MSC Guidelines for Review of Short Circuit Analysis

Procedure Number: E2-19 **Revision Date: 04/28/00**

References

a. 46 CFR 111.51

b. 46 CFR 111.52

c. IEEE Standard 141-1976, Recommended Practice for Protection and Coordination of Commercial Power Systems

d. Work Instruction E2-4, Coordination Study

e. Work Instruction E2-7, Electrical One-Line

f. Work Instruction E2-7, Ship's Service Generator / Switchboard

g. Matthews, John H. 1993. *An Introduction to the Design and Analysis of Building Electrical Systems*, New York: Chapman and Hall.

Disclaimer

Contact Information

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Background

- An important safety aspect of electrical systems is the ability of components to withstand the mechanical and thermal forces associated with short circuits (faults). Protective devices such as fuses and breakers must not only have the appropriate trip setting, but must be rated not to explode when subjected to currents many hundreds of times greater than their trip setting (as would be seen in a fault). Additionally, bus bars and panel boards must be rated so as not to rip apart from the intense mechanical forces associated with fault currents. This document outlines the basic procedure for ensuring that electrical system components are rated appropriately based upon the associated maximum asymmetrical fault current level.

- Plan submittal and regulatory requirements are divided into two categories: systems below 1500 kW, and systems above 1500 kW in total aggregate generating capacity. Systems above 1500 kW require calculation of short circuit currents using an established method. Systems below 1500 kW do not require this level of detail and employ assumptions.

General Review Guidance

- Systems less than 1500 kW:
    - Check the drawing notes for a minimum rating of all panelboards and protective devices. This should be on the electrical one-line. Also check the switchboard diagram for bus rating.
    - For an AC system, the max asymmetrical system short circuit current is considered to be 10 times the aggregate normal rated generator currents plus four times the normal rated currents for all connected motors. All system components should be rated above this value (46 CFR 111.52-3(b) & (c))
    - For a DC system, the maximum short circuit current is considered to be 10 times the aggregate normal rated generator currents plus six times the normal rated currents for all connected motors. All system components should be rated above this value. (46 CFR 111.52-3(a))

Systems above 1500 kW

- For systems above 1500 KW, a separate submittal must address the short circuit analysis (46 CFR 111.52-5). This submittal should contain a summary of the maximum fault currents under the following conditions:
    - 3-phase bolted fault on the load side of each protective device
    - fault on the distribution bus with all generators running in parallel supplying the largest possible motor load
- The summary should include enough data to verify short circuit calculations. This data includes, but is not limited to: generator and motor ratings and impedances, transformer per-unit impedence, rating and reactance to resistance (X/R) ratio, cable type, length and impedance. Check the summary to ensure that the computed value of maximum asymmetrical fault current does not exceed the associated protective device rating. Reference the electrical one line and switchboard diagrams as applicable.

- AC fault currents are termed "asymmetrical" because the first cycle of the fault is typically much larger than subsequent cycles. It is this first cycle that generates the mechanical force that system components must be able to withstand. For a theoretical background on this phenomenon, see reference (e).

- Shipboard generator ratings determine the maximum fault current level. The maximum current a generator will supply is determined by its impedance value. In general, the closer a fault is to a shipboard generator, the higher the value of fault current.

- Independently verify the following fault currents to see if they are within a reasonable range:
  - Main distribution bus (switchboard).
  - Electrical propulsion, as applicable.
  - Steering system feeders.
  - Fire fighting systems.

- The above systems are considered vital and are the subject to the coordination requirements of 46 CFR 111.51-3 (see MSC Procedure **E2-4**, Coordination Study)

- During a bus fault, current is supplied from all the ship's service generators and motors connected to the bus. Current is supplied from motors due to their excess rotational inertia. All feeders that are not connected to motors or generators will contain insignificant values of current because their impedance is high relative to the fault impedance. Therefore, only motor and generator feeders are considered during a bus fault.

- To compute a main bus asymmetrical fault, first determine the individual impedances from the motors and generators to the bus. These impedances are then added in parallel to determine the total impedance. The maximum symmetrical fault current is the system voltage divided by this value. An asymmetrical multiplication factor is then applied; this factor can be found using IEEE STD 141-1976, pages 205-206.

- A fault in a non-motor/generator feeder is computed as above, except the impedance of the feeder in which the fault occurred is added in series with the impedance computed for the bus fault.

- A fault in a motor/generator feeder is computed as follows:

  - Add all of the motor/generator to bus impedances in parallel, with the exception of the fault feeder impedance.
  - Take this value and add it in series with the fault feeder impedance.
  - Divide the system voltage by this resultant aggregate impedance value.
  - Multiply the divided voltage by the asymmetrical multiplication factor.

- Typical impedance and X/R ratio values for rotating machines and cable can be found in IEEE STD 141-1976, pages 197 to 202.

- The typical per-unit impedance of a transformer is around 5%.

Attachments: None