Zonal Load Factor Analysis

Electric Power Load Analysis (EPLA)

Revision of 27 May 2026

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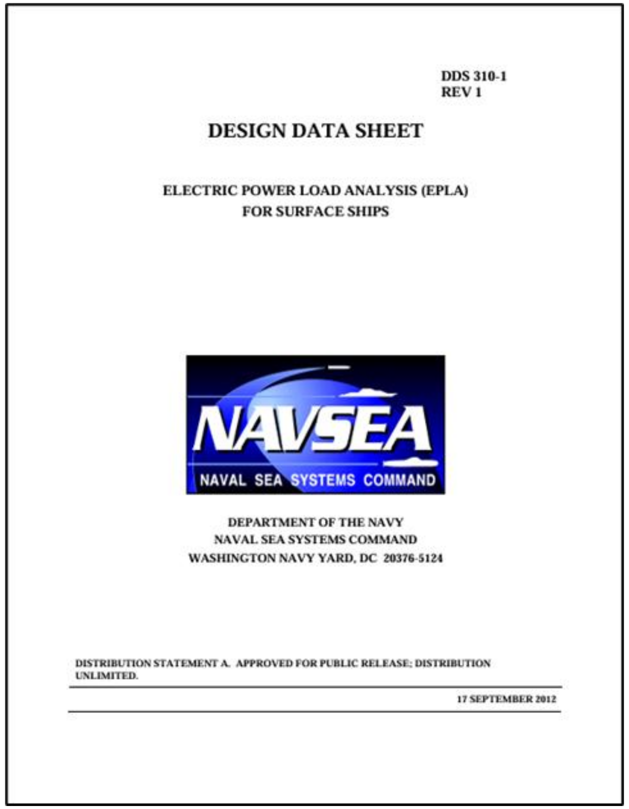
Essential Questions

What is the purpose of zonal load factor analysis?	Remember
How is the zonal load factor calculated?	Apply
How is the zonal load factor applied?	Apply

Zonal Load Factor Analysis

- With cycling or intermittent loads, load factor analysis (based on 24-average load) underestimates the required rating of power system equipment.
- Zonal load factors are modifications of the load factor for 24-hour average computations to account for additional capacity needed due to cycling loads
  - Does not impact load factors for constant power loads
  - Is not perfect
    - Can still under-estimate the required rating
    - Much closer than load factor analysis
- Process defined in DPC 310-1


DDS 310-1
REV 1

DESIGN DATA SHEET

ELECTRIC POWER LOAD ANALYSIS (EPLA)
FOR SURFACE SHIPS

NAVSEA
NAVAL SEA SYSTEMS COMMAND

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Zoal Load Factor analysis

- For each load determine …
  - Connected Load (kW)
  - Peak Load (kW)
  - Average Load (kW)
- 24-hour average load factor is average load divided by the connected load
- Calculate the zonal load factor for each load
- Calculate the zonal operating load for each load
  - Zonal load factor times the connected load
- Calculate the residual zonal power demand for each load
  - Peak load minus the zonal operating load
- Calculate the zonal total operating load
  - Sum of all the zonal operating loads plus the maximum residual zonal power demand
- Calculate zonal demand power
  - Apply margin and service life allowance (SLA)

Calculating Zonal Load Factor

- Based on relative magnitudes of other loads powered by the electrical system equipment

$$L_{fz_j} = L_{f_j} + \left(\frac{P_{P_j}}{P_{L_j}} - L_{f_j}\right)\left(\frac{P_{P_j}}{\sum_{i=1}^{n} L_{f_i} P_{L_i}}\right) \text{ for } \frac{P_{P_j}}{\sum_{i=1}^{n} L_{f_i} P_{L_i}} < 1.0$$

$$L_{fz_j} = \frac{P_{P_j}}{P_{L_j}} \text{ for } \frac{P_{P_j}}{\sum_{i=1}^{n} L_{f_i} P_{L_i}} \geq 1.0$$

