IEEE Std 45.1 Update

IEEE ESTS 2023

Alexandria VA, August 1, 2023

Norbert Doerry and John Amy

Agenda

- Introduction to IEEE 45 series of standards
- IEEE 45.1 update project description and current status
- Major Changes
- Minor Changes
- Future Plans

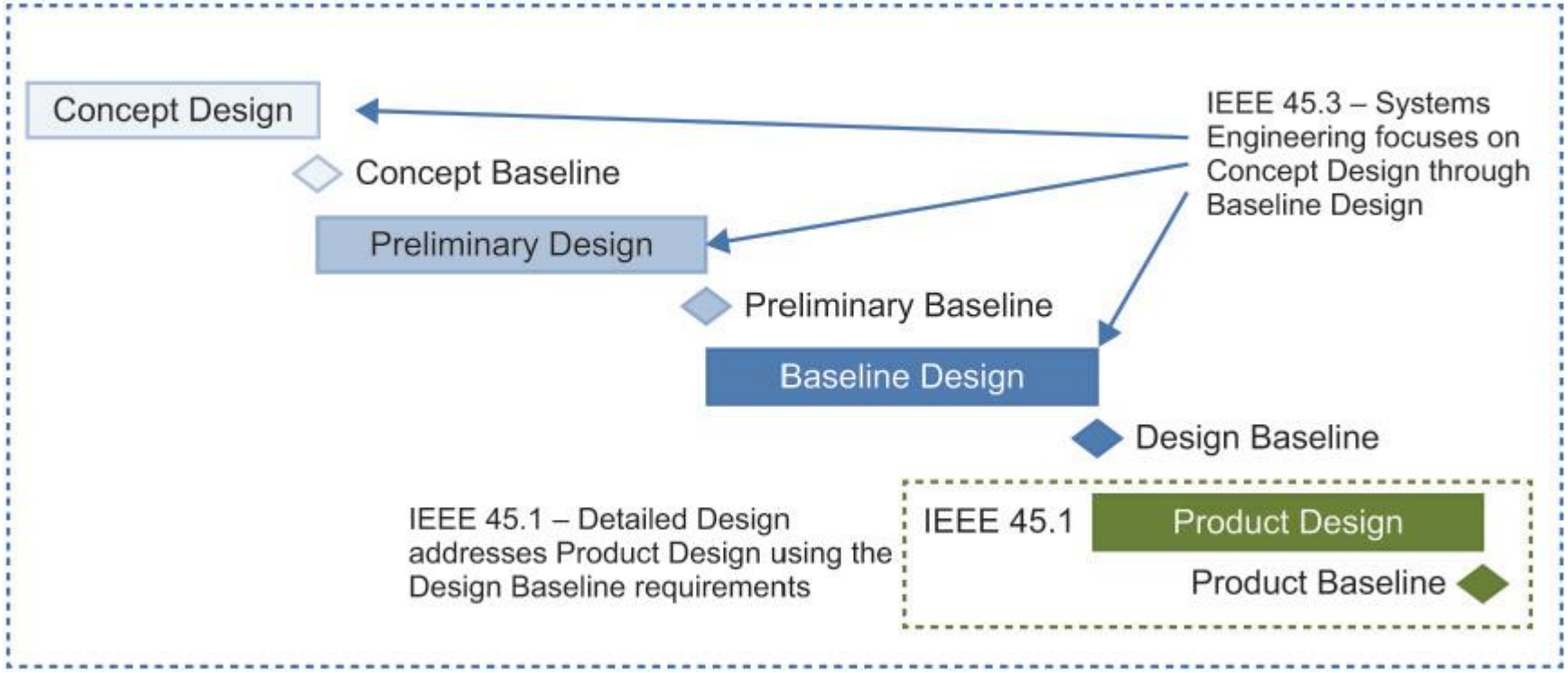
IEEE 45 Series of Standards:
Recommended Practice for Electrical Installations on Shipboard

