CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
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ENGINEERING SPECIFICATION

CE-ES-2002

STANDARD ENGINEERING DESIGN GUIDELINES FOR AREA SUBSTATIONS, TRANSMISSION SUBSTATIONS AND *PUBLIC UTILITY REGULATING STATION (*PURS) FACILITIES

SECTION I GENERAL REQUIREMENTS

REVISION 05

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1.0 PURPOSE

1.1 The purpose of this Standard Engineering Design Guideline Specification is to establish the basic philosophy to be followed in the engineering and design of Consolidated Edison's Area and Transmission Substations, henceforth called "Substations", and ***Public Utility Regulating Station (***PURS**)** Facilities.

1.2 The design criteria is specified herein to assure the uniform application of this design philosophy, thereby, insuring that the highest degree of reliability and "Environmental Excellence" – consistent with sound engineering practices, economic guidelines, operating requirements, safety and environmental awareness – are attained in the design and construction of the Company's Substations and PURS Facilities.

2.0 APPLICATION

2.1 This specification shall apply to the design of all new Area and Transmission Substations and PURS Facilities and any modifications and/or extensions to existing facilities. However, it is not intended for use as part of any construction bid document.

2.2 When modifications and/or extensions are to be made to existing Substations and PURS Facilities, emphasis shall be placed on maintaining and upgrading the already established physical design. Control and metering schemes shall follow the established pattern in that particular station in order to maintain ***consistency*** and to facilitate the task of operating and maintaining that Substation or PURS Facility.

2.3 Where feasible, modifications to existing Substations or PURS Facilities should be brought up to the latest standards contained in this Design Guide, or the latest industry standards.

3.0 APPLICABLE STANDARDS AND REFERENCES

3.1 National Electrical Code (NEC)

3.2 National Electrical Safety Code (NESC)

3.3 Institute of Electrical and Electronics Engineers (IEEE)

3.4 National Electrical Manufacturer's Association (NEMA)

3.5 American National Standards Institute (ANSI)

3.6 Occupational Safety & Health Administration (OSHA)

3.7 North American Electric Reliability Corporation (NERC) Standards

3.8 Northeast Power Coordinating Council (NPCC)

4.0 GENERAL DESIGN CRITERIA

4.1 General

4.1.1 The general design of Substations can differ greatly; depending largely on the conditions that must be met. The final design will depend on the following factors:

a. The terrain and topography of the site.

b. The size of the station, i.e., number of feeder positions, transformers, etc.

c. Available space for future expansion.

d. Transmission feeder point of entry (P.O.E.), types of transmission system, i.e., overhead or underground.

e. Distribution feeder entry and outlet systems.

f. The medium of insulation, i.e., air, oil or SF6.

g. Indoor versus outdoor installations.

h. The system voltage.

4.1.2 **E**lectrical equipment ***should be physically arranged in the most simple and efficient manner possible from the standpoints of*** reliability, operability, environmental excellence, constructability and maintainability; therefore, a number of different designs should be evaluated in order to select the ***optimal*** layout.

4.1.3 Table 1 is a checklist of items to be considered when designing an Area Substation.

4.1.4 Table 2 is the checklist of items to be considered when designing for Transmission Substations.

4.1.5 Table 2A is the checklist of studies to be performed when designing for Transmission Substations and/or equipment installation.

4.1.6 Table 3 is the checklist of items to be considered when designing PURS Facilities.

TABLE 1

CHECKLIST OF ITEMS FOR AREA SUBSTATION DESIGN

- Primary and secondary voltage to be used
- Substation MVA capacity, current and future
- Future expansion needs
- MVA rating and short circuit rating (interrupting and close & latch rating)of switchgear
- Number of distribution feeder positions, initial and final.
- Size and layout of station property
- Indoor vs. outdoor design
- Maintenance requirements including equipment testing
- Electrical clearances
- ***L&P*** requirements
- ***Standby generator as required (Pressurizing Plants, Storm Hardening etc…)***
- Grounding Design
- Control Room Layout
- 125 VDC system requirements
- Cable and Trench Layout
- ***Protection & Metering Schemes, Accuracies of instrument transformers***
- Roadway Layout
- Primary and Secondary Voltage Relaying Schemes
- Aesthetic appearance of station
- Type of primary feeder cables
- One Line High Tension drawing
- Lighting Design
- Type of ***Buildings/Structures***
- Routing of Metal Clad Bus
- Number and location of Capacitor Banks
- Type of Circuit Switchers and Interrupters (Interrupting Rating)
- Type of Metal Clad Switchgear
- Environmental Aspects including Oil Water Separator and SPCC requirements
- Transformer MVA rating and % Impedance
- Communication / IR Systems Requirements
- Single Bus (H-Bus) Design VS Double Syn Bus Designs
- Lightning / Surge Protection
- ***Automation, SCADA, HMI, PA Systems, Alarm requirements***
- GIS Equipment
- Series Reactors
- Corporate Security, Cyber Security
- Design for OSHA arc flash requirements

TABLE 2

CHECKLIST OF ITEMS FOR TRANSMISSION SUBSTATION DESIGN

- Primary and secondary voltage to be used
- System Studies ***(Table 2A)***
- Substation capacity, current and future
- Future expansion needs
- BIL rating of Equipment
- Number of transmission feeder positions, initial and final.
- Size and layout of station property***, air insulated versus SF_6 Bus***
- Maintenance requirements including equipment testing
- Electrical clearances
- ***L&P*** requirements
- Grounding Design
- Control Room Layout
- 125 VDC system requirements
- Cable and Trench Layout
- Roadway Layout
- ***Protective*** Relaying ***& Metering*** Schemes***, PT/CT accuracy***
- Aesthetic appearance of station
- Type of primary transmission cables
- One Line High Tension drawing
- Lighting Design
- ***Need for load breaking ground switch based on transient studies (Table 2A)***
- Type of structure
- Number and location of Shunt / Series Reactors
- Environmental Aspects, Oil Water Separator sizing and location
- Type of Circuit Switchers and Interrupters (Interrupting Rating)
- Type of Metal Clad Switchgear
- Transformer MVA rating and % Impedance
- Circuit Breaker (Continuous & Short Circuit Ratings)
- Phase Angle Regulators
- Breaker and A Half Bus Configuration
- Ring Bus Configuration
- Automation, SCADA, HMI***, PA Systems, and Alarm requirements***
- Communication / IR Requirements
- Lightning / Surge Protection
- Corporate Security, Cyber Security

4.1.7 The final design should consider the possibility that any piece of equipment to be installed may fail. The equipment should be arranged so that such a failure will disrupt the station to the least possible extent and not jeopardize station nor system reliability. Particular attention should be made toward the space requirements for on-site repair, maintenance activities of existing equipment, or removal of any failed equipment.

4.1.8 A review shall be performed to determine the impact of a failure event (i.e.: explosion, fire, collapse of a structure, etc.) ***at all station areas including the impact*** on equipment, ***operation of equipment, the continued operation of the facility, as well as preventing a station shutdown.***

4.1.9 The Substation shall be designed to provide the normal full load power transfer capabilities under contingency conditions. The supply or transfer capability shall be consistent with the contingency design of the associated transmission feeders for a Transmission Substation or distribution networks for an Area Substation.

4.1.10 The aesthetic and environmental impacts of the new or modified Substation and PURS Facility toward its surrounding area shall also be considered. Structural design, lighting, architectural treatments, landscaping, noise emission, pollution prevention techniques, etc. should be included in the engineering design and environmental review process. In addition, the Substation and PURS Facility should present as low and inconspicuous a silhouette as possible, consistent with good engineering practices.

4.1.11 The overall design of the Substation and PURS Facility shall be in accordance with this Standard Engineering Design Guideline. The components and systems shall meet and conform to all applicable ANSI, EIA, IEEE, IES, NEMA and OSHA standards, all federal, state and local environmental laws and regulations and all applicable Con Edison specifications and procedures.

4.2 High Tension Operating Diagram

4.1.12 A first design step shall be the development of the High Tension Operating Diagram, i.e., a single line schematic representation of the Substation ***or PURS*** using standard symbols to show all of the switching connections and all major pieces of equipment.

a. In order to prepare this diagram, the following design parameters are required and should be established in consultation with the Transmission Planning Department and the Substation Planning Section of the Distribution Engineering Department.

