Most Common Errors in Service Entrance and Load Side Installations Prior to Final DU Inspection

Industrial and Commercial Buildings

Primary Voltage / Overhead

For RME Forum – November 28, 2014

IIEE Convention

Presented by : Ray Anthony Rodriguez
Team Leader- Meralco South CBG Technical Support

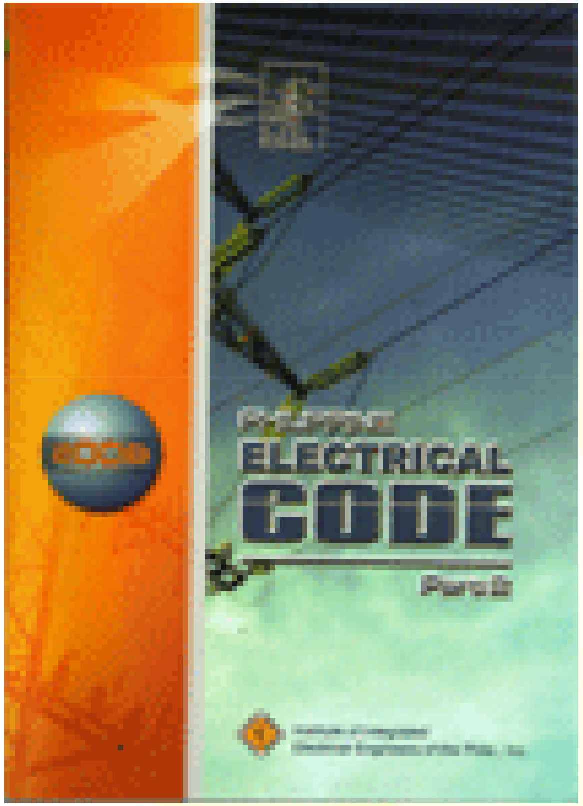
Format of Presentation:

1. Error Mentioned or Shown
2. Relevant Standards or Codes
3. Possible Corrections (-optional)

Contents :

1. What is Primary Metering?
2. RME Responsibilities
3. Errors
   a. Not Enough Clearance/Distance
   b. Location of Lightning Arresters
   c. Using ABS instead of LBS
   d. Not Proper Coordination
   e. Not Appropriate Transformer BIL and Connections

References :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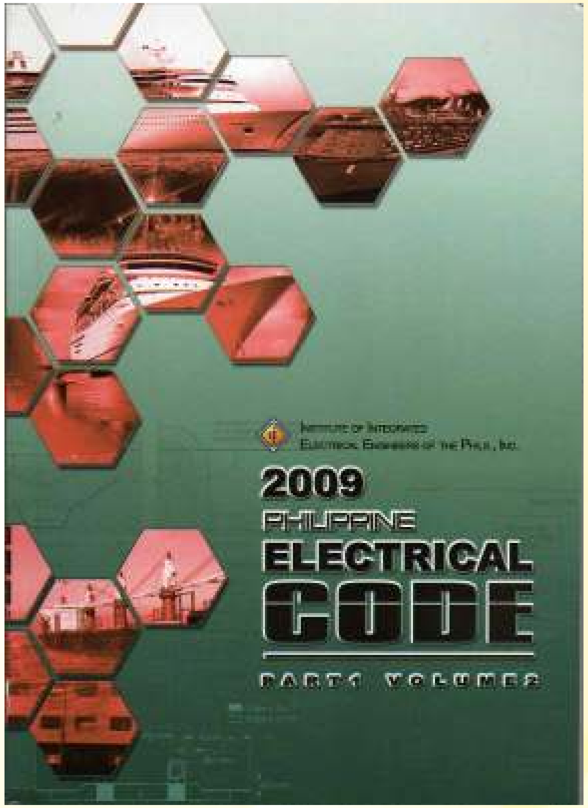
ELECTRICAL
CODE


Institute of Integrated
Electrical Engineers of the Phils., Inc.
2009
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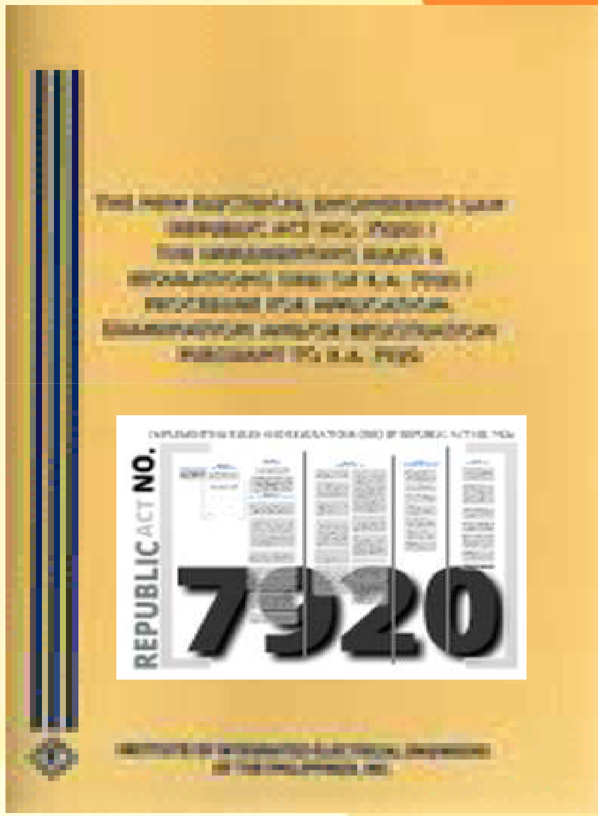
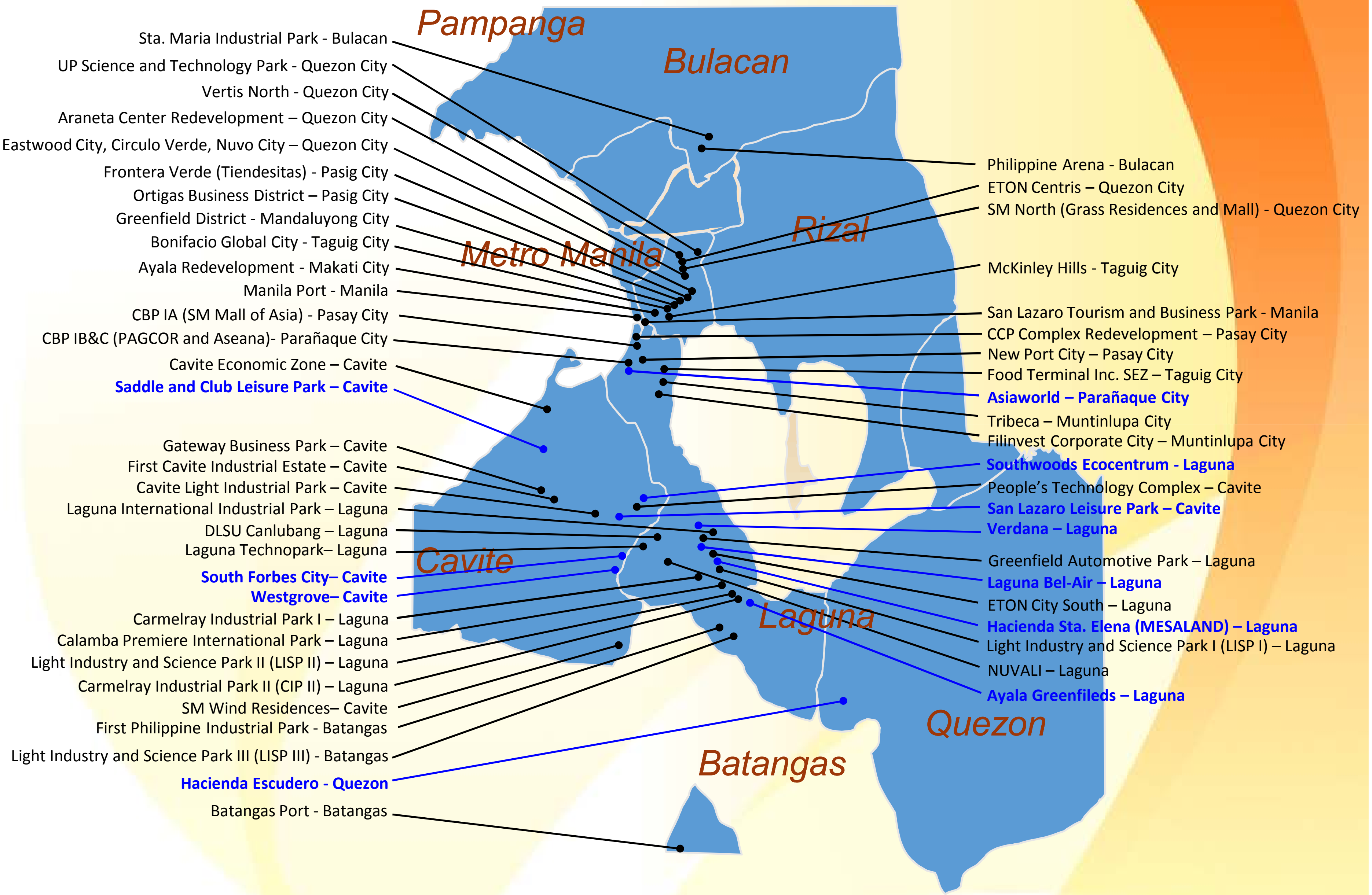
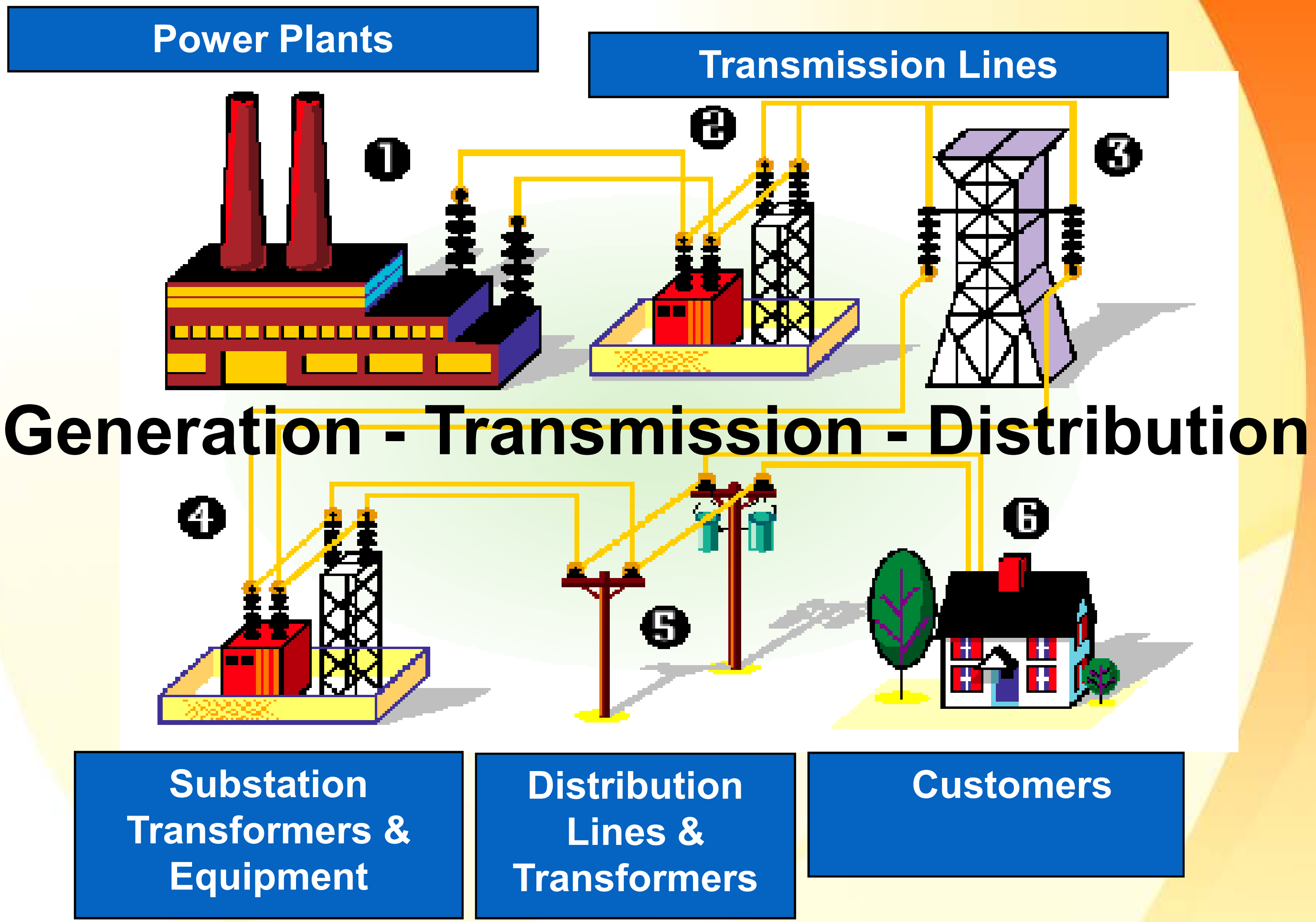
ELECTRICAL
CODE
PART 1 VOLUME 2

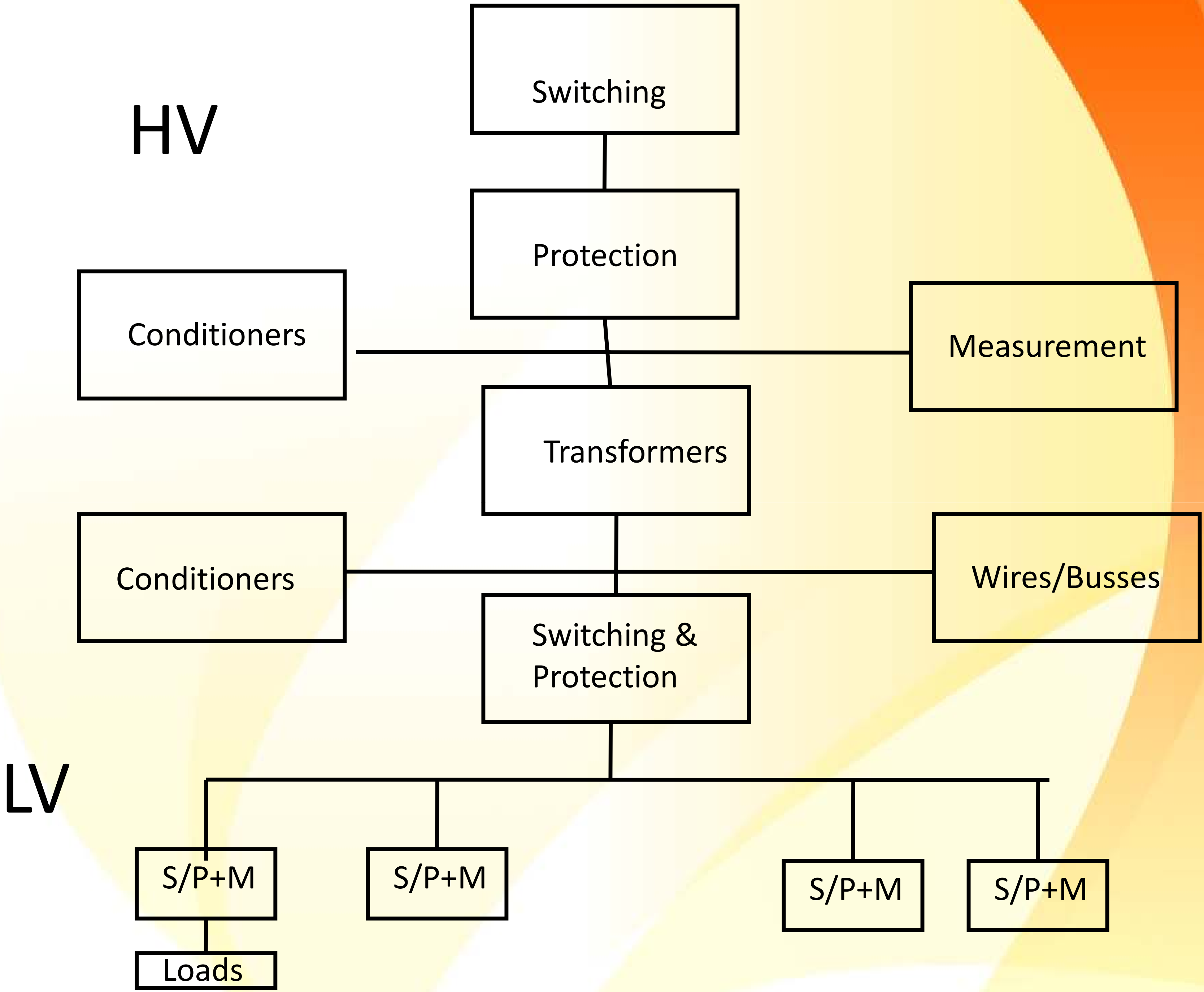

REPUBLIC ACT NO.
7920

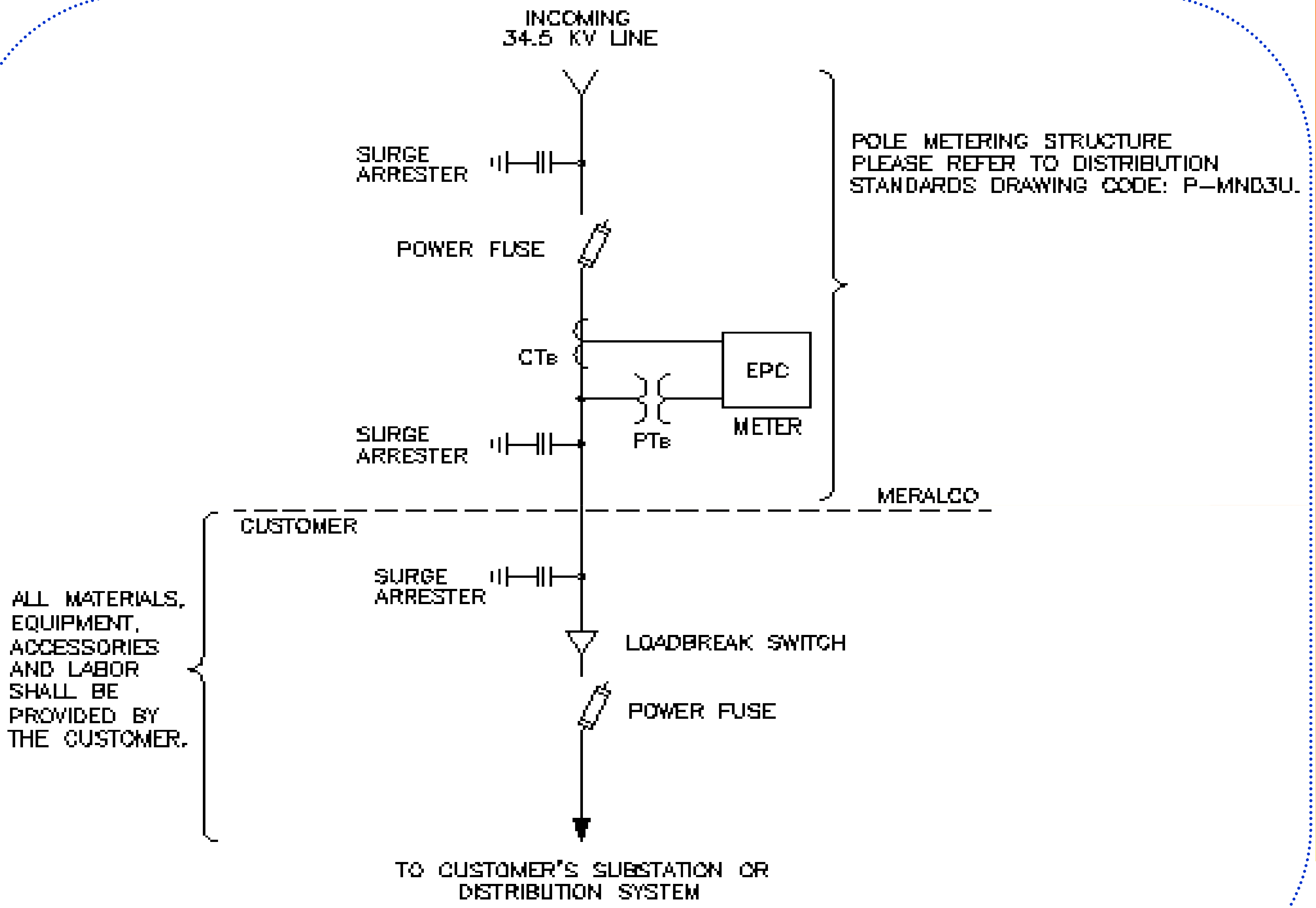
Major Load Growth Centers



***Note:** Black Fonts – High Growth Areas, Blue Fonts – Dormant Growth Areas*


Power Plants
Transmission Lines
1
2
3
Generation - Transmission - Distribution
4
5
6
Substation Transformers & Equipment
Distribution Lines & Transformers
Customers

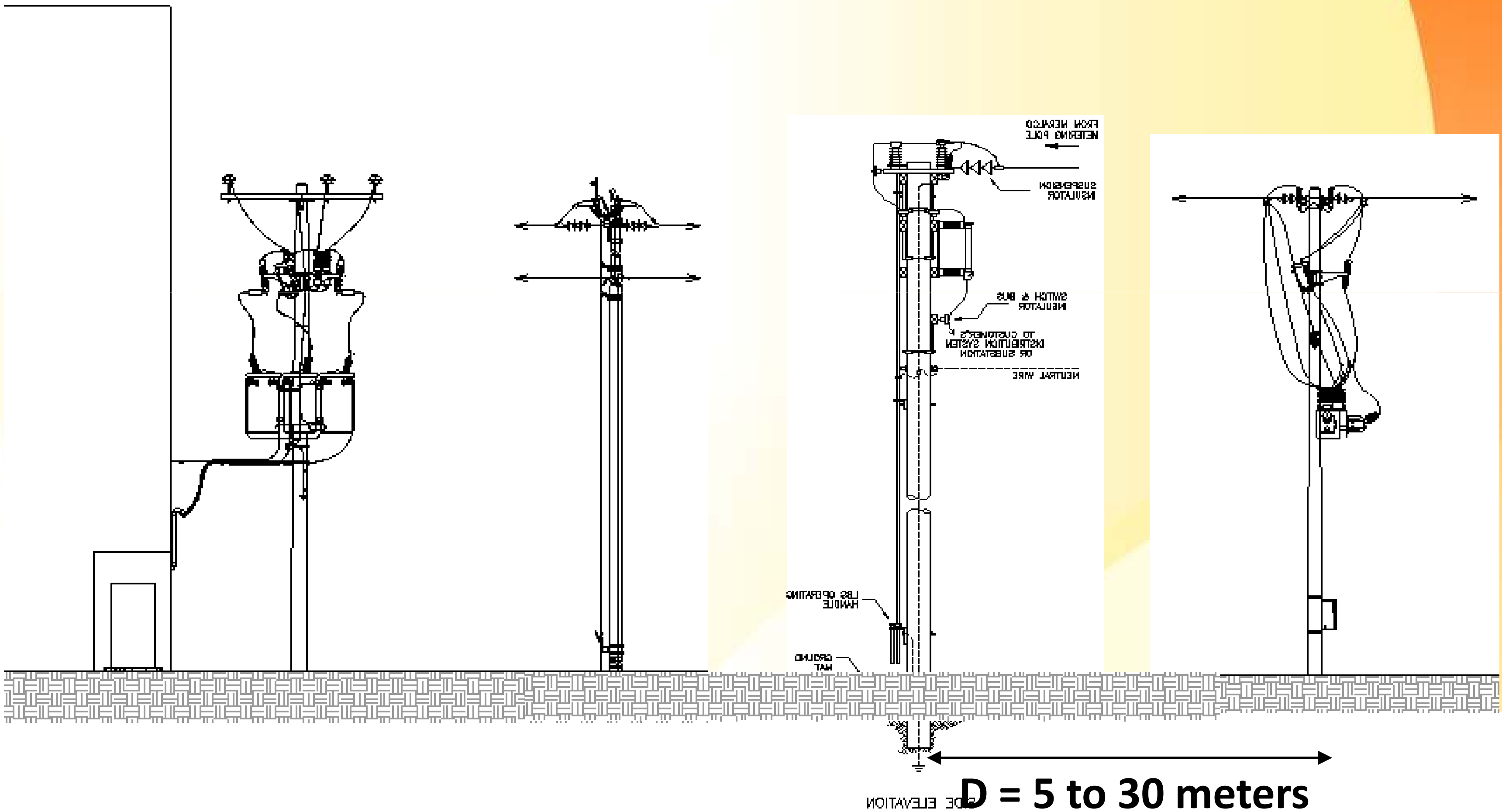

HV
Switching
Protection
Conditioners
Measurement
Transformers
Conditioners
Wires/Busses
Switching &
Protection
LV
S/P+M
S/P+M
S/P+M
S/P+M
Loads