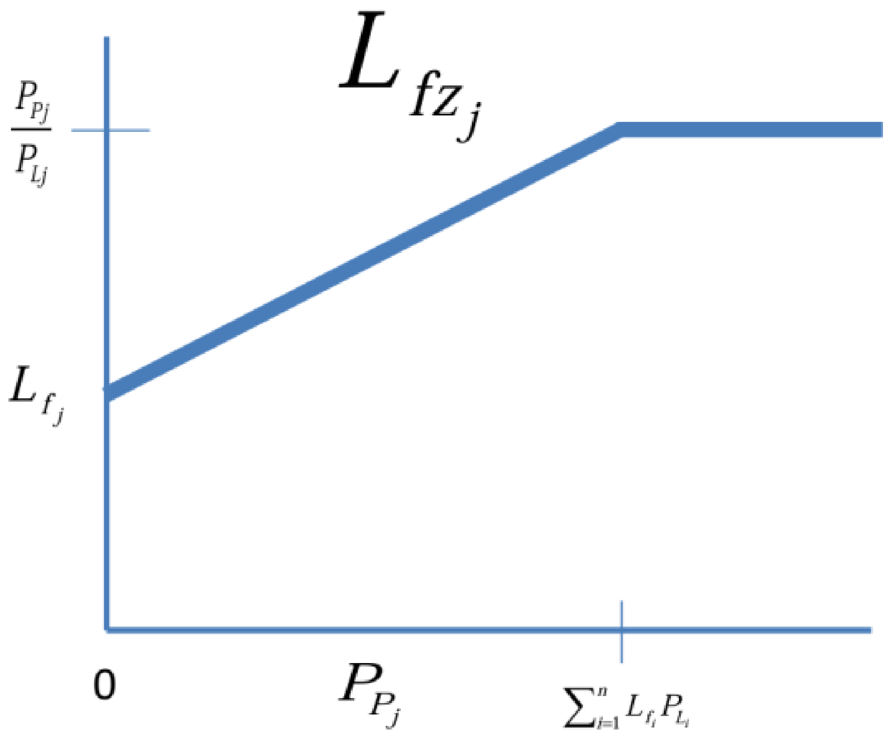
L_{fz_j} = Zonal load factor for load j

L_{f_j} = Load factor for load j for 24-hour average calculations

P_{L_j} = Connected Load (kW) for load j

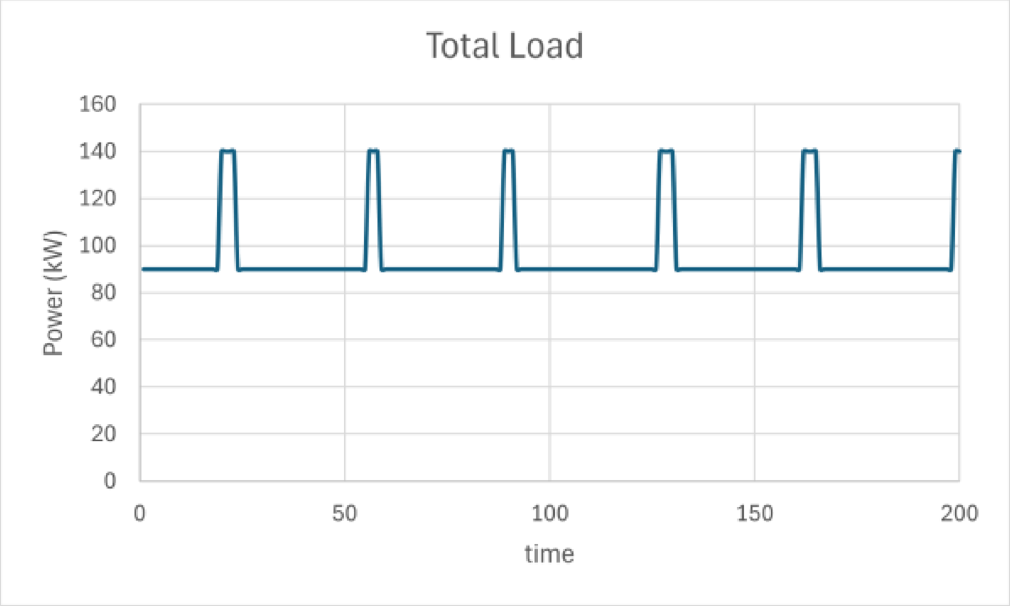
P_{P_j} = Peak Load (kW) for load j

n = Number of loads



Example 1

- 9 constant power loads (10 kW each) and one cycling load
  - Peak value 50 kW
  - On time between 3 and 4 time units
  - Off time between 27 and 36 time units
- Average value of total load is 95 kW
- Peak value of total load is 140 kW
- Load factor for 24 hour calculations
  - Constant power loads = 1.0
  - Cycling Load = 0.10
- Zonal load factor
  - Constant power loads → $L_{fz_j} = 1 + (1-1)\left(\frac{10}{95}\right) = 1$
  - Cycling load → $L_{fz_j} = 0.10 + (1-0.10)\left(\frac{50}{95}\right) = 0.574$
- Zonal operating load
  - Constant power loads = 10 kW
  - Cycling load = 0.574 × 50 = 28.7 kW
- Residual zonal power demand
  - Constant power load = 0 kW
  - Cycling load = 50 – 28.7 = 21.3 kW
- Zonal total operating load
  - 9 × 10 + 28.7 + 21.3 = 140 kW.