(1) The geographic location of the new Substation or installation of new equipment within the existing Substation.

(2) Any new or additional transfer capacity or loading requirements and the required voltage levels of the incoming transmission lines or outgoing distribution feeders, respectively.

(3) For Transmission Substations, the anticipated (maximum calculated) value of the short circuits and the maximum switching

voltage surges which could be expected under normal operating conditions as well as contingency operating conditions.

(4) The final development and configuration of the Substation.

4.3 Ratings

4.3.1 The ratings of the required equipment are usually based upon normal loadings, load cycles, ambient service conditions and the life of the insulation. This information shall be obtained from the Equipment and Field ***or Transmission Feeder Engineering Sections*** and are based on ANSI Standards and Manufacturer's Data.

a. In general, equipment should be sized for continuous operation at the maximum continuous value specified by the manufacturer.

b. In order to provide a common set of guidelines for operation during contingency conditions, emergency ratings (time and current) are established for various equipment and conductors. The durations of these emergency ratings are based on an assumed life expectancy of the installation of 40 years. Emergency ratings are ***defined by CE-EI-2205. Any specific or detailed questions on ratings should be referred to the SME for that equipment.***

4.4 Reliability

4.4.1 All substation systems shall be designed in accordance with NERC and NPCC requirements, latest revisions.

4.4.2 All ***critical*** systems shall be designed such that a single failure of any component does not take out redundant systems. For example, the loss of one AC or DC Load Board does not ***cause*** the loss of supply to a switchgear section or transformer.

4.4.3 All critical circuits and loads, i.e. relay protection circuits, supplies to switchgear sections, shall have redundancy. Circuit physical separation and automatic transfer switches are required as applicable***. R***efer to CE-ES-2002, ***Section III,*** Part 2, Relay Protection, Part 4, DC Power Supply systems and Part 6, 120/208 Volt AC Light and Power Supply***, latest revisions, for details*****.**

4.4.4 Transfer switches shall be separated from **both sources, ideally adjacent to the load, and in accordance with all paragraphs in this section. Where redundant critical systems are fed from transfer switches, they should be separated from each other as well.**

4.4.5 *AC & DC Load Boards (service switchboards) No.1 and No.2 shall be installed in separate electrical equipment rooms.*

4.4.6 *In retrofit applications, the recommended separation would be in separate fire areas, or on opposite sides of a large equipment room, with a minimum separation of 30ft per IBC table 602. It would also be recommended that smoke purge equipment covering the room be fed via critical circuits.*

4.4.7 *Physical separation must be maintained between critical operations power systems to assure operability of critical and supervisory equipment in a safe manner including consideration for a potential arc flash hazard, smoke conditions, and catastrophic failures. A hazard risk assessment shall be performed for all new BES facilities to review separation requirements and feasibility of various alternative designs.*

4.4.8 ***A single*** component ***or system*** failure shall not jeopardize the integrity of the Substation or PURS Facility. ***Arc-flash (AC only) and Selective Coordination Studies of AC & DC auxiliary power systems are required.***

TABLE 2A

TRANSMISSION SYSTEM STUDIES (for reference)

- ***Electromagnetic Transients (EMT) Comprehensive Analysis***
- ***Task 1: Model Development and Validation***
- ***Task 2: Transmission Line Switching Analysis***
- ***Task 3: Lightning Surge Analysis and Insulation Coordination***
- ***Task 4: Ground Switch Induced Current and TRV Analysis***
- ***Task 5: Normal and Stuck Breaker Transient Overvoltage Evaluation***
- ***Task 6: Transformer-Limited Fault Analysis***
- ***Task 7: X/R Ratio, AC Decrement, and TRV Analysis for [Station] Breakers***
- ***Task 8: Grounding and Bonding Analysis***
- ***Task 9: Capacitor Bank Energizing and De-Energizing Analysis***
- ***Task 10: Very Fast Transient Overvoltage (VFTO) for Disconnect Switch Operation within the [Station] GIS***
- ***Task 11: Frequency Scan Screening Analysis***
- ***Task 12: Ferro-resonance Analysis***
- ***Task 13: Final Report and Recommendations***

For Systems Impact Study – see NY-ISO and Transmission Planning Group requirements

TABLE 3

CHECKLIST OF ITEMS FOR PURS FACILITIES DESIGN

- ***Primary and secondary voltage to be used***
- ***Future expansion needs***
- ***MVA rating and short circuit rating (interrupting and close & latch rating) of switchgear.***
- ***Size and layout of station property***
- ***Indoor vs. outdoor design***
- ***Maintenance requirements***
- ***Electrical clearances***
- ***Light and Power requirements***
- ***Grounding Design***
- ***Control Room Layout***
- ***Cable and Trench Layout***
- ***Roadway Layout***
- ***Aesthetic appearance of station***
- ***Alarm Panel Design and requirements***
- ***One Line High Tension drawing***
- ***Lighting Design***
- ***Security Protection / Cyber Security***
- ***Type of structure***
- ***Environmental Aspects***
- ***Design for OSHA arc flash requirements***

5.0 SITE SELECTION AND TOPOGRAPHY

5.1 When a new Substation or PURS Facility is being considered, and the approximate location of the station has been established, a search for suitable properties in the general vicinity shall be conducted jointly by Central Engineering and Real Estate.

5.2 The new site shall be level, with good access roads nearby and preferably screened from public view by trees, terrain, other buildings, etc. The location, reliability considerations, and right of ways will determine if either underground or overhead feeders should be installed. For Area Substations, a site with access on three sides for outgoing distribution feeders is preferred.

5.3 In the event that the site mentioned above is not available, then the selection shall be based on an economic evaluation of the considerations listed below:

5.3.1 A hilly site may require expenditures for grading the property, i.e. excavation or the possible filing of low areas may be required.

5.3.2 Draining of the property may require extensive work, including an environmental site assessment and possible effluent discharge permitting.

5.3.3 For the ring bus configuration, overhead feeders crossing over bus sections are prohibited. For the breaker and a half configuration, feeder connection to the syn buses are prohibited.

5.3.4 When underground feeders must be installed, vehicle access for the cable transporting and pulling rigs must be provided.

5.3.5 The presence of rock and wet areas such as wetlands, may make the construction cost of manholes and below grade trenches and conduits very high.

5.3.6 Access roads may have to be provided to existing public roads for the transportation of large equipment onto the site.

5.3.7 Extensive work may have to be done to provide containment facilities for any possible dielectric fluids spills where the site is located adjacent to sewers, rivers and brooks or other surface waters.

5.3.8 Environmental site assessment studies and remediation efforts must be considered and costs evaluated for a site with a possible history of past contamination, and/or evidence that soil/ground water contamination exists.

5.3.9 The need for water may require the drilling of wells or long pipe runs to obtain water from a public source.

5.3.10 Extensive landscaping and Electric Magnetic Fields (EMF) and ambient noise studies may be required to satisfy public objections to noise and EMF concerns.

5.3.11 Local codes, zoning laws, ordinances and permits must be studied to determine the cost associated with any special restrictions, which may be imposed. The Project Development Section of Central Engineering shall be consulted regarding these restrictions.

5.3.12 The differences in transmission and distribution costs because of location must be considered.

5.3.13 Overhead line crossings near the Substation or PURS Facility should be avoided.

5.4 Preferred future substation sites should be located in the flood free zones. However, in areas where real estate availability is limited, installation in a flood prone zone may be necessary. In that instance, substation design basis must satisfy the Design Flood Elevation requirements for the location, refer to CE-SS-2014, Standard Engineering Guidelines for Central Operations Facilities.

5.4.1 Storm Hardening measures may have to be implemented to ***achieve*** the Design Flood Elevations for Equipment.

6.0 FACILITY ARRANGEMENT

6.1 Transmission Substation Arrangement

6.1.1 In addition to the size of the Substation's property and the surrounding area, the Substation arrangement shall be based upon the following criteria:

a. The station's bus configuration can be air or gas insulated, i.e., the following equipment can be air or gas insulated: circuit breakers, bus, bushings, potheads, surge arresters, transformer bushings, disconnect switches, ground switches, etc. SF6 gas is a green -house gas that is environmentally regulated. When any type of insulating gas is considered, its environmental impact should also be considered.

b. Whether the station arrangement shall be "breaker-and-a-half," "single ring bus," "double ring bus" or other, this configuration shall be decided jointly by the Transmission Planning, Distribution Engineering (Substation Planning Section) and Central Engineering (CE) Departments.

