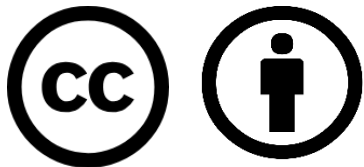


# Generator Capacity Sizing

## Electric Power Load Analysis (EPLA)

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

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# Essential Questions

What are the sources of requirements for determining the number and type of generator sets?	Remember
What are the requirements for determining the number and type of generator sets for IPS and non-IPS ships?	Understand
What other considerations are there for selecting generator sets?	Understand
What are the requirements for emergency generator sets?	Understand

# Sources of requirements

- 46 CFR 111.10 Coast Guard, Department of Homeland Security, Electrical Engineering, Electrical Systems – General Requirements.
- 46 CFR 112 Coast Guard, Department of Homeland Security, Electrical Engineering, Emergency Lighting and Power Systems.
- ABS Marine Vessel Rules
- IEEE Std 45.1, IEEE Recommended Practice for Electrical Installations on Shipboard—Design

# Basic Requirements

- Supply the maximum margined electric load with service life allowance.
- With the largest generator set out of service ...
  - Non-IPS ships: Supply the maximum margined electric load with service life allowance.
  - IPS ships: Supply the maximum margined ship service electric load with service life allowance plus sufficient propulsion power to achieve the smaller of one half the design speed or 7 knots. (IEEE Std 45.1)
  - Note: CFR requirements are stated somewhat differently

# Other considerations

- Commonality of generator sets
  - Try to keep the number of types to 1 or 2
  - Reduce logistics support and training requirements
  - Transient response of operating different types of generator sets should be performed
- Minimum loading of generator sets
  - Create a generator set scheduling table
  - Ensure complete range from minimum load (without SLA) to maximum (with SLA) can be supported without overloading or light loading any generator set
    - Most prime movers should not be operated for extended periods of time below a specified power level – typically 20% of its rating.
    - If light loading is unavoidable, then determine impact on operating and support costs.
  - Options to avoid light loading
    - Use an MTG /MDG (large generator set) with a lower rating and more ATG/ADG (smaller generator sets).
    - If allowed, use energy storage (ESM-F2 functionality) with a power rating equal to the ATG/ADG and operate with only a single generator set online.

# Other considerations (continued)

- Ability to evenly power main switchboards or buses in split plant
  - For IPS usually results in an even number of MTG/MDGs and ATG/ADGs
  - For non-IPS usually results in an odd number of generator sets
    - Requirement to supply load with largest generator set out of service
- Fault current
  - If largest generator set is greater than about 10 times the power rating of the smallest generator set, then smallest generator set's fault current may be less than the rated current of the largest generator set.
    - May preclude using traditional time-current based circuit breaker coordination
  - If high voltage to low voltage transformers employed, the fault current on the secondary of the transformer may be greater than circuit breakers can interrupt.
    - May require:
      - operating in split plant;
      - more, lower rated transformers;
      - isolating power electronic converters

# Other considerations (continued)

- Dynamic response of paralleled generator sets
  - Different generator sets will have different dynamic responses when subjected to disturbances.
  - If paralleled generator sets of different types are subjected to a disturbance, the resulting transient response may lead to one or both generator sets tripping offline.
  - May be addressed through
    - Advanced controls
    - Energy storage with ESM-F4 functionality

# Emergency Generators

- Supply power to the emergency switchboard.
- Prime mover must be either a diesel engine or gas turbine.
- Must start and power the emergency switchboard within 45 seconds.
- Rating normally no less than the connected load of the emergency loads.
  - Some ships use a standby generator as an emergency generator.
    - Requires robust and reliable load shedding with emergency loads the highest priority.
    - Standby generator should meet same requirements as emergency generator.
  - Rating can be less than the connected load of the emergency loads with sufficient analysis to indicate the rating of the emergency generator is sufficient.