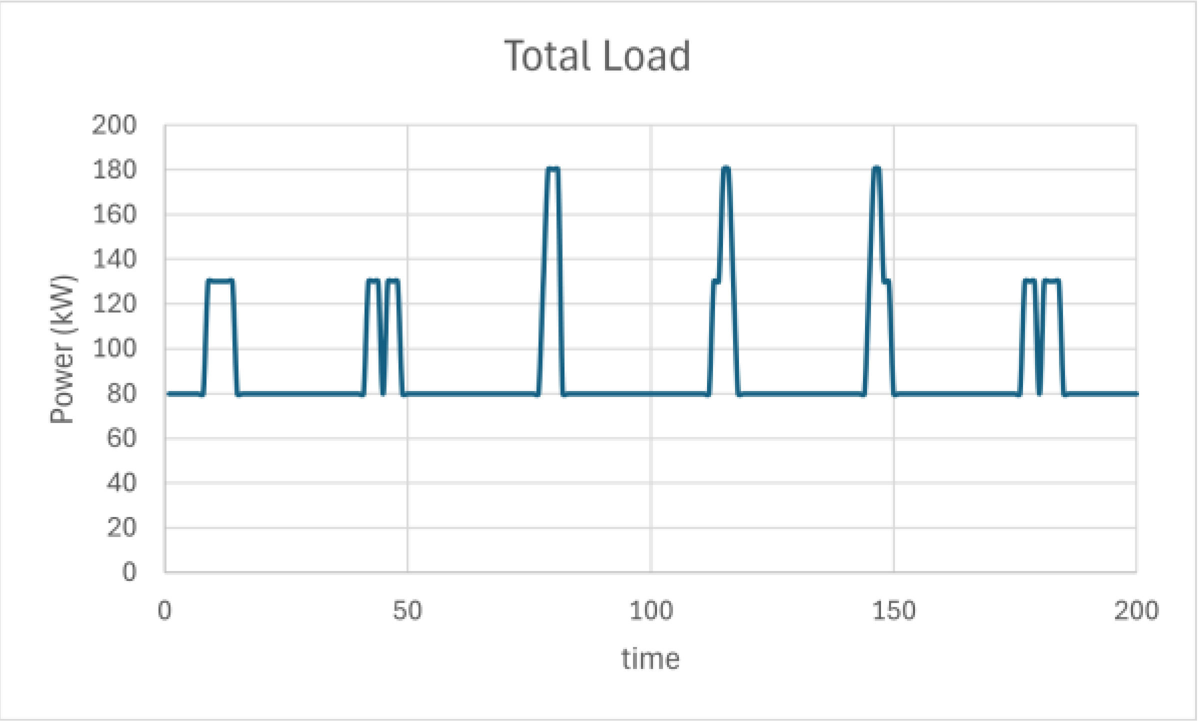
- Using Average Value of 95 kW will likely lead to undersized power system equipment.
- Using Zonal total operating load of 140 kW helps ensure equipment will not be overloaded.
- Must still apply margin and SLA.

Example 2

- 8 constant power loads (10 kW each) and 2 cycling load
  - Peak value 50 kW
  - On time between 3 and 4 time units
  - Off time between 27 and 36 time units
- Average value of total load is 90 kW
- Peak value of total load is 180 kW
- Load factor for 24 hour calculations
  - Constant power loads = 1.0
  - Cycling Load = 0.10
- Zonal load factor
  - Constant power loads = 1.0
  - Cycling load →

$$L_{fz_j} = 0.10 + (1 - 0.10)\left(\frac{50}{90}\right) = 0.60$$

- Zonal operating load
  - Constant power loads = 10 kW
  - Cycling load = 0.6 × 50 = 30 kW
- Residual zonal power demand
  - Constant power load = 0 kW
  - Cycling load = 50 – 30 = 20 kW
- Zonal total operating load
  - 8 × 10 + 2 × 30 + 20 = 160 kW.