6.1.2 An open air insulated bus configuration requires that the exposed conductors shall be separated from each other by a sufficient distance to permit the air to act as a dielectric which will withstand flashovers under the worst electrical and atmospheric conditions. Typically, this requires approximately ten times the amount of land area as that required for a gas insulated station.

6.1.3 In an open bus design, the conductors shall be supported on structures and insulators at a sufficient height above ground and away from structures (fences, buildings, etc.), to provide adequate ground clearances and safe distances to personnel (see Table No.4).

TABLE 4

OPEN BUS DESIGN – MINIMUM ELECTRICAL CLEARANCES - VERTICAL

Within Substation Property	138 kV (650 BIL)	345 kV (1300 BIL)
Height of Low Bus (from grade)	17	23
Height of High Bus from grade)	27	38
Height of Bottom of Insulator, Lightning Arresters, Coupling Capacitor, etc. (from grade or floor)	8.5 (note 1)	***8.5*** (note 1)
Equipment Access Roadway	26	32
Walkways and Buildings (with no roof access)	17	23
Clearance from Center of Conductor		
Building	20	32
Communication Cables	9	16
Distribution Cables	7	14
Outside(perimeter) fencing	13.7	18.3

Within Substation Property	138 kV (650 BIL)	345 kV (1300 BIL)
In Public Areas		
Height above Railroads Tracks	33	40
Height above Streets and Roadways	26	32

NOTE

1. See Paragraph 6.3.4.
2. All clearances are in feet.
3. Modifications to existing station shall maintain original BIL the station was designed for.

6.1.4 Air insulated, metal clad buses have been used for voltage levels up to 138 kV. Regarding this type of construction (phase segregated or phase isolated type), the conductors are supported on spool type insulators and enclosed in metallic weatherproof enclosures.

6.1.5 The gas insulated bus design ***shall employ*** an inert gas, such as SF6, as the insulating medium. The advantage of this design is the greater degree of compactness which can be achieved, thus permitting the installation of the required equipment in a much smaller space, i.e., this type of design requires the least amount of area for a given configuration and is normally used at higher voltages.

6.1.6 For the gas insulated bus design, components such as circuit breakers, potheads, disconnect and ground switches, CCVT, potential transformers and transformer bushings are all provided with an SF6 atmosphere in a metallic enclosure. These metal-clad buses and equipment can be installed as closely together as good maintenance and construction practices permit. ***Ergonomic consideration shall be included*** in the design and operations of systems, which shall be applicable with all regulations.

6.1.7 Other phase insulated bus design (technology) such as resin impregnated paper or polymer can be used for special applications with SME concurrence from Electrical Engineering or Equipment and Field Engineering.

6.1.8 The choice of Substation arrangement shall depend upon the following issues:

a. Land availability

b. Whether overhead or underground feeders are being terminated

c. Reliability requirements

d. Economic constraints

e. Environmental impact and compliance to laws and regulations

f. The "breaker-and-a-half" design utilizes three circuit breakers for every two transmission circuits or feeder positions. It offers a high degree of security because a faulted circuit will not affect the other operating sections of the station and two syn buses are available for power transfer (refer to Standard Drawing No. 303032, latest revision, for a typical one-line diagram). For detailed high tension drawings showing all ground switches, disconnect switches, etc. and the nomenclature for all equipment, refer to Drawing No. 303042, latest revision, "One Line Diagram of 138 kV or 345 kV Breaker–And-A-Half Bus High Tension Connections."

g. The "ring bus" design requires only one circuit breaker per transmission circuit or feeder position and is, consequently, less costly. However, a double circuit outage may separate the load from the supply circuits. To avoid such a contingency, load circuits should be alternated with supply circuits, i.e., two tie feeders should not be installed adjacent to each other. Where alternate connections are not possible, the use of an additional circuit breaker (two breakers between the adjacent feeders) should be considered. This additional position could be used for a future load feeder (see Standard Drawing No. 303043 and 340139, latest revisions, for a typical one-line diagram). For detailed high tension drawings showing all ground switches, disconnect switches, etc. and the nomenclature for all equipment for all equipment, see Drawing No. 303043, latest revision, "One Line Diagram of 138 kV or 345 kV Double Ring Bus High Tension Connections."

6.2 Area Substation Arrangement

6.2.1 Depending on the size and shape of the Substation property for an area Substation, the transformers, switchgear sections and control room ***may*** be arranged in ***the following*** ways.

a. One arrangement suggests positioning switchgear sections side by side in a straight line with the corresponding transformers also arranged in a straight line ***(i.e.*** Bruckner, Plymouth Street).

b. The other typical arrangement suggests positioning the transformers on the outer perimeters of the property and the associated switchgear located in the interior of the property (i.e. East 40th Street).

c. A third arrangement suggests positioning electrical equipment that produces significant levels of EMF like transformers and bus ducts away from residential buildings or zones that are adjacent to the Substation property (i.e., Parkview or Murray Hill).

> ***NOTE***
>
> ***If there is a site constraint and/or limited availability of transmission feeders, 3G concept design could be utilized sharing a spare transformer between two nearby stations***

6.2.2 The Area Substation should be designed as an indoor Substation as a preferred method. All switchgear sections, battery rooms, test equipment, control room, shall be located in one control building with the latest Substation reliability enhancements incorporated into this design. All switchgear sections for the new installations or existing Substation expansions may be installed outdoors where zoning ordinance prohibits indoor installations.

6.2.3 The standard 13 kV, 27 kV and 33 kV bus configurations for the Area Substation is the double syn bus design. This station bus arrangement utilizes two separately non-connected syn buses to connect the transformers. Each transformer is supplied from the bulk transmission network by a sub-transmission feeder cable.

a. Network load feeders are served from several bus sections with feeder placement balanced to provide diversity. The bus section then utilizes two normally closed circuit breakers as a means of supply (transformer and syn bus circuit breakers).

b. A maximum of four transformers are operated under load at any one time due to the short circuit capability of the switchgear. The fifth transformer is operated as a switchable in-place spare (refer to Standard Drawing No. 303034, latest revision, for typical one line diagram).

c. For detailed one-line high tension drawings showing all equipment and the nomenclature for equipment, refer to Drawing No. A247626, latest revision, for 138/13.8 kV Substations and Drawing No. A247627, latest revision for 138/27 kV Substations.

6.2.4 The advantage to the double Syn bus design lies in the fact that two separate sources are available to supply the load bus sections. If the transformer or feeder is out of service the section will be supplied via its Syn bus and vice versa.

6.3 Electrical Clearances

6.3.1 As stated in Paragraph No. 6.1.5, the gas-insulated station can be installed with a minimum amount of space between equipment except for passageways and maintenance areas. However, open-air type bus arrangements require that adequate electrical clearances be provided between live parts, live parts and ground, and live parts and structures over and above those required passageways and maintenance.

6.3.2 In a "ring-bus" design, the main bus runs ***shall be*** placed as close to the ground level as possible. The taps leading to the transformer or feeder terminals are then located at a higher elevation. This configuration is used in order to keep the cost of the circuit breaker foundations and the bus and disconnect switch supports at a minimum. A tabulation of the minimum design bus elevations is provided in Table No. 4. The minimum phase-to-phase and phase to ground spacing is provided in Table No. 5***, and design basis spacing is provided in Table No. 5A.***

TABLE 5

OPEN BUS DESIGN – MINIMUM ELECTRICAL CLEARANCES

	69 kV (350 BIL)	*138 kV (650 BIL)*	*345 kV (1300 BIL)*
Phase to Phase (metal to metal)	*3 Feet 0 Inches*	*8 Feet 0 Inches*	*12 Feet 0 Inches*
Phase to Ground (metal to metal)	*2 Feet 1 Inch*	*5 Feet 0 Inches*	*9 Feet 0 Inches*

TABLE 5A

OPEN BUS– DESIGN BASIS ELECTRICAL CLEARANCES

	69 kV (350 BIL)	***138 kV (650 BIL)***	***345 kV (1300 BIL)***
Phase to Phase centerline spacing (design basis)	***6 Feet 0 Inches***	***11 Feet 0 Inches***	***15 Feet 0 Inches***

NOTE

1. The phase-to-phase clearance at terminals (bushings) of transformers and circuit breakers is less than the values specified above. Therefore, the spacing of bus which connects to these terminals shall be expanded to the above distances as close to the unit as physically possible.

