overall topic is complicated is it involves three distinct realms of activity that arguably have equal share of the overall issue. These three realms of activity are: Marinas; Motorcraft; and Infrastructure. Marinas are intended to include boatyards and all facilities that are expressly designed to support motorcraft. Motorcraft are intended to include boats and other water-borne vessels that provide water based transport and come and go into and out of marinas and boatyards. Infrastructure is intended to include all the normal electrical service found in the built environment that supports the marinas and boatyards. The primary characteristics of this topic are illustrated in Figure 3.

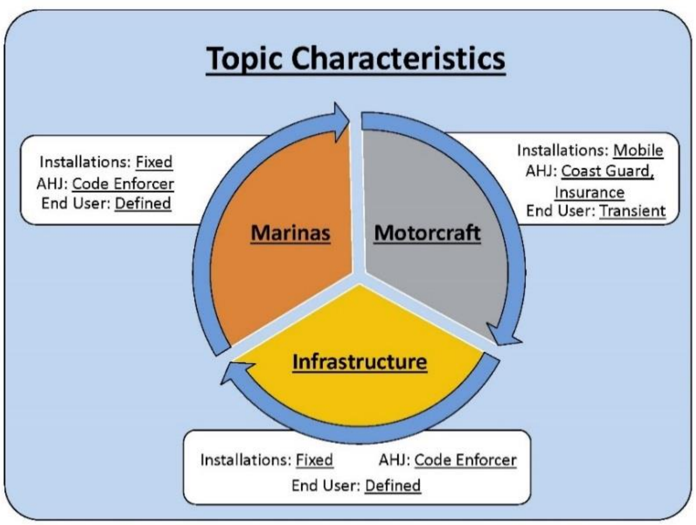


Figure 3: Topic Characteristics

The different characteristics of each of these three realms of activity help to understand the importance and complex interrelationship of the electrical equipment involved. The Marinas use electrical equipment that is generally in fixed locations, with end-use operators that are permanently located and well defined. The Authority Having Jurisdiction (AHJ) is normally the local code official. In contract, Motorcraft use electrical equipment that is mobile and can move from location to location, and similarly the boat owner/operator in more transient than for a fixed marina. The local code official generally has no authority on motorcraft, and the regulatory oversight is generally applied via the Coast Guard or by insurance companies. The Infrastructure is all the electrical equipment from the grid and beyond that supports the electrical equipment in the marinas. Similar to the marinas, the infrastructure uses electrical equipment that is generally in fixed locations, utilize end-use operators that are permanently located and well defined, and local code official serves as the AHJ.

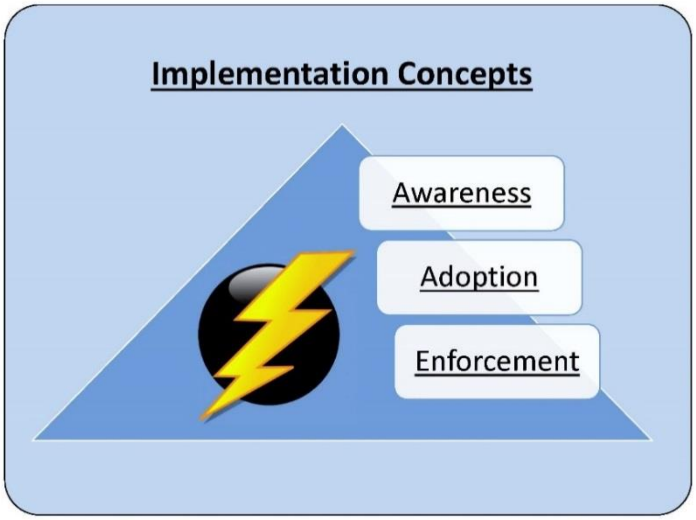


Figure 4: Implementation Concepts

Another concept that arose from the discussion was that there are multiple approaches for implementation, and these are referred to as Implementation Concepts. Three types evolved from this discussion, and these are: Awareness; Adoption; and Enforcement. These are illustrated in Figure 4, and each requires unique features depending on the realm of activities previously identified in Figure 3.