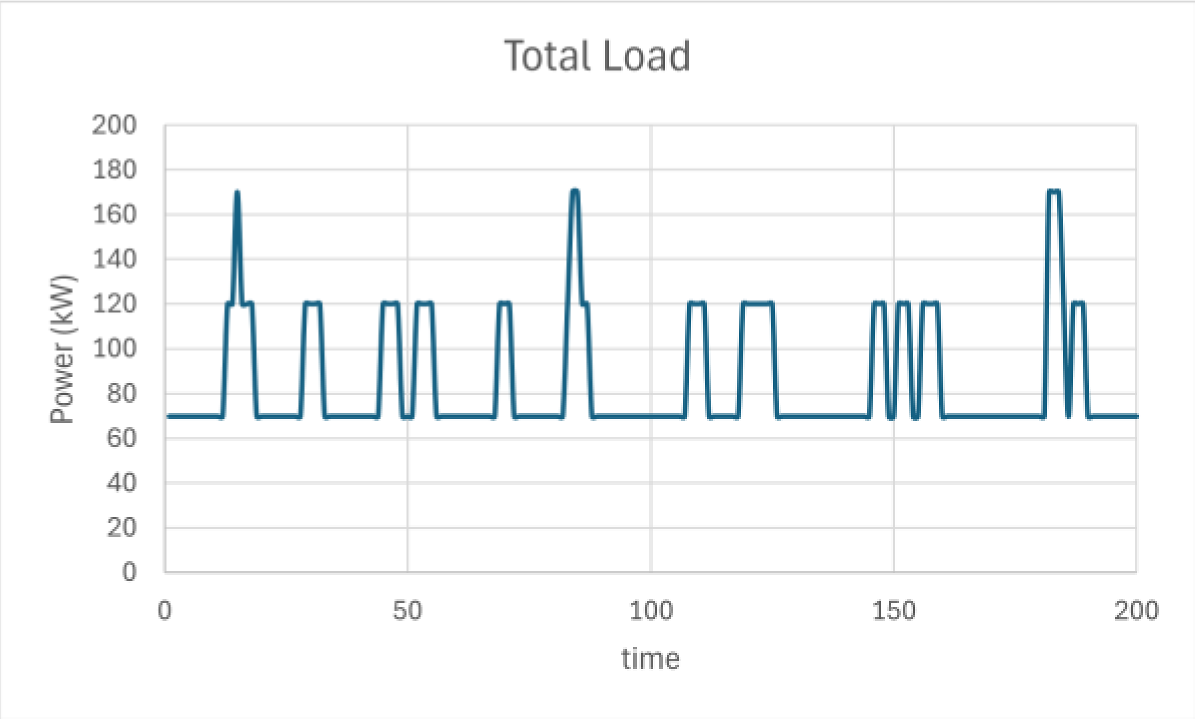
- Using Average Value of 90 kW will likely lead to undersized power system equipment.
- Using Zonal total operating load of 160 kW helps ensure equipment will not be overloaded…
  - A little lower than 180 kW peak but likely manageable
- Must still apply margin and SLA.

Example 3

- 7 constant power loads (10 kW each) and 3 cycling load
  - Peak value 50 kW
  - On time between 3 and 4 time units
  - Off time between 27 and 36 time units
- Average value of total load is 85 kW
- Peak value of total load
  - Theoretical = 220 kW
  - Observed = 170 kW (All three cycling loads on at same time is unlikely)
- Load factor for 24 hour calculations
  - Constant power loads = 1.0
  - Cycling Load = 0.10
- Zonal load factor
  - Constant power loads = 1.0
  - Cycling load

$$L_{fz_j} = 0.10 + (1 - 0.10)\left(\frac{50}{85}\right) = 0.629$$

- Zonal operating load
  - Constant power loads = 10 kW
  - Cycling load = 0.629 × 50 = 31.4 kW
- Residual zonal power demand
  - Constant power load = 0 kW
  - Cycling load = 50 – 31.4 = 18.6 kW
- Zonal total operating load
  - 7 × 10 + 3 × 31.4 + 18.6 = 183 kW.



- Using Average Value of 85 kW will likely lead to undersized power system equipment.
- Using Zonal total operating load of 183 kW helps ensure equipment will not be overloaded…
  - A little lower than 220 kW theoretical peak
  - More than observed peak 170 kW
- Must still apply margin and SLA.

Final note

- Power equipment typically are able to sustain overloads for short periods of time
  - Transformers and synchronous generators are very robust and generally can tolerate short term overloads that are not likely, but possible.
  - Power electronic sources usually are not as robust.
    - May require more detailed analysis to determine if cycling loads will result in Quality of Service defined service interruptions.
- Zonal load factors are greater than or equal to 24-hour average load factors
  - Will provide the same or a more conservative estimate for the required power.
  - The worst possible case electric load may be greater than that predicted by zonal load factors.