BUILDING ELECTRICAL SYSTEMS

SERVICE ENTRANCE AND ELECTRIC SERVICE SWITCHBOARDS

CONTENTS PAGE

1. GENERAL

1.01 This section covers the design of the service entrance and the electric service switchboard. The design will depend upon the power service available and the load requirements.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 The electric utility company should be consulted in the preliminary stages to determine the services available, the physical requirements, metering and similar factors. A load analysis should be made as covered in Section 760-400-200 for Telecommunications Buildings or Section 760-400-210* for Data Processing Buildings to determine the size and types of loads to be served.

2. PRIMARY VS SECONDARY

2.01 Depending on the availability from the serving electric utility, two classes of supply voltage are normally offered:

(a) Primary voltage (above 600 volts), eg, 5KV, 13.8KV, etc

(b) Secondary voltage (below 600 volts) 480Y/277V, 208Y/120V, etc.

2.02 Refer to Section 760-400-110, Voltage, for more detail and definitions.

* Check Divisional Index ***760*** for availability.

2.03 In choosing between primary and secondary power, the building engineer should consider:

- Load analysis, initial, and ultimate
- Building size
- Initial equipment cost
- Annual costs (capital and operating)
- Code requirements
- Operation and maintenance.

A. Primary

2.04 Buying power at the primary voltage should be considered only when the electrical load is large (above 2500 KVA) or in very large buildings. It is strongly recommended that any decision to do this be made only after a careful CUCRIT study is made utilizing an accurate estimate of all the costs.

2.05 Usually the power utility offers lower rates per KWH if the primary power is supplied and the primary switchgear and transformer are owned, installed, and operated by the customer.

2.06 High voltage switchgear and transformers are very expensive and require expert and costly maintenance. Since the power company is not responsible for transformer replacement, some redundancy must be provided, which further increases the costs. Many power company tariffs are structured so that the primary power discount does not offset the extra cost.

2.07 Because the power transmission distances in most buildings are relatively small, there is usually not much savings involved. Considerable building space is also required for the primary switchgear and transformers.

B. Secondary

2.08 For all but the smallest buildings (under 100 KVA ultimate), 480 volts is the preferred service voltage. Refer to Section 760-400-110, Voltage, for definitions and transformer configurations.

2.09 The following table provides a ***guide*** for the selection of the economic secondary voltage for a particular installation:

TOTAL LOAD (KVA)	SERVICE VOLTAGE
10 — 80	240 /120 — 1Ø
70 — 200	208Y/120 — 3Ø
100 — 5,000	480Y/277 — 3Ø

3. SERVICE ENTRANCE TRANSFORMER

3.01 Transformer vaults should usually be avoided. In certain instances, an engineering study may indicate that a vault is the most economical long-range solution to a service entrance. Additionally, local codes or ordinances may require the use of a vault.

3.02 A pad mounted transformer is desirable from both appearance and cost standpoint if it can be obtained at little or no extra cost. It can be located near the service entrance equipment, and made inconspicuous by architectural treatment.

3.03 Where pole mounted transformers are considered, the extra cost of an underground entrance might be justified if the building and the area are a bit above average in appearance.

4. SERVICE ENTRANCE CONDUIT AND CONDUCTORS

A. Conduit

4.01 For all service entrances, both primary and secondary, it is recommended that Schedule 40, PVC conduit be used without concrete encasement.

4.02 To accommodate unforeseen growth or replacement of deteriorated service entrance conductors, a spare conduit should be provided.

B. Conductors

4.04 Aluminum alloy conductors should be used for most service entrances except those under 200 amperes. Circumferential crimp type connectors with suitable joint compound shall be used. Aluminum should not be used where it is exposed to the weather near salt water or other corrosive atmospheres.

4.05 Where multiple phase conductors are used, cable limiters (protectors) shall be provided at both ends of the service entrance conductors where network service is furnished by the power company.