2. With approval from Chief Engineer - Electrical Engineering ***or Chief Engineer - Equipment and Field Engineering,*** clearances shown in Table 5 can be reduced when necessary up to minimum values specified by ***IEEE/ANSI C37.32*** for BIL corresponding to 350 kV, 650 kV and 1300 kV for the 69 kV, 138 kV and 345 kV systems respectively.

3. Any further clearance reduction **beyond IEEE/ANSI C37.32 shall be** justified only through insulation coordination study performed by SME, with concurrence from the Chief Engineer - Electrical Engineering ***or Chief Engineer - Equipment and Field Engineering.***

4. ***Approved clearance reduction dimension shall be identified and noted on the construction drawing.***

5. All clearances are in feet.

7.3.2 In a “breaker-and-a-half” design, the bay buses ***shall be*** placed as close to the ground as possible and the “Syn” (common) buses ***shall be*** located at a higher elevation. Again, this is done to minimize circuit breaker foundation and support structure costs.

7.3.3 All surge arresters, potential transformers, coupling capacitor potential (voltage) transformers, coupling capacitor potential devices, etc., having a clearance of less than that indicated in Table 4, between the bottom of the insulator stack and grade (for both the 138 kV and 345 kV installations) shall be enclosed within an individual or common, 6 foot high fence enclosure.

7.3.4 ***The Substation ground grid and grounded structures (ground fault carrying paths) and transmission feeders (69 kV and above) shall be separated by a distance of at least two feet.*** If the distance is less than two feet, then the grounding cables ***shall*** be placed into FRE conduits at the locations of crossings. All instances of less than two feet separation and /or any protective measures taken shall be referred to the Transmission Engineering Section for resolution and approval. Under no circumstances, shall it be less than 1 foot. This criterion applies to both pipe type cable and solid dielectric cable.

6.4 Control House

6.4.1 A central control building (outdoor design) or a central control room (indoor design) shall be provided for each Substation and PURS Facility. The use of a centralized control location will permit a more rapid response by the Substation operator to alarms and automatic operations (during attended operation) thereby shortening the restoration time following "trip-outs."

6.4.2 The control house shall contain the following equipment and be sized accordingly:

a. Use of Substation Automation Systems (SAS) with Human Machine Interface (HMI) is preferred for all new installations.

b. For all protective relaying system panels and cabinets, the preferred design is for the first line and second line equipment to be installed in separate rooms. An acceptable alternative is for the first line equipment to be installed on one side of an aisle or walkway, and the second line equipment on the other side, separation is provided by distance.

c. Alarm monitoring system, fire alarm controls panel, local control panel, digital fault recorder, SER, supervisory control and telemetering cabinets, etc. These components shall be centrally grouped for efficient viewing, use and operation by the Substation operator.

d. Lighting panels, AC and DC panel boards, rectifiers, static invertors, etc.

e. All communications facilities i.e., radio transceiver and control console, telephones, telephone termination boxes and interface equipment, etc.

6.4.3 For the Area Substation, in addition to the above mentioned equipment, the control room shall also contain the following:

a. Network startup/shutdown panel

b. Load shedding panel (see 6.4.3.d)

c. Load Management System Panel – This panel shall be installed for all new installations. It combines the voltage reduction panel and load shedding panel into one panel.

6.4.4 The control house shall include two separate battery rooms, one for Battery No. 1 and one for Battery No. 2.

6.4.5 Locker, washroom and lavatory facilities should be included, separate for male and female employees where possible.

6.4.6 Sufficient space for the future installation of protective relaying and control equipment to accommodate the ultimate, planned development of the Substation or PURS Facility shall also be provided.

6.4.7 The control house shall be constructed either with a "pedestal" type (floating) floor to facilitate cabling and equipment installation and relocation or with trenches. Overhead tray systems should be considered for modification or renovation works in an existing control room. Fire protection facilities and barriers to maintain primary and back-up protective relay system cable separation shall be installed. The following are the advantages of the installation of a floating floor:

Cable installation is simplified through the utilization of all available space under the floor.

a. Cable replacement is possible, since most cables will be installed next to each other rather than on top of the other.

b. Fire protection between first and second line cabling is achieved via the installation of fire retardant barriers underneath the floor tiles.

c. Cabling for an added piece of equipment is easily accomplished.

d. The installation cost has to be compared with that of concrete trenching before the final selection of one system over the other.

6.4.8 Two individual, physically separated cable entrances (conduits or trench) shall be provided into the control house for the primary and back-up protective relaying system cabling. In addition, two physically separate conduit entrances shall be provided for the Route No. 1 and Route No. 2 communication copper cables or fiber optic cables.

7.0 STRUCTURAL REQUIREMENTS

7.1 Insulation Coordination

7.1.1 The insulation strength of the electrical equipment designed and installed in a Substation must be coordinated with the expected electrical stresses; i.e., the magnitude, duration and probability of internally generated over-voltages (due to switching surges) and externally (due to lightning strikes, power crosses, faults, etc.) generated over-voltages; and the characteristics of the surge protective devices to be installed.

7.1.2 In order to provide an equal basis for coordinating the insulation of various electrical equipment, the insulating strength of each device is specified, based on its ability to withstand an over-voltage under certain specific conditions. This rated withstand voltage level is referred to as the "Basic Lightning Impulse Insulation Level" (BIL) of the equipment.

7.1.3 The BIL rating of a piece of equipment is determined and established by Con Edison and verified by the manufacturer by performing specific factory tests. These tests include a full wave voltage impulse test, where the test wave shall have a virtual front time (based on the full wave impulse voltage) equal to or less than 1.2 microseconds and a time to the 50 percent value of the test voltage equal to or greater than 50 microseconds. The crest magnitude of the full wave impulse voltage which is successfully "withstood" is the BIL rating of the device.

7.1.4 Since the BIL levels for the transformers and the remainder of the station equipment can vary, the surge arresters for the transformers should be mounted on the transformers (or as close as possible to them) with the ratings shown in Table 6. When the surge arresters are used to protect other equipment (such as circuit breakers, buses, potential transformers, etc.) a different rating should be selected. Table No. 6 shows the BIL rating for the equipment.

TABLE 6

BIL RATINGS OF MAJOR TRANSMISSION SUBSTATION EQUIPMENT ***(AIS)***

	138 kV		345 kV	
Equipment	Internal	External	Internal	External
Transformer and Shunt Reactors	550	650	1050	1175
Circuit Breakers	650 (1)	650	1300 (1)	1300
Potential Transformers	550	650	1175	1175
Coupling Capacitor Potential Devices	-	650	-	1550 (2)
Terminations (Potheads)	-	650 (3)	-	1300 (3)
Disconnect Switches	-	650	-	1300
Bus Supports	-	650	-	1300
Shunt Capacitor Banks	(4)	650	(4)	1300

NOTE

1. The internal BIL may vary on gas circuit breakers, depending on the pressure and temperature of the interrupting medium.
2. This is an industry standard, different BIL ratings can be obtained at extra cost.
3. This BIL is required to protect the high pressure, pipe type cables.
4. Shunt capacitor banks are built from smaller capacitor units grouped on racks. The BIL refers to the complete rack assembly.

7.1.5 In order to limit the surge voltages that may be imposed on the equipment and safely bypass these over-voltage surges to ground, surge protectors (surge arresters) are installed in the Substation. In addition to bypassing any surges which may develop, these devices should be able to withstand the rated maximum voltage without discharge. The switching surge withstand protection ratio is the maximum surge voltage it will discharge without failure to the maximum crest voltage it will withstand per ANSI C62.22.