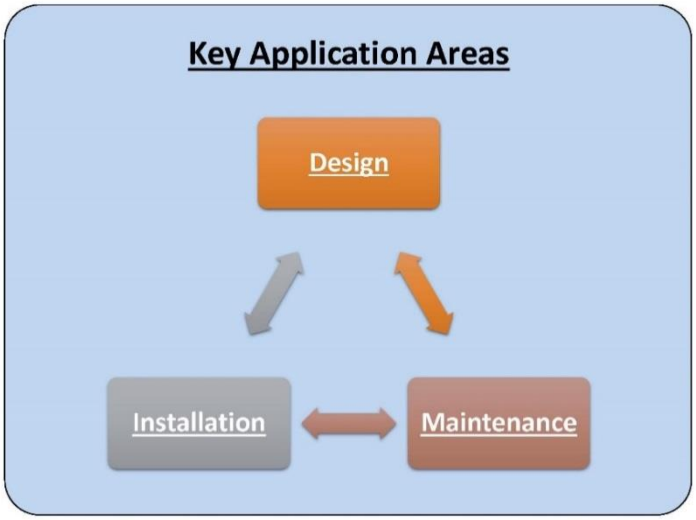


Figure 5: Key Application Areas

In similar fashion, discussion revealed the concept of three key application areas as: Design; Installation; and Maintenance. These are different from the realms of activity in Figure 3, and equally apply to each of these realms. The key application areas are illustrated in Figure 5.

The discussion of these conceptual elements forms the basis for the primary solution approaches. Multiple knowledge gaps and possible research projects were identified, and each falls into one of these three solution approaches. These are identified in Figure 6 and are: Technical; Awareness; and Regulatory.

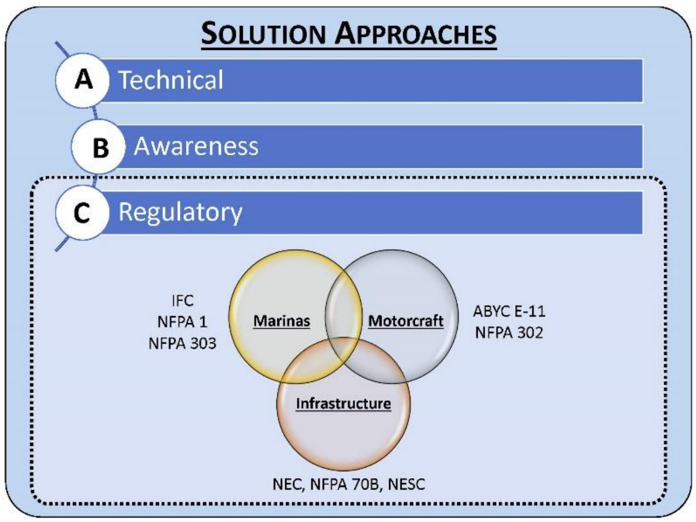


Figure 6: Solution Approaches

Figure 6 expands the Regulatory solution approach to clarify the model regulatory documents that apply in each of the three realms of activity identified earlier in Figure 3. Here, we see that for Marinas the key documents of interest are: NFPA 303, Fire Protection Standard for Marinas and Boatyards; NFPA 1, Fire Code; and the International Fire Code. For Motorcraft the applicable documents are: NFPA 302, Fire Protection Standard for Pleasure and Commercial Motorcraft; and ABYC E-11, “AC & DC Electrical Systems on Boats”. For the Infrastructure the primary documents are: the National Electrical Code (NEC); NFPA 70B, Recommended Practice for Electrical Equipment Maintenance; and the National Electrical Safety Code (NESC).

The scopes of these specific regulatory documents are important, as well as the level of their adoption and regulatory implementation. For example, some documents are focused on maintenance and re-inspection like NFPA 70B, while others only address new installations like the NEC. Some documents have scopes that narrowly define the applications they address, like the NESC focusing on the transmission of electricity by power plants through the grid to facilities. Further, some documents are less widely adopted by regulators like NFPA 70B, while others such as the NEC has significant regulatory impact as one of the world’s most widely adopted codes (e.g., used in virtually all 50 United States as well as multiple other countries). All of these factors add complexity to the proposed regulatory enhancements to address identified gaps to mitigate ESD, and suggest consideration of multiple solution approaches versus any single line of action.