This should be coordinated with the power company. The protectors shall have a minimum interrupting capacity equivalent to the available short circuit current. Refer to Section 760-400-800*, Short Circuit Analysis, for details in performing this study.

5. ELECTRIC SERVICE SWITCHBOARD

A. Distribution Configurations

5.01 One of the most important design features of the power distribution system is the means of transferring loads to the stand-by power plant during outages of commercial power. For information on this, refer to Section 760-400-215, Switching Arrangements for Stand-By Power.

B. Location

5.02 It is important for the building engineer to be involved in the floor plan layout from the start. To the extent that it does not interfere with other more important building layout considerations, the service entrance equipment should be located to minimize the length of the major circuits, ie, from the service transformer, and to the central office power plant, computer equipment, mechanical equipment, and the stand-by power plant.

5.03 In order to operate and maintain the switchboard, a clearance of 4'-0" in rear (rear accessible switchboards) and 5'-0" in the front are recommended. As a minimum, the requirements of paragraph 110-16 of the National Electrical Code (NEC) NFPA 70 must be met. Space should be reserved for future growth.

5.04 Electrical switchboards shall not be located where a single catastrophe (eg, an engine room fire) might result in the loss of both commercial and stand-by power sources. A 1-hour fire rated wall should be provided between the electric service switchboard and the stand-by engine.

5.05 The switchboard shall not be located in the boiler room or other location where it is subject to excessive heat or fire damage. Water, steam, or other pipes should not be located over the electric service switchboard. Where such conditions cannot be avoided, install sheet metal pans or gutters around the piping in the vicinity of the switchboards to minimize the possibility of water damage.

* Check Divisional Index *760* for availability.

5.06 Piping and conduit shall not be installed such that it might interfere with the expansion of the switchboard.

5.07 If located in a basement where there is any possibility of flooding, the switchboard should be mounted on a 6 inch concrete pad.

C. Size

5.08 Specifying the proper size for the service entrance and power distribution facilities is one of the most important elements of good design. Design for realistic load estimates, allow for growth but do not try to provide for large unforeseen contingencies.

5.09 Design for flexibility, which means the ability to economically add to the system to accommodate unexpected growth. One of the worst aspects of overdesign is that even if unforeseen requirements do materialize some day, often the overdesigned facility is not adequate. The design should cover a period of at least 10 years and may be for as long as 20 years where growth is expected to be slow and stable.

5.10 The power requirements of electronic telephone switching systems grow very slowly as compared to their initial requirements. Therefore, relatively small capacity surpluses will usually last a long time. This, together with the fact that reinforcement of the service entrance portion of the switchboard (the main bus and disconnect) is difficult and costly, suggests that a long design period (20 years) is usually desirable for this equipment in central offices. Other portions of the system, eg, distribution sections and transfer switches, should be designed for a much shorter period (8 to 10 years).

5.11 When designing a new electrical service, it is always a good practice to compare the load analysis with the actual load of a similar building. Although no two buildings are exactly alike, similarities do exist and this type of verification can help reduce serious sizing errors.

5.12 As a general rule, no single switchboard should be larger than 2000 amps at 480 volts. If more power is required, provide additional switchboards. In addition to increasing reliability and safety, this incremental sizing provides the advantage of possibly deferring additional switchboards until actual load growth dictates.

5.13 Normally, Telco buildings will not require more than three 2000 ampere, 480 volt switchboards. Very large administrative buildings (over 500,000 square feet) and major equipment and data processing buildings might require more power. The design for such buildings is rather specialized and beyond the scope of this practice.

D. Type

5.14 The NEMA Type I General Purpose Enclosures shall be used for all indoor installations where environmental conditions are normal. Class I switchboards shall be used only for front access boards. Class II construction (group or panel mounted circuit breakers) is recommended.