7.1.6 The surge protectors shall be coordinated with the Substation's BIL levels and shall have a protective margin of 20% minimum. They shall be installed as close as possible to the equipment being protected.

7.1.7 It should be noted that surge arresters are not designed to protect against direct high energy lightning strikes at the Substation terminations. These devices are designed to handle voltage surges entering the Substation due to switching operations in other parts of the system or from lightning strikes on the "high line" several tower sections away from the Substation.

7.1.8 Protection against temporary over voltages may require special surge arresters. ***EMT*** studies should be performed to determine the ***voltage and energy ratings*** and/or number of surge arresters to be installed where the potential for switching over voltages exists, which can lead to failure ***or damage to equipment. In addition the selection should take into consideration the voltage transient durations compared to the continuous, temporary, and impulse ratings of the arrester.***

7.1.9 Surge Arresters ensure that the equipment BIL is not exceeded. Table 7 list the standard surge ***arrester*** ratings. ***Note that the arrester ratings below are rated voltage based on IEEE standards but does not represent the arrester duty cycle or protective levels, which would typically be used to determine insulation coordination.***

TABLE 7

7.1.10 TRANSMISSION SUBSTATION SURGE ARRESTER RATINGS***, RMS values***

Equipment to be protected***, system voltage***	138 kV	345 kV)
Bus	120 (1)	312
Switchgear	120 (1)	312
Transformer		
1050 kV BIL Internal		312
900 kV BIL Internal		312
550 kV BIL Internal	120 (1), (3)	

NOTE

1. In specific locations 144 kV rated arresters may be used

2. In specific locations 312 kV rated arresters may be used if the protective margin is satisfactory.
3. For Delta connected windings, if the primary can be isolated from the effectively grounded 138 kV system, 144 kV rated arresters shall be used.
4. The ratings for the Surge Arresters are in kV, line to ground.

7.2 Bus and Supporting Structures

7.2.1 As a preference, all buses shall be rigid-type, mounted on ground supported structures with supporting steel below the insulators.

7.2.2 Strain type buses can be used where economically justified.

7.2.3 Short flexible links or bus expansion connectors shall be utilized as connections to all apparatus terminals and equipment (i.e. potheads, arresters, ***potential devices or coupling capacitors,*** etc.), where possible. This should prevent any lateral stress from being passed on to the pothead or other terminal thus mitigating any dielectric fluid leaks or SF6 gas emissions to the environment as well as equipment operating problems (disconnect misalignments). ***Where flexible connections cannot be used, minimum 2.5 inch O.D., SPS Aluminum Alloy 6063-T6 pipes can be used with provisions for expansion (sliding or expansion connectors).***

7.2.4 The bus should be designed and installed in the recommended arrangements shown on Standard Drawing Nos. 303035, 303036 and 303037, latest revisions. All installations shall be designed with B-phase as the center phase.

7.2.5 All supporting structures shall ***be designed to minimize bracing***. Lattice type structures shall be avoided because of their unsightly appearance. Each supporting structure design shall be arranged for a maximum clearance under the structure to allow for the installation of any future equipment.

7.2.6 The rigid bus conductors shall be tubular aluminum; ANSI Schedule 40 or Schedule 80, ALCOA Aluminum Alloy 6063-T6 or equivalent and be capable of sufficient current carrying capacity. The standard bus size is 5” Outer Diameter (OD) for 138 kV and 5” O.D. for 345 kV to achieve a 3000 AMP bus rating. For long runs, the recommended sizes are 5” O.D. and 6” O.D. respectively. The spacing of the support insulators shall be determined by the short circuit stresses imposed on the conductors combined with an assumed wind and ice load. The design should accommodate the following momentary and short circuit current values:

Short Circuit Current	138 kV	345 kV
Momentary (3 Phase) Asymmetrical	101 kA	101 kA
Short Time (3 Phase) Symmetrical	63 kA	63 kA

7.2.7 The wind and ice loading conditions are listed in Specification No. CE-SS-2006 "Design of Substation and Transmission Structures." The value shall be selected from Section III, Part 1, Chapter 5.0 Specific Design Requirements.

7.2.8 The bus conductors shall be welded (inert gas, heliarc welding) except where the buses are to be connected to the equipment. All such connections shall be bolted with Everdur (silicon-bronze), high strength aluminum alloys, or stainless steel hardware. Use of compression type connections allowed only with prior concurrence from Electrical Engineering.

7.2.9 Whenever bus spans exceed the lengths given in Table No. 8, inner aluminum tubing for vibration damping should be considered. The recommended dampers are ALCOA internal bus dampers. As an alternative to the ALCOA bus dampers, the sizes of ACSR multi-strand core conductors given in Table 9 shall be inserted in the tubular bus:

TABLE 8

MAXIMUM VIBRATION-FREE SPAN LENGTH TABULAR BUS

Nominal Pipe Size	Maximum Safe Span Length
1	5’ – 0”
1¼	6’ – 3”
1½	7’ – 0”
2	9’ – 0”
2½	10’ – 9”
3	13’ – 3”
3½	15’ – 3”
4	17’ – 0”
4½	19’ – 0”
5	21’ – 3”
6	25’ – 3”

NOTE

1. Lengths based on one loop of vibration
2. Lengths apply to both Schedule 40 and Schedule 80 tabular bus.
3. Lengths can be increased approximately 20% with reasonable certainty that there will be no vibration.

TABLE 9

Bus Size (inches)	Recommended Minimum Size ACSR (Circ. Mills)
3	266,800
3½	397,500
4	795,000
5	1,431,000
6	1,590,000

The inner aluminum tube lining shall be free to rotate. The bus liner shall be made of 6063-T6 aluminum alloy or equivalent. The Table 10 gives the details of all sizes of bus required:

TABLE 10				
		Diameter (Inches		
Nominal Bus Size (Inches/Schedules)	Bus O.D.	Bus I.D.	Liner O.D.	Liner Wall Thickness (Inches)
4/40	4.500	4,026	3.750	0.0625
4/80	4.500	3.826	3.750	0.0625
5/40	5.563	5.047	4.500	0.0625
5/80	5.563	4.813	4.500	0.0625
6/40	6.625	6.065	5.000	0.0625
6/80	6.625	5.761	5.000	0.0625

7.2.10 Generally, mid-span bus splices are to be avoided. If this is not possible, cast aluminum alloy couplers must be used to join the conductors. These couplers must be welded to the bus.

7.2.11 Bus supporting points and the use of various type (rigid, sliding, flex or expansion) connectors should be carefully selected and should include allowance for future bus expansion.

7.2.12 Bus connectors and supports should be of the “Corona Free” design. They should be made of cast or forged aluminum alloy, and its strength shall not be less than ALCOA Aluminum Alloy 195-T4.

7.2.12.1 Surge arresters shall not be used as bus supports unless prior concurrence from Electrical Engineering. In such instances, surge arrestors design specification shall state that arrestor is designed for bus supporting application, and ***the force imposed on the arrester in all directions (e.g., vertical, sheer, etc.) must be less than the designed load of the arrester.***

7.2.13 When aluminum hardware is being furnished, it shall be coated with a No. 205 aluminate finish. Bolts and nuts shall be Aluminum Alloy 2024-T4 or equivalent. The torque values for the various aluminum bolt sizes shall be:

TABLE 11			
Bolt Size	Threads/Inch (National Coarse Class 2 Fit)	Torque (Ft/Lbs.)	Ultimate Tensile Load (Lbs.)
3/8	16	11	4,300
1/2	13	23	8,000
5/8	11	40	12,000
3/4	10	55	19,200

7.2.14 All surfaces, bolts, nuts and washers are to be coated with an anticorrosive lubricant such as NO-OX-ID, Grade A special or equivalent.