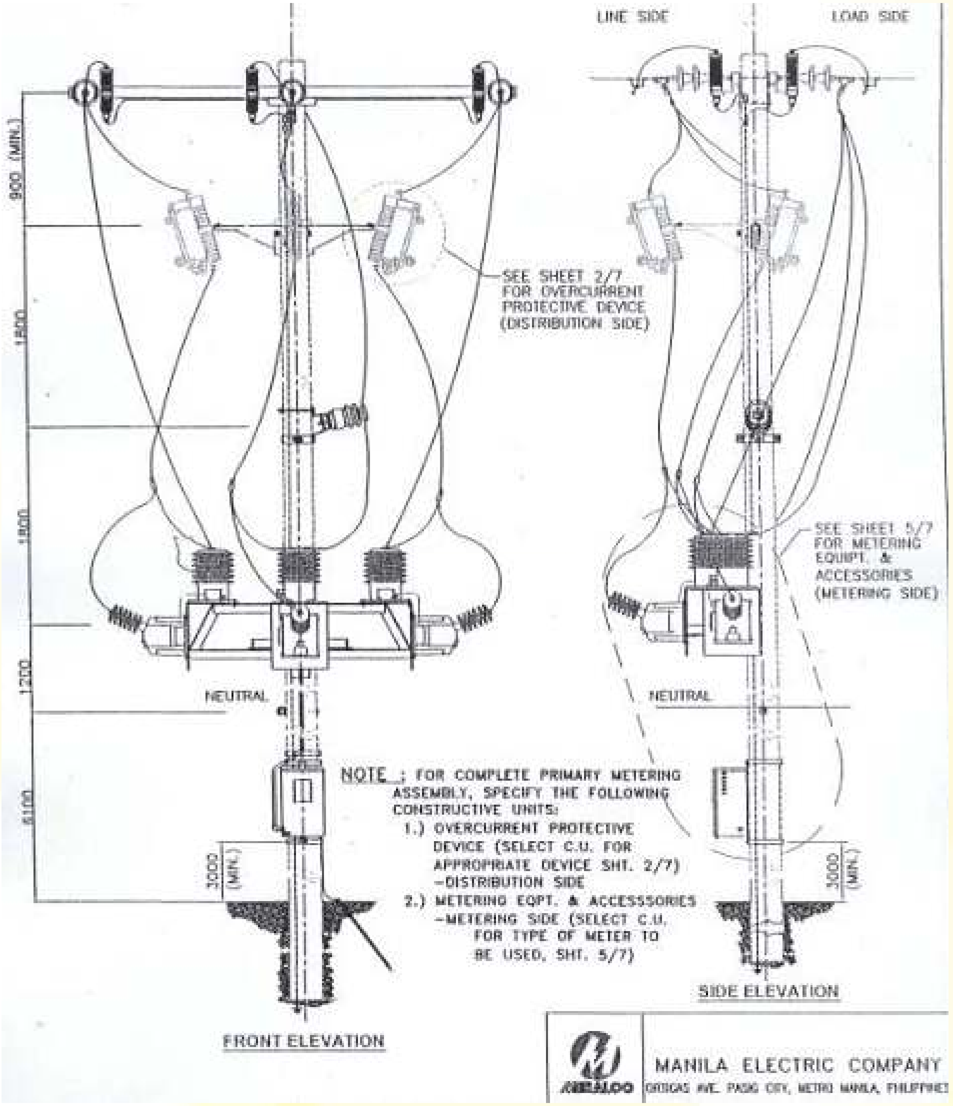
Note: The first private pole shall be located within thirty (30) meters but not less than five (5) meters from the pole metering.

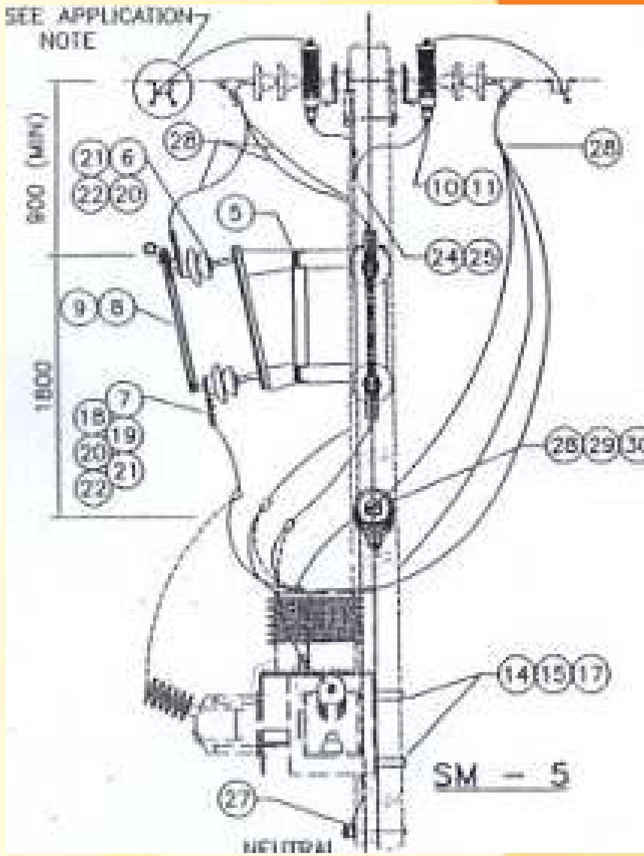
Primary Metering Pole

Primary Service, Overhead Installation, Customer-Owned Transformer



Primary Metering Pole





Registered Master Electrician's Responsibilities based on RA 7920 :

Republic of the Philippines
Congress of the Philippines
Metro Manila

Third Regular Session

Begun and held in Metro Manila, on Monday the twenty-fifth day of July, nineteen hundred and ninety-four.

[REPUBLIC ACT No. 7920]

AN ACT PROVIDING FOR, A MORE RESPONSIVE AND COMPREHENSIVE REGULATION FOR THE PRACTICE, LICENSING, AND REGISTRATION OF ELECTRICAL ENGINEERS AND ELECTRICIANS

Be it enacted by the Senate and House of Representatives of the Philippines in Congress assembled:

ARTICLE IV

Sundry Provisions Relative to the Practice of Electrical Engineering

A registered electrical engineer's field of practice includes charge or supervision of operation and maintenance of electrical equipment in power plants, industrial plants, watercraft, electric locomotive, and others; manufacture and repair of electrical supply and utilization equipment including switchboards, power transformers, generators, motors, apparatus, and others; teaching of electrical subjects; and sale and distribution of electrical equipment and systems requiring engineering circulations or application of engineering data; and

A registered master electrician's field of practice includes the installation, wiring, operation, maintenance and repair of electrical machinery, equipment and devices, in residential, commercial, institutional, commercial and industrial buildings, in power plants, substations, watercrafts, electric locomotives, and the like: Provided, that if the installation or the machinery is rated in excess of five hundred kilovolt-amperes (500 kVA), or in excess of six hundred volts (600V) the work shall be under the supervision of a professional electrical engineer or a registered electrical engineer.

Most Common Errors in Service Entrance and Load Side Installations Prior to Final DU Inspection

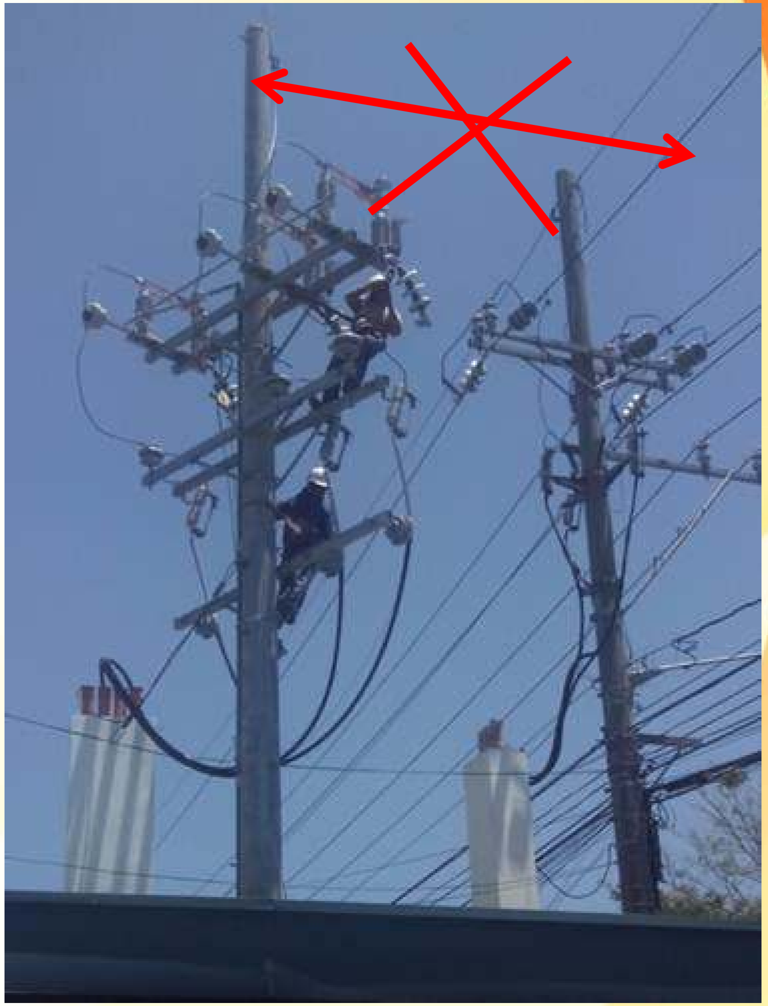
Not Enough Clearance from other Conductors, Buildings, Structures and Trees

Typical Distribution Standards

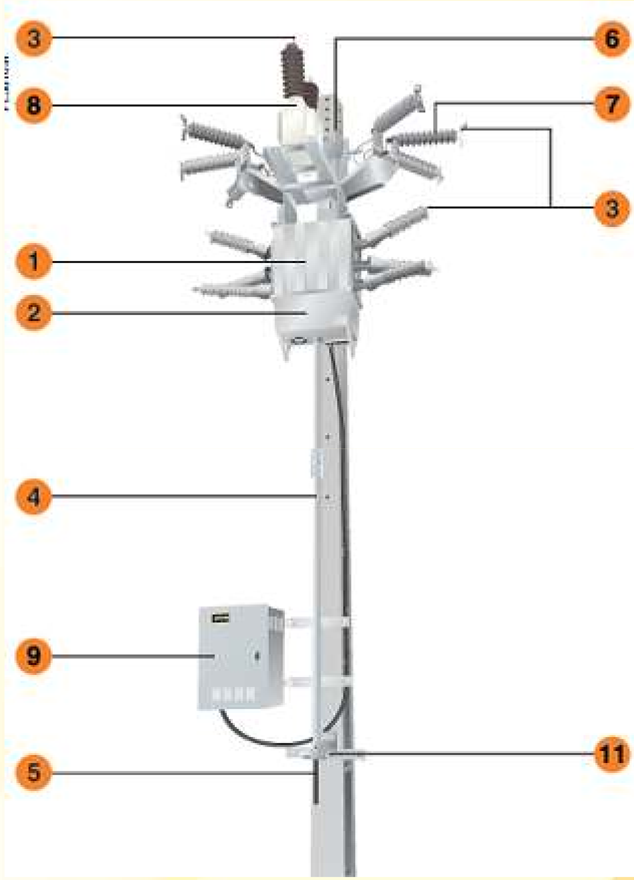
Upper Level Conductors	Open Secondary upto 750V	Primary upto 13.8 kV Y or Delta	34.5Y/20 kV	115 kV
Lower Level Conductors/ Nature of Surface	mm (ft-in)	mm (ft-in)	mm (ft-in)	mm (ft-in)
Vertical Clearance of Wires, conductors or cables above ground, etc, when it crosses over or overhang the surface				
Railroad Tracks	7500 (24' 7")	8100 (26' 7")	8100 (26' 7")	8580 (28' 2")
Roads, streets and other areas subject to truck traffic	5000 (16' 5")	5600 (18' 4")	5600 (18' 4")	6080 (19' 11")
Driveways,parking lots and alleys	5000 (16' 5")	5600 (18' 4")	5600 (18' 4")	6080 (19' 11")
Spaces and ways subject to pedestrians or restricted traffic only	3800 (12' 6")	4400 (14' 5")	4400 (14' 5")	4880 (16')
Vertical Clearance at Supports Between Line Conductors				
13.8 kV Y or Delta	470 (1' 7")	600 (2')	660 (2' 2")	1160 (3' 10")
34.5Y/20 kV	530 (1' 9")	660 (2' 2")	725 (2' 4")	1220 (4')
115 kV	1030 (3' 5")	1160 (3' 10")	1220 (4')	1720 (5' 7")

Distance from DU Primary Metering Pole Is less than 5 meters

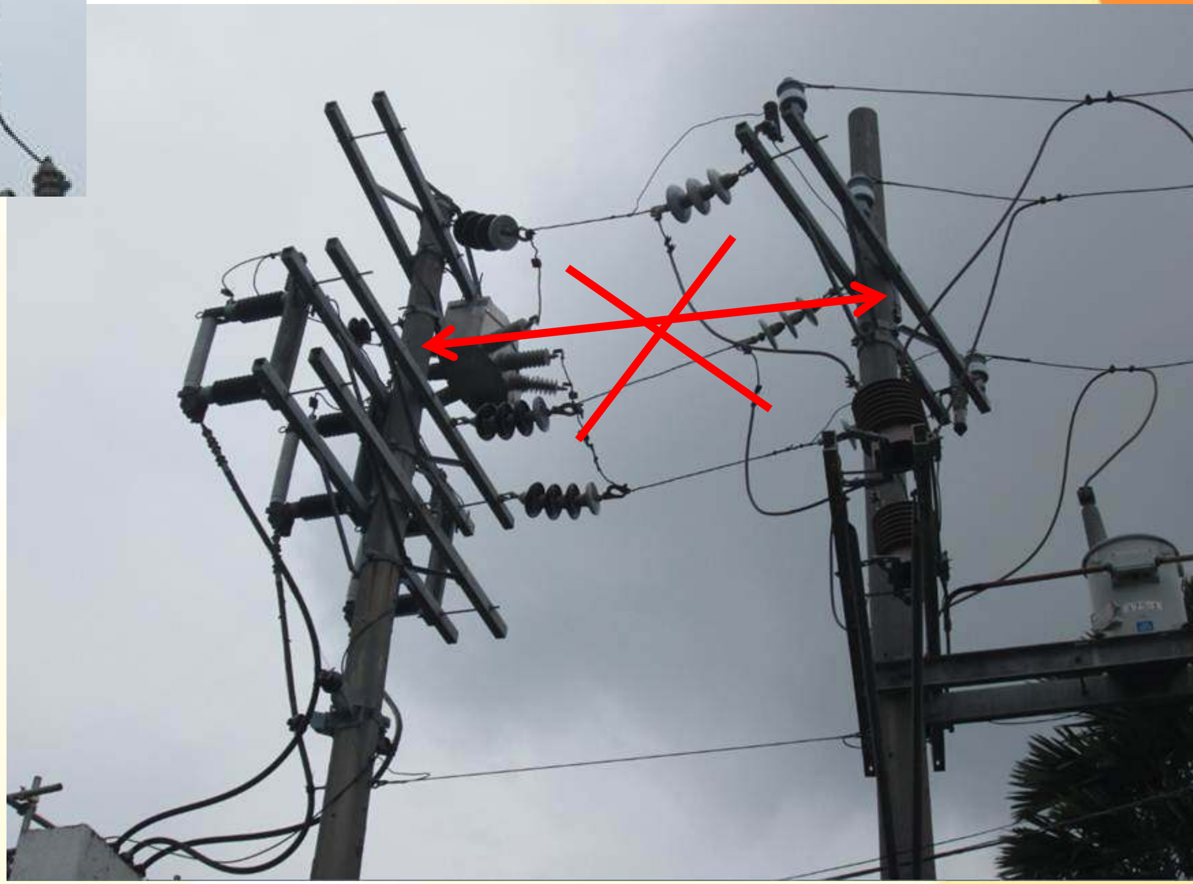
Too Near to DU Pole and Lines



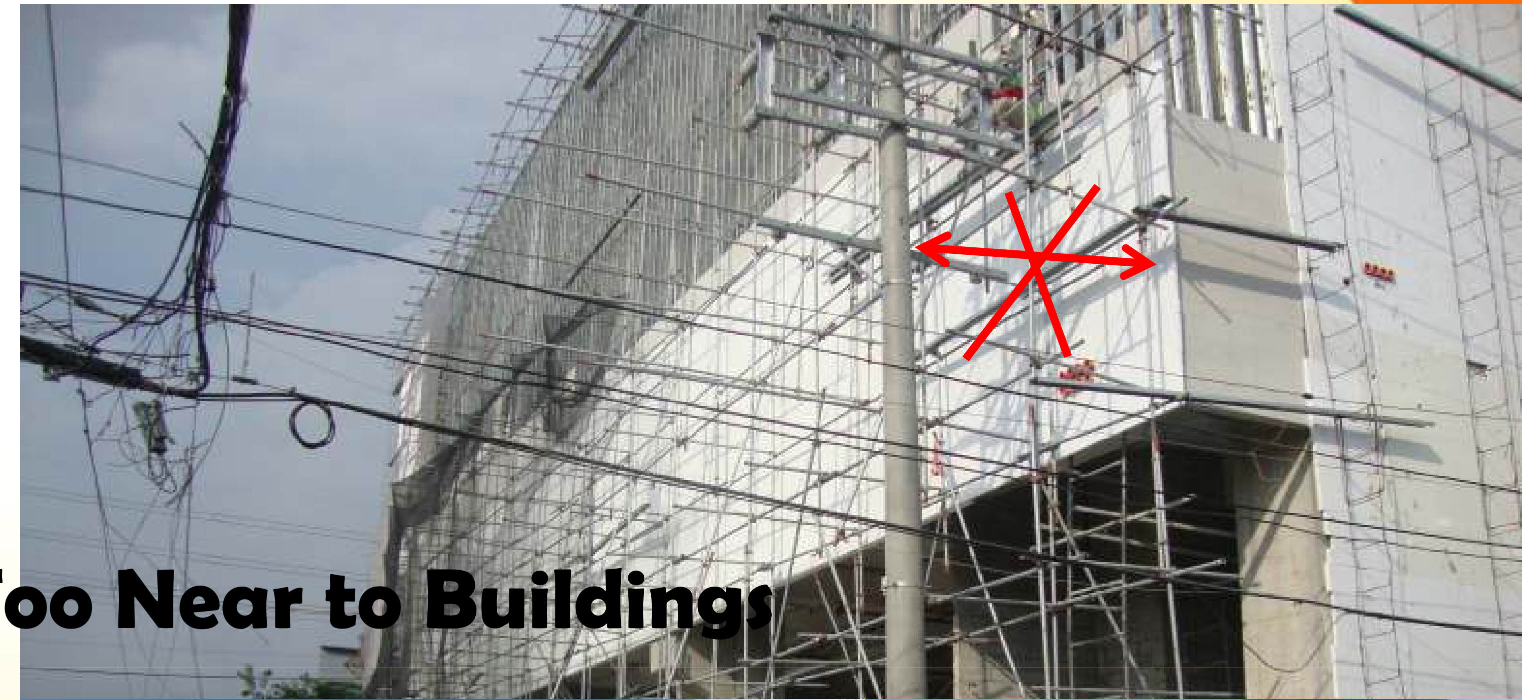
SF6 Gas Circuit Breaker Pole-Type



Not Enough Working Clearance Between Poles and Insulators



Too Near to Buildings



Too Near to DU Primary Lines

Vertical Clearance Between Supply Conductors Supported on the Same Structure

For 34.5/ 20 kV lines = 725 mm or 2’ 4”

Clearances Between Wires , Conductors or Cables Carried on Different Supporting Structures

For 34.5/ 20 kV lines only
Horizontal = 1500 mm
Vertical = 600 mm

Distance from DU Primary Metering Pole Is less than 5 meters

Working Clearance and distance from building

Not Enough Working Clearance

Installing or Removing Holders

SM Power Fuse Holders can be installed in or removed from the mounting using a **Universal Pole** equipped with an S&C **Station Prong**.

Lifting holder out of (or into) a Non-Disconnect Style SM Mounting.

Closing (or opening) the clamping arm on the fuse clip

Not Enough Clearance from Trees

Enough Clearance from Trees & Buildings

Crisscrossing of DU and Customer's Wires –also clearances

Sangley Point – Navy & Air Force

Not Enough Clearances from Buildings

Not Enough Clearances from Buildings

Typical Distribution Standards

Upper Level Conductors	Open Secondary upto 750V	Primary upto 13.8 kV Y or Delta	34.5Y/20 kV	115 kV
Lower Level Conductors/ Nature of Surface	mm (ft-in)	mm (ft-in)	mm (ft-in)	mm (ft-in)
Vertical Clearance of Wires, conductors or cables above ground, etc, when it crosses over or overhang the surface				
Railroad Tracks	7500 (24' 7")	8100 (26' 7")	8100 (26' 7")	8580 (28' 2")
Roads, streets and other areas subject to truck traffic	5000 (16' 5")	5600 (18' 4")	5600 (18' 4")	6080 (19' 11")
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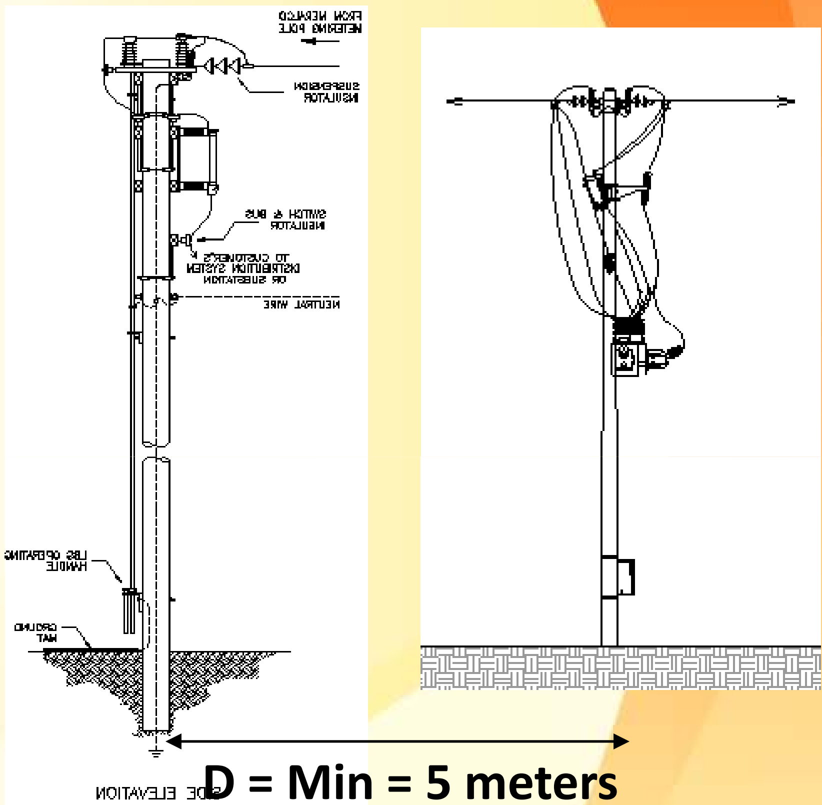
34.5Y/20 kV	530 (1' 9")	660 (2' 2")	725 (2' 4")	1220 (4')
115 kV	1030 (3' 5")	1160 (3' 10")	1220 (4')	1720 (5' 7")

Service Equipment

- The customer shall install a service equipment after the metering installation:
  - ✓ The applicant's service equipment shall be a circuit-breaking device with a short circuit protection and loadbreaking capability (e.g. a combination of loadbreak switch and power fuse, power circuit breaker, etc.).
  - ✓ For pole-metering installation, the service equipment shall be located not less than five (5) meters from the pole-metering.