- IEEE Std. 45.1-2017: Design (In Revision)
- IEEE Std. 45.2-2011: Controls and Automation (In Revision)
- IEEE Std. 45.3-2015: Systems Engineering
- IEEE Std. 45.4-2018: Marine Sectors and Mission Systems
- **IEEE Std. 45.5-2014: Safety Considerations**
- IEEE Std. 45.6-2016: Electrical Testing
- **IEEE Std. 45.7-2012: AC Switchboards**
- IEEE Std. 45.8-2016: Cable Systems

IEEE 45.1 Design

- IEEE Std 45.1 provides recommended practice for design recommendations for
  - ac power systems,
  - dc power systems,
  - emergency power systems,
  - shore power,
  - power quality and harmonics,
  - electric propulsion and maneuvering systems,
  - motors and drives,
  - thrusters,
  - steering systems installed shipboard
- IEEE Std 45. 1 is intended for use with the other IEEE Std 45 series of documents.
- IEEE Std 45.1 provides an effective set of integration requirements and identifies key issues and recommended solutions or options.

IEEE Std. 45.1 focus

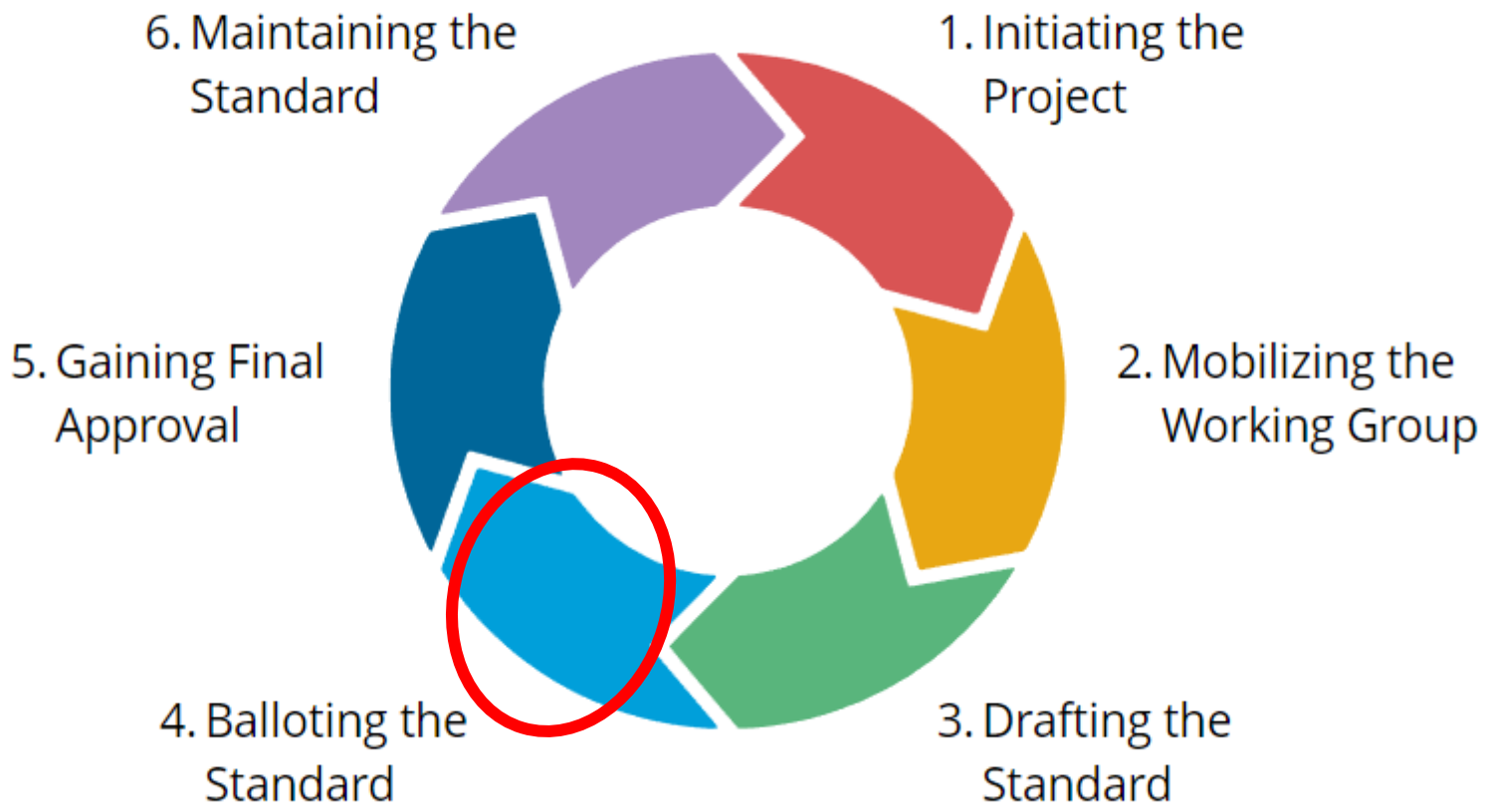


Need for update project (from the PAR)

- Although IEEE Std 45.1-2017 is only four years old, there has been tremendous advances in shipboard electrical power system technology.
- This revision intends to update recommended practices in areas such as
  - system studies,
  - Electric Power Load Analysis,
  - grounding methods,
  - common mode current control,
  - differential mode non-fundamental frequency current control,
  - variable speed drives, low voltage d.c. interface standards,
  - voltage drop calculations,
  - variable speed generator guidance,
  - Transformer guidance,