7.2.15 For new ***138kV*** installations, station post type insulators should be used. The flashover characteristics must conform to the BIL selected for other equipment, See Table No. 12. Extra creepage distance shall be specified for all insulators. ***Approved resistance graded insulators are recommended in locations subject to high contamination (i.e. Near roadways, waterways, etc.).***

TABLE 12

TRANSMISSION SUBSTATION INSULATORS

	138 kV			345 kV		
Type Insulator	No.	BIL	Bolt Circle	No.	BIL	Bolt Circle
Cap & Pin	4	750	5”	-	-	-
Post	1 or 2	750 (3)	5”	3 or 4	1300 (1)	5” or 7”
Suspension (5¾” x 10” Discs)	7 to 12	760 to 930	-	16 to 29	1350-1615	
Strain (5¾” x 10” Discs)	7 to 12	1200	-	16 to 29	1350	-

NOTE

1. The size of the bolt circle depends on the cantilever strength of the insulator.
2. The number of disc depends on the type of insulators selected for the application. In polluted areas, special long leakage distance insulators shall be specified. It is recommended that at least one extra disc be used in each string above the number required to obtain an impulse flashover value equivalent to the BIL of the Substation (e.g. 9 insulators at 138 kV). In existing Substation, use the same type and number of insulators as the insulators already installed.
3. For new installations and modifications with existing stations 650 BIL insulators can be used.

7.2.16 For 345 kV installations, only post type insulators should be used. The insulator strength will be determined by the combined short circuit, wind and ice load per IEEE 605 standard.

7.2.17 The supporting insulators should be specified for vertical, under-hung or 45º cantilevered mounting depending on the design of the station and where they shall be used.

7.2.18 When a set of three bus support insulator stacks (one per phase) are to be installed "in line," as a general rule, they shall be mounted on a common, double support stand.

7.2.19 For 345 kV disconnect switch insulators, an insulator strength higher than normally provided for supports may be required because of the added stress imposed by the operation of these disconnect switches. The required insulator strength shall be verified by calculation.

7.2.20 The supporting structures and stands for the disconnect switches, surge arresters, coupling capacitors, insulators, etc. shall be fabricated from structural shapes of galvanized steel. These structures should be pre-assembled by the fabricator to the maximum extent, consistent with shipping and erection limitations. Structural members should be welded, except for bolted mounting of the appurtenances to be supported.

7.2.21 All structures shall be self-supporting with a minimum of cross-bracing and be fabricated of hot galvanized steel. Lattice type structures shall be avoided because of their unsightly appearance. None of the structural members shall have a thickness of less than 0.250 Inches.

7.2.22 All disconnect switch supporting structures shall be uniform in design for the low and high bus, respectively.

a. The disconnect switch structure design, as a general rule, shall have space, openings and factory drillings provided for the future installation of ground switches on both terminals, if they are not initially provided. Initial ground switch requirements shall be indicated on the one-line diagram.

b. The structural design shall allow a maximum amount of clear space beneath the structure.

c. For the 138 kV disconnect switch assemblies, the minimum vertical clear space beneath the supporting stand shall be:

(1) 9 ft. – 0 inch. for the low bus of 17 ft. height.

(2) 20 ft. – 0 inch. for the high bus of 27 ft. height.

d. For the 345 kV disconnect switch assemblies, the minimum vertical clear space beneath the supporting standard shall be:

(1) 11 ft. – 0 inch. for the low bus of 23 ft. height.

(2) 26 ft. – 0 inch. for the high bus of 38 ft. height.

7.2.23 All pothead stands shall be designed to accommodate one pothead per phase (see the latest revision of Standard Drawing No. A167904 for 138 kV installations and Drawings No. A168009, for 345 kV installations). If double potheads are required for specific 138 kV terminations, such a requirement will be specified by the Transmission Planning Department, the minimum clearance of 5' – 0" between phase and ground shall be maintained for 138 kV equipment. All pothead stands shall be uniform in design and shall be provided with a platform on the top of the stands for personnel access and maintenance.

a. For the 345 kV pothead stands, the platform shall extend on all sides, a minimum of three feet from the centerline of each pothead. This platform should accommodate and support a temporary installation of three field erected, air conditioned housings around the potheads for the maintenance and preparation of the pothead cable terminations. Drawing No. A166333 latest revision, shows the field erected humidity chamber.

b. Each pothead stand shall be equipped with a set of sleeves, capable of accepting a set of removable posts and safety railings. These railings will be temporarily mounted on the pothead platform to insure the safety of Company personnel while they are working on the pothead structure (See Standard Drawing No. 303038 latest revision). A minimum of one set of removable railings shall be required for each station. These railings shall meet OSHA standards.

c. See Table 13 for a list of standard drawings for other structures, i.e., disconnects switch stands, surge arrester stands, etc.

TABLE 13

ALL STATION REFERENCE DRAWINGS

DRAWING NUMBER	TITLE
A159080	Assembly of Standard 138 kV Double Pothead Structure
A159887	Details and General Notes for Cable Troughs
162474	Current Transformers At 138 kV And 345 kV Potheads
167934	Schematic Diagram Of Typical Tap Changer Control For Large Power Transformers
166333	Humidity Chamber For 345 kV Potheads
167904	Assembly of Standard 138 kV Single Pothead Structure and Electrolysis
167913	Assembly and Detail of Station Shut-Down and Re-Energization Control Panel
167934	Schematic Diagram of Typical Tap Changer Control for Large Power Transformers
167935	Typical Schematic Wiring for Oil Insulated Transformer Cooling Equipment
167975	Schematic Of Circuit Breaker, Disconnect Switch, PAR Or Transformer Tap Changer Auto/Manual Control And Indication
167991	Typical Schematic Piping Diagram for a Pressurization Plant
A168009	Assembly Of Standard 345 kV Pothead Structure Substations
168491	Installation of Thermocouples for Oil Circulating Pipes on Feeders
177608	Block Diagram Of S/S Transformer Remote Manual Control Of Voltage Reduction
181895	Typical Ground Connections For Electrical Equipment And Structures In Area Substations and Generating Stations
190950	Relay Board Nameplates
211791	Installation of Emergency Diesel Generator for Temporary Usage

TABLE 13 (Cont'd)

ALL STATION REFERENCE DRAWINGS

DRAWING NUMBER	TITLE
213741	Typical Diesel Generator Foundation
214215	Procedure For Purchasing And Fabricating Nameplates For Protective Relays, Multi-Contact Relays And Timer Relays
217432	Concrete Electrical Cable trench & cover for Skip & H2O Truck Load
218484	General Notes, Symbols and Mounting Details for Interior and Exterior Lighting Yard Operating Areas
218486	Typical Underground Conduit And Pipe Details And Direct Buried Cable
218491	Assembly Of Standard 138 kV And 345 kV Single Pothead Structure-Plan And Sections
218492	Assembly and Details of Dielectric Fluid Piping for 138 and 345 kV Feeder Pipes
218495	Standard Above Grade Conduit Connections For Electrical Equipment
218501	Installation Details For Equipment Signs For Area Substations
221319	Loading Tabulation of Miscellaneous Electrical Equipment Supports
221320	Standard Details of Foundation for Miscellaneous Electrical Equipment Supports
221323	Standard Foundation for 65 MVA Area Substation Transformer
221335	Standard Structural Support For 138 kV Single Pothead-Plan, Elevation And Sections
221336	Standard Structural Support For 138 kV Single Pothead-Sections
221341	Standard Details for Connection of New Electric Trench to Existing Electric Trench
221345	Standard Indoor Cable Trench for Switchgear House – Plant and Sections
233088	Standard Structural Support For 138 kV 3 Phase Bus Support
233090	Standard Disconnect Switch Stand For 138 kV Bus and 345 kV High and Low Bus
233091	Standard Structural Support For 345 kV Single Pothead-Plan, Elevation And Sections
233092	Standard Structural Support For 345 kV Single Pothead-Sections
233093	Standard Structural Support For 345 kV 3 Phase High And Low Bus Support