Figure 7: Typical Electrical Installation at a Marina

3) SUMMARY OBSERVATIONS

The goal of the workshop has been to address and clarify the research priorities for electrical applications involving marinas, boatyards and floating buildings. The bottom-line intent is to provide useful information for directing future resources to efforts for preventing the occurrence of ESD events and mitigating their severity if they do occur.

Various research oriented efforts have been generated from the workshop discussions, and these are grouped according to the following three solution approaches: (i) technical; (ii) awareness; and (iii) regulatory. As certain proposed topics were identified, it was noted that some should be packaged using the FPRF Code Fund form for consideration as a potential research project. Anyone can submit these forms at any time, and a bland copy of the form is located in Annex D as well as at www.nfpa.org/CodeFund.

3.1) Summary Observations for "Technical" Solution Approaches

The Solution Approaches identified during the workshop that have been categorized as "Technical" include the following:

- Develop statistically valid data on currents (that expands on the 2008 study)
- Address the modeling of the person (different ages and gender) in the water, to investigate the behavior of the human body when it is subjected to electric fields. Due to the obvious difficulties in experimental verifications, such modeling may be carried out through numerical techniques, based on a mathematical representation of the human anatomy, which takes into account the boundaries of the internal organs.
- Identify and clarify the technical approaches in other parallel arenas, such as large shipping ports, military, IEEE applications, swimming pools, etc.
- Identify safe thresholds for emergency response to electrified water Injury (i.e., electric shock rescue), and establish the baseline criteria and approaches for ESD rescue.
- Conduct a hazard analysis that includes:
    - Defining the hazard,
    - Defining the appropriate levels of protection and strategies, and
    - Providing data for substantiation.
- Develop novel technologies and methods that would realistically enable field sensors and evaluation.
- Conduct field test evaluation in marinas that:
    - Establishes database(s)
    - Addresses ground fault detection devices
    - Clarifies leakage test of equipment
- Collect and analyze field data to clarify trip levels.
- Establish the basis for leakage current in marinas and motorcraft, with a focus on pre-event rather than post-event.
- Use modeling to establish device reliability for GFCIs (ground fault circuit interrupters) and RCDs (residual current devices) in marinas with harmonics.
- Define the threat level and clarify the appropriate levels and times for tripping electrical equipment.
- Consider technical solutions beyond only ground fault detection, which would not address other sources such as utility leakage.

- Clarify optimum location of ground fault equipment (e.g., branch circuits, feeder, receptacles, etc.)
- For ground fault protection, clarify the failure mode and default for safe levels. Also clarify the optimum levels, time, geometry, risk, etc. Consider approach with low level alarm and higher level trip.
- Consider a "transformer that isolates" (which is not the same as an isolation transformer). This would establish a new ground, and isolate the neutral. Consider for multiple transformers.
- Consider a "TN Island" that would create an island of loads. This would be transformer oriented and likely in the pedestals, and establish grounding of earth to grounding of the motorcraft.
- Establish the parameters for the design and development of a "marine grade" GFCI. This may be similar to the special purpose GFCI being considered by CMP-2.
- Consider an ECCI (Escaped Current Circuit Interrupter) approach. This would provide low-level fault detection and trip on any conductor imbalance.
- Clarify specific ground fault protection on the main, and necessary personal protection at the pedestal.
- Consider the inclusion of background currents for all research (or studies or measurements) of dangerous current levels and trip limits.

3.2) Summary Observations for "Awareness" Solution Approaches

The Solution Approaches identified during the workshop that have been categorized as "Awareness" include the following:

- Provide a policy focused report that clarifies the code enforcement landscape and also addresses the motivating political will among other motivating factors (e.g., insurance, litigation, consumer social media, etc.).
- Initiate a public safety campaign similar to other fire related and safety issues, such as fire prevention week, learn not to burn, stop, drop and roll, etc.
- Generate a white paper on marina safety to support public education efforts., which could ultimately reside as an annex in one of the applicable regulatory documents (e.g., NFPA 303)
- Collect and analyze data on ESD incidents, and expand on earlier summary of events from ESD Foundation.
- Clarify the need for tamper-resistant features to be balanced with public education.
- Clarify approach, content, and protocol for signage (e.g., no water entry including maintenance), and messages necessary for certain water entry (e.g., maintenance).
- Engage other key constituent groups and stakeholders in a public education campaign (e.g., marinas, insurers, Coast Guard, victim groups, maintainers, MMMA, AMI, marina designers, installers, enforcers, consumers, etc.
- Engage NFPA public education resources.
- Monitor and establish working relationships with other key constituents groups, such as the International Marina/Boatyard Conference.