3C DISTRIBUTORS

OLD COSMOS SAN PEDRO

OLD FORD

SHIN HEUNG

SAMSUNG
CPIP

CALTEX
BIÑAN

CPIP and Carmelray 2

BOY SCOUT
OF THE PHILS, LOS BAÑOS

HV SWITCHGEAR B
BESIDE METERING POLE

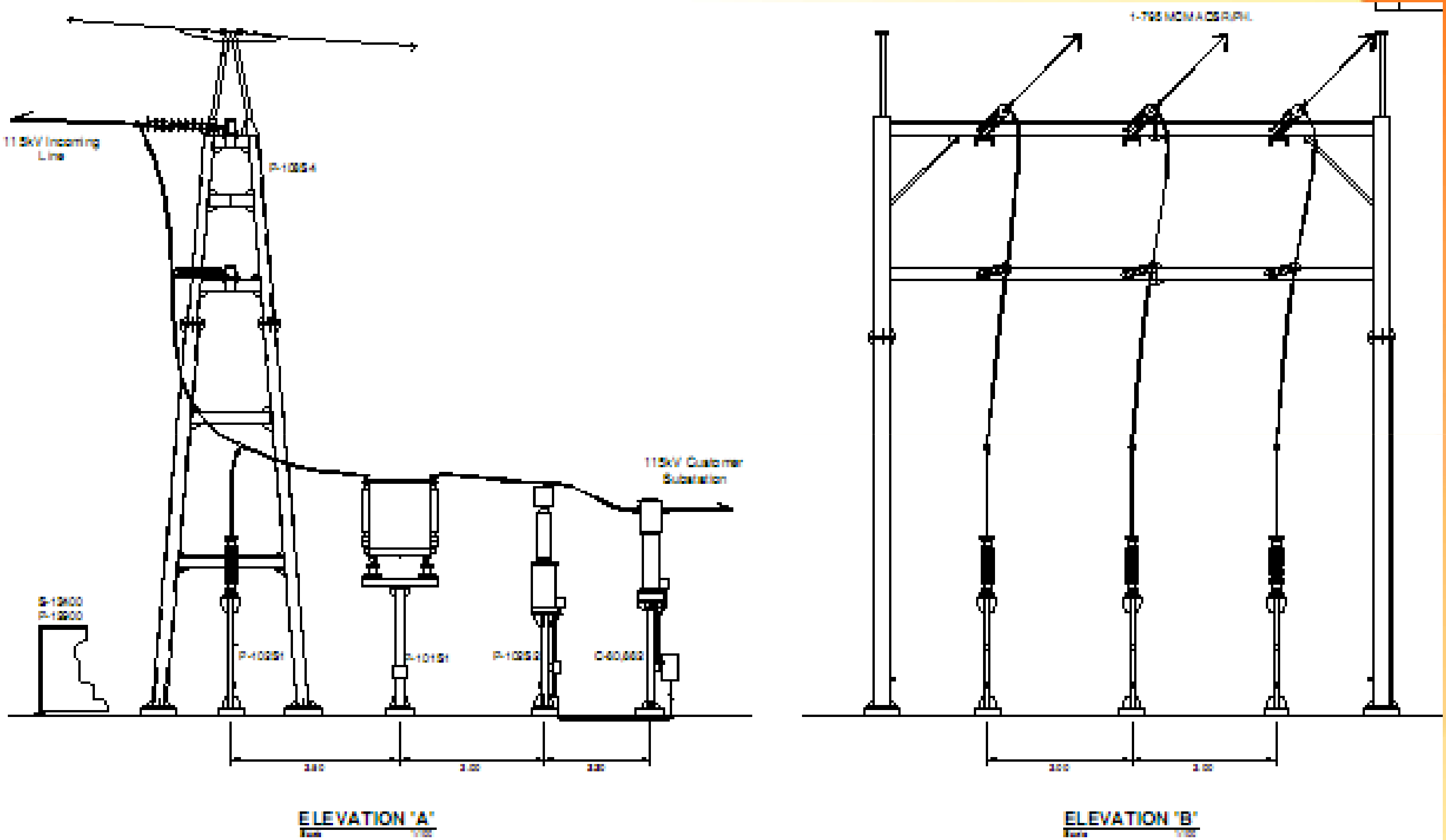
PNCC SLEX

PEC Part 2 –Table 3.4.6.3 (a) on 115 kV

Table 4.2.4.1: Vertical Clearance at Supports Between Line Conductors

Upper Level Conductors →	Shielded primary and secondary cables spun on grounded messenger; grounded neutrals; communication cables on grounded messenger	Open Supply Conductors					
		Secondary up to 750 V	Primary up to 13.8 kV Y or Δ	34.5Y/ 20 kV	69kV	115kV	230kV
Lower Level Conductors ↓	**mm (ft-in)**	**mm (ft-in)**	**mm (ft-in)**	**mm (ft-in)**	**mm (ft-in)**	**mm (ft-in)**	**mm (ft-in)**
Communication conductor	1000 (3'-4")	1000 (3'-4")	1000 (3'-4")	1000 (3'-4")	1000 (3'-4")	1020 (3'5")	1720 (5'7")
Supply Conductors:							
Open conductor 0 to 750V; shielded primary cables and secondary supply cables spun on grounded messengers; effectively grounded neutrals	410 (1'4")	410 (1'4")	470 (1'7")	530 (1'9")	730 (2'5")	1030 (3'5")	1725 (5'8")
13.8 kV Y or Δ		410 (1'4")	600 (2')	660 (2'2")	860 (2'10")	1160 (3'10")	1860 (6'1")
34.5Y/20 kV				725 (2'4")	920 (3')	1220 (4')	1920 (6'4")
69kV					1120 (3'8")	1420 (4'8")	2120 (6'11")
115kV						1720 (5'7")	2415 (7'11")
230kV							3115 (10'3")

Example of 115 KV Substations



Example of 115 KV Substations

Linden STA ROSA 115 KV

YAZAKI
TORRES

ABI, Cabuyao

CPIP, Batino

REFERENCES

ALL ABOUT ABOVE 600V
-PEC Vol. 1 Part 1 Article 1.10.3.1 to 1. 10.3.6

CHAPTER 1. ARTICLE 1.10 Requirements for Electrical Installations

1.10.3 Over 600 volts, Nominal - page 47

Table 1.10.3.2 Minimum Distance from Fence to Line Parts – page 48

Table 1.10.3.5(a) Minimum Depth of Clear Working Space at Electrical Equipment - page 52

Table 1.10.3.5(e) Elevation of Unguarded Live Parts Above Working Space – page 53

REFERENCES

ALL ABOUT ABOVE 600V
-PEC Vol. 1 Part 1 Articles 2.25.1.14 to 2.25.1.26

CHAPTER 2. ARTICLE 2.25 Outside Branch Circuits and Feeders

2.25.3 Over 600 volts - page 132

Table 2.25.3.11 Clearances over Roadways, Walkways, Rail, Water, and Open Land – page 135

Table 2.25.3.12 Clearances over Buildings and Other Structures – page 135

REFERENCES

ALL ABOUT ABOVE 600V

- **PEC Vol. 1 Part 1 Articles 3.0.2.1 to 3.0.2.12**

CHAPTER 3. ARTICLE 3.0 Wiring Methods

3.0.2 Requirements for over 600 volts, Nominal – page 328
Table 3.0.2.20 Minimum Cover Requirements – page 330

PEC Vol. 1 Part 1 Article 4.90.2.4

CHAPTER 4. ARTICLE 4.9 Equipment Over 600 volts

4.90.2.4 Minimum Space Separation – page 790
Table 4.90.2.4 Minimum Clearance of Live Parts – page 791

REFERENCES

- Distance from distribution lines – Article 3.4.5.3 from PEC 2008 part 2 pp.140-147 .

- Height wrt to distribution poles – Table 3.4.10.5 (b) (1)a p.194 from PEC 2008 part 2.

REFERENCES

- Distance between conductors or personnel – Article 3.4

  - Table 3.4.6.2 (a) (1) Horizontal Clearance between wires, conductors or cables at supports,

REFERENCES

- Table 3.4.6.2 (a) (2) a Horizontal clearance between line conductor smaller than 30mm2 at support based on sags.

from PEC 2008 part 2 pp.162-164

REFERENCES

- Clearance from trees – Article 3.4.5.3 from PEC 2008 part 2 pp.1471 PEC 2009 part1 vol.1

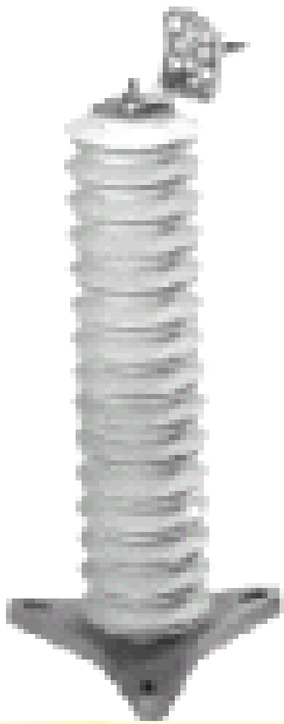
Location of Lightning Arresters

Should be located at the Highest Point

Due to Lightning Strikes

Typical Surge Arresters

Distribution Type



Station Type

Mall STA ROSA

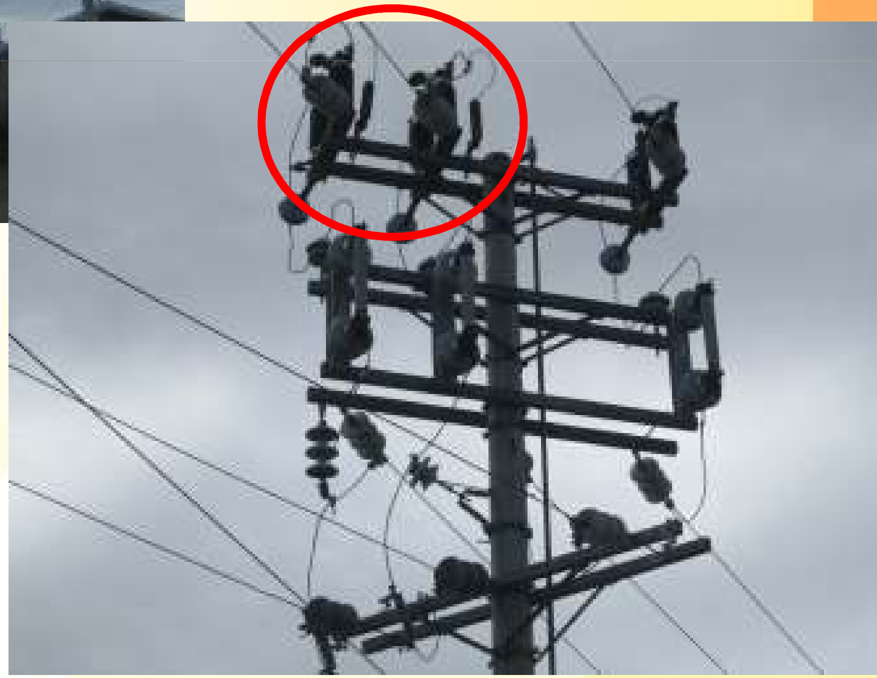
Below the
Load Break Switch
Should be above or
The same level

Calamba Industrial

Below the
Load Break Switch
Should be above or
The same level

Right Sample
Lightning Arrester Above all

Right Sample - Lightning Arrester Same Height of LBS



Typical Surge Arresters Specifications :

Surge Arrester

System Nominal Voltage	Voltage Ratings (kV)		Discharge Level
kV	Ur	MCOV	
34.5	27	22	Class II
13.8	12	10	Class II
13.2	12	10	Class II

*Ur- Rated Voltage

MCOV-Maximum Continuous Operating Voltage

REFERENCES

- Lightning arrester location –
  Article 2090.3.11 p275-281 from
  PEC 2009 part 1 vol.

Using Air Break Switches Instead of Load Break Swithces

Air Break Switches are special switches designed isolate a circuit. The are usually employed in out door installations. Special Arcing Horns are provided to quench the arc which occurs when the current is interrupted. These switches are usually operated by a handle which is located at the ground level. Their operation can also be mechanised.

Air Break Switches should not be used to interrupt load currents. They are isolating devices. They can, however, be used to interrupt small currents such as the exciting current of a transformer or the capacitive charging current of a long transmission line. A variation of the Air Break Switches is the Load Switch which can interrupt current on load as it has special arc quenching device.

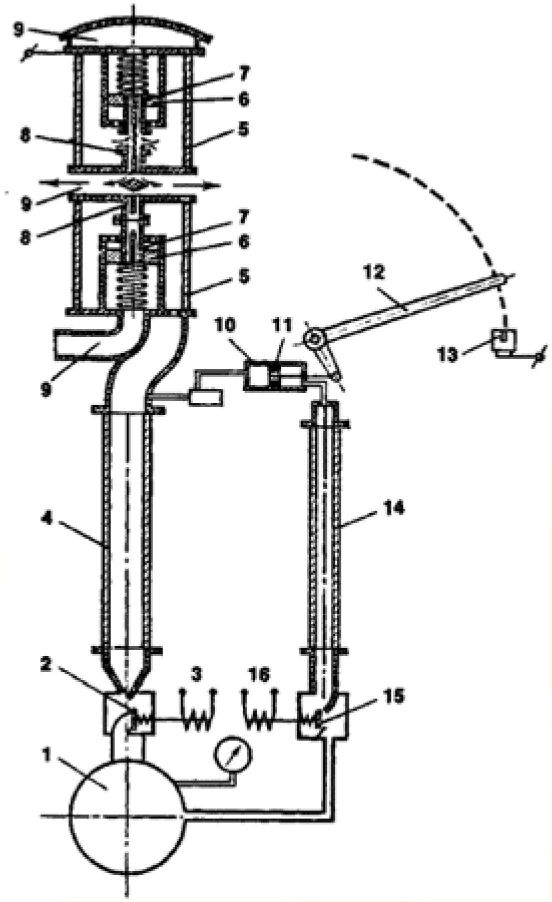
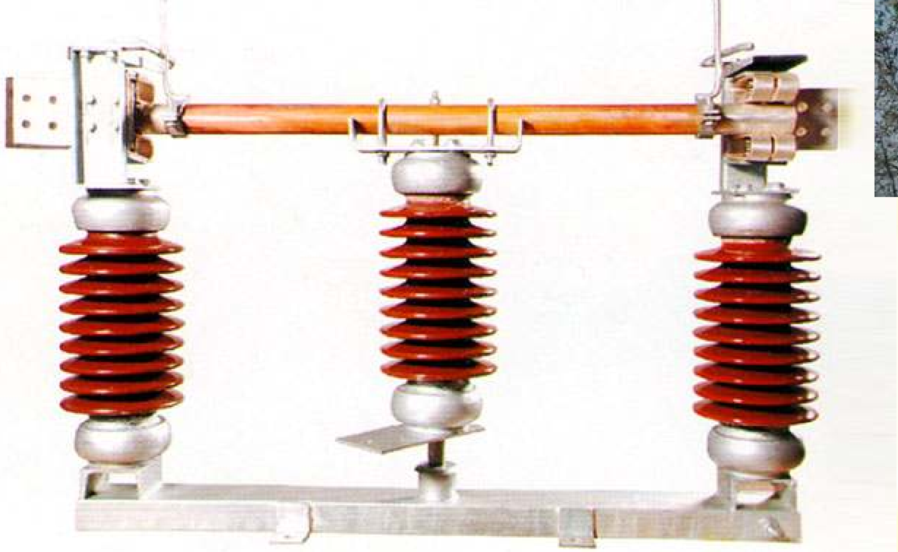


Figure 1. Schematic diagram of an air-break switch for currents up to 35 kV: (1) compressed-air reservoir, (2) air-blast valve, (3) electromagnet, (4) air line, (5) arc blowout chamber, (6) pistons, (7) and (8) contacts, (9) gas-escape channels, (10) cylinder, (11) piston, (12) and (13) isolating switch contacts, (14) air line (15) valve, (16) electromagnet.

Air Break Switches

Air Break Switch



Load Break Switches

A load break switch is a disconnect switch that has been designed to provide making or breaking of specified currents.

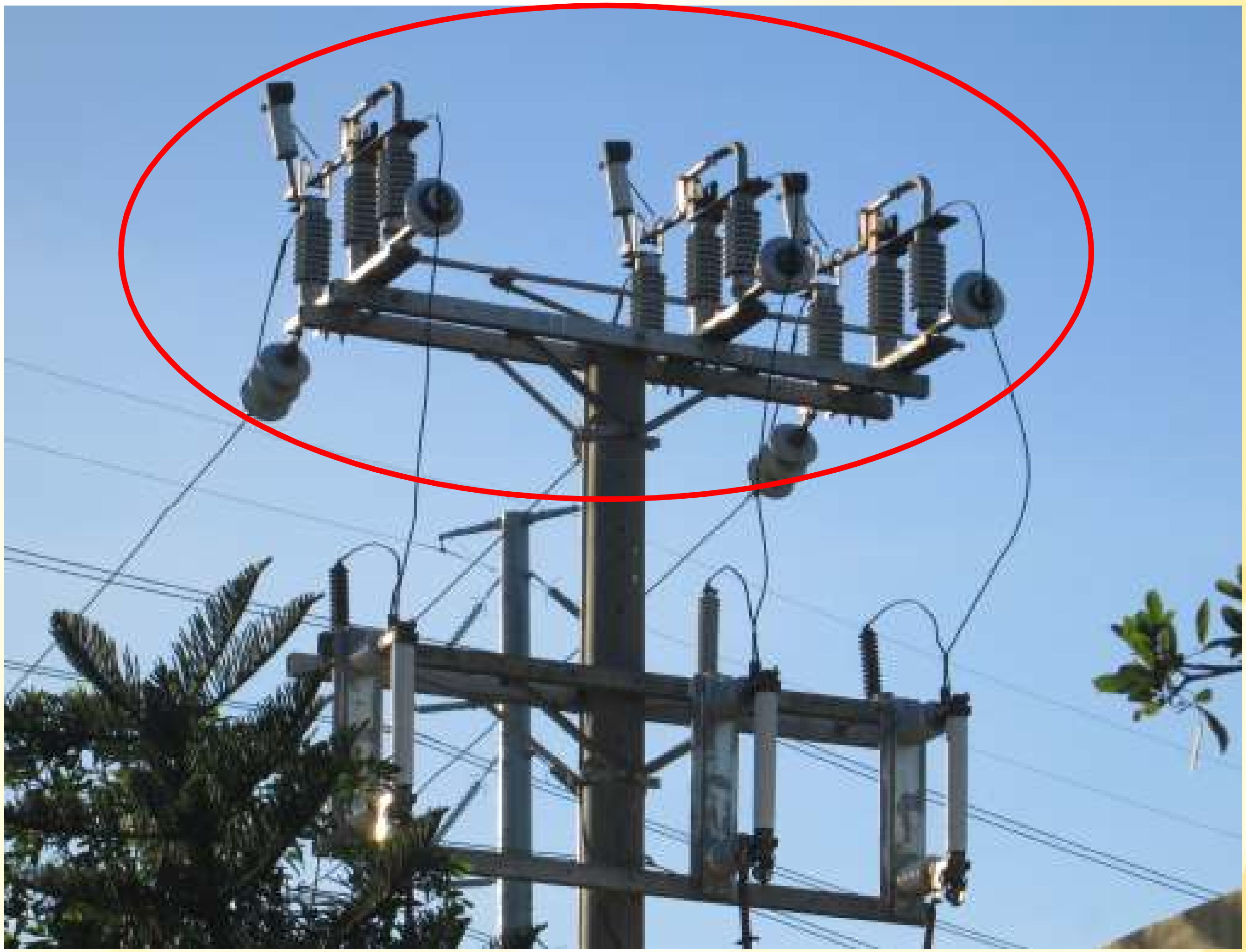
This is accomplished by addition of equipment that increases the operating speed of the disconnect switch blade and the addition of some type of equipment to alter the arcing phenomena and allow the safe interruption of the arc resulting when switching load currents.

Disconnect switches can be supplied with equipment to provide a limited load switching capability. Arcing horns, whips, and spring actuators are typical at lower voltages.

These switches are used to de-energize or energize a circuit that possesses some limited amount of magnetic or capacitive current such as transformer exciting current or line charging currents.

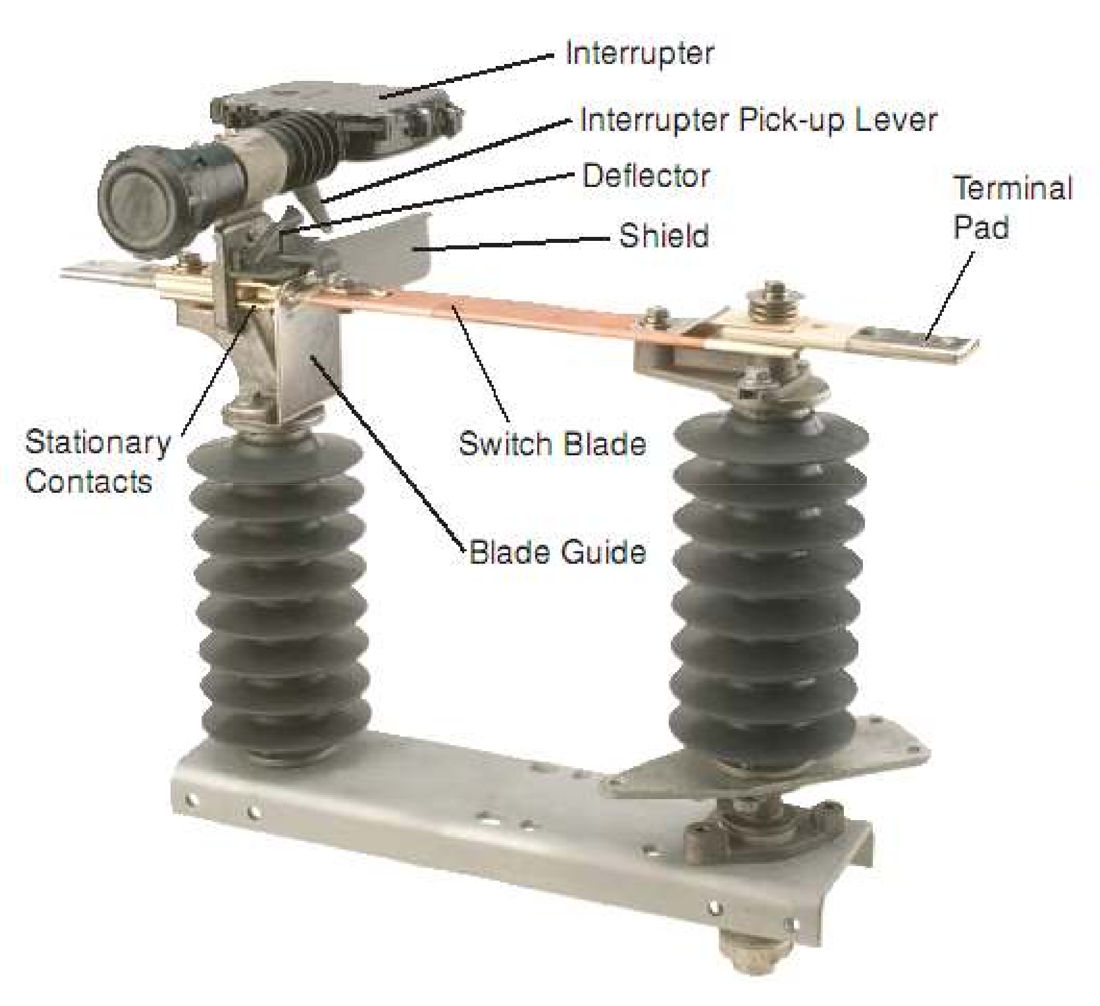
An air switch can be modified to include a series interrupter (typically vacuum or SF6) for higher voltage and current interrupting levels. These interrupters increase the load break capability of the disconnect switch and can be applied for switching load or fault currents of the associated equipment.