233094	Standard Structural Support For 138 kV And 345 kV High And Low Bus Single Phase Bus Supports, Surge Arresters, CCPD And Potential Transformers
233095	Standard Support for 345 kV Three Phase CCPD
233096	Standard Combined Support For 345 kV 3 Phase Bus And Disconnect Switch Structure
233097	Standard Combined Support For 345 kV CCPD And Wave Trap Structure
233098	Standard Support For 345 kV CCPD
233099	Standard Supports For 345 kV Bus – Aluminum
233101	Standard Combined Support For 345 kV Bus
233102	Standard Combined Support For 345 kV CCPD And Wave Trap – Aluminum
233103	Standard Support For 345 kV Single Phase Bus And CCPD
233671	Standard Structural Support For 138 kV Pothead And Ground Switch- Plan, Elevations And Sections
233672	Standard Structural Support For 138 kV Pothead And Ground Switch- Plan, Elevations And Sections
233830	Various Substations – Typical Mounting Details for Installation of Capacitor Banks
239612	Foundation Details for Electrical Equipment Supports
242434	Fire Protection System Remote Manual Station For Deluge Valves
243543	Telephone Test Switch Device Arrangement
247486	List Of Alarms For Station Annunciator
247487	Schematic Diagram Of Alarm Circuits Points 1 To 20
247488	Schematic Diagram Of Alarm Circuits Points 21 To 40
247489	Schematic Diagram Of Alarm Circuits Points 41 To 60
247490	Terminal Block Arrangement & Designations For Station Alarm Pane
247500	Schematic Wiring Diagram -Station Shutdown & Re-Energizing Control Network A
247501	Schematic Wiring Diagram -Station Shutdown & Re-Energizing Control Network B
247502	Diagram Of Internal Connections For Station Shutdown & Re-Energizing Control Panel
247504	Voltage Reduction Panel Schematic Wiring Diagram For 5 Bank Area Substation
247511	Schematic Wiring Diagram – DC Control For Back Up Panel

247512	3 Line AC Schematic For Transformer Backup Panel
247513	Wiring Diagram of Backup Panel
247514	Wiring Diagram of Backup Panel
247520	Simplified Schematic-13 kV Area S/S-Sects 1 & 2
247521	Simplified Schematic-13 kV Area S/S-Sects 3 & 4
247522	Simplified Schematic-13 kV Area S/S- Sect 5 & Syn Buses
247523	Simplified Schematic-27 kV Area S/S-Sects 1 & 2
247524	Simplified Schematic-27 kV Area S/S-Sects 3 & 4
247525	Simplified Schematic-27 kV Area S/S-Sect 5 & Syn Buses

247619	Station Alarm Panel-Assembly & Detail
247620	120/208 Volt Load Boards 1 & 2-Construction
247622	One Line Diagram-120/208 Volt L & P
247624	Typical Entrances/Crossovers For Conduits
247626	One Line Diagram-13/138 kV Connections
247627	One Line Diagram-27/138 kV Connections
247628	Typical Conduit Duct Bank
247633	Termination PVC, Entering Side Of Trench
250242	Control Room Arrangement
250244	Structural Detail Outdoor Back Up Panel
251974	Standard Structural Support For 138 kV Double Pothead
251975	Standard Structural Support For 138 kV Double Pothead Stand
252001	Standard Pipe Supports And Hangers For Fire Protection
253603	All Station Underground Standard
253761	13 kV Cap Bank Schematic
253762	27 kV Cap Bank Schematic
301953	Permanent Freeze Pit for 138 and 345 kV High Pressure Cable Pipe
303000	Distribution of Ground Fault Current From Ground Connections To Ground Grid
303003	Method Of Grounding Surge Arresters
303006	Physical Arrangement Of Fence And Parallel Transmission Lines
303008	The Magnetic Field Around A Bus Carrying Current
303009	Electrostatic Field Due To The Current

303010	Equivalent Circuit Of A Control Cable Exposed To The Electric And Magnetic Field Of The Bus Current
303011	Moisture Absorption By Concrete Cubes Embedded In Soil
303012	Typical Ground Connection For Building Column
303013	One Line Diagram Transmission Substation Light And Power Supply System (Typical)
303014	One Line Diagram Area Substation Light And Power Supply System (Typical)
303017	Substation Communication Model Layout (Typical)
303018	Plan View Of Substation Communication Facilities Equipment (Typical)
303019	Protection Of Telephone Facilities Entering Substations (Typical)
303020	Section View Of Transformer Moat Overflow Drain Pit
303021	View Of Oil Water Separator Within Retention Pit

DRAWING NUMBER	TITLE
303022	Section View Of Collecting Pit With Oil Trap For Transformer Secondary Containment
303023	View Of Oil Trap Separator For Station Drainage
303024	Typical Moat Configuration For Substation
303025	Moat With Geo-Synthetic Liner For Substation
303026	Moat With Concrete Floor (Typical)
303027	Substation Communication Connection Arrangement And Maintenance Responsibilities
303028	Secondary Containment Facility For New Power Transformer Installation
303029	Secondary Containment For Substation Drainage Systems
303030	Sump Pit With Alarm For Secondary Containment Facility
303031	Various – Substation Control And Instrumentation Architecture
303032	Typical One Line Diagram Of Breaker-And-A-Half Design
303034	One Line Diagram For Area Substation Double Syn Bus Design
303035	Typical 138 kV Ring Bus Circuit Spacings
303036	Typical 345 kV Ring Bus Circuit Spacings
303037	Typical 345 kV Breaker-And-A-Half Circuit Spacings
303038	Typical Design For Removable Railing For Pothead Platforms

DRAWING NUMBER	TITLE
303043	One Line Diagram Of 138 kV And 345 kV Double Ring Bus High Tension Connections- Detailed
303046	Recommended Connection for Leased for Telephone Cables
303048	Transmission Substation Potential Source Connections
303051	Typical Conduit Installation of Conduits Entering Through Side of Trench
303053	Typical Conduit Installation of Pocket Type Switchgear Floor Design
303054	Typical Conduit Installation for Terminating Conduit in Switchgear
303055	Typical Electrical Clearance of Concrete Encased Conduit Bank from 138 and 345 kV Feeder Pipes
303056	Typical Conduit Bank Installation for Encasing Conduits on Concrete
303057	Typical Conduit Installation of Conduits Entering Through Bottom of Cable Trench
303058	Typical Conduit Installation for Direct Buried Cable
303059	Typical Conduit Installation for Conduits Terminating in Precast Trench
303060	Cable Entry into Equipment Cubicle
303061	Control Cable Terminations
303062	Termination of Shielded Instrument Cables
303063	Typical Method for Patching Openings in Relay Panels – Method 1

TABLE 13 (Cont'd)

ALL STATION REFERENCE DRAWINGS

DRAWING NUMBER	TITLE
303064	Typical Method for Patching Openings in Relay Panels – Method 2
303065	Typical Method for Patching Openings in Relay Panels – Method 3
306356	Typical Arrangement of Piping for Permanent Installation of Dielectric Fluid Flow Meters for Pressurizing Plants
306357	Typical Arrangement of Piping for Permanent Installation of Dielectric Fluid Flow Meters for Pressurizing Plants
307528	Chain Link Fence of Hazardous Waste Storage Area
328488	Panel Arrangement for Load Management System
328958	Schematic Diagram of 208 Volt AC Network A Load Shedding Circuit
328959	Schematic Diagram of 208 Volt AC Network B Load Shedding Circuit
328960	Diagram of internal Connections of the Load Management Cabinet
330259	Flexi test Switch Open Network Start Up/Shut Down System and Load Management System Trouble Alarm
332939	Schematic Diagram of Operating Procedures for 13 kV Capacitor Bank C1
332940	Schematic Diagram of Operating Procedures for 13 kV Capacitor Bank C2
332941	Schematic Diagram of Operating Procedures for 13 kV Capacitor Bank C3
340121	General Arrangement of 138/13 kV Control Equipment, Mezzanine and Second Floor-Plan
340122	General Arrangement of 138/13 kV Control Equipment, Mezzanine and Second Floor-Sections
340123	General Arrangement of 138/13 kV and Control Equipment – Street Access
340126	General Arrangement of 138/13 kV and Control Equipment – Sections
340139	One Line Diagram Of 138 or 345 kV Single Ring Transmission Substation High Tension Connections
340328	Grounding 1st Floor Plan
340329	Installation Of Isolators/Surge Protectors For Feeder Cathodic Protection
340338	Grounding Details