  - fault protection for power electronic based systems,
  - energy storage,
  - shore power,
  - creepage and clearance,
  - electric propulsion,
  - power hardware in the loop (PHIL) and control hardware in the loop (CHIL)
  - simulation,
  - insulated bus pipe / bus duct.

PAR = Project Authorization Request

IEEE Standards Development Process



P45.1 Working Group Officers

- P45.1 Working Group Chair:
  - Norbert Doerry (doerry@ieee.org)
- P45.1 Working Group Vice-Chair:
  - Bob Koebke (rkoebke@columbiagroup.com)
- P45.1 Working Group Secretary
  - John Prousalidis (jprousal@naval.ntua.gr)

IEEE 45 Working Group Chair: Dwight Alexander (DWIGHT.ALEXANDER@ngc.com)

IEEE Industry Applications Society/Petroleum & Chemical Industry(IAS/PCI)

Schedule

- Spring 2021: Identify need for update and develop PAR (Project Authorization Request)
- June 2021 – Sept 2021: PAR approval process
- Oct 2021 – Nov 2021: Develop list of candidate contributions
- Oct 2021 – Jan 2023: Develop draft sections (contributions)
- Jan 2023 – Feb 2023: Integrated Review
- Feb 2023 – April 2023: Mandatory Coordination – Form Balloting Group
  - Balloting Group Invitation (Feb 14 – Mar 15)
  - Concurrent Mandatory Coordination
- May 2023 – Sept 2023: Ballot
  - Formed Comment Resolution Group
  - 45 days initial Ballot (April 30 – June 14)
  - Comment resolution and recirculation
- Sept 2023 – Nov 2023: Publish

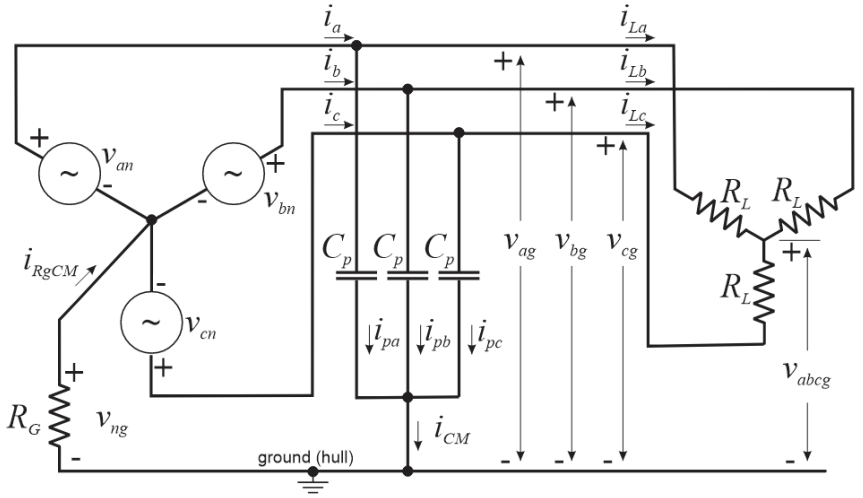
First Working Group Meeting: October 15, 2021 (1000 EDT) via Webex
Following Meetings: approximately every 2 weeks via Webex