5.15 Access panels should not be too large for safe handling. Doors should be used instead of large panels.

5.16 Provide adequate ventilation openings at top and bottom of switchboard sections.

E. Main Disconnect

5.17 All new switchboards should have a single main fused disconnect including an electrical trip for remote operation. The remote manual trip station for the main disconnect shall be located near the exit to the switchboard area to disconnect power in emergency. Recommended equipment is:

(a) ***Up to 800 Amperes:*** Automatic molded case switches.

(b) ***Above 800 Amperes:*** High pressure contact switches.

(c) ***Current Limiting Fuses "Class L":*** The fuses installed initially should not necessarily be the ultimate fuse size, but should be as small as possible, taking into account the initial load and the fuse mountings. Size the fuse at or below the ampacity of the service conductors.

F. Transfer Device

5.18 To provide automatic transfer of essential loads to the stand-by power plant, the following is recommended:

(a) ***Up to 600 Amps:*** Automatic double throw switch, either relay or motor actuated.

Note: Any mechanically held transfer switch which is listed under Underwriters Laboratories Standard 1008 is acceptable. Permanent magnet instead of mechanical holding is permissible for switches smaller than 100 amperes.

(b) ***Above 600 Amps:*** Motor operated molded case circuit breakers.

5.19 All transfer switches, except those made up of circuit breakers, should be protected on the load side with current limiting fuses to match the switch rating. Provide a warning notice to disconnect power to the switch before replacing these fuses.

5.20 Do not oversize the switch, but rather design for a reasonable time period and plan to add additional switches if growth warrants.

5.21 Transfer switches should usually be installed in or near the service switchboard, and not at the stand-by plant. However, it is possible that in smaller sizes (under 100 amperes) there might be advantages to including the switch in a packaged stand-by plant.

5.22 Do not provide more transfer devices than necessary. Usually more than one device is required initially only when the essential load exceeds the capacity of the automatic stand-by power plant. Refer to Section 760-400-215, Switching Arrangements for Stand-By Power, for further details.

G. Bus Bars

5.23 Aluminum bus bar shall be provided for all new switchboards. Copper shall be used only for additions to existing copper bus. Aluminum bus shall be Type 6101-T63 aluminum alloy with 22,000 psi tensile strength. Bus to be tin plated over its entire length.

5.24 Use heavy flat washers, lockwashers, and SAE Grade 5 high strength steel bolts at joints and connections. Welded joints will eliminate the danger of loose connections and the periodic maintenance required with bolted joints.

5.25 Specify bus bar bracing adequate for the available short circuit current. The bus bars should be arranged for easy extension into future switchboard sections.

H. Neutral and Ground Bus

5.26 Each new switchboard shall have a neutral bus, electrically isolated from the switchboard framework, and continuous for the full length of the switchboard. It shall be of the same size and ampacity as the phase buses.

5.27 Each new switchboard shall also have a ground bus continuous for the full length of the switchboard sized at 25 percent of the ampacity of the phase buses and electrically connected securely to each switchboard section.

5.28 The neutral and ground buses shall be bonded inside the switchboard with a ***Main Bonding Jumper*** in accordance with NEC, paragraph 250-79. However, it is recommended that the cross-sectional area of the MAIN BONDING JUMPER be no less than 25 percent that of the service entrance phase conductors and no smaller than 4/0 copper instead of the smaller sizes required by the NEC.

5.29 The ground bus shall be connected to the building grounding electrode system in accordance with Article 250-H of the NEC. For the supplementary grounding electrode required when a water pipe is used as the principal grounding point, a concrete encased electrode per NEC, Article 250-81(c) is acceptable. Sections 802-001-180, 190, and 191, Grounding, cover grounding electrodes in detail.

I. Overcurrent Protection

5.30 Thermal magnetic molded case circuit breakers should normally be specified throughout. Do not use power circuit breakers or the more expensive molded case circuit beakers with solid state tripping devices unless absolutely necessary. Any adjustable instantaneous trip units should be set to the minimum values possible without causing nuisance tripping.