3.3) Summary Observations for "Regulatory" Solution Approaches

The Solution Approaches identified during the workshop that have been categorized as "Regulatory" include the following:

- Identify and clarify the regulatory approaches in other parallel arenas, such as large shipping ports, military, IEEE applications, swimming pools, etc.
- Identify and coordinate all terminology and concepts used for electrical safety in the NEC and all other applicable documents.
- Generate summary of similar re-inspection and maintenance regulatory efforts (e.g., New Jersey approach to address swimming pools, etc.)
- Explore novel regulatory approaches that will promote re-inspections for these applications. In doing so, consider the following:
  - Philosophical approach of NFPA 3 Recommended Practice for Commissioning of Fire Protection and Life Safety Systems, which does not address electrical systems, implying that once they are in place they are okay forever (which is not necessarily true).
  - History that led to the development of NFPA 73, .Standard for Electrical Inspections for Existing Dwellings.
  - Model the requirements in NFPA 99, Health Care Facilities Code, on re-inspections.
- Conduct an "aging electrical equipment" research study for marinas and similar applications, similar to the earlier FPRF project that addressed this topic.
- Develop a scope coordination master plan for all the applicable regulatory documents, and clearly indicate who has responsibility for addressing/maintaining this topic, and include an outline of who will extract from who.
- Clarify regulatory oversight for all aspects of this issue, with consideration of ultimate goal of preventing ESD incidents.
- Develop adoption strategy for NFPA 303.
- Consider new on-site power generation sources, such as photovoltaic, wind turbines, and energy storage systems.

3.4) Solution Approach Priorities

As a final task for wrapping-up the workshop, attendees were asked to clarify the priority of key solution approaches they had identified in the preceding lists. One item received multiple indications as needing consideration, and this was the following Regulatory approach:

- Develop a scope coordination master plan for all the applicable regulatory documents, and clearly indicate who has responsibility for addressing/maintaining this topic, and include an outline of who will extract from who.

The following Technical approaches were indicated worthy of prioritization:

- Conduct field test evaluation in marinas by: establishing database(s), addressing ground fault detection devices, and clarifying leakage testing of equipment
- Define the threat level and clarify the appropriate levels and times for tripping electrical equipment.
- Address the modeling of the person in the water, to investigate the behavior of the human body when it is subjected to electric fields.
- Clarify specific ground fault protection on the main, and necessary personal protection at the pedestal.

The following Awareness approach was indicated worthy of prioritization:

- Initiate a public safety campaign similar to other fire related and safety issues, such as fire prevention week, learn not to burn, stop, drop and roll, etc.

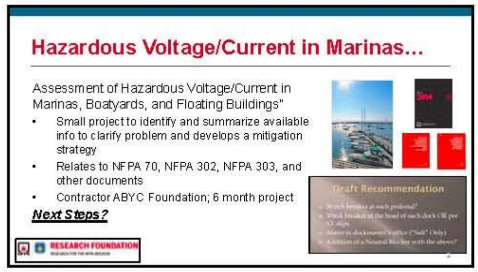
ANNEX A: WORKSHOP PARTICIPANTS AND ATTENDEES

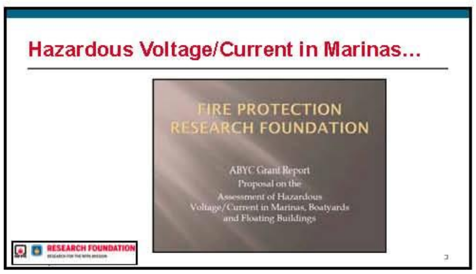
The following were the workshop attendees at the research planning session on "*Hazardous Voltage/Current in Marinas, Boatyards and Floating Buildings*", held in Linthicum, Maryland on Thursday 13 August 2015.