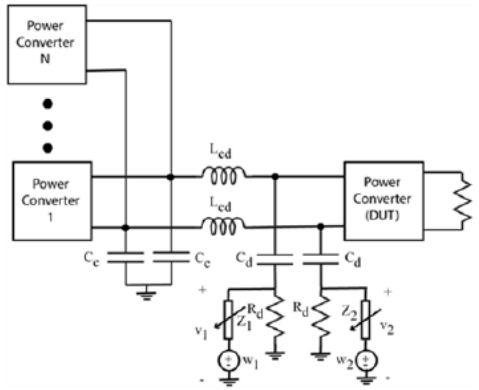
Major Changes

- Common Mode annexes
- Creepage and Clearance / Insulation System Guidance
- Voltage interface standards
- System Grounding
- Variable Frequency Drive (VFD) guidance
- Transformers
- Energy Storage
- Electric Propulsion
- Deletion of sections covered in other 45.x standards

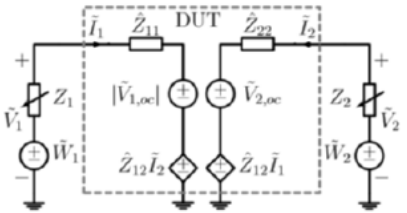
Common Mode Annexes

- Annex C: Common Mode Fundamentals (informative)
  - Provides basic concepts as applied to shipboard power systems
  - Provides list of references for additional information
- Annex D: Utilizing Thévenin Circuits for Common-Mode Evaluation of Power Electronic Systems (informative)
  - Provides overview of method for characterizing power system equipment to develop Thévenin circuit models
  - Provides overview of method to develop worst case Common Mode (and Differential Mode) behavior estimates
  - Provides list of references for additional information





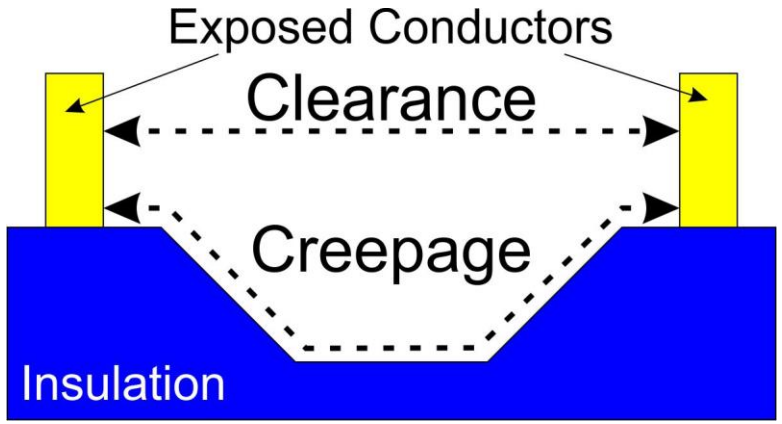
(a)



(b)

Creepage and Clearance / Insulation System

- New section 7.7 Insulation system design
  - Section 7.7.1 Creepage and Clearance
    - Identifies specific standards that should be consulted.
    - Identifies lack of appropriate standards for the shipboard environment for dc systems
  - Section 7.7.2 Coordinated Insulation Design
    - Identifies techniques to determine if existing insulation in equipment is adequate for the shipboard environment.
- Updated many individual equipment sections.
  - Fixed errors
  - Use of consistent language



Voltage interface standards

- Updated nominal system voltages
  - Deprecated 380 volts ac and 2400 volts ac
- AC power characteristics updated to reflect commercial practice as an alternate to Mil-STD-1399-300 interfaces
- Clearly defines reference values to apply percentages.