Load Break Switch



Load Break Switch

Load Break Switch



Specifications & Ratings:

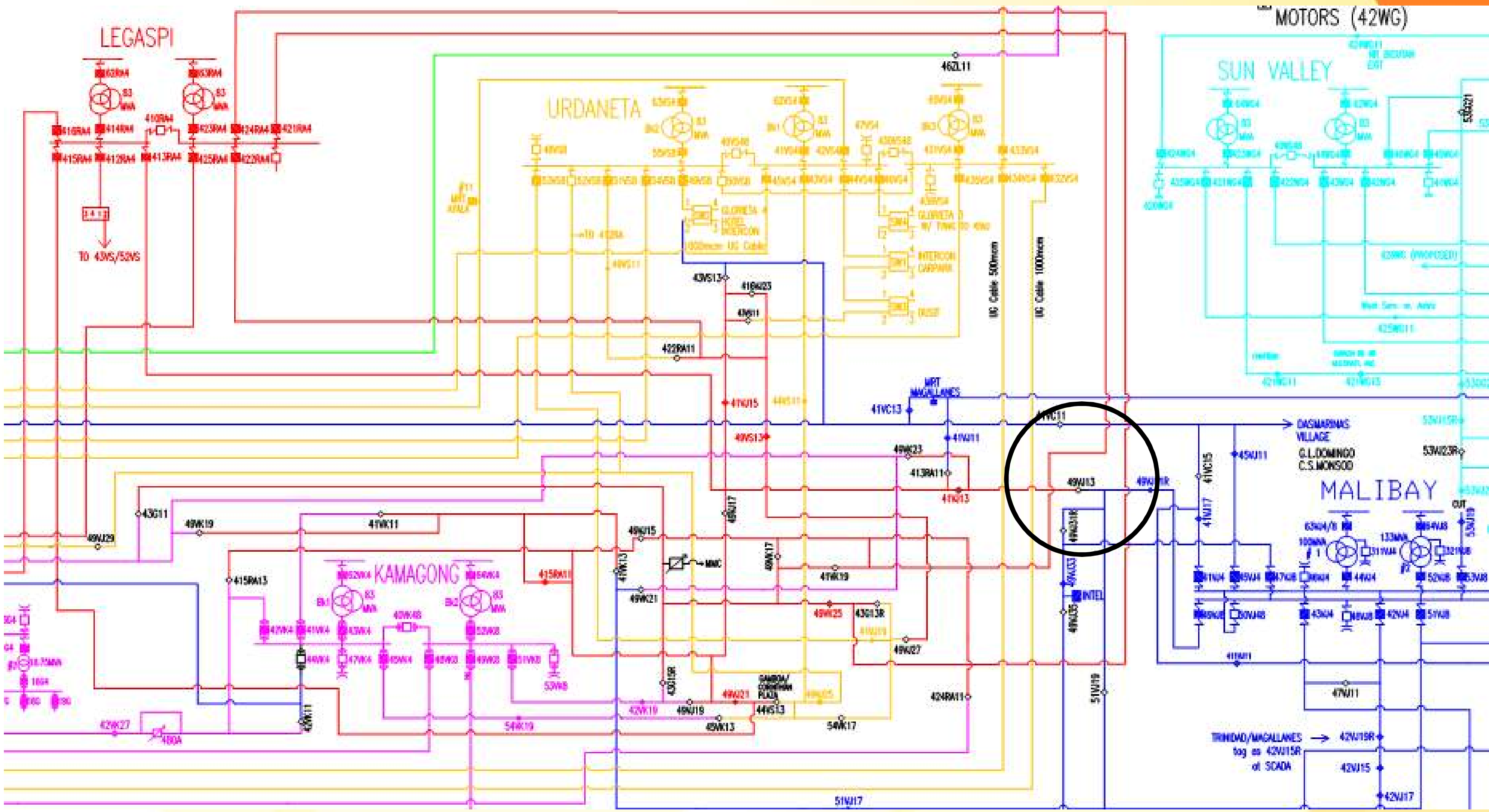
LOAD BREAK SWITCH

The load break switch shall be three-pole, gang-operated, and with a highly visible position ("Closed" or "Open") indicator. The following are the minimum ratings and specifications for load break switch:

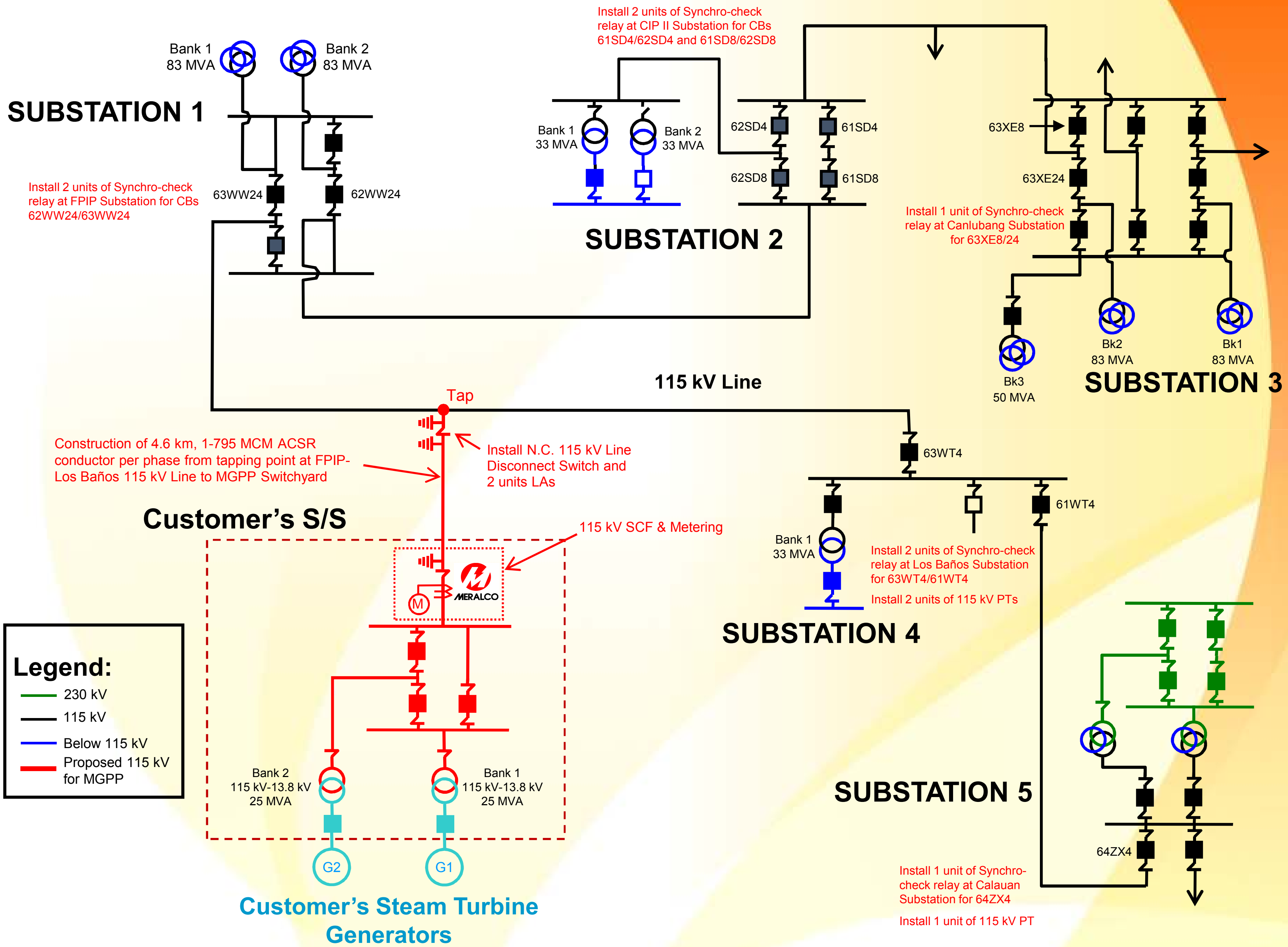
System Nominal Voltage	Voltage Rating	Frequency Rating	Continuous Current Rating	Momentary Rating (Asym)	Basic Impulse Insulation Level
kV	kV	Hz		kA	(kV, min.)
13.2	14.4	60	as required	40	95
13.8	14.4	60	as required	40	110
34.5	34.5	60	as required	30	110

Not Proper Coordination Of Protective Devices

Sample: Meralco Circuit Interconnection



Sample: Meralco Circuit Interconnection

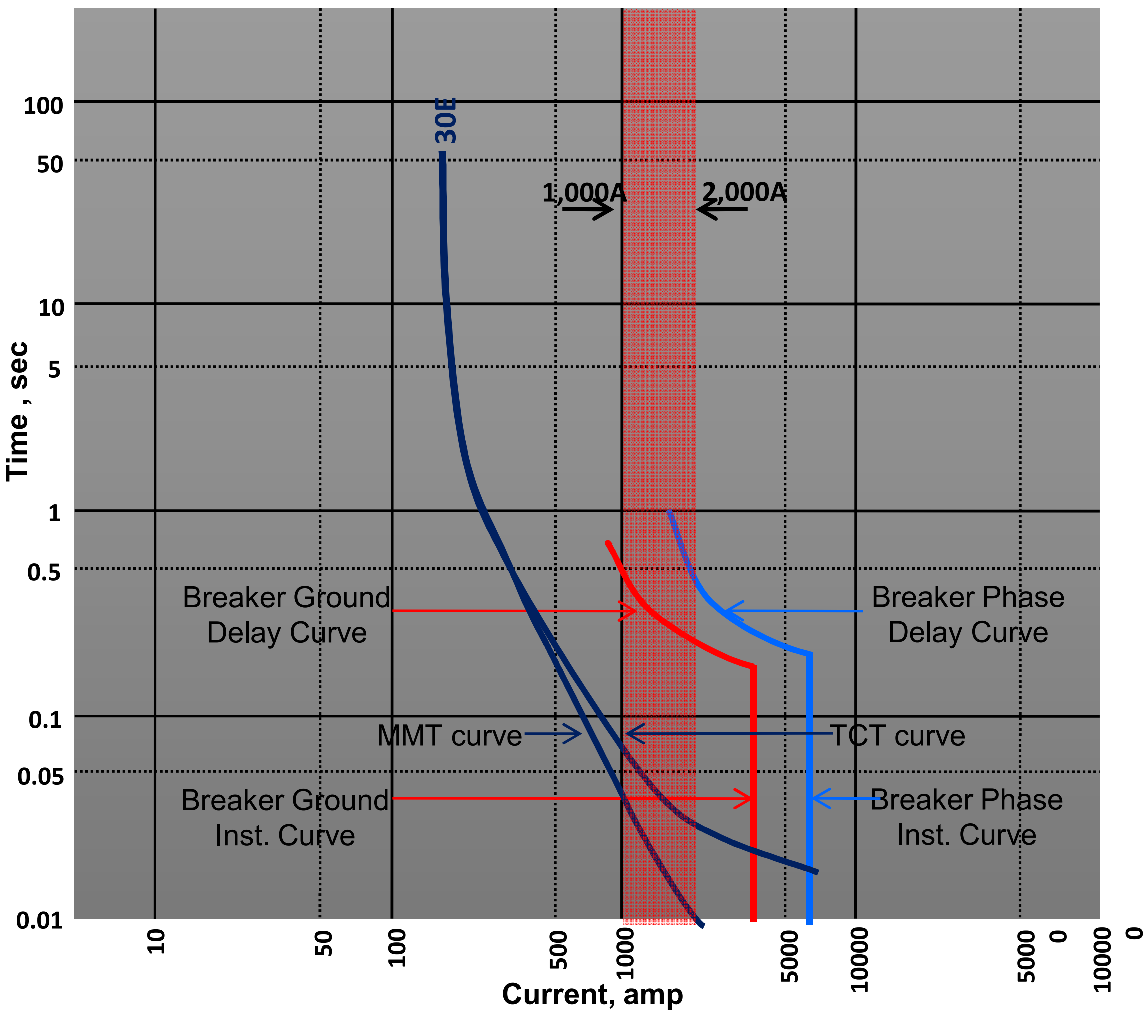


Sample: Meralco System Bus Fault Duty Report

MERALCO SYSTEM BUS FAULT DUTY REPORT
2010 YEAR END SYSTEM CONDITION
PSS/E SHORT CIRCUIT RUN
MVA, KA, IMPEDANCE (OHMS,P.U.)

BUS NO.	BUS NAME	BUS KV	CIRCUIT NUMBER	FAULT MVA		FAULT CURRENT, kA		FAULT IMPEDANCE, ohms				
								Zpos		Zzero		X0/X1
13709	ABUBOT	34.5	CARRIER CIRCUIT	282.60	249.43	4.73	4.17	0.5949	4.1696	1.1535	5.7781	1.3858
12904	AGUINALDO	34.5	12VH, 13VH, 14VH	384.24	398.82	6.43	6.67	0.2069	3.0908	0.2053	2.7503	0.8898
13604	ANGAT	34.5	CARRIER CIRCUIT	138.39	85.66	2.32	1.43	2.6321	8.1881	7.2115	23.3976	2.8575
14101	AYALA ALABANG 1	34.5	412WR, 413WR, 414WR, 415WR	464.46	619.99	7.77	10.38	0.0228	2.5626	0.0056	0.6340	0.2474
14102	AYALA ALABANG 2	34.5	423WR, 424WR	439.25	299.78	7.35	5.02	0.0227	2.7096	0.0680	6.4914	2.3957
19601	BACOOR	34.5	410WX, 415WX, 414WX, 413WX, 412WX	436.42	367.14	7.30	6.14	0.0286	2.7272	0.0276	4.2712	1.5662
18401	BAGBAGUIN	34.5	412YZ, 413YZ, 414YZ, 415YZ	437.79	590.54	7.33	9.88	0.0337	2.7186	0.0075	0.6090	0.2240
10201	BALIBAGO	34.5	41XV, 42XV, 43XV, 45XV	542.16	461.75	9.07	7.73	0.0222	2.1953	0.0560	3.3418	1.5223
10304	BALINTAWAK 4	34.5	41E, 43E, 45E, 47E	448.98	375.84	7.51	6.29	0.0093	2.6510	0.0081	4.1987	1.5838
10302	BALINTAWAK 5	34.5	51E, 53E, 55E, 57E	464.43	610.93	7.77	10.22	0.0094	2.5628	0.0023	0.7191	0.2806
10303	BALINTAWAK 6	34.5	402E, 403E 404E, 405E	455.34	508.38	7.62	8.51	0.0091	2.6140	0.0050	1.7958	0.6870
13301	BF PARANAQUE 1	34.5	42WU, 43WU, 44WU, 45WU, 47WU	452.55	598.02	7.57	10.01	0.0179	2.6300	0.0052	0.7107	0.2702
13302	BF PARANAQUE 2	34.5	NOT YET AVAILABLE	452.55	598.02	7.57	10.01	0.0179	2.6300	0.0052	0.7107	0.2702
11605	BINONDO	34.5	41N, 43N, 45N	411.56	364.52	6.89	6.10	0.3369	2.8724	0.4312	3.9884	1.3886
10401	BOCAUE 1	34.5	43YE, 44YE, 46YE	628.08	442.43	10.51	7.40	0.0275	1.8949	0.0321	4.2805	2.2590
10402	BOCAUE 2	34.5	47YE, 50YE	685.74	691.44	11.48	11.57	0.0273	1.7355	0.0257	1.6926	0.9753
10501	BOTOCAN	34.5	41D, 42D	262.12	241.10	4.39	4.03	0.2938	4.5313	0.2369	5.7236	1.2631
15001	CAINTA 1	34.5	42XG, 44XG, 46XG, 47XG, 48XG	461.79	496.52	7.73	8.31	0.0211	2.5774	0.0135	2.0366	0.7902
15002	CAINTA 2	34.5	421XG, 423XG, 424XG	450.03	602.92	7.53	10.09	0.0208	2.6447	0.0051	0.6328	0.2393
37801	CAMARIN1	34.5	432TC, 433TC, 434TC, 435TC	426.85	565.06	7.14	9.46	0.0394	2.7882	0.0098	0.7423	0.2662
14301	CANLUBANG 1	34.5	41XE, 43XE, 45XE, 47XE	423.88	360.87	7.09	6.04	0.0461	2.8076	0.0426	4.2786	1.5239
14302	CANLUBANG 2	34.5	52XE, 53XE, 55XE	424.78	361.18	7.11	6.04	0.0460	2.8017	0.0426	4.2821	1.5284
14303	CANLUBANG 3	34.5	431XE	292.48	258.65	4.89	4.33	0.0462	4.0692	0.0376	5.6662	1.3924
77003	CAPASCO	34.5	41RG4	279.81	270.80	4.68	4.53	0.0290	4.2537	0.0237	4.6783	1.0998
14901	CARMELRAY 1	34.5	413QW, 414WQ, 415WQ, 416WQ	412.70	553.29	6.91	9.26	0.0418	2.8838	0.0096	0.6855	0.2377
12808	CAVITE	34.5	CARRIER CIRCUIT	118.91	148.94	1.99	2.49	3.9223	9.2092	1.3371	3.7222	0.4042
30901	CBP 1A_1	34.5	410RF, 412RF, 413RF, 415RF, 416RF	439.62	587.22	7.36	9.83	0.0265	2.7073	0.0064	0.6658	0.2459
30902	CBP 1A_2	34.5	NOT YET AVAILABLE	439.62	587.22	7.36	9.83	0.0265	2.7073	0.0064	0.6658	0.2459
12901	CUBAO 1	34.5	42VQ, 43VQ, 45VQ, 46VQ	446.00	488.26	7.46	8.17	0.0270	2.6686	0.0193	1.9757	0.7403
12902	CUBAO 2	34.5	48VQ, 51VQ, 52VQ	443.43	459.19	7.42	7.68	0.0267	2.6841	0.0177	2.4077	0.8971
13701	DASMARINAS 1	34.5	42DA, 43DA	381.51	407.03	6.38	6.81	0.0065	3.1198	0.0040	2.5330	0.8119
13702	DASMARINAS 2	34.5	41DA, 44DA	409.64	510.83	6.86	8.55	0.0066	2.9056	0.0023	1.1789	0.4057
14001	DILIMAN 1	34.5	42VU, 43VU, 45VU, 46VU	444.68	371.56	7.44	6.22	0.0238	2.6765	0.0238	4.2568	1.5904
14002	DILIMAN 2	34.5	423VU, 424VU, 426VU	433.83	426.42	7.26	7.14	0.0239	2.7435	0.0448	2.8863	1.0520

Protection Coordination



1MVA
34.5 kV
Load = 16.7A

L-G fault = 1,000A
3P fault = 2,000A

Minimum size of fuse = 30E
16.7 x 1.6 = 26.72 ≈ 30E

Coordinated

Using Maximum Rating
Instead of proper coordination
With DU protection

Using the Maximum Value of Fuse Link instead Of the one properly coordinated with the DU

Ratings

Fuse Type	kV			Amperes, RMS, Symmetrical		
					Interrupting	
	Nominal	Maximum	BIL	Maximum	60 Hz	50 Hz
SM-4	7.2 14.4 25 34.5	8.3 17.0 27 38	95 110 150 150 & 200	200E 200E 200E 200E	15 600 12 500 9 400 6 250	15 600 12 500 9 400 6 250
SM-5	7.2 14.4 14.4 25 34.5	8.3 17.0 17.0 27 38	95 110 110 150 150 &200	400E & 720E 400E 720E 300E 300E	26 000 34 000♠ 25 000 20 000 17 500	26 000 25 000 25 000 20 000 17 500

♠ 25 000 amperes for systems above 15.5 kV thru 17.0 kV.

Using the Maximum Value of Fuse Link instead Of the one properly coordinated with the DU

Ratings

kV			Amperes, RMS			Leakage Distance to Ground, Minimum	
Nom.	Max	BIL	Cont.	Interr., Asym.		Inches	mm
				60 Hz	50 Hz		
14.4	15	110	100	10 000	8 000	8-1/2	216
				16 000	12 800	8-1/2	216
			200	12 000	9 600	8-1/2	216
			Disconnect 300	—	—	8-1/2	216
25	27	125	100	8 000	6 400	11	279
				12 000	9 600	11	279
			200	10 000	8 000	11	279
			Disconnect 300	—	—	11	279
		150	100	8 000	6 400	17	432
				12 000	9 600	17	432
				12 000	9 600	26	660
			200	10 000	8 000	17	432
			Disconnect 300	—	—	17	432
				—	—	26	660

Proper Coordination of Fuses

KVA ↓	Fuse Cut-Out				Power Fuse (SMD-20)				Power Fuse (SM-5)			
	Customer Side				Customer Side				Customer Side			
	Rating	Sym (kA)	Assym (kA)	MVAsc	Rating	Sym (kA)	Assym (kA)	MVAsc	Rating	Sym (kA)	Assym (kA)	MVAsc
Fault Areas →	Low Fault (< = 478 MVAsc)				High Fault (479<MVAsc<600)				Very High Fault (601<MVAsc<1000)			
3-50 kVA	6K	8	12	478								
3-75 kVA	6K	8	12	478								
3-100 kVA	8K	8	12	478								
3-167 kVA	15K	8	12	478								
3-250 kVA	20K	8	12	478								
3-333 kVA	30K	8	12	478								
1500 kVA	40K	8	12	478	40E	10	16	600	40E	17.5	28	1000
2000 kVA	65K	8	12	478	65E	10	16	600	65E	17.5	28	1000
2500 kVA	80K	8	12	478	80E	10	16	600	80E	17.5	28	1000
3000 kVA	80K	8	12	478	80E	10	16	600	80E	17.5	28	1000
3500 kVA					100E	10	16	600	100E	17.5	28	1000
4000 kVA					125E	10	16	600	125E	17.5	28	1000
4500 kVA					125E	10	16	600	125E	17.5	28	1000
5000 kVA					150E	10	16	600	150E	17.5	28	1000
5500 kVA					150E	10	16	600	150E	17.5	28	1000
6000 kVA									175E	17.5	28	1000
6500 kVA									175E	17.5	28	1000
7000 kVA									200E	17.5	28	1000
7500 kVA									200E	17.5	28	1000
8000 kVA									250E	17.5	28	1000
8500 kVA									250E	17.5	28	1000
9000 kVA									250E	17.5	28	1000

LEGEND:

3 MVA and below – low fault areas - FCO

1 MVA and below – high and very high fault areas – FCO with CLF

Above 1 MVA but not to exceed 3 MVA – high fault areas – SMD-20

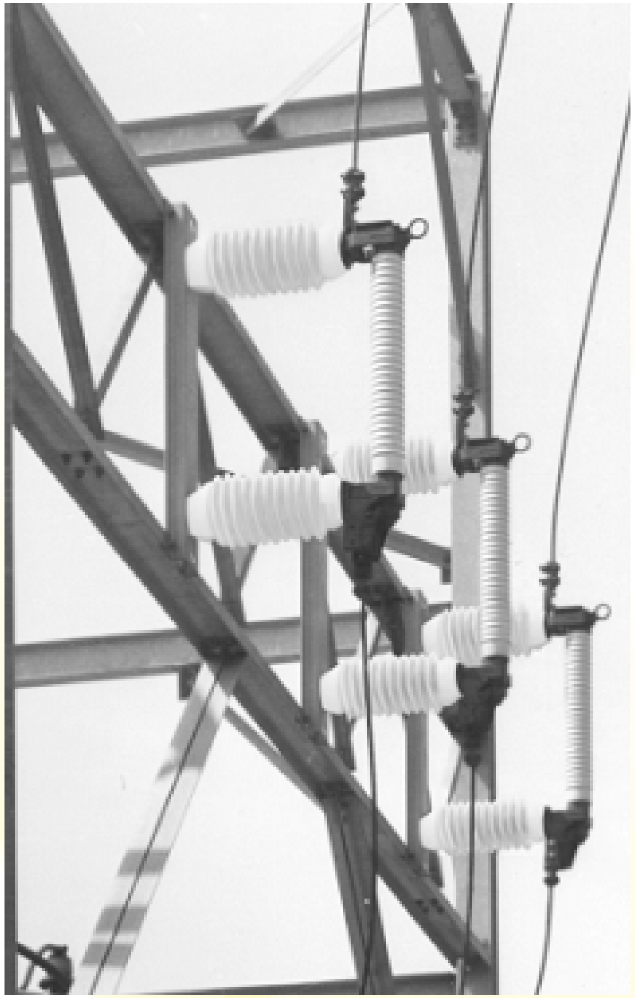
Above 3 MVA but not to exceed 5.5 MVA – low and high fault areas – SMD-20

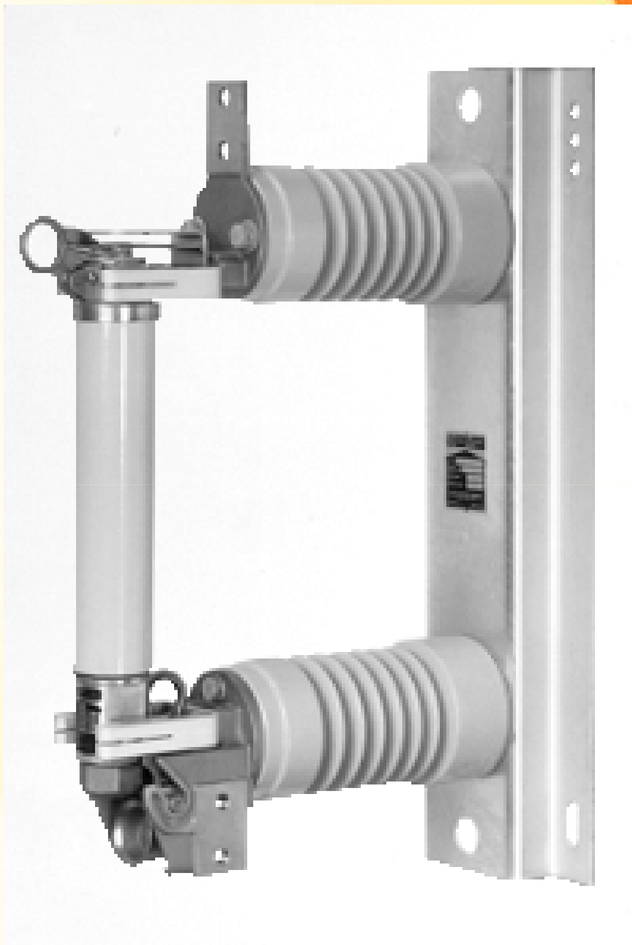
Above 1 MVA but not to exceed 5.5 MVA – very high fault areas – SM-5

Above 5.5 MVA but not to exceed 9 MVA – all areas – SM-5

Power Fuse or
Fuse Cutouts ?