5.31 Specify interrupting capacity on all breakers. Do not specify higher interrupting capacity than is required. The higher the interrupting capability of a device the higher the cost. Refer to Section 760-400-800, Short Circuit Analysis, for a simple method of calculating fault current values in a distribution system.

5.32 Take full advantage of the lower interrupting capacity that might be permitted for the circuit breakers because of the protection afforded by the main current limiting fuses. See paragraph 5.17.

5.33 In larger switchboards use current limiting fuses to protect the circuit breakers in various sections of the switchboard, again allowing for the use of circuit breakers with lower interrupting ratings.

5.34 The loads served by all overcurrent devices should be identified by permanent nameplates.

5.35 Provide spare fuses in a spare fuse cabinet located near the switchboard.

J. Ground Fault Protection

5.36 Provide ground fault protection to trip the main disconnect on all 480 volt switchboards. Refer to Section 760-400-500*, Ground Fault Protection, for application information.

K. Lightning (Surge) Protection

5.37 Provide lightning protection in all buildings except where service is obtained from an underground network. Refer to Section 760-400-520*, Lightning and Surge Protection, and SD-81968-01 for specific application data. Section 876-100-100 covers electrical protection principles.

L. Metering

5.38 Provide a voltmeter and phase selector switch with ability to read phase to phase and phase to neutral voltages on all new switchboards. Provide an ammeter only for service above 800 amperes. These meters should be supplied with 2 percent accuracy and sized so that the average load shall read approximately half to two thirds scale. The use of rectifier type meters is not recommended if there will be a large amount of harmonic distortion from high intensity discharge lighting or uninterrupted power supplies (UPS). It is recommended that no KW-HR meters be provided other than the one required by the serving utility.

5.39 Stranded wire shall be used for metering and control circuitry, shall not be smaller than No. 14 AWG and should be insulated with a material rated not less than 90°C. Crimp type, insulated terminations shall be used. All wiring shall be identified through the use of wire markers and permanently identified terminal blocks.

* Check Divisional Index *760* for availability.

M. Pull Box

5.40 If a pull box is provided above the switchboard, it should be adequately isolated by a fire resistant barrier. Pull boxes should never be used as a horizontal wireway which will transverse vertical section of the switchboard.

N. Operating Instructions

5.41 Provide instructions for operation of transfer devices, including emergency manual operation, prominently displayed near the switchboard. Also, provide an easily readable, single line schematic of the building AC system, posted prominently in a well lighted location near the switchboard.

6. REFERENCES

6.01 This material was based on the following references:

Industrial Power Systems Handbook—Beeman-McGraw-Hill, 1965

Recommended Practices for Electrical Power Distribution for Industrial Plants, IEEE STD 141-1976 "Red Book"

Recommended Practices for Electrical Power Distribution in Commerical Buildings, IEEE STD 241-1983 "Gray Book"

Mechanical and Electrical Equipment for Buildings—McGuiness, Stein, Reynolds-Wiley Press, 6th Edition

National Fire Protection Association (NFPA) 70, National Electrical Code (NEC)

National Electrical Manufacturers Association (NEMA) Standard PB-2-1978

Aluminum Association Electrical Conductor Handbook, 1982 Edition

Section 760-400-100—Planning

Section 760-400-110—Voltage

Section 760-400-200—Electrical Load Analysis for Telecommunications Buildings

Section 760-400-210—Electrical Load Analysis for Data Processing Centers

Section 760-400-215—Switching Arrangements for Standby Power

Section 760-400-500—Ground Fault Protection

Section 760-400-520—Lightning and Surge Protection

Section 760-400-800—Short Circuit Calculations

Section 802-001-180—General Grounding Requirements

Section 802-001-190—Ground Systems Material

Section 802-001-191—Grounding Electrode Requirements.

Section 876-100-100—Electrical Protection Principles