Table 2 —Alternating current (ac) power characteristics

Characteristics	Limits
Frequency	
a) Frequency tolerance	± 5%
b) Frequency transient:	
1) Frequency transient tolerance	± 10%
2) Frequency transient recovery time	5 s
c) Frequency modulation	
Voltage	
a) Voltage tolerance:	+6% / -10%
b) Voltage transient:	
1) Voltage transient tolerances	± 20%
2) Voltage transient recovery time	1.5 s
c) Line Voltage Unbalance (3 phase systems only)	3 %
Combined	
a) Sum of Frequency tolerance (%) and Voltage tolerance (%)	+6% / -10%

Characteristics	Limits
Voltage	
a) Steady state:	
1) Steady-state voltage tolerance (rms)	±1.5%
2) Steady-state voltage range (rms) (0 to rated power)	±4%
3) Steady-state voltage ripple (rms)	4%
3) Steady-state peak-to-peak voltage deviation	18%
b) Voltage transient:	
1) Voltage transient tolerance	± 20%
2) Voltage transient recovery time	1.5 s

System Grounding

- Additional Guidance
  - Grounding transformers
  - Grounding resistors
  - DC Blocking networks
  - DC grounding
- Improved drawings

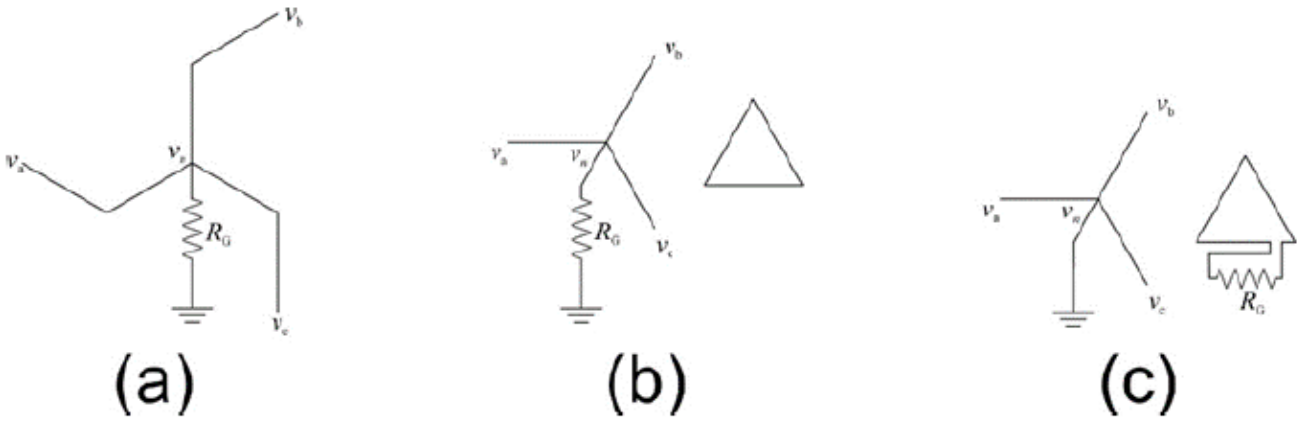


Figure 6—Grounding transformer configurations
(a) zig-zag transformer (b) wye-delta transformer (c) wye-broken-delta transformer