Power Fuses





Specifications & Ratings :

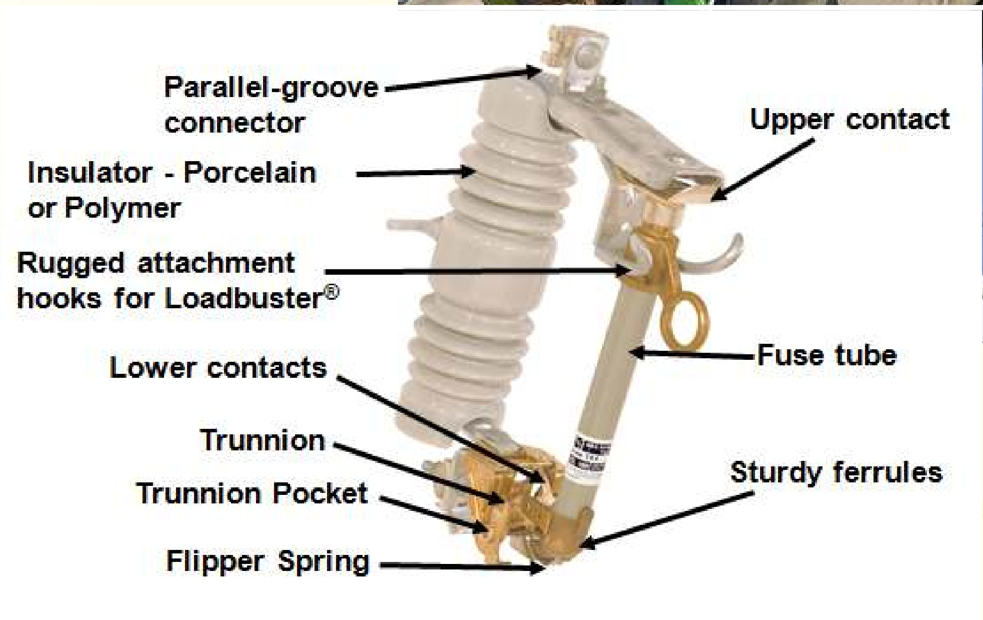
Power Fuse

minimum ratings and specifications of a customer's power fuse

System Nominal Voltage	Voltage Rating	Frequency Rating	Continuous Current Rating	Interrupting Capacity		Basic Impulse Insulation Level
kV	kV	Hz		Sym	Asym	(kV, min.)
13.2	14.4	60	as required	25	40	95
13.8	14.4	60	as required	25	40	110
34.5	34.5	60	as required	17.5	28	200

✓ **A minimum of three (3) spare refill units is also recommended.**

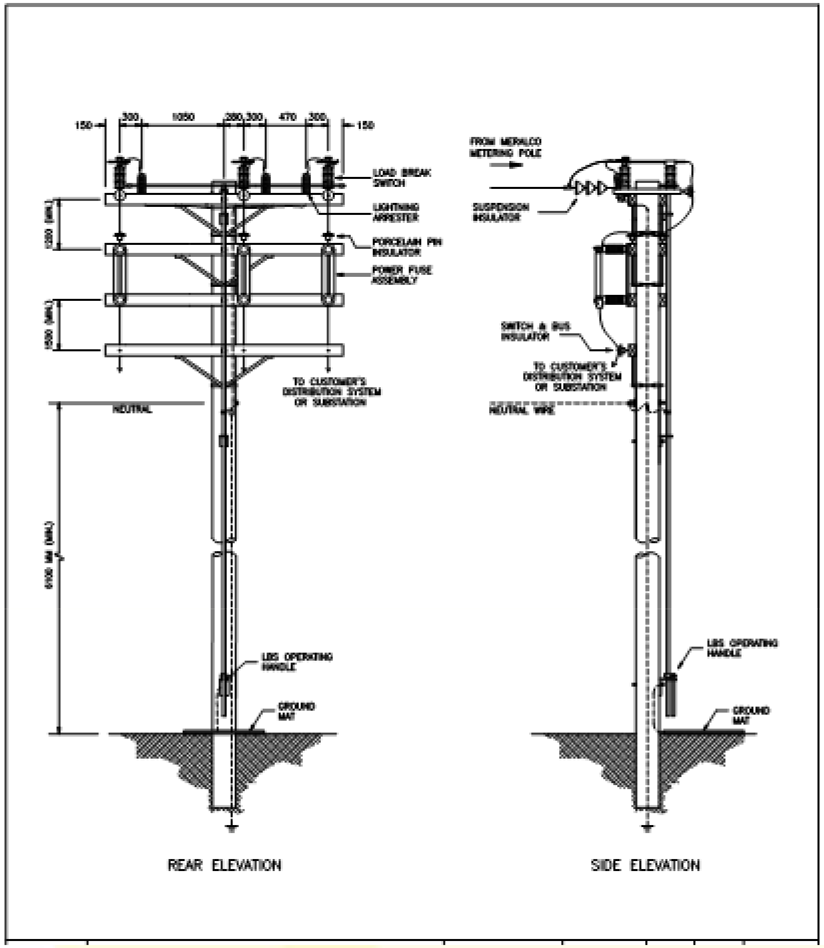
Fuse Cutouts

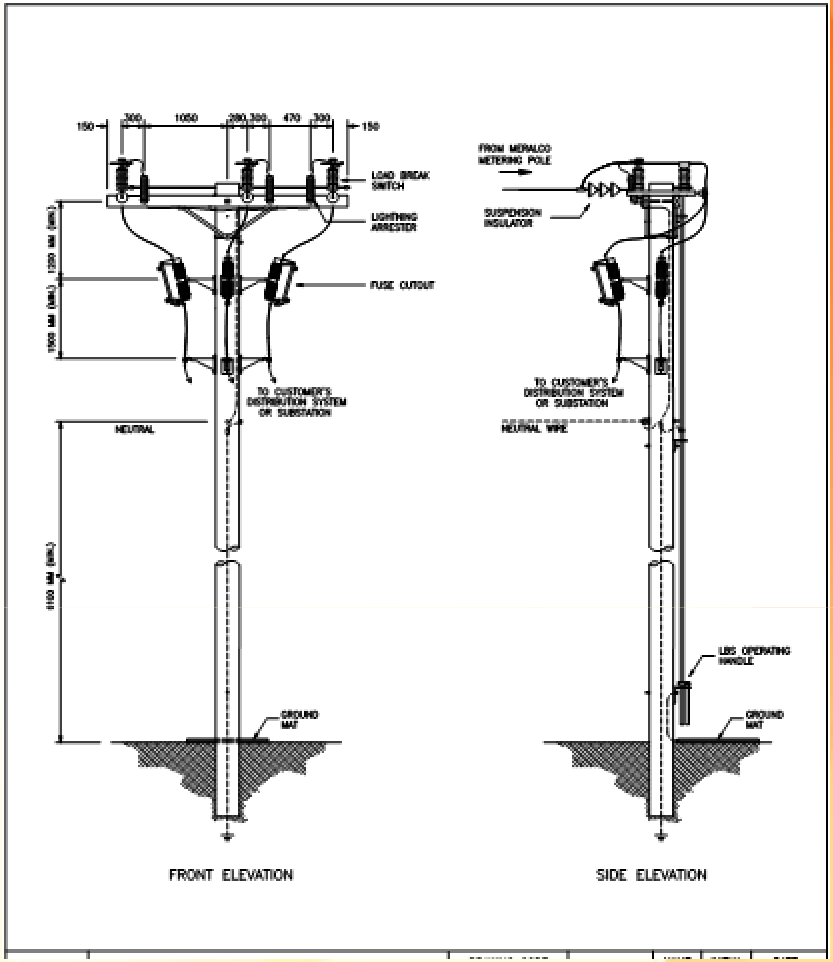


Fuse Cutout

System Nominal Voltage	Voltage Rating	Frequency Rating	Continuous Current Rating	Interrupting Capacity	Interrupting Time Rating	Basic Impulse Insulation Level
kV	kV	Hz		kA	max.	(kV, min.)
13.2	14.4	60	as required	16	5	95
13.8	14.4	60	as required	16	5	110
34.5	34.5	60	as required	16	5	200







Power Fuse or Fuse Cutouts ?

Proper Coordination of Fuses

KVA	Fuse Cut-Out				Power Fuse (SMD-20)				Power Fuse (SM-5)			
	Customer Side				Customer Side				Customer Side			
	Rating	Sym (kA)	Assym (kA)	MVAsc	Rating	Sym (kA)	Assym (kA)	MVAsc	Rating	Sym (kA)	Assym (kA)	MVAsc
Fault Areas	Low Fault (< = 478 MVAsc)				High Fault (479<MVAsc<600)				Very High Fault (601<MVAsc<1000)			
3-50 kVA	6K	8	12	478								
3-75 kVA	6K	8	12	478								
3-100 kVA	8K	8	12	478								
3-167 kVA	15K	8	12	478								
3-250 kVA	20K	8	12	478								
3-333 kVA	30K	8	12	478								
1500 kVA	40K	8	12	478	40E	10	16	600	40E	17.5	28	1000
2000 kVA	65K	8	12	478	65E	10	16	600	65E	17.5	28	1000
2500 kVA	80K	8	12	478	80E	10	16	600	80E	17.5	28	1000
3000 kVA	80K	8	12	478	80E	10	16	600	80E	17.5	28	1000
3500 kVA					100E	10	16	600	100E	17.5	28	1000
4000 kVA					125E	10	16	600	125E	17.5	28	1000
4500 kVA					125E	10	16	600	125E	17.5	28	1000
5000 kVA					150E	10	16	600	150E	17.5	28	1000
5500 kVA					150E	10	16	600	150E	17.5	28	1000
6000 kVA									175E	17.5	28	1000
6500 kVA									175E	17.5	28	1000
7000 kVA									200E	17.5	28	1000
7500 kVA									200E	17.5	28	1000
8000 kVA									250E	17.5	28	1000
8500 kVA									250E	17.5	28	1000
9000 kVA									250E	17.5	28	1000

LEGEND:

3 MVA and below – low fault areas - FCO

1 MVA and below – high and very high fault areas – FCO with CLF

Above 1 MVA but not to exceed 3 MVA – high fault areas – SMD-20

Above 3 MVA but not to exceed 5.5 MVA – low and high fault areas – SMD-20

Above 1 MVA but not to exceed 5.5 MVA – very high fault areas – SM-5

Above 5.5 MVA but not to exceed 9 MVA – all areas – SM-5

Multiple Set of Power Fuses

Multiple Sets of Power Fuses or Back-to-back Power Fuses

Reduced /Corrected to Just One (1) set of Power Fuses

Not Appropriate Transformer Specifications and Connections

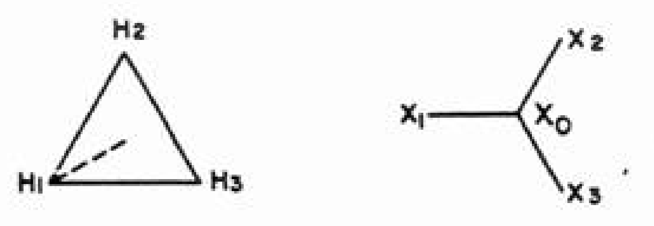
Transformer Connections:

- **The preferred transformer connection is delta primary, wye secondary;**
- **<u>the wye grounded delta connection is not allowed</u>.**

TRANSFORMER CONNECTON

(Advantages and Disadvantages)

Case I. Delta – Grounded Wye
(Recommended – why?)



Advantages:

1. **Complete symmetry and currents with respect to the three (3) lines to neutral.**

2. **It provides two different values of secondary voltage instead of one; i.e -480/277v. (Less expensive in design compared to delta – delta connections in terms of insulation).**

3. **Stable neutral because of the delta, primary and good current balance; i.e., overall loading can be closely balanced.**

4. **Most satisfactory connection due to a wide applications in LV distribution systems, i.e., commercial buildings of power and lighting service.**

Disadvantages:

1. It is also susceptible to ferroresonance *, especially during 1ø sequential switching when energized in series with cable capacitance to ground.

2. The bank cannot be parallel with D-D or Y-Y banks because of the phase difference of 30 degrees between line voltages of the banks on the secondary side.

* Ferroresonance can occur when an unloaded three phase system consisting mainly of inductive and capacitive components is interrupted by single phase means.
In the electrical distribution field this typically occurs on a medium voltage electrical distribution network of transformers (inductive component) and power cables (capacitive component). If such a network has little or no resistive load connected and one phase of the applied voltage is then interrupted, ferroresonance can occur.
If the remaining phases are not quickly interrupted and the phenomenon continues, overvoltage can lead to the breakdown of insulation in the connected components resulting in their failure.
The phenomenon can be avoided by connecting a minimal resistive load on the transformer secondaries or by interrupting the applied voltage by a 3-phase interrupting device such as a ganged (3-pole) circuit breaker.
When ferroresonance does occur in a transformer, high voltages three to five times the rated primary can appear on the primary, in the core and on the secondary

A. <u>Advantage to Distribution Utility</u>

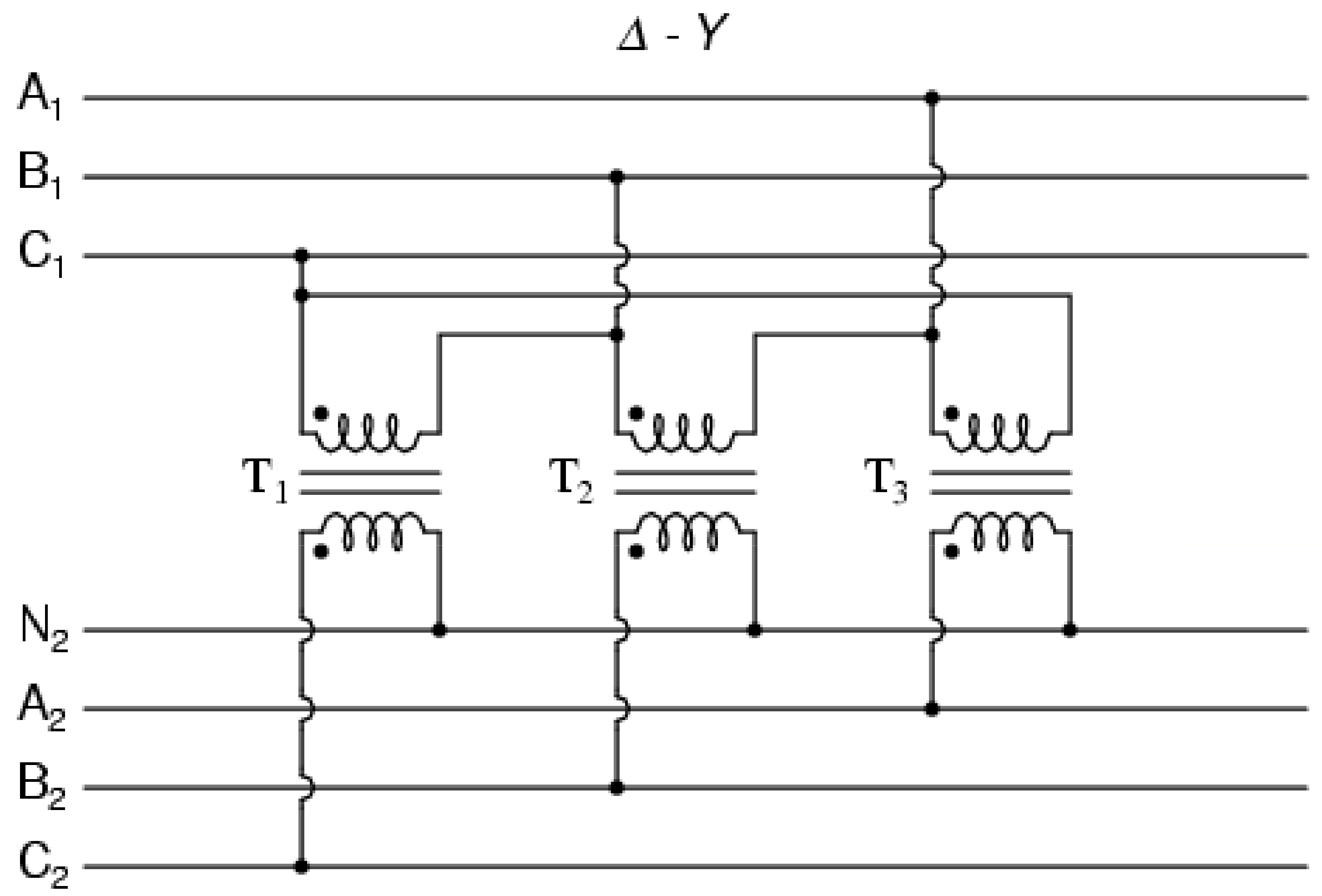
1. Any unbalancing of load the secondary will just be contained at the primary. System neutral current will not be affected.

B. <u>Advantage to Wye Grounded Secondary to Customer</u>

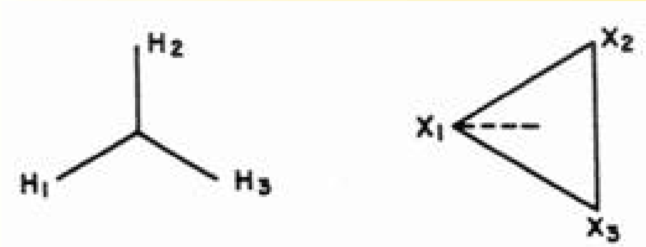
1. Smaller fault current.

2. Fault in any leg will be readily isolated. (In delta connected secondary, it is necessary to have two legs on before it can be isolated. If only any one legs on faulty, it is necessary to wait for a fault on another leg before it can be isolated.