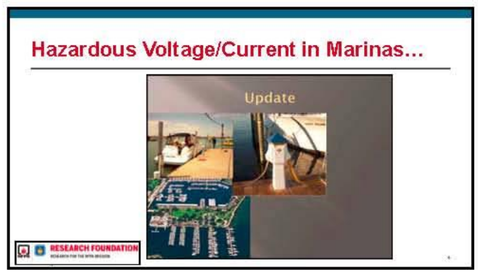
Randal Andress, Huntsville AL (call in)
Paul Brazis, UL LLC
Brett Brenner, ESFI (call in)
Ed Brill, SEA Ltd.
Larry Budd, Charles Marine
Ken Bush, MD SFMs Office & NFPA 303 Chair
Steve Campolo, Leviton (call in)
Ron Chilton, North Carolina DOI & CMP-19 Chair
Shane Clary, Bay Alarm Company (call in)
Donny Cook, IAEI
James Cote, Cote Marine
Gregory Davis, ESI
Mark Earley, NFPA
Lanny Floyd, Electrical Safety Group
Charlie Game, E. C. Game Engineering
Casey Grant, FPRF
John Goodsell, Hubbell
Palmer Hickman, IBEW
Ray Lauriello, Southern NJ Chapter of IAEI
Doug Lee, CPSC
Tim McClintock, NFPA
John McDevitt, MSFP & NFPA 302 Chair
Massimo Mitolo, ESI
Jim Rowland, South Jersey Electrical Inspectors Association
Larry Russell, NFPA
Jeff Sargent, NFPA
Terry Victor, Tyco / SimplexGrinnell
Wayne Waggoner, TN Fire Sprinkler Contractors Association (call in)
Chris Walker, Eaton
Donald Zipse, Electrical Forensic

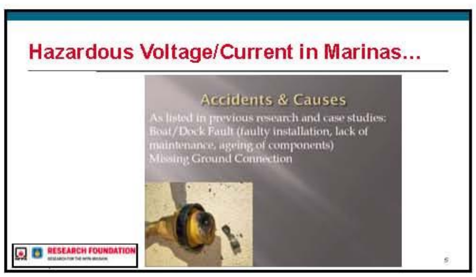
ANNEX B: WORKSHOP POWERPOINT SLIDES: OVERVIEW

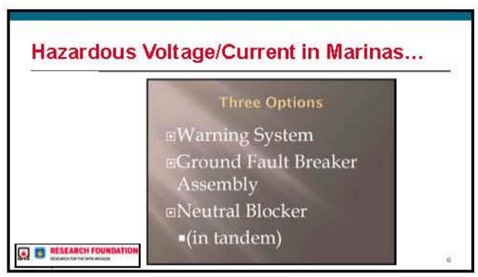
8/13/2015











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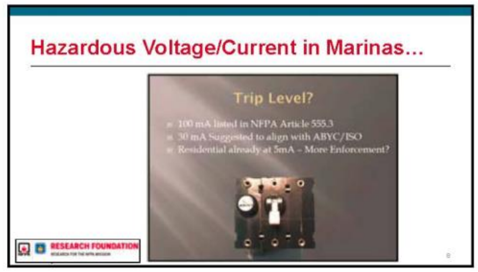
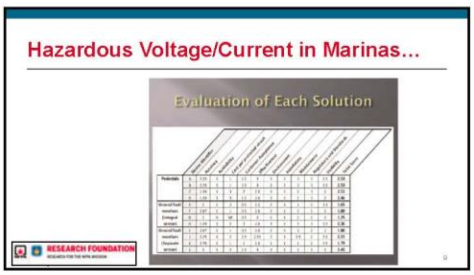
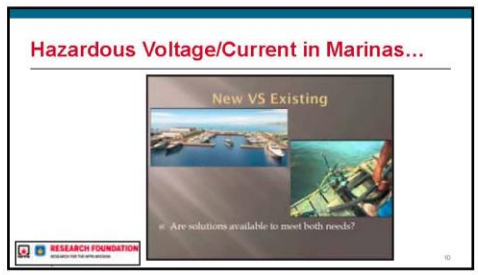
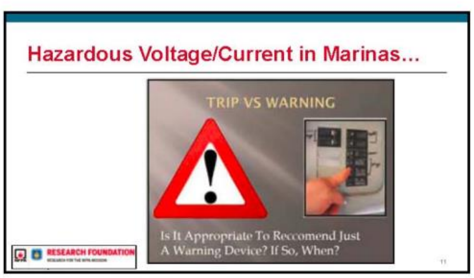
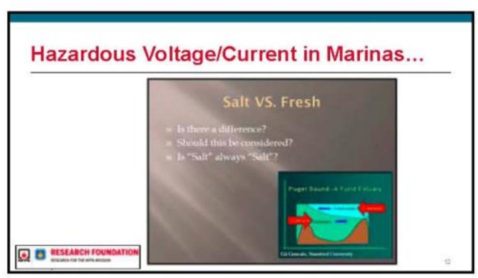
Annex B: Workshop PowerPoint Slides Overview (1 of 3)