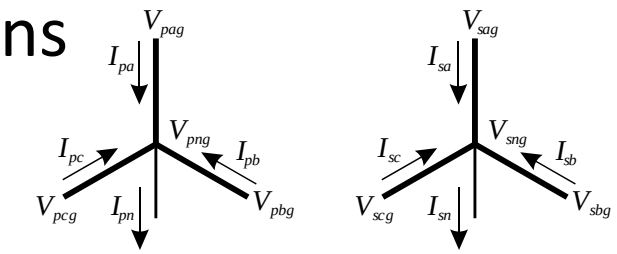
Variable Frequency Drives

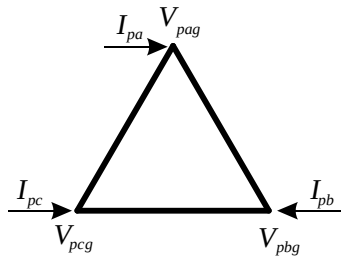
- Standardized on using the term Variable Frequency Drive
- Refers to IEEE 45.2 for smaller VFDs
- Highlights importance of grounding
- Incorporates coordinated insulation design and creepage and clearance.
- Addresses regeneration

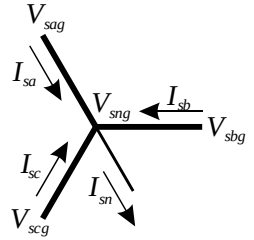
https://commons.wikimedia.org/wiki/File:Variable_frequency_drive.jpg

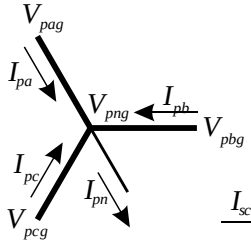
Transformers

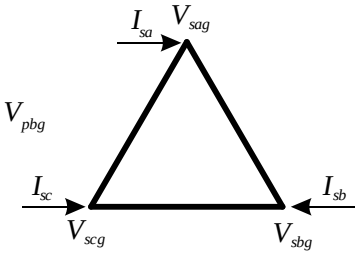
- Provides recommendations for different winding combinations
  - Wye-wye
  - Wye-delta
  - Delta-wye
  - Delta-delta
  - Multi-winding

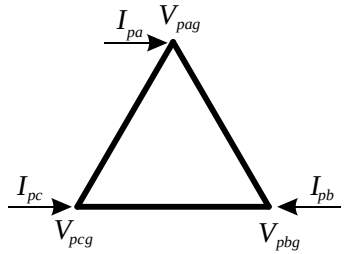


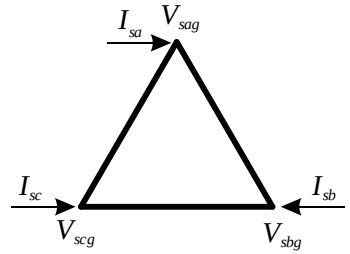












Energy Storage

- Energy storage had been focused on batteries (and mostly lead acid based)
- Added guidance for Flywheels
  - SAND2015-10759
  - DOE Energy Storage Handbook
- Added guidance for Supercapacitors
  - ABS Guide for Use of Supercapacitors in the Marine and Offshore Industries

https://upload.wikimedia.org/wikipedia/commons/2/22/Skeleton_Technologies_ultracapacitators.jpg

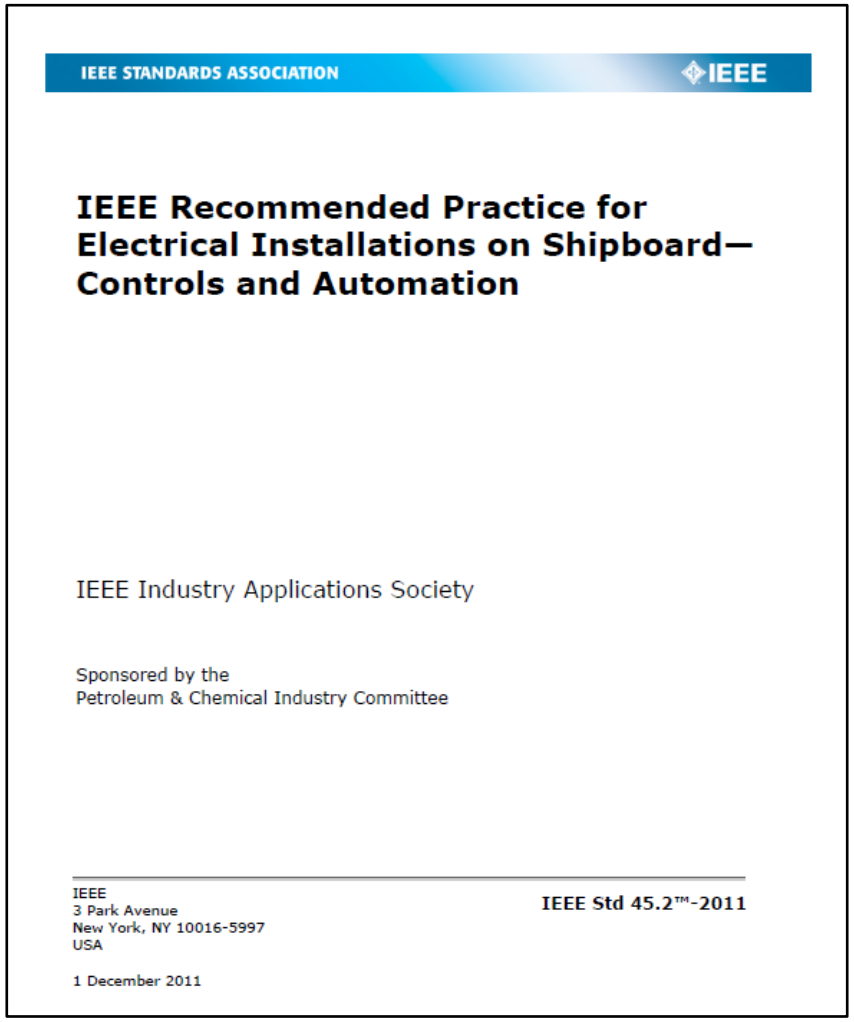
Electric Propulsion

- Changed focus from non-integrated electric drive to integrated electric drive
- Focus on propulsion motors and associated equipment

U.S. Navy photo by Chris Hatch

Deletion of sections covered in other 45.x standards

- Section 12 Electrical Power System Control
  - Largely eliminated (duplicative of IEEE Std. 45.2)
  - Renamed Voice Communications Systems (old 12.5)
- Various sections referencing controls have been modified to refer to IEEE 45.2 instead of providing guidance.
- Various sections references cables have been modified to refer to IEEE 45.8
- Various sections referencing testing have been modified to refer to IEEE 45.6


IEEE STANDARDS ASSOCIATION

IEEE

IEEE Recommended Practice for Electrical Installations on Shipboard—Controls and Automation

IEEE Industry Applications Society

Sponsored by the
Petroleum & Chemical Industry Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 45.2™-2011

1 December 2011

Minor Changes

- Updated referenced standards
- Added Autonomous and Remote control functions clause
- Added Design life and Removal Routes clause
- Added Fuel Cells clause
- Added Embarked vehicle power clause
- Deleted Semi-automatic navigation light panel figure from Section 17.13
- Modified clause 22, System Studies, analysis, and reports to only include requirements on the content and conduct of the studies / analysis and not invoke requirements on the system.
- Added electrical components clause 24.5 (under materials)
- Added section 29.5 for Total Waveform Distortion Measurements
- Added section 29.6 Cathodic Protection Sacrificial Anodes
- Broadened applications of EPLA in Annex B
- Added a nameplate clause 9.3.2 for Shore Power

Future Plans

- Quarterly Meetings
  - Identify topics for next revision – collect proposed “change packages”
  - Identify open questions
  - Track progress on open questions
  - Determine when an amendment or revision project should be initiated
- Example open questions
  - How should Common Mode current and voltage limits be established?
  - What are better sources of load factors for Electric Power Load Analysis?
  - Is there a better method for estimating electric load?
  - What guidance should be provided for fault protection design in power electronics based systems?
  - What guidance should be provided for insulated bus pipe and bus duct?
  - Should the guidance for emergency power be updated to reflect new technology?
  - What should the creepage and clearance requirements be for dc systems?
  - What additional guidance should be provided to assist in integration of energy storage?

Questions?

doerry@ieee.org