3. Economy in insulation, since than delta connected secondary.


Δ - Y
A1
B1
C1
T1
T2
T3
N2
A2
B2
C2

<u>Case IV. Grounded Wye – Delta</u>:



Advantages:

1. **Drastically reduces the possibility of ferroresonance.**

2. **In case of fuse blowing of one line on the primary, 3-phase power is continued to be served the secondary. It operates as an open type-open delta bank and a the wye connection continues to carry the load as much a 58% of a closed.**

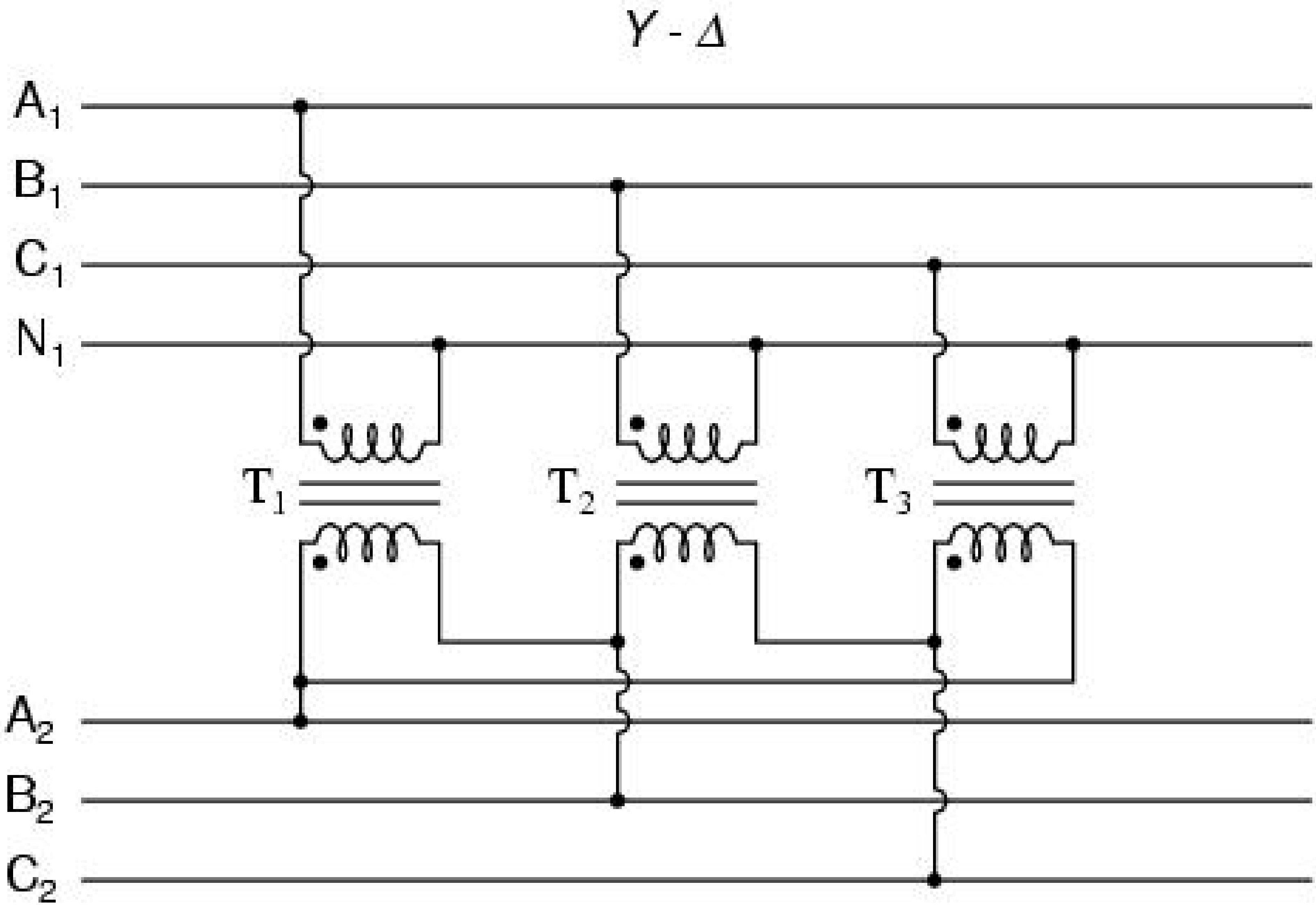
3. **All voltages are balanced and no roving neutrals are present.**

Disadvantages:

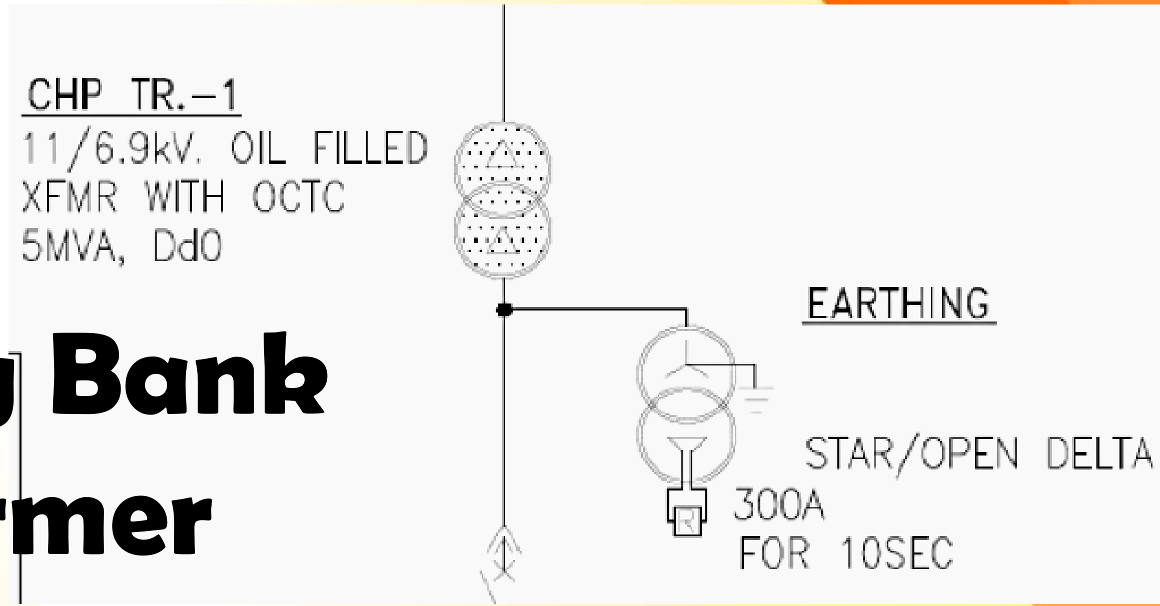
1. **Transformer bank acts as grounding transformer for fault external to itself.**

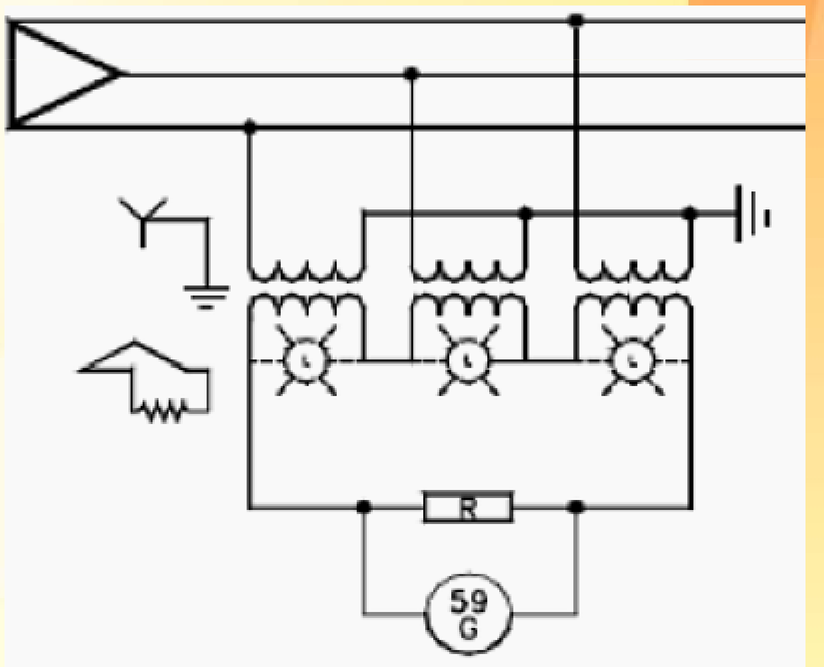
2. **Unbalanced in load between phases cause current to flow in other wye-delta transformer banks connected to the same line.**

3. **If transformer normally carries 100% load, fuse blowing n one line on the primary will cause the remaining two phases (open wye - open delta operation) overload by 73%.**


Y - Δ
A1
B1
C1
N1
T1
T2
T3
A2
B2
C2

Grounding Bank Transformer






Definition of
Basic Insulation Level (BIL)

Transformer BIL:

BIL is an abbreviation for Basic Impulse Level. Impulse tests are dielectric tests that consist of the application of a high frequency steep wave front voltage between windings, and between windings and ground.

The BIL of a transformer is a method of expressing the voltage surge that a transformer will tolerate without breakdown.

When lightning strikes a transmission line, a traveling wave is created. This traveling wave travels along the line and damages the transformer winding.

Insulation levels are designed to withstand surge voltages, rather than only normal operating voltages.

Since the insulation lines and equipment is protected by surge arresters draining the surges rapidly before the insulation is damaged, the arrester must operate below the minimum insulation level that must withstand the surges.

> Specifications & Ratings of Customer-Owned Equipment / Devices

Transformer Bank

Type of Transformers	Basic Impulse Insulation Level (kV, Minimum)		
Distribution Transformers, kVA	13.2 kV	13.8 kV	34.5 kV
Distribution Transformers	95	95	150
Padmounted, Compartmental-type Transformers	95	110	150
Power Transformers	110	110	200
Dry Type Transformers	110	110	200

ANSI- IEEE and IEC on BIL

Table 3.8.4-1 Insulation Level Requirement When Tested in Accordance with ANSI C29.1-1988

Nominal voltage (between phases) (kV)	Rated dry flashover voltage of insulators[1] (kV)	Nominal voltage (between phases) (kV)	Rated dry flashover voltage of insulators[1] (kV)
0.75	5	115	315
2.4	20	138	390
6.9	39	161	445
13.2	55	230	640
23.0	75	345	830
34.5	100	500	965
[illegible]	[illegible]	765	1145
69.0	175		

[1]Interpolate for intermediate values.

Table 3.8.4-2 IEC Standard Insulation Levels for Voltages Less than 300 kV

Highest voltage for equipment (phase-to- phase) kV (r.m.s. value)	Standard short-duration power-frequency withstand voltage kV (r.m.s. value)	Standard lighting impulse withstand voltage kV (peak value)
3.6	10	40
7.2	20	60
12	28	75
17.5	38	95
[illegible]	[illegible]	125
36	70	170
[illegible]	[illegible]	250
72.5	140	325
123	185	450
	230	550
145	185	450
	230	550
	275	650
170	230	550
	275	650
	325	750
245	275	650
	325	750
	360	850
	395	950
	460	1 050

What to choose ?

At 34.5 kV:

For ANSI – 100 BIL

At 36 kV:

For IEC – 70 BIL only

ANSI- IEEE and IEC on BIL

2. STANDARD :

THE TRANSFORMER IS DESIGNED · MANUFACTURED AND TESTED IN ACCORDANCE WITH THE PURCHASER'S SPECIFICATION AND APPLICABLE PARTS OF IEC 60076 STANDARD ·

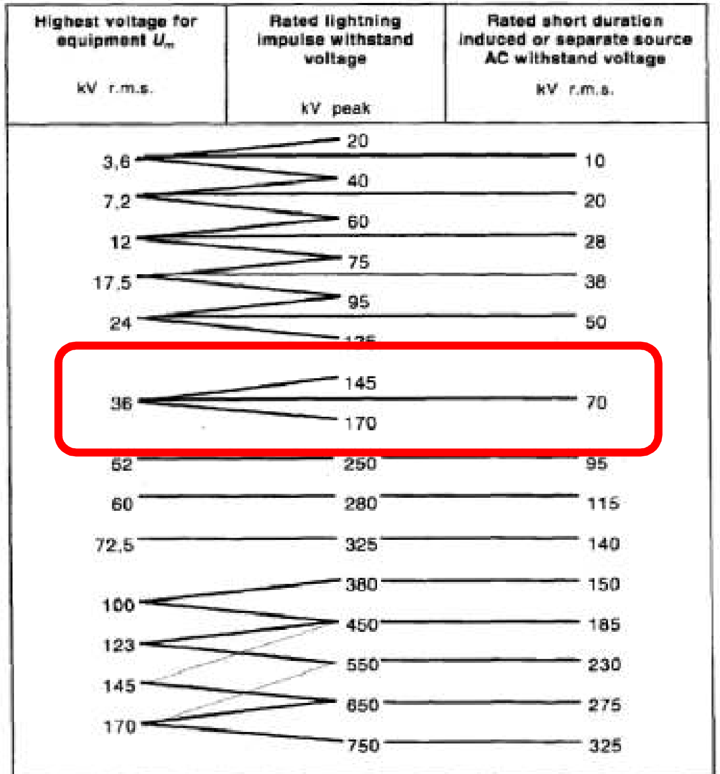
01. Item		1	
02. Quantity		2	
03. φ —Hz—kVA		3 φ 60Hz 2500/3125 kVA	
04. Type		ONAN/ONAF CONSERVATOR	
05. High Voltage	(V)	F 36225	105.0%
		F 35363	102.5%
		R 34500 Δ	100.0%
		F 33638	97.5%
		F 32775	95.0%
06. Low Voltage	(V)	400/231 Y	
07. BIL	(kV)	HV 170 LV —	
08. AC VOLTAGE	(kV)	HV 70 LV 3	

What to choose ?

Let the Professional Electrical Engineer (PEE) states his reasons why he choose IEC instead of the ANSI-IEEE standards and certify it with his PRC license.

60076-3 © IEC:2000 – 27 –

Table 2 – Rated withstand voltages for transformer windings with highest voltage for equipment $U_m \leq 170$ kV – Series I based on European practice



NOTE Dotted lines may require additional phase-to-phase withstand tests to prove that the required phase-to-phase withstand voltages are met.

Low-voltage windings with $U_m \leq 1,1$ kV shall be tested with 3 kV separate source AC withstand voltage.

What is the difference between Power Transformers and Distribution Transformers?

Those transformers installed at the ending or receiving end of long high voltage transmission lines are the power transformers. The distribution transformers (generally pole mounted) are those installed in the location of the city to provide utilization voltage at the consumer terminals.

• Power transformers are used in transmission network of higher voltages for step-up and step down application (400 kV, 200 kV, 110 kV, 66 kV, 33kV) and are generally rated above 200MVA.
•Distribution transformers are used for lower voltage distribution networks as a means to end user connectivity. (11kV, 6.6 kV, 3.3 kV, 440V, 230V) and are generally rated less than 200 MVA.
•A power transformer usually has one primary and one secondary, and one input and output. A distribution transformer may have one primary and one divided or "Tapped" secondary, or two or more secondaries.
•Power transformers generally operate at nearly full – load. However, a distribution transformer operates at light loads during major parts of the day.
•The performance of the power transformers is generally judged from commercial efficiency whereas the performance of a distribution transformer is judged from all – day – efficiency.
•The rating of a high transformer is many times greater than that of distribution transformer.
•In Power Transformer the flux density is higher than the distribution transformer.
•Power transformer's primary winding always connected in star and secondary winding in delta while in distribution transformer primary winding connected in delta and secondary in star.
•In The Sub station end of the transmission line, The Power Transformer Connection is Star-Delta.(For the purpose of Step down the Voltage Level)
•In the star up of the Transmission line (H-T), The Connection of the power Transformer is Delta – Star (For the purpose of Step Up the Voltage Level) But in case of Distribution Transformer, But Generally it is used in there-phase Step down distribution transformer(Delta – Star).

REFERENCES

4. Insulator KV rating – Table 3.8.4.1. p.245 from PEC 2008 part 2 or table 3.1.1.64 p.361 f.

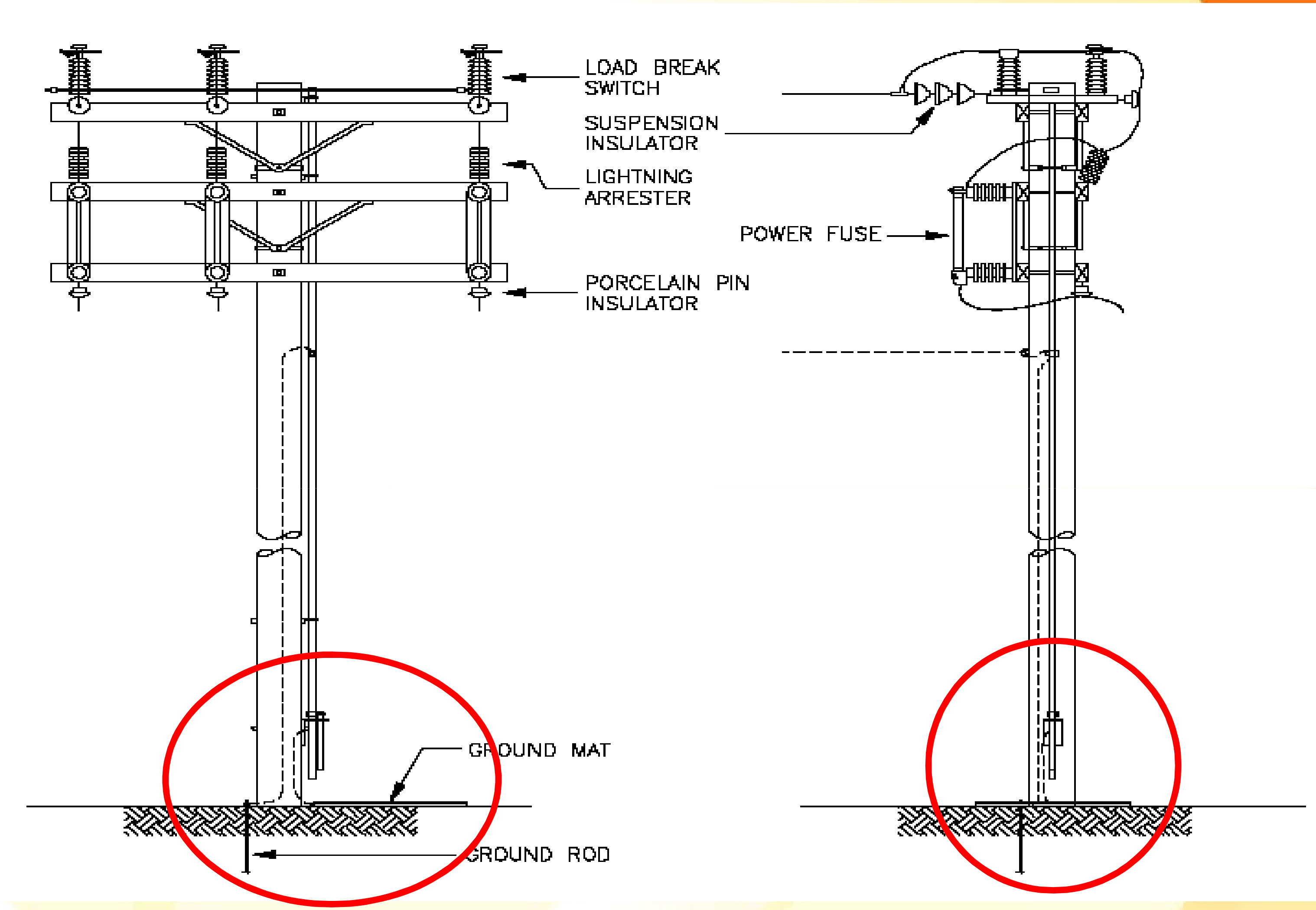
LBS Handle Not Connected to Grounding Mat

No Grounding Mat

Operating handle not grounded

LBS Handle NOT Connected to the Ground Mat Or Grounded

Ground Mat Connected to the LBS Handle



Ground Mat Connected to the LBS Handle

Location of LBS Handle and Ground Mat

Ground Mat Connected to the LBS Handle

Ground Mat Example
Illustrative purpose only

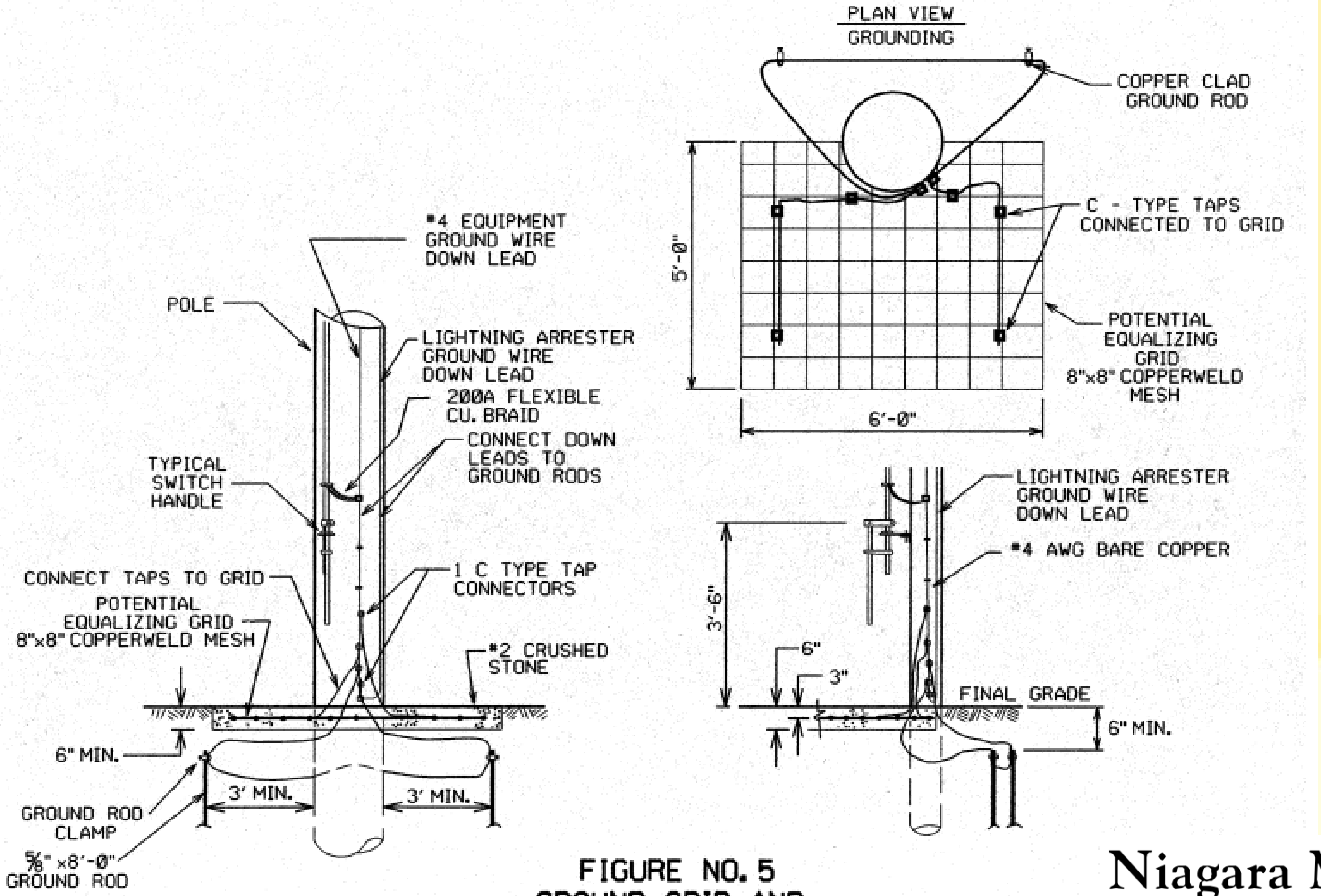
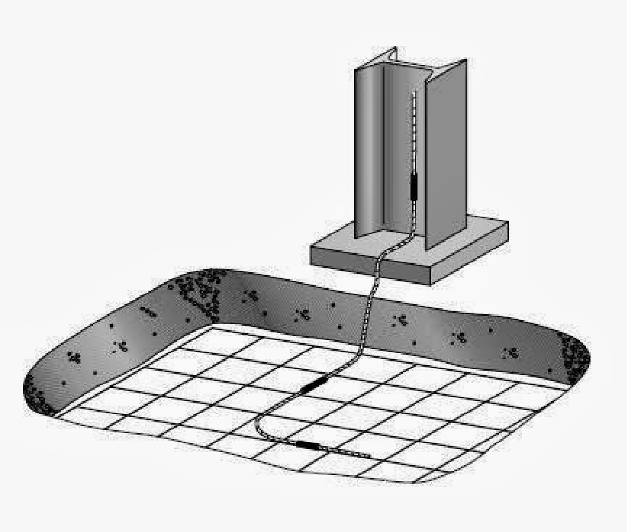
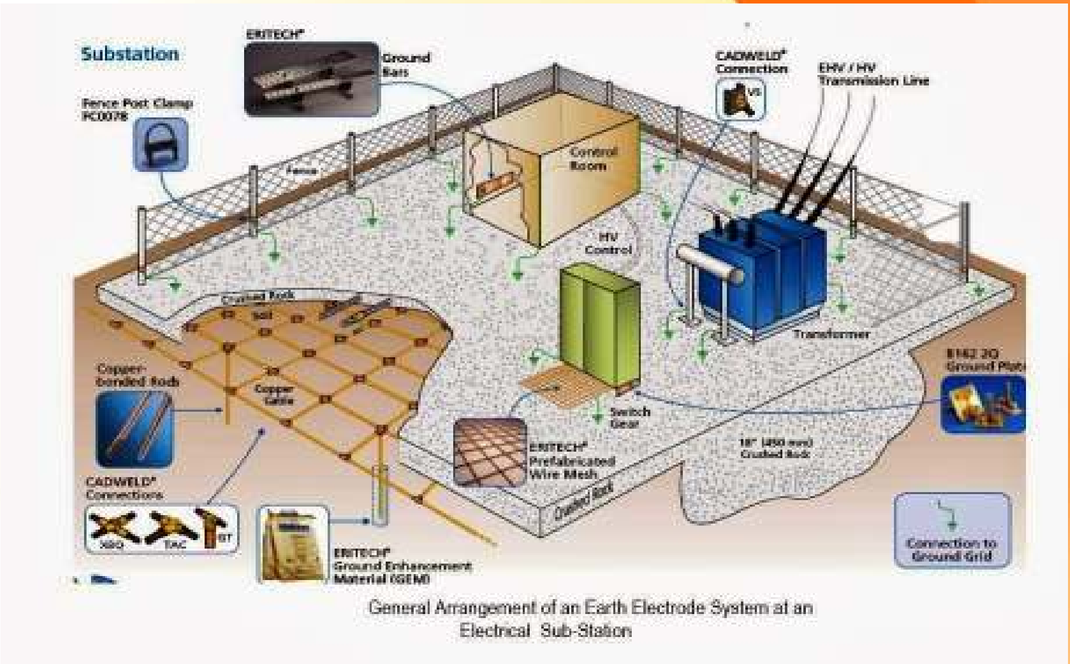


FIGURE NO. 5
GROUND GRID AND
SWITCH HANDLE GROUNDING

Niagara Mohawk
A **National Grid** Company

Ground Mat Example
Illustrative purpose only





REFERENCES

- Grounding mat connection and material – Article 2.90.3.20 - 2.90.3.32 pp. 284-291 from PEC 2009 vol.