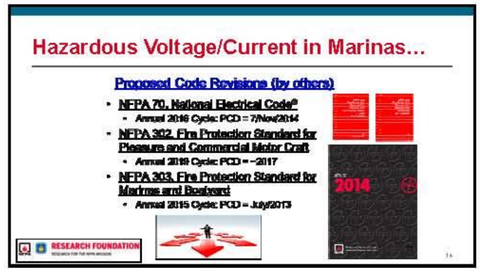








Annex B: Workshop PowerPoint Slides Overview (2 of 3)



Annex B: Workshop PowerPoint Slides Overview (3 of 3)

ANNEX C: WORKSHOP POWERPOINT SLIDES: NEC IMPLICATIONS

8/13/2015

Marinas

Tennessee

- Open Marina.
- NEC Articles 555 & 682.

Tennessee

- Open Marina.
- NEC Articles 555 & 682.

Tennessee

- Open Marina.
- NEC Articles 555 & 682.

Illinois

- Marina & Floating Building.
- NEC Articles 555, 553, & 682.

Illinois

- Open Marina.
- NEC Articles 555 & 682.

1

Annex C: Workshop PowerPoint Slides NEC Implications (1 of 8)

Illinois

- Open Marina.
- NEC Articles 555 & 682.

Florida

- Open Marina.
- NEC Articles 555 & 682.

Florida

- Open Marina.
- NEC Articles 555 & 682.

Florida

- Open Marina.
- NEC Articles 555 & 682.
- Building is in the water. Not sure if it is floating. Does it matter?

Massachusetts

- Open Marina with floating building on the pier.
- NEC Articles 555, 553 & 682.

Massachusetts

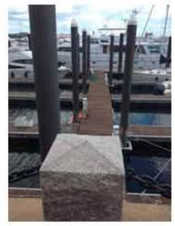
- Open Marina with floating building on the pier.
- NEC Articles 555, 553 & 682.

Annex C: Workshop PowerPoint Slides NEC Implications (2 of 8)

Massachusetts

- Open Marina with floating building on the pier.
- NEC Articles 555, 553 & 682.

Massachusetts



- Open Marina.
- NEC Articles 555 & 682.

Massachusetts

- Open Marina.
- NEC Articles 555 & 682.

California

- Pier.
- NEC Article 682.

California

- Pier.
- NEC Article 682.

California

- Marina.
- NEC Articles 555 & 682.

Annex C: Workshop PowerPoint Slides NEC Implications (3 of 8)

California

- Marina.
- NEC Articles 555 & 682.

California

- Marina & Building (Not floating, but does it matter).
- NEC Articles 555 & 682.

California

- Marina.
- NEC Articles 555 & 682.

Washington DC

- Marina.
- NEC Articles 555 & 682.

Alabama

- Marina & Floating Building.
- NEC Articles 555, 553, & 682.

Alabama

- Open Marina.
- NEC Articles 555 & 682.

Annex C: Workshop PowerPoint Slides NEC Implications (4 of 8)

Alabama

- Roofed Open Sided Marina.
- NEC Articles 555 & 682.

Alabama

- Marina/Pier & Floating Building.
- NEC Articles 555, 553, & 682.

Alabama

- Open Marina.
- NEC Articles 555 & 682.

Alabama

- Open Marina.
- NEC Articles 555 & 682.

Alabama

- Roofed Open Sided Marina.
- NEC Articles 555 & 682.

Alabama

- Open Marina with Fueling Dispenser.
- NEC Article 555, 514, & 682.

Annex C: Workshop PowerPoint Slides NEC Implications (5 of 8)

Alabama

- Residential Boathouses & Piers.
- NEC Articles 555? & 682, 210.8.

Alabama

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- NEC Articles 555? & 682, 210.8.

