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POWER SYSTEM DESIGN

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standard and Specification covers requirements governing the design of power distribution systems

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. International Electro Technical Commission Publication (IEC)

   34-1 Recommendations for Rotating Electrical Machinery

2. IEEE Standard

   S-135 Power Cable Ampacities

3. ANSI Standards

   C37.13 Low Voltage AC Power Circuit Breakers
   C84.1 Voltage Ratings for Electrical Power Systems and Equipment

4. AIEE Transactions

   Paper 55-142 Time Variation of Industrial System Short Circuit Currents and Induction Motor Contributions (Part 11 Applications and Industry, Vol. 74, 1955, pp. 90-101)

5. IEEE - Transactions on Industry and General Applications

   Transactions IGA Mar./ April, 1955 pp. 130-139 - Allowing for Decrement and Fault Voltage in Industrial Relaying

DEFINITIONS AND TERMINOLOGY

Acceptable and preferred practices - Where this Project Standard and Specification lists more than one type of equipment or method as acceptable, the Contractor shall make the selection based on installed cost. Where one particular type of equipment or method is listed as preferred, it shall be selected provided it is lower or equivalent in installed cost to other acceptable types or methods.

Adjusted maximum demand:
- based on firm load data is equal to 1.0 times maximum demand.
- based on non-firm load data shall be equal to 1.1 times estimated maximum demand.

Cascading of low-voltage circuit breakers - involves non-selective applications above the interrupting ratings of some breakers. Application rules for cascading are given in ANSI C37.13.

Demand factor - the ratio of the maximum demand of a system, or part of a system, to the total connected load of the system, or part of the system, under consideration.

Firm load data - the load data derived from actual equipment performance characteristics and duty cycles.

Load factor - the ratio of the average load over a designated period of time to the peak load occurring in that period.

Motor continuous overload capability/service factor - a multiplier which, when applied to the rated horsepower, indicates horsepower loading which may be carried continuously without exceeding by more than 10^{o}C at continuous

Secondary-selective substations – they have two busses, each supplied by a normally-closed incoming line circuit breaker and connected together by a normally-open bus tie circuit breaker. (As used herein, the term "secondary-selective" is applicable to dually fed substations with or without transformers). The dual sources normally divide the loads in non-paralleled operation. Upon failure of one source the substation is isolated from the failed source and the de-energized bus section is connected to the source remaining in service. This "transfer" of load may be manual or automatic.

Spot network substations - substations supplied from two or more sources which normally divide the substation load in paralleled operation. Upon failure of one source, the substation is isolated from the failed source by automatic operation of directional overcurrent relaying. This provides high order of supply continuity in the event of faults, but imposes higher fault interrupting duty than does secondary selective operation with sources of the same capacity.

The 8-hour maximum demand of loads - the greatest root-mean-square value the load can take during any 8-hour period. It is the equivalent thermal aging load.

The 15-minute maximum demand of loads - the greatest average load which can occur for a 15 minute period.
overload/service factor loading rated temperature rise per IEC-34-1, if rated voltage and frequency are maintained.

DOCUMENTATION

Wiring Diagrams

One-line diagrams shall cover all power circuits and excitation circuits including metering and protective relaying. The diagrams shall include the following information:

a. Major equipment ratings indicated below:

Major Equipment	Ratings To Be Shown On One-Line Diagrams
Generators	V, kW, PF, Xd", Xd'
Power Transformer	kVA, (OA/FA), V, tap range, impedance, BIL if arresters applied at same voltage
Circuit Breakers	Continuous A, interrupting MVA or kA, momentary kA if different from interrupting BIL if arresters applied at same voltage. (Specify whether symmetrical or asymmetrical basis used for kA ratings).
Bus	Continuous A, momentary kA (specify symmetrical or asymmetrical basis).
Arresters	kV operating
Neutral Grounding Devices	A (limit)
Current Transformers	Ratios
Potential Transformers	Ratios
Cable supplying power transformers and switchyards	Size

b. Number and connections of current and potential transformers.

c. Connection of power transformer windings (such as wye or delta), type of neutral grounding.

d. Relay description including manufacturer's model No., time characteristics, range and number of elements.

e. Dotted lines to associate the major protective relays with the auxiliary relays or primary circuit devices which they actuate, using arrows at the end of these lines to point to the devices operated.

f. Maximum and minimum short circuit levels on which design was based.

g. Identification and size of individual loads connected to each switchgear, motor control center, turnaround power center and switch rack bus.

h. Reacceleration step number for each motor provided with automatic reacceleration control.

Schematic, connection and interconnection diagrams shall be furnished for troubleshooting and maintenance. Vendors drawing shall be used to the maximum practicable extent.

Interconnection diagrams shall show the same terminal numbers and device and conductor designations that appear on the connection diagrams. They shall also indicate locations of terminals if the equipment has terminals in more than one location.

Data

1. Machine computation shall be used to prepare the following data:

Data	Contractor's Computer Program
Load Data Short Circuit Data Voltage Profiles and line loading during: a. Steady state, normal b. Steady state, emergency c. Large motor starting d. Reacceleration Large motor rotor heating	

   The Contractor shall utilize his own computer programs for the above, use hand calculation (for simple systems), or omit computations of conditions which are not applicable or from inspection can be seen to be no problem.

2. Use of other specialized companies program is also acceptable.
3. Load data and short circuit data shall be furnished by the Contractor to the Owner's Engineer on at least two occasions:
   - Before major electrical equipment (such as power transformer) is purchased.
   - When one-line diagram is presented for final approval and loads are final.
4. Load data shall be accompanied by a one-line diagram (may be simplified) with loads and busses numbered to match computer results. Actual duty cycles shall be used for non-continuous loads.
5. Short circuit data shall be accompanied by impedance diagrams for positive and zero sequence networks, and corresponding one-line diagram (may be simplified). Busses and impedance shall be labeled to match the computer results.