Most Common Errors in Service Entrance Installations Prior to Final DU Inspection

-End of Presentation-

Industrial and Commercial Buildings

Primary Voltage / Overhead

For RME Forum – November 28, 2014

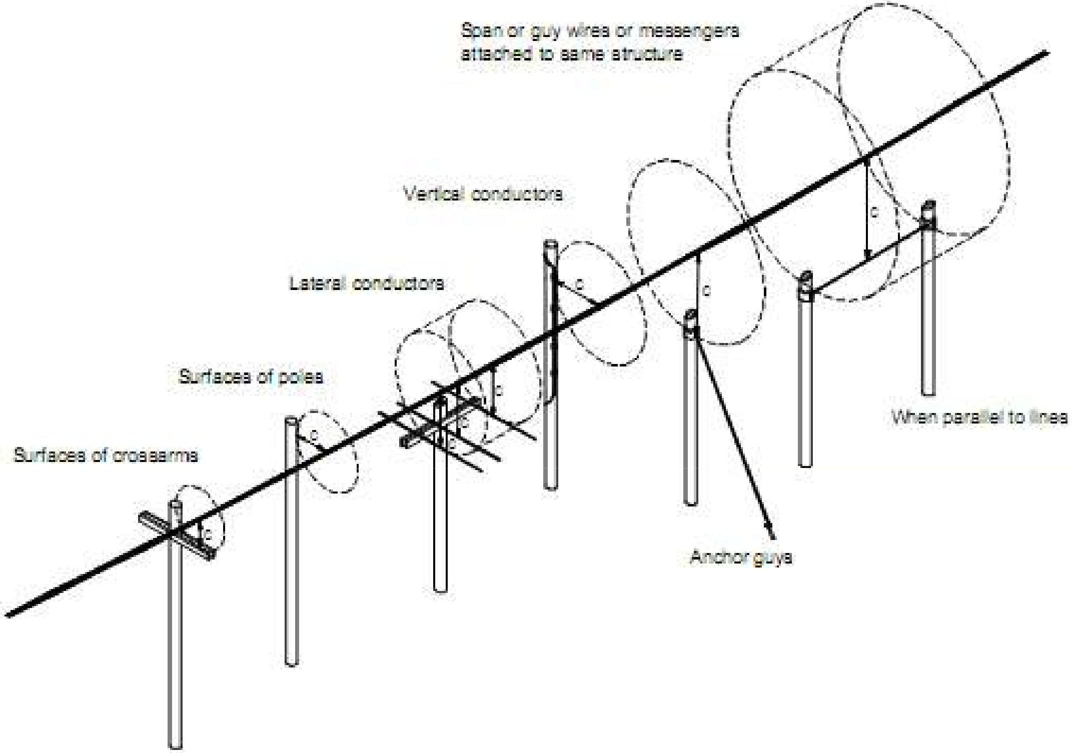
IIEE Convention

Presented by : Ray Anthony Rodriguez

Team Leader- Meralco South CBG Technical Support

Addendum 1
Typical Distribution Standard Clearances

Typical Distribution Clearances to Supporting Structures



NOTES:
1. Values for clearances "C" shall be as per Table 4.2.7.1
2. Notes of Table 4.2.7.1 shall also apply.

Fig. 4.2.7.1: Clearance of Line Conductors in Any Direction to Supporting Structures, and to Vertical and Lateral Conductors, Span or Guy Wires Attached to the Same Support

Typical Distribution Clearances

Vertical Line Configuration

Pole with Vertical Line and Horizontal Line Configuration

Horizontal Line Configuration

Triangular Line Configuration

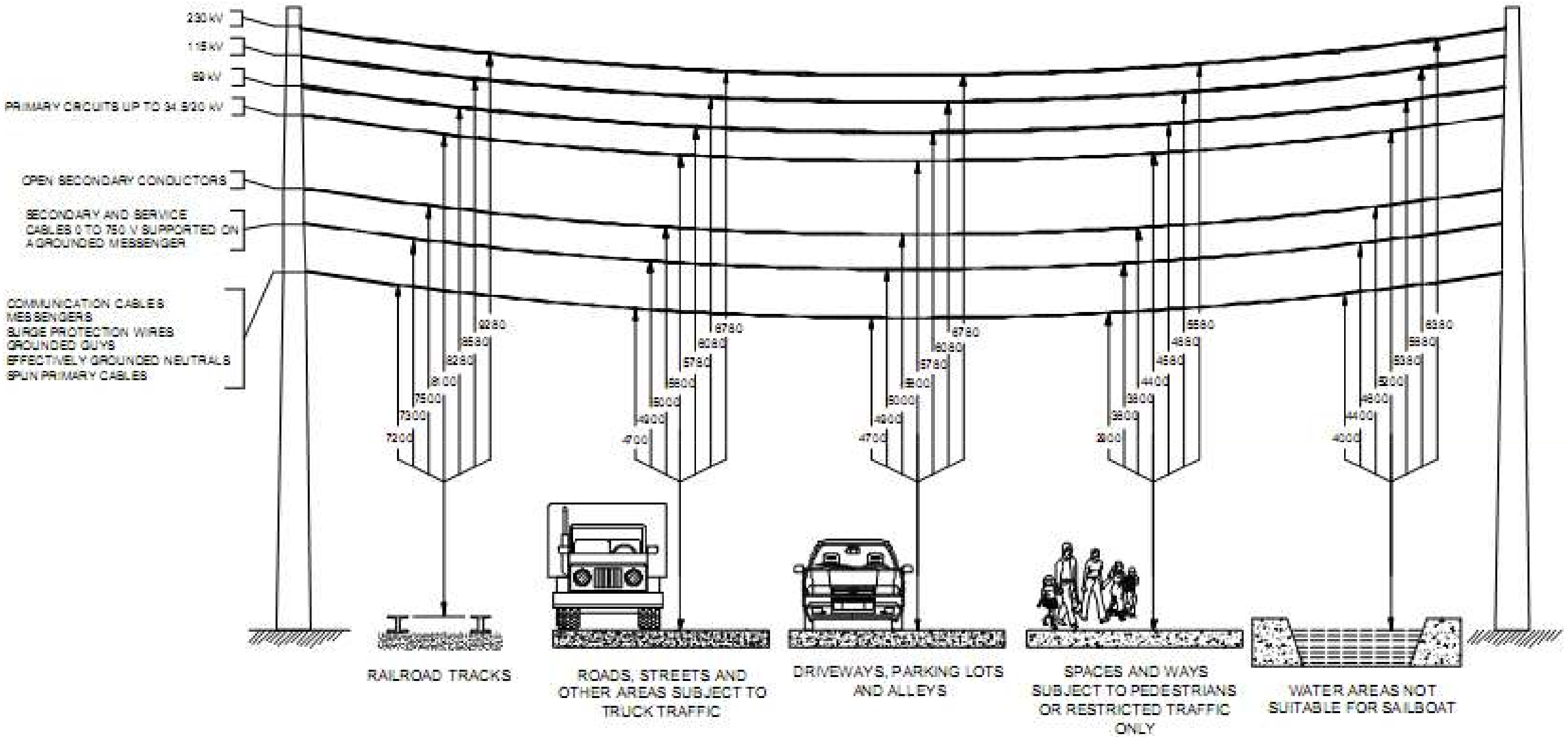
Customer-Owned Facilities

The applicant's primary distribution facilities and substation **shall comply** with the provisions of the latest edition of the **Philippine Electrical Code** regarding safety and clearance requirements.

Vertical Clearance of Conductors Above Ground or Other Surfaces

Nature of Surface Below	Railroad Tracks	Roads, streets and other areas subject to truck traffic	Driveways, parking lots and alleys	Spaces and ways subject to pedestrians or restricted traffic only	Water areas not suitable for sailboat
	mm	mm	mm	mm	mm
Primary Circuits upto 34.5/20 kV	8100	5600	5600	4400	5200

Typical Distribution Clearances from Roadways



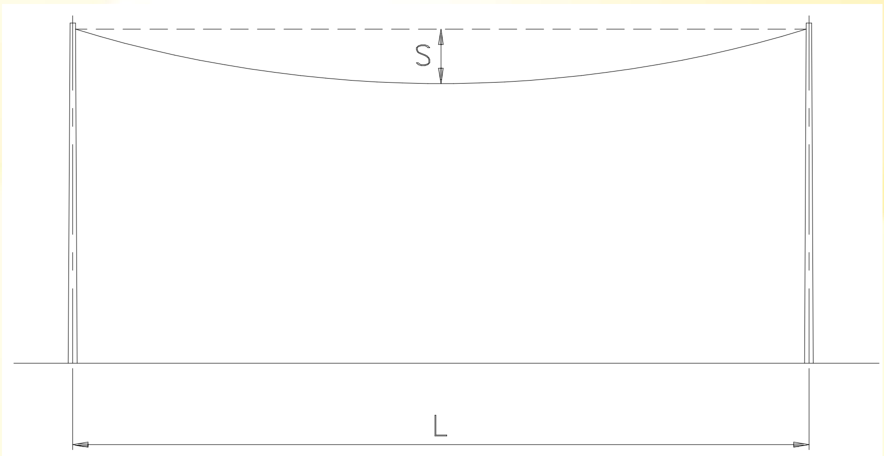
Notes: 1. This figure is based on Table 4.2.1.1(a).
2. All dimensions are in mm.

Fig. 4.2.1.1 (a): Vertical Clearance of Wires, Conductors or Cables Above Ground, Rails or Water [where wires, conductors or cables cross over or overhang the surface]

Sag

SAG = measured vertically from conductor (below its end points) to the straight line joining its support/vertical drop of the mid-point of a span of conductor below its end supports.

SPAN = horizontal distance between support points



Level Span

Vertical Clearance Between Supply Conductors Supported on the Same Structure

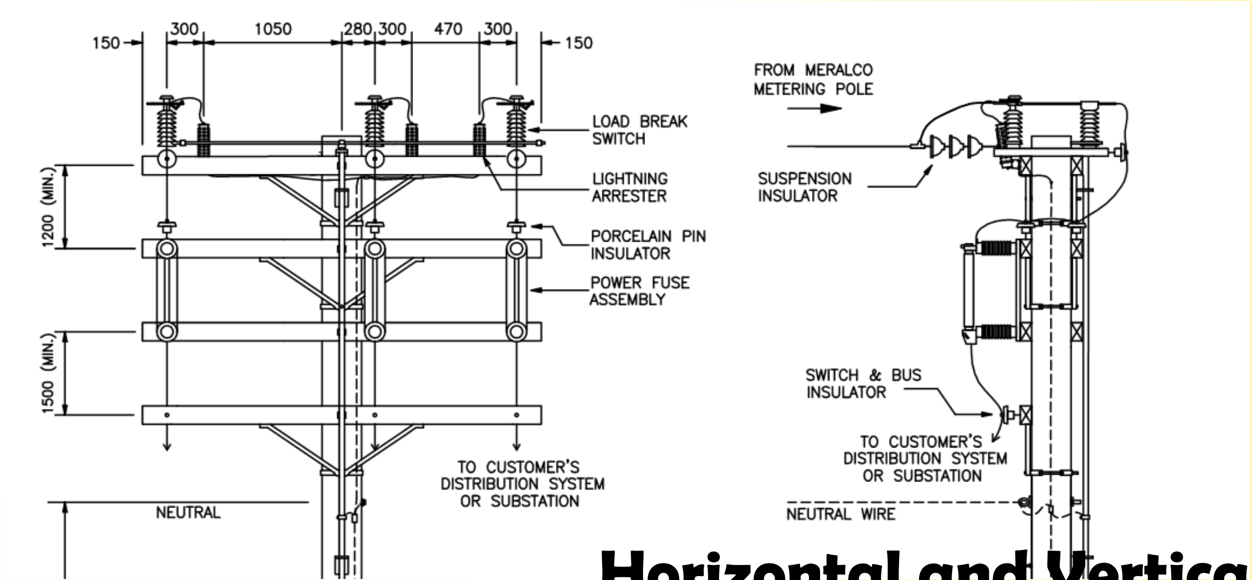
For 34.5/ 20 kV lines = 725 mm or 2’ 4”

Clearances Between Wires , Conductors or Cables Carried on Different Supporting Structures

For 34.5/ 20 kV lines only

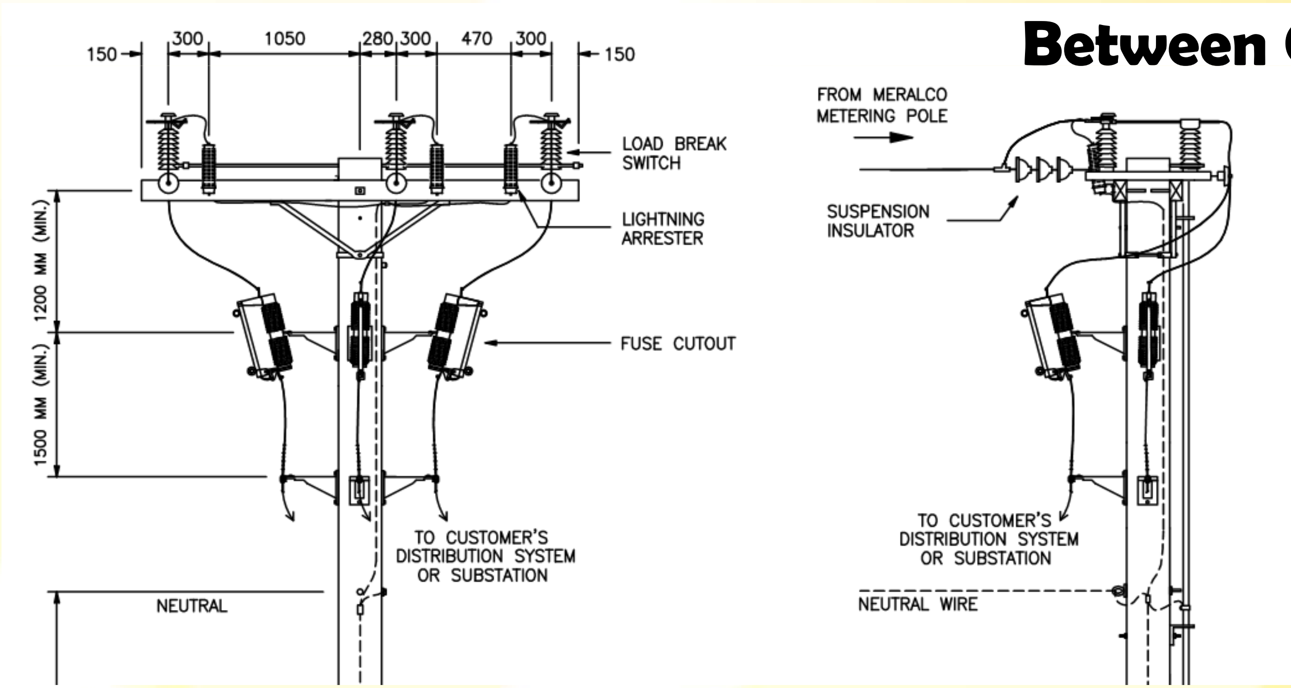
Horizontal = 1500 mm

Vertical = 600 mm



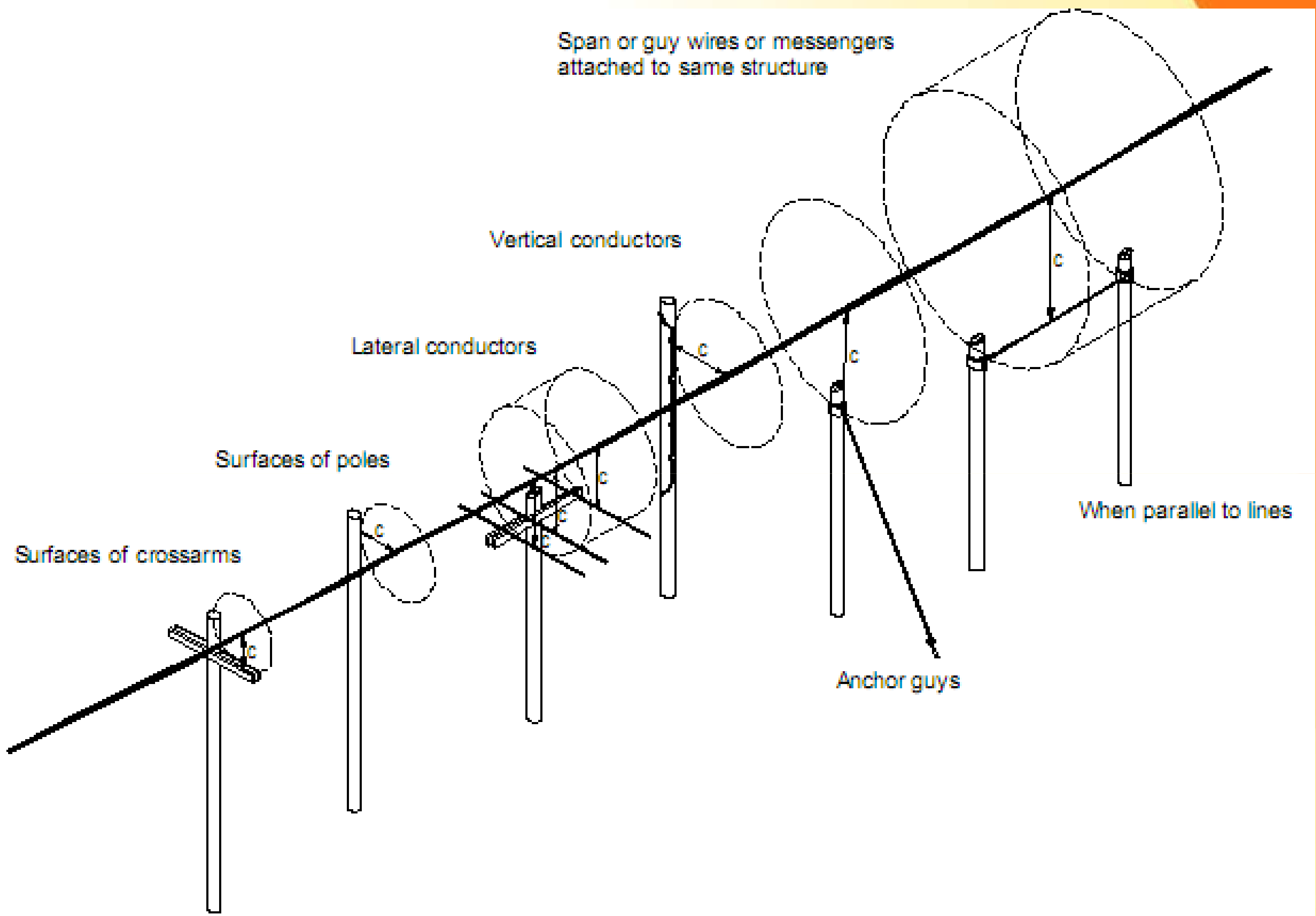
Power Fuse

Horizontal and Vertical Clearance Between Conductors



Fuse Cutout

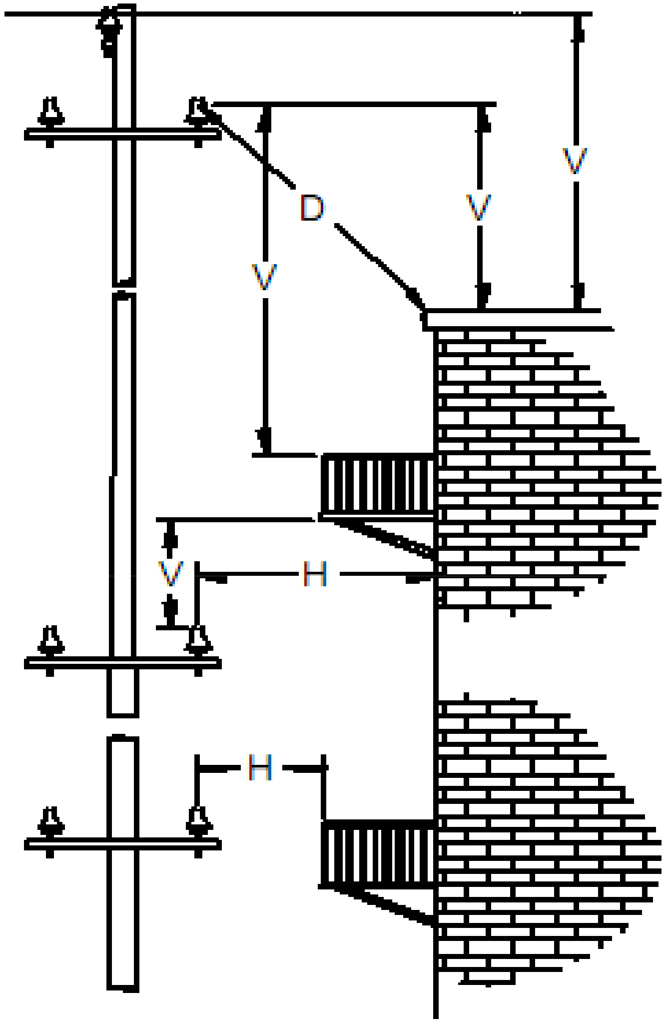
Clearances In Any Direction from Line Conductors to Supports and to Vertical or Lateral Conductors, Span or Guy Wires Attached to the Same Support


Span or guy wires or messengers
attached to same structure
Vertical conductors
Lateral conductors
Surfaces of poles
Surfaces of crossarms
When parallel to lines
Anchor guys
C

Clearance of Line Conductors From	Vertical and Lateral conductors:		Span or Guy Wires or Messengers attached to the same structure				
	Of the same Circuit	Of other Circuits (same	When parallel to lines	Anchor Guys	All other	Surfaces of Crossarms	Surfaces of Poles
	mm	mm	mm	mm	mm	mm	mm
Primary Circuits upto 34.5/20 kV	240	410	560	320	410	205	205