Annex C: Workshop PowerPoint Slides NEC Implications (6 of 8)

Alabama

- Residential Boathouses, Piers, & equipment (pumps, fountains, etc.)
- NEC Articles 555? & 682, 210.8.

Alabama

- Residential Boathouses, Piers, & equipment (pumps, fountains, etc.)
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Annex C: Workshop PowerPoint Slides NEC Implications (7 of 8)

NEC Text

210.8 Ground-Fault Circuit-Interrupter Protection for Personnel. Ground-fault circuit-interrupter protection for personnel shall be provided as required in 210.8(A) through (C). The ground-fault circuit-interrupter shall be installed in a readily accessible location.

Informational Note: See 215.9 for ground-fault circuit-interrupter protection for personnel on feeders.

(A) Dwelling Units. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in the locations specified in 210.8(A)(1) through (10) shall have ground-fault circuit-interrupter protection for personnel.

NEC Text

(3) Outdoors
(8) Boathouses

(B) Other Than Dwelling Units. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in the locations specified in 210.8(B)(1) through (8) shall have ground-fault circuit-interrupter protection for personnel.

(4) Outdoors

NEC Text

(C) Boat Hoists. GFCI protection shall be provided for outlets not exceeding 240 volts that supply boat hoists installed in dwelling unit locations.

NEC Text

ARTICLE 553
Floating Buildings

I. General

553.1 Scope. This article covers wiring, services, feeders, and grounding for floating buildings.

553.2 Definition.

Floating Building. A building unit, as defined in Article 100, that floats on water, is moored in a permanent location, and has a premises wiring system served through connection by permanent wiring to an electrical supply system not located on the premises.

NEC Text

ARTICLE 555
Marinas and Boatyards

555.1 Scope. This article covers the installation of wiring and equipment in the areas comprising fixed or floating

piers, wharves, docks, and other areas in marinas, boatyards, boat basins, boathouses, yacht clubs, boat condominiums, docking facilities associated with residential condominiums, any multiple docking facility, or similar occupancies, and facilities that are used, or intended for use, for the purpose of repair, berthing, launching, storage, or fueling of small craft and the moorage of floating buildings.

Private, noncommercial docking facilities constructed or occupied for the use of the owner or residents of the associated single-family dwelling are not covered by this article.

Informational Note: See NFPA 303-2011, *Fire Protection Standard for Marinas and Boatyards*, for additional information.

NEC Text

ARTICLE 682
Natural and Artificially Made Bodies of Water

I. General

682.1 Scope. This article applies to the installation of electrical wiring for, and equipment in and adjacent to, natural

or artificially made bodies of water not covered by other articles in this *Code*, such as but not limited to aeration ponds, fish farm ponds, storm retention basins, treatment ponds, irrigation (channels) facilities.

8

Annex C: Workshop PowerPoint Slides NEC Implications (8 of 8)

ANNEX D: CODE FUND REQUEST FORM

The following is the Code Fund Request Form (available at www.nfpa.org/CodeFund) used to package and consider projects by the Fire Protection Research Foundation:

Project Statement Form

Return to research@nfpa.org

Fire Protection Research Foundation, One Batterymarch Park, Quincy, MA 02169-7471

1) **Proposed Project Title:**

2) **Problem Statement (One or two sentences addressing "What is the research or data need?"):**

3) **Research Objective (One or two sentences addressing "What is needed to solve the problem?" Examples include: Develop guidance for a specific issue, Determine effectiveness of current code/standard requirement):**

4) **Project Description (One or two paragraphs on study design & expected tasks. Project tasks can include literature reviews, data collection, loss summaries, field usage surveys, code comparisons, statistical analysis, computer modeling, hazard analysis, risk assessments, fire testing, recommendation development, and gap identification.):**

5) **Data Collection (If data collection is part of the project scope, does data exist? If data exists, is it available to be used in the study? Please identify potential data sources.)**

6) **Relevant NFPA Document(s), Technical Groups, or Foundation strategic research agenda item & How Project Will Impact:**

7) **Organizations That Could Possibly Fund (Examples: government grants, industry consortia, stakeholders):**

8) **When Do You Need Project Deliverables (when is information needed to coordinate with document revision cycles, sense of urgency):**

9) **Submitted By (Staff Liaison/TC Chair/etc) and Date Submitted:**

Form Updated: 24 July 2015