6. Voltage profile calculations shall show voltage profiles and variations during normal operations and during motor starting or reacceleration, whichever governs.
7. Cable sizing bases shall be furnished, covering implementation of the requirements of this Project Standard and Specification with regard to the following:
   a. Ampacity derating basis for grouping of cables.
   b. Ampacity derating basis for special conditions, such as cables installed in ducts.
   c. Sizing basis to meet voltage drop limitations during normal operation and during motor starting or reacceleration.
   d. Sizing basis to meet short circuit withstand.
8. Relay data shall be furnished for each adjustable relay or other protective device as follows:
   a. Device symbol number and circuit to which applied.
   b. Device identification including manufacturer's model number, time characteristic and ampere of voltage range.
   c. Device setting calibration point and one or more check points.
9. Tabular form shall be used to present relay data. Additional columns shall be provided for recording actual test values (voltage, current and time) corresponding to calibration and check points resulting from field setting, calibration and test.
10. Relay coordination shall include a set of curves showing for each voltage level all phase relays and other phase protective devices. A separate but similar set of curves shall be provided for all ground relays and other ground protective devices. Symmetrical maximum and minimum short circuit levels shall be shown on each set of curves. The phase relaying coordination shall include the following:
    - For a voltage level supplied through a transformer, the transformer primary protective relaying plotted in terms of secondary amperes, allowing for the 16% shift in delta-wye transformers for phase-to-phase secondary faults; also the transformer through-fault withstand point.
    - For substation with automatic transfer, and for subsubstations with time-undervoltage relay for motor tripping, the coordination between undervoltage and overcurrent relaying (see IEEE Transaction on Industry and General Applications, March/April 1965, pp. 130-139 for method); also, setting of transfer blocking overcurrent and undervoltage relays.
11. Relay coordination curves shall be furnished on two occasions:

- Before current transformer ratios and relay ranges and characteristics are specified to the supplier. This issue of the coordination is preliminary and need only be complete and accurate enough to verify selection of proper ratios, ranges and characteristics.
- When Relay Data is presented for final approval.

12. Decrement effects shall be shown in the relay coordination if in-plant generation contributes to faults.
13. Generator data shall be furnished for all generators except instrument or emergency lighting generators. These data shall consist of:
    a. Direct and quadrature axis subtransient, transient and synchronous reactances.
    b. Negative and zero sequence impedances.
    c. Decrement curves for three-phase and phase-to-phase faults, with generator operating at full load and with exciter under control of voltage regulator. If not available, furnish decrement curves for three-phase and phase-to-phase faults with generator at full load and with constant full load field excitation.
    d. Exciter full load and ceiling voltages.
    e. No load and full load generator field current.
    f. Direct and quadrature axis transient and subtransient open-circuit time constants.
    g. Stator leakage reactance.

POWER SYSTEM ARRANGEMENT AND PROTECTION

Motor Supply and Reacceleration

1. Full voltage starting shall be used for all motors provided the following conditions are met:
    a. For motors having infrequent starting, the voltage drop during starting shall not exceed any of the following values which would:
        - Prevent the motor’s starter from remaining closed successfully during starting.
        - Cause starters of other motors to chatter or dropout.
        - Cause of other motors to stall.
    b. For motors starting more frequently than once per hour, the voltage at the bus supplying the motors does not drop below 90% of the system nominal voltage when these motors start individually.
    c. Relays can be set to give both protection and coordination.

2. Supply to spare and multiple-service motors. If motors are designated as “normal and spare”, “2 of 3 normally running”, or equivalent, or if 2 or more motors in the same service can operate independently for partial service (as in air-cooled heat exchanger fans and paralleled cooling water circulation pumps), the following shall govern:
    a. If such motors are fed directly from secondary selective or spot network busses, the supply to motors of each service shall be divided between (or among) the busses.
    b. If such motors are fed from radially supplied busses (which may be supplied radially from secondary selective or spot network substation busses), it is preferred that the supply to motors of each service be divided between independently radially supplied busses it is acceptable if they are supplied from a common bus.
3. Bus maintainability with unspared critical motors. If it is specified that busses be maintainable with a plant in service, all unspared motors necessary to plant operation shall be arranged for alternate feed from 2 busses. An acceptable arrangement is a controller cubicle on each bus but only one controller for each such motor, plus one spare controller (of each type used for such motors) for the plant. This requirement will normally be specified only for substations feeding 2 or more plants with staggered turnarounds, or feeding plants likely to have unplanned turnarounds.
4. Bus extendibility with unspared critical motors. If it is specified that busses be extendable with a plant in service, and the busses feed unspared motors necessary to plant operation, one of the following shall be provided:
    a. Supply unspared critical motors as mentioned above, or
    b. Provide sectionalizing means at the end of each bus to permit addition of future equipment with the bus in service. Spare circuit breaker cubicles are acceptable.

    This requirement will normally be specified only for main substations, either purchased-power substations or generating plant busses.
5. Supply to single-phase motors. Lighting panel boards shall not supply single-phase motors driving services defined as critical.
6. Motor Reacceleration. Motors designated as having reacceleration requirements of Necessary (A) or Desirable (B) shall all be automatically reaccelerated. Where reacceleration in more than one step is required, motors (A) shall be in earlier steps than motors (B). Step priority among motors having the same reacceleration requirement designation shall be based on process priorities to be specified.