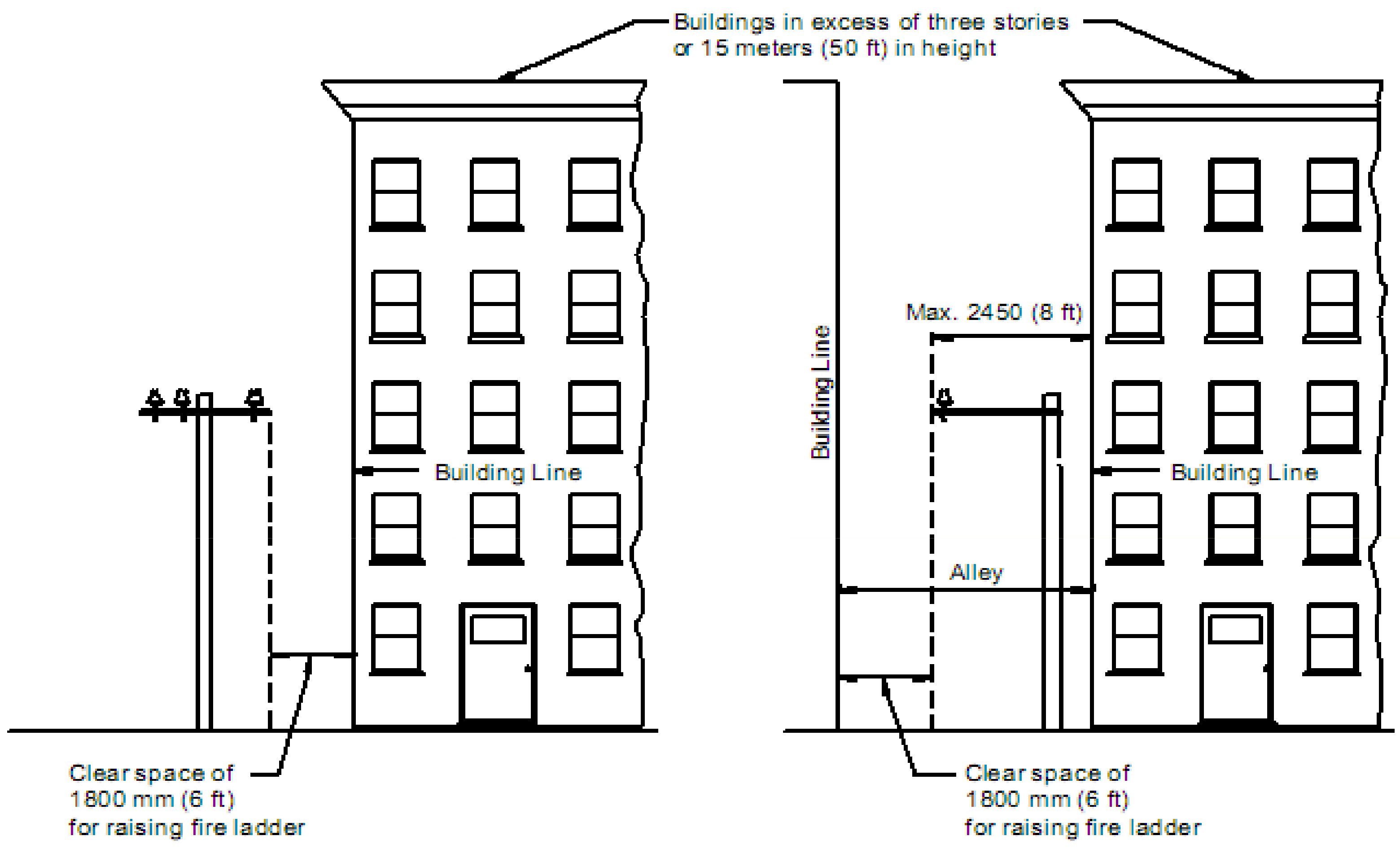
Clearances of Wires, Conductors, Cables and Rigid Energized Parts from Buildings, Signs, Chimneys, Radio and TV Antennas, Tanks and Other Installations Except bridges

Clearance of	Buildings						
	Horizontal	Vertical				Signs, Chimneys, billboard, radio and TV antennas, tanks, and others not classified as buildings or bridges	
		Over or under roofs or projections not readily accessible to pedestrians	Over or under balconies or roofs accessible to pedestrians	Over roofs accessible to vehicles but not trucks	Over roofs accessible to trucks	Horizontal	Vertical
	mm	mm	mm	mm	mm	mm	mm
Primary Circuits upto 34.5/20 kV	2300	3800	4100	4100	5600	2300	2450



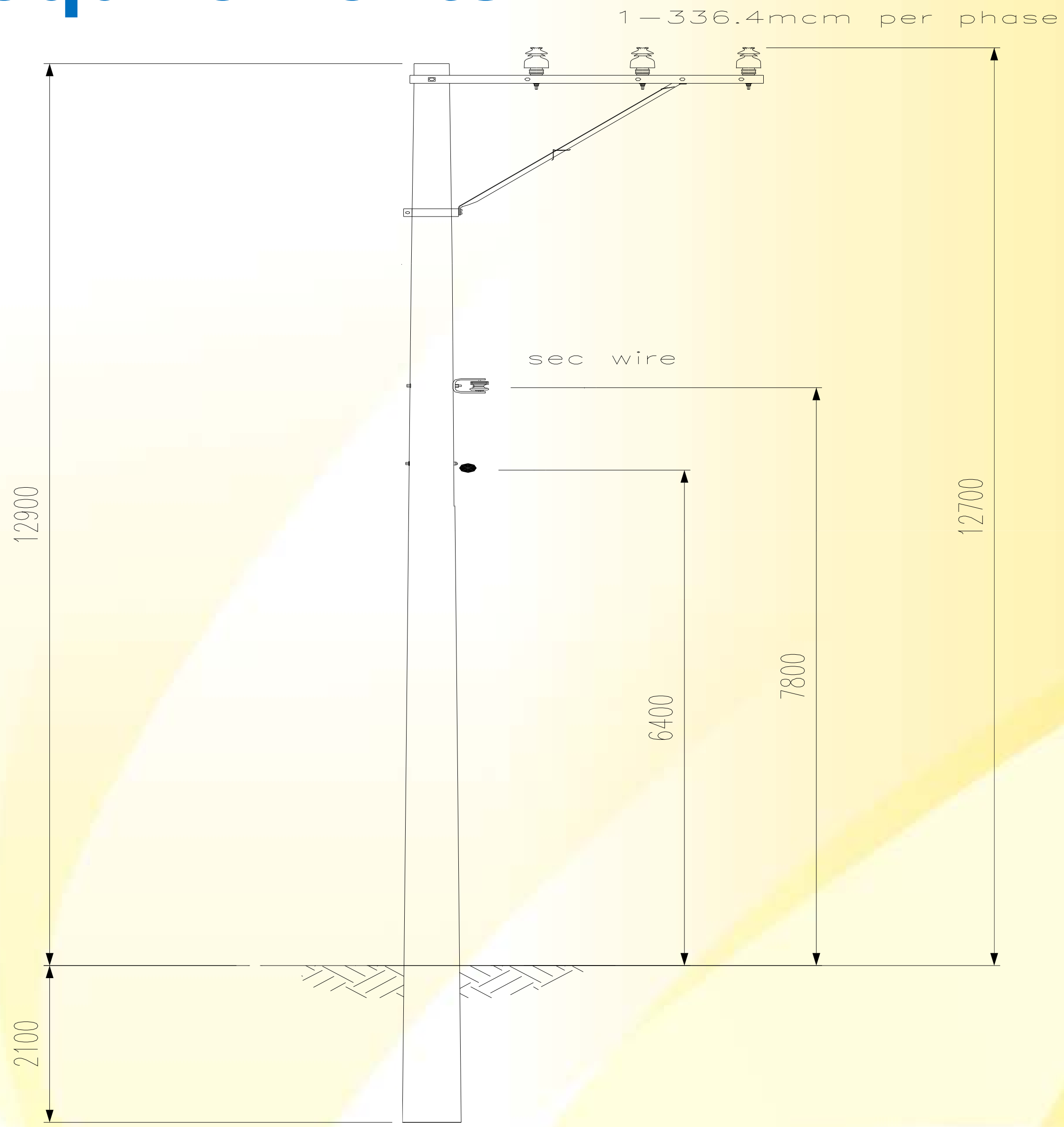
H = Horizontal
V = Vertical
D = Diagonal

The horizontal clearance governs above the roof level to the point where the diagonal equals the vertical requirement. From this point, the diagonal shall be equal to the vertical clearance requirement.

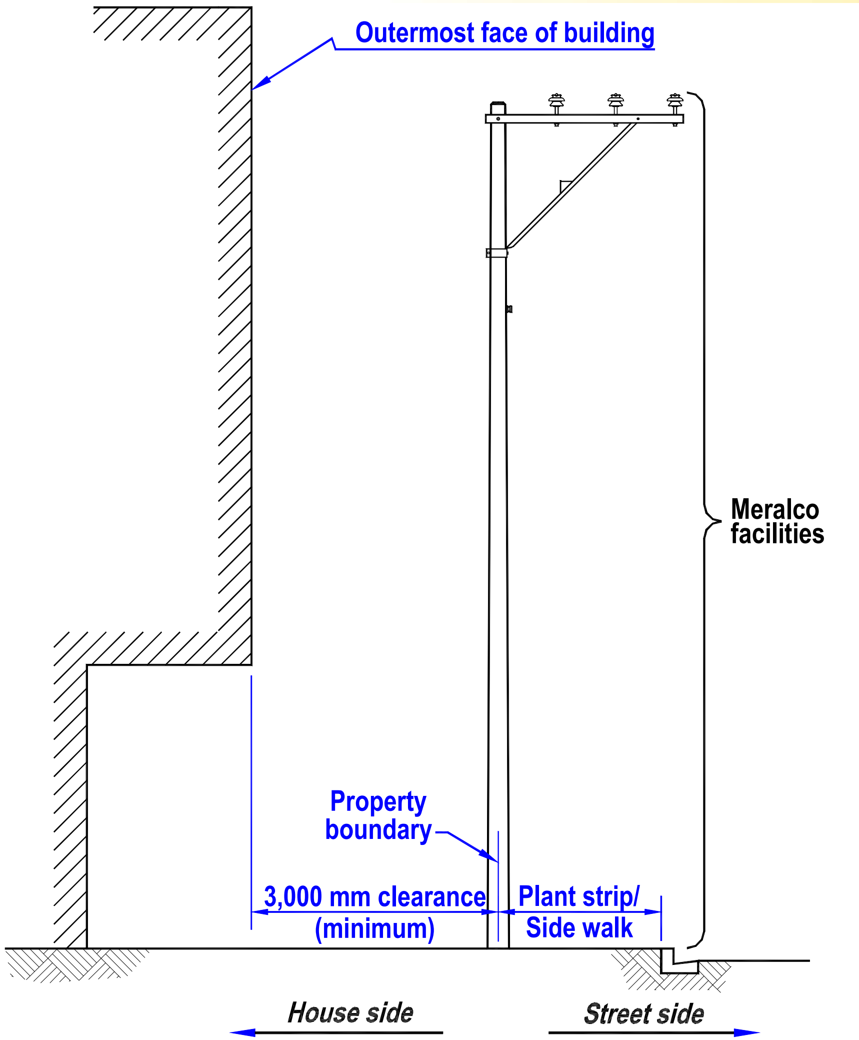


Buildings in excess of three stories
or 15 meters (50 ft) in height
Building Line
Clear space of
1800 mm (6 ft)
for raising fire ladder
Building Line
Max. 2450 (8 ft)
Building Line
Alley
Clear space of
1800 mm (6 ft)
for raising fire ladder

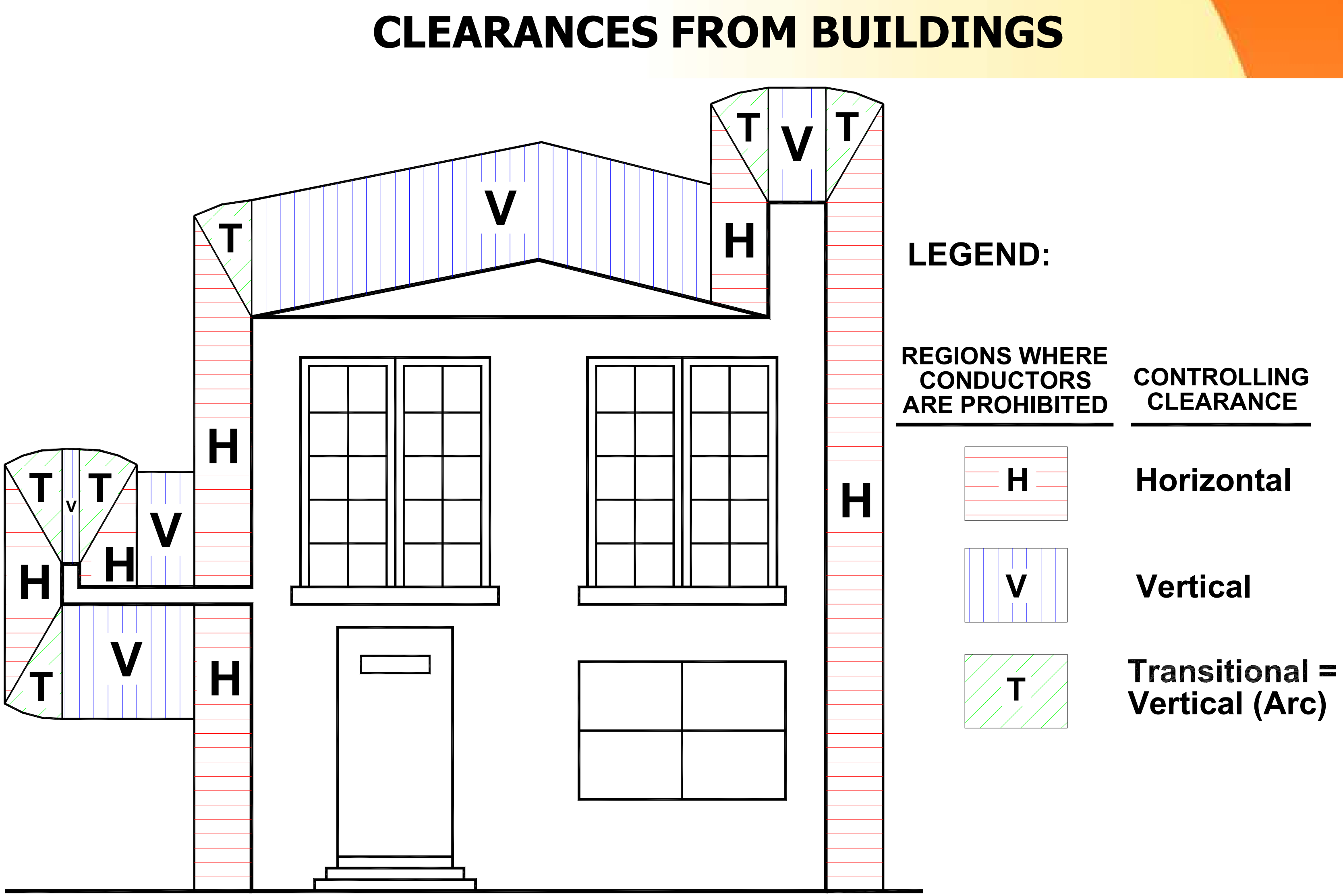
PEC Requirements



Typical Distribution Clearances

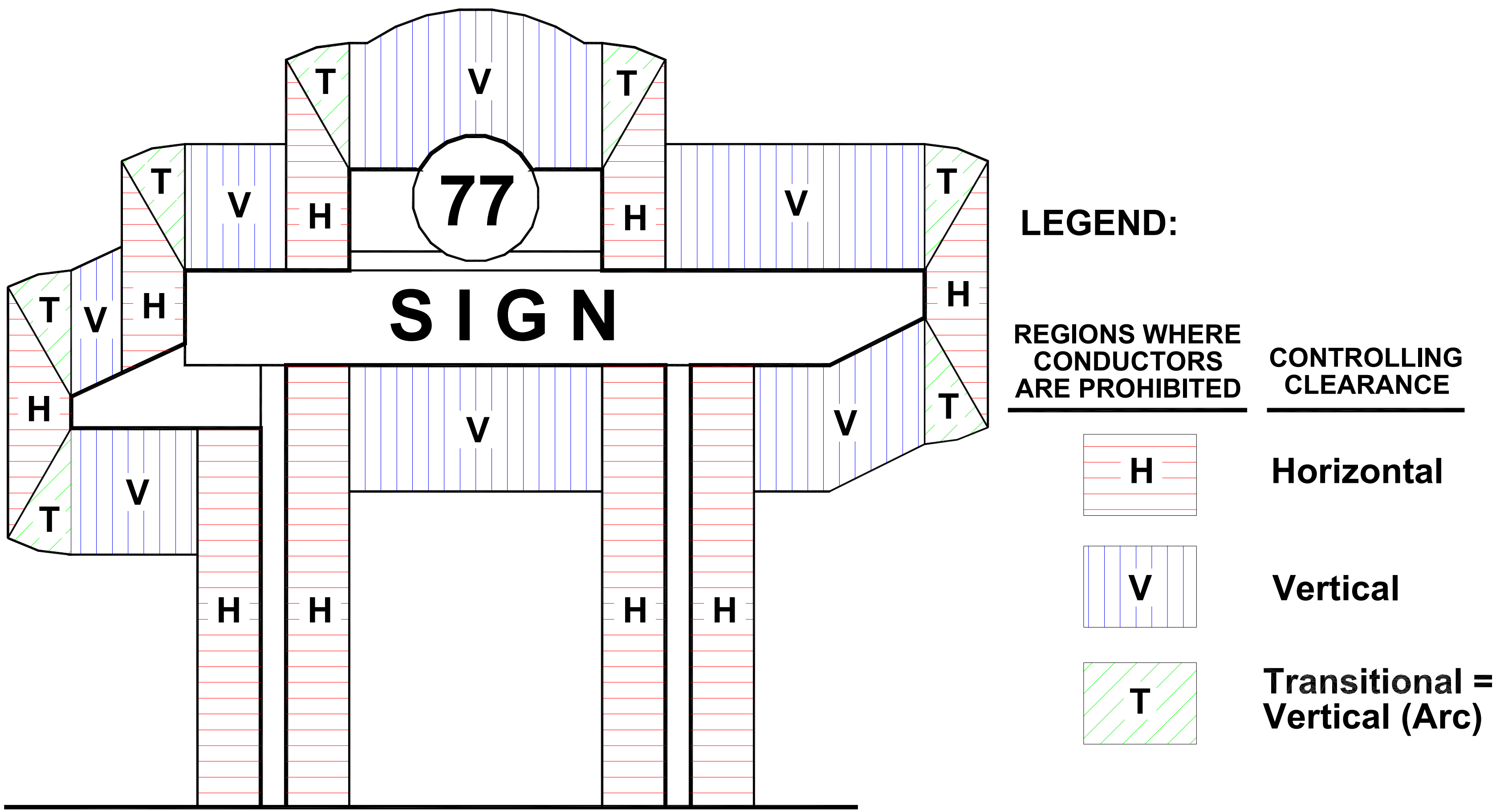


Typical Distribution Clearances



Typical Distribution Clearances

CLEARANCES FROM OTHER STRUCTURES



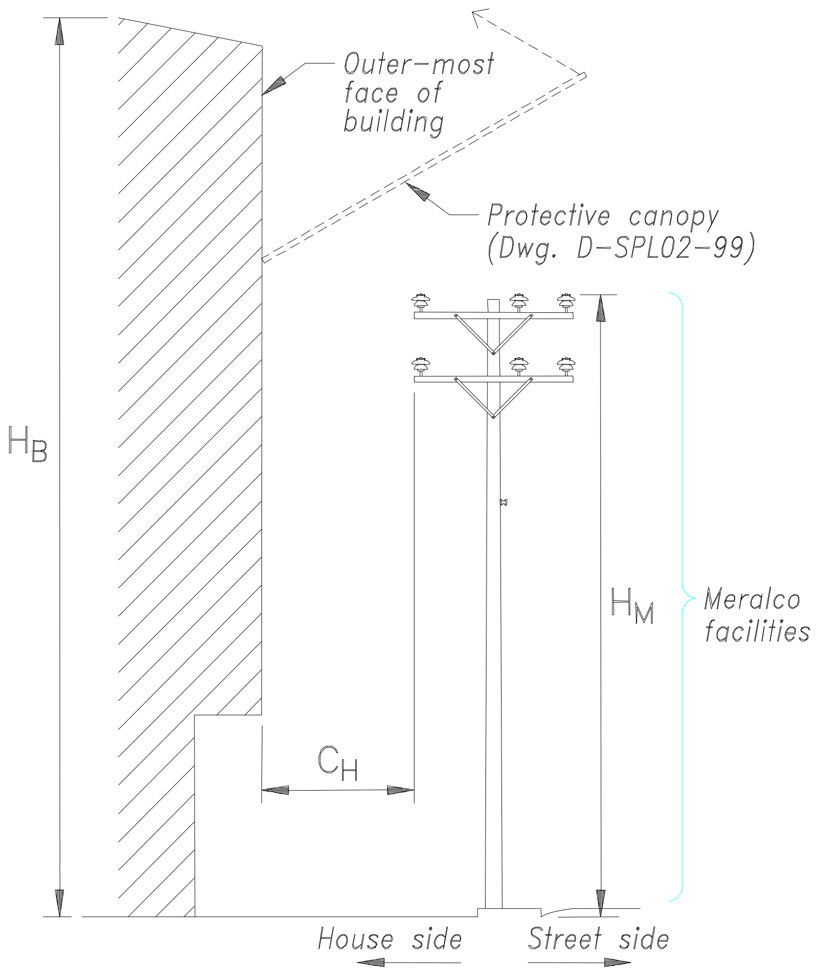
Typical Distribution Clearances

Minimum Clearance (in Millimeters) of Exposed/Non-insulated Wires, Conductors, Cables, and Unguarded Rigid Energized Parts Adjacent but Not Attached to Buildings and Other Installations Except Bridges

Clearance of	Meralco System Voltage, kV		
	6.24/3.6, 13.8/7.96, 34.5/20		115
	Open Supply Conductors	Unguarded Rigid Parts	Open Supply Conductors
1. Buildings			
a. Horizontal			
(1) To walls, projections, and guarded windows	2 300	2 000	2 750
(2) To unguarded windows	2 300	2 000	2 750
(3) To balconies and areas readily accessible to pedestrians	2 300	2 000	2 750

Typical Distribution Clearances

b. Vertical			
(1) Over or under roofs or projections not readily accessible to pedestrians	3 800	3 600	4 250
(2) Over or under balconies and roofs readily accessible to pedestrians	4 100	4 000	4 550
(3) Over roofs accessible to vehicles but not subject to truck traffic	4 100	4 000	4 550
(4) Over roofs accessible to truck traffic	5 600	5 500	6 050
2. Signs, chimneys, billboards, radio and television antennas, tanks, and other installations not classified as buildings or bridges			
a. Horizontal	2 300	2 000	2 750
b. Vertical (over or under)	2 450	2 300	2 900



CH < (HB - HM)/2

Where:

H_B = Height of the building above ground

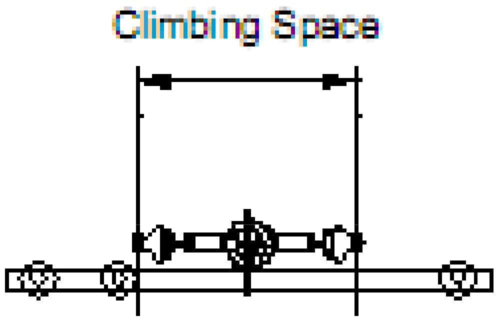
H_M = Height of the topmost part of Meralco facilities measured at the same level of reference as the building

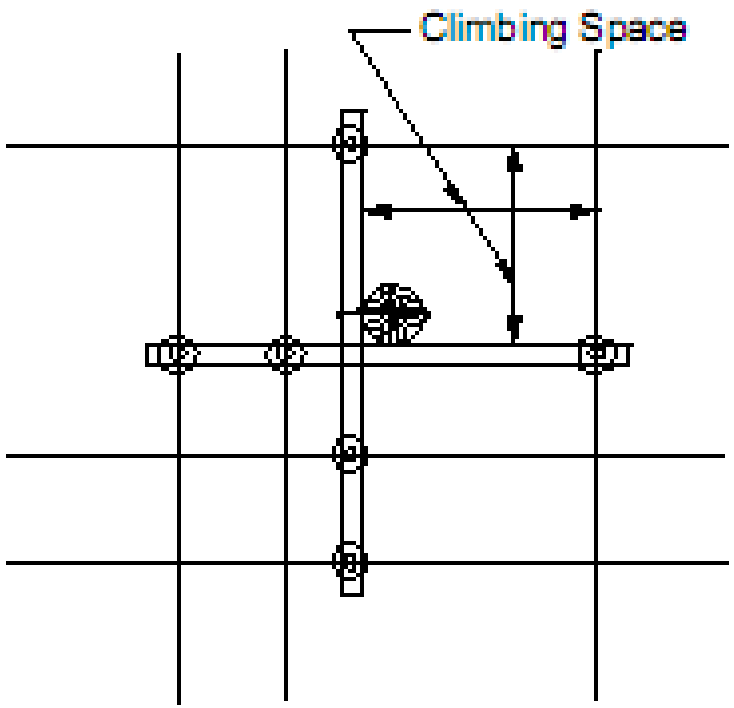
C_H = Horizontal clearance between the outermost face of the building and the nearest part of Meralco facilities

Horizontal Clearance