DRAWING NUMBER	TITLE
340345	Installation Of Shielding Plates For 13 kV Distribution Manholes
340404	Installation Of Cathodic Protection For 138 kV Feeders
340958	Transmission Control Room Layout
340982	One Line Diagram 120/208 Volt AC Supply Load Boards 1 And 2 For Breaker And A Half Transmission Substation
341073	Arrangement And Outline Of 125 Volt Dc Load Board 1
341255	General Arrangement Of Type “B” Signs For Relay Panels
341256	General Arrangement Of Type “C” Signs For Relay Panels
341257	General Arrangement Of Type “A” Signs For Relay Panels
341258	General Arrangement Of Type “D” Signs For Relay Panels
341259	Standard Drawing Format For Ordering Signs On Station Electrical Material List
342310	Schematic Diagram Of Operating Procedure For 13 kV Capacitor Bank C4
344638	Standard Cable Block Diagram 27 kV 5 Bank Area Substation Sheet 1 Of 5
344639	Standard Cable Block Diagram 27 kV 5 Bank Area Substation Sheet 2 Of 5
344640	Standard Cable Block Diagram 27 kV 5 Bank Area Substation Sheet 3 Of 5
344641	Standard Cable Block Diagram 27 kV 5 Bank Area Substation Sheet 4 Of 5
344642	Standard Cable Block Diagram 27 kV 5 Bank Area Substation Sheet 5 Of 5
344643	Standard Cable Block Diagram 13 kV 5 Bank Area Substation Sheet 1 Of 5
344644	Standard Cable Block Diagram 13 kV 5 Bank Area Substation Sheet 2 Of 5
344645	Standard Cable Block Diagram 13 kV 5 Bank Area Substation Sheet 3 Of 5
344646	Standard Cable Block Diagram 13 kV 5 Bank Area Substation Sheet 4 Of 5
344647	Standard Cable Block Diagram 13 kV 5 Bank Area Substation Sheet 5 Of 5
344648	Operating Procedure For Key Interlock System Of High Voltage Test Set Equipment
344649	Lock And Key Schedule For Key Interlock System Of High Voltage Test Set Equipment

8.0 ENVIRONMENTAL CONSIDERATIONS

8.1 Electromagnetic Fields (EMF)

8.1.1 Design methods to mitigate the effects of electromagnetic fields due to the operation of electrical equipment located within the Substation or PURS Facility and the possible exposure of the public to those fields should be considered for additions or modifications to an existing Substation or PURS Facility.

8.1.2 The following design methods should be considered in order to mitigate EMF exposure by station personnel as well as the public:

a. Distance – The design should arrange new equipment such that potential sources of EMF (high current carrying components like bus, cable, capacitor banks, etc.) are located at a specified distance from the fenced property line, thereby resulting in negligible EMF levels at the property line.

b. Configuration – Reconfigure and reorient components within the station. Utilize triangulation and phase transposition of bus and cable to mitigate EMF through cancellation effects. Reorient EMF sources making them perpendicular (rather than parallel) to public areas, thereby, achieving minimum field intensities in these areas due to the vectorial displacement of the magnetic field with respect to the conductor. Run equipment connecting bus and cable in a three-phase configuration rather than single phase.

c. Shielding – The design should consider grounded metallic shields or mesh for equipment and distribution feeder outlets. Aluminum and steel plates, copper mesh and mu-metal have been used as shielding materials. Although this method will yield reduced EMF levels, it may create interference with other related station design concerns (HVAC, operational aspects, interlock scheme). Therefore, this approach could be more costly due to detailed engineering requirements.

8.2 Arc Flash Hazard (Design for OSHA Arc Flash Requirements)

8.2.1 Con Edison is required to complete an Arc Flash Hazard Analysis for all Con Edison utility facilities in compliance with OSHA CFR1910.269 "Electric Power Generation, Transmission, and Distribution".

a. For Voltages less than 15kV, the IEEE 1584 method shall be used to calculate the potential hazard level.

b. For Voltages of 15kV and greater, the ArcPro software shall be used to calculate the potential hazard level.

c. Additional calculation methods may be used where compliant with OSHA requirements and the calculation method has been Validated and Verified as required by CE-0402 "Engineering Calculations".

8.2.2 Con Edison is required to complete an Arc Flash Hazard Analysis for all Con Edison non-utility facilities in compliance with NFPA 70 "National Electrical Code (NEC)" and the NYC Building Code.

8.2.3 Existing Arc Flash Hazard Analysis will be re-evaluated whenever a change to the existing facility or individual equipment causes a change in the available short circuit current, clearing time of protective devices, the working distance between employees and live equipment, or other factors that may change the hazard level.

a. Where an updated Arc Flash Hazard Analysis indicates a change in required FR clothing and/or PPE, inform EH&S of the change.

b. The updated Arc Flash Hazard Analysis will be documented and archived as per CE-0402 “Engineering Calculations”.

8.2.4 Arc Flash Hazard mitigation strategies shall be considered wherever the Arc Flash Hazard Analysis indicates a potential hazard exposure greater than 8 cal/cm^2.

a. Mitigation strategies will consider methods for changing at least one of the key variables of the Arc Flash Analysis; available short circuit, clearing time of a fault, distance between the employee and the source of the arc flash.

b. Mitigation strategies may include changes to equipment selection to reduce the likelihood of an arc flash occurrence or reduce the exposure of the employee to the arc flash.

c. Mitigation strategies may include changes to work practices, such as the ability to work on equipment only when de-energized.

8.3 Environmental Excellence

8.3.1 The EH&S design of the Substation or PURS Facility shall follow all applicable federal, state and local laws and regulations. EH&S design issues are identified by the application of CEHSP A11.03 “Environment, Health and Safety Considerations In ***Project Engineering and*** Planning.” This review also identifies the applicable company procedures and specifications. The purpose of the review is to provide the required environmental design guidelines to insure environmentally sound and responsible design for all Area and Transmission Substation or PURS Facilities.

8.3.2 CEHSP E04.15 “Waste Minimization” shall be utilized as a guideline to avoid and/or mitigate pollution and/or reduce waste as feasibly and practically possible within the boundaries of the engineering design.

8.3.3 The CEHSP E04.01 “Hazardous Waste Management Program Overview” provides design guidance to incorporate the principles of pollution prevention into the new facility. Pollution prevention seeks to eliminate the release of all pollutants (hazardous and non-hazardous) to all media (land, air and water). In addition, pollution prevention also includes water conservation and protection of natural resources.

8.3.4 Each Substation will be designed with the following environmental, health and safety areas:

a. Hazardous Waste Storage Area

b. Asbestos Waste Storage Area

c. Solid Waste Storage Area

8.3.4 Details on the design of ***hazardous waste*** storage areas are contained in CEHSP E04.01 “Hazardous Waste Management” and CEHSP E04.06 ***“***Storage***.” Details***

on the design of asbestos waste storage areas are contained in the Con Edison Asbestos Management Manual, Chapter 7. "Waste Storage, Transportation, and Disposal." Details on solid waste storage areas are contained in CEHSP E05.03 "Solid Waste Storage and Disposal."

8.3.5 The installation of all underground and above ground storage tanks shall be equipped with the appropriate leak monitoring and detection systems, corrosion systems, corrosion protection, spill and overflow protection equipment, secondary containment facilities, etc. in accordance with applicable Federal, State and Laws and regulations. A Spill Prevention Control and Countermeasure (SPCC) ***Plan*** shall be developed in accordance with CEHSP E03.04 "SPCC Plans".

8.3.6 The design of a new facility or any modification, involving the use, handling, installation, storage, removal, encapsulation, enclosure, transport, or disposal of Asbestos Containing Material should be performed under the guideline of the Asbestos Management Manual.

8.3.7 All new installations shall utilize non-PCB filled (O-PPM) equipment such as transformers, reactors, capacitors, etc., in accordance with the latest Con Edison environmental, health and safety procedures and associated specifications.

8.3.8 The design shall include methods and procedures to safely remove and properly dispose of any hazardous substances and wastes that affect this design in accordance with Con Edison's environmental, health and safety procedures.

8.3.9 The design shall provide the required containment and/or diversion facilities for those materials listed or characterized as hazardous substances that cannot practically and economically be disposed of, in accordance with this specification.

8.3.10 The design should acknowledge and include (if applicable) the required permits needed for temporary storage, transport and disposal of any hazardous waste created by or generated by this design, unless the activity and/or the Substation is conditionally exempt or unless otherwise directed by the Facility Manager.

8.3.11 Noise levels for all installed equipment will be within the property line noise abatement rules for the area where the station is built.