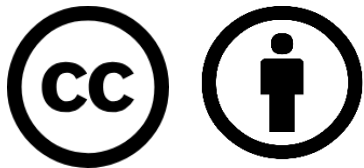


Cable, Bus Duct, and Bus Pipe Capacity Sizing

Electric Power Load Analysis (EPLA)

Revision of 6 May 2026

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<http://doerry.org/norbert/MarineElectricalPowerSystems/index.htm>

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Essential Questions

What determines the required ampacity of cable, bus duct, and bus pipe?	Understand
What are the factors that determine the ampacity of cables, bus duct, and bus pipe?	Understand
What are the impacts of non-fundamental frequency currents, installation details and ambient temperature on ampacity of cables, bus duct, and bus pipe?	Understand
How do bus pipe and bus duct installations differ from cable?	Understand
How can voltage drop calculations impact the size of cable, bus duct, and bus pipe?	Understand

Introduction

- Cables, bus duct, and bus pipe current rating (ampacity) is based on:
 - Limiting the temperature of the interface between the conductor and insulation to a value that enables insulation to achieve the stated design life.
 - Limiting the temperature of the outer surface to a value that is safe to touch.
- Voltage drop calculations may also impact cable selection
 - Long cables may result in voltage at load interface being outside of power quality requirements.
 - Typically mitigated by using a larger (greater ampacity) cable with lower impedance.



Cables on Emerald Princess (Photo by Norbert Doerry)



Insulated bus pipe cross section (Photo by Norbert Doerry)

Load analysis – Required ampacity

- Traditional load analysis
 - Assumes many loads where variation of the total load around the mean is small.
 - Usually applicable at the total ship level
 - Cables, bus duct, and bus pipe usually only serve a subset of the total load
 - The variation of the total load around the mean is relatively larger
 - Extended periods of time in an overload may result in insulation damage within the transformer
- Zonal load factor method (DPC 310-1)
 - Zonal load factors account for variability in the total load due to having non- constant power loads
 - Almost always results in a larger operating load as compared to the traditional load analysis
 - Reduces risk of overloading cables, bus duct, and bus pipe.
- Suse load flow or limiting load flow analysis to determine the worst case for bus-ties
 - Doerry, Norbert, "Shipboard power system limiting load flow and load flow analysis", IEEE ESTS 2025, Alexandria VA, August 5-8, 2025.

Margin and service life allowance

- Margin accounts for uncertainty in the operating load estimate during design and construction
 - IEEE Std 45.1 recommendation
 - Detail Design Margin: 5% for existing follow-on designs to 20% for new first-time designs
 - Construction Margin: 5% for existing follow-on designs to 20% for new first-time designs
- Service life allowance (SLA) accounts for growth in load while the ship is in-service
 - IEEE Std 45.1 recommendation
 - 20% (1% per year for 20 years)

Rated Ampacity

- Generally provided by manufacturer data sheets
- Naval cable data provided in MIL-HDBK-299
- Rated ampacity is based on
 - Ambient air temperature
 - Installation method (cable packing)
 - Presence of non-fundamental frequency current components

LSTSGU Cable Ampacity
(bold-red-italic values are estimated)

Type and Size	Conductor size	Ampacity (Maximum Rated Current) (50 °C) (kA)
LSTSGU-3	16 AWG (Class B)	0.010
LSTSGU-4	14 AWG (Class B)	0.017
LSTSGU-9	10 AWG (Class B)	0.036
LSTSGU-14	9 AWG (Class B)	0.047
LSTSGU-23	7 AWG (Class B)	0.064
LSTSGU-30	Navy Standard 30 (19)	<i>0.073</i>
LSTSGU-40	4 AWG (Class C)	<i>0.083</i>
LSTSGU-50	3 AWG (Class C)	0.101
LSTSGU-60	2 AWG (Class D)	<i>0.110</i>
LSTSGU-75	1 AWG (Class C)	0.136
LSTSGU-100	0 AWG (Class D)	0.160
LSTSGU-125	00 AWG (Class D)	<i>0.181</i>
LSTSGU-150	000 AWG (Class D)	0.216
LSTSGU-200	0000 AWG (Class D)	0.250
LSTSGU-250	250 MCM (Class C)	<i>0.282</i>
LSTSGU-300	300 MCM (Class D)	0.320
LSTSGU-350	350 MCM (Class D)	<i>0.361</i>
LSTSGU-400	Navy Standard 400 (127)	0.400

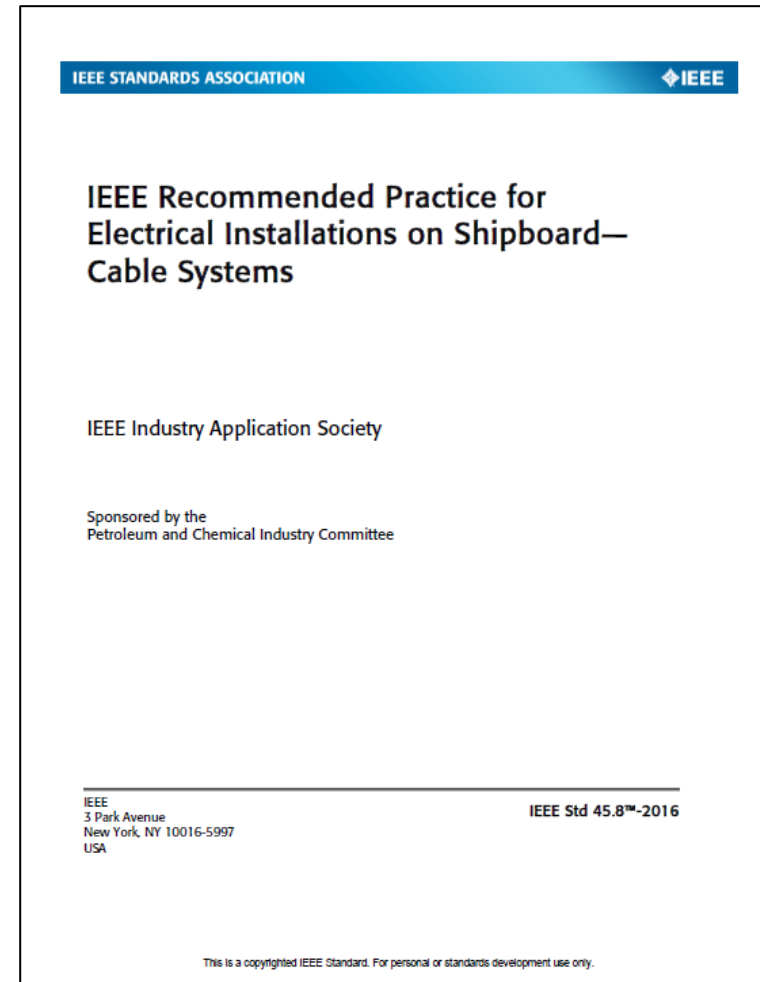
Doerry, Norbert, "Voltage Drop Calculations on Shipboard Power Systems", presented at 16th International Symposium on Practical Design of Ships and Other Floating Structures PRADS 2025, Ann Arbor, MI, USA, October 19th - 23rd 2025. (2025b)

Harmonic and common mode currents

- Harmonic and common mode currents create heat within the cable, bus duct, or bus pipe
 - Currents do not contribute to useful work
 - High Frequency current components concentrated on the outer edges of the conductor (skin effect) and experience a higher resistance that can increase heating,
- Manufacturer datasheets should be consulted to determine impact of non-fundamental frequency currents on the published rated ampacity of the cable

Ambient temperature adjustments

- IEEE Std 45.8 provides tables for adjusting the ampacity of a cable based on ambient temperature



Installation method adjustments

- Manufacturer's datasheets should specify the assumed installation method for the rated ampacity.
- IEEE Std. 45.8 describes process for adjusting the ampacity of a cable based on the installation method.
- Suggests following relative multipliers to the rated ampacity:
 - 1.0 Single banked, at least one cable diameter between adjacent cables
 - 0.85 Single banked, less than one cable diameter between adjacent cables
 - 0.68 Double banked, two layers of cables on the same cable tray

Cable on NS Savannah



Photo by Norbert Doerry

Voltage drop calculations

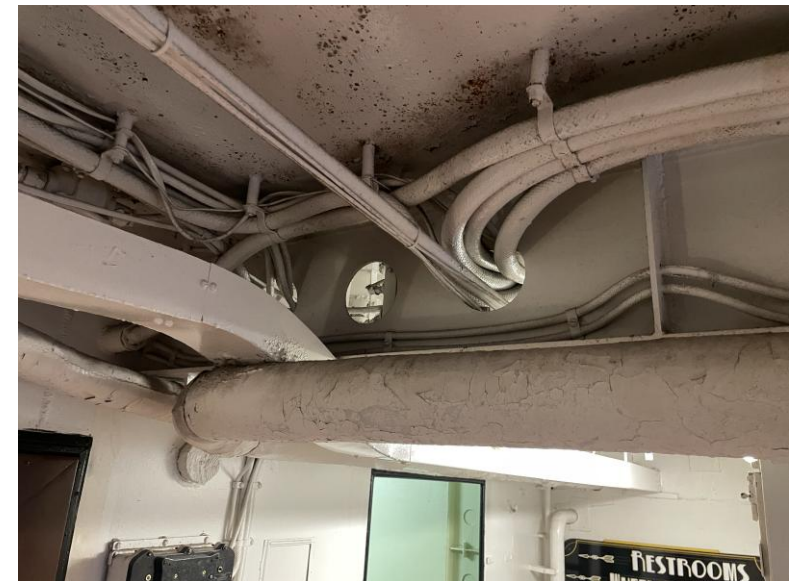
- Long cables may employ a larger (higher ampacity) conductor size to help ensure the voltage at the load remains within voltage interface standards
- Process for conducting voltage drop calculations described in:
 - Doerry, Norbert, "Voltage Drop Calculations on Shipboard Power Systems", presented at 16th International Symposium on Practical Design of Ships and Other Floating Structures PRADS 2025, Ann Arbor, MI, USA, October 19th - 23rd 2025.

Bus Pipe and Bus Duct vs Cable

- Maximum conductor size on cable usually limited by bend radius
 - Too large of a bend radius is impractical for shipboard arrangements.
 - Bend radius is typically on the order of 8 times the cable diameter
 - Most shipboard cables are less than 2.5 inches in diameter
- Bus pipe and bus duct use special fittings that enable a very small bend radius
 - Enables much higher ampacity
 - May eliminate need to externally parallel cables



Insulated bus pipe cross section (Photo by Norbert Doerry)



Cable on USS Alabama (BB-60) (Photo by Norbert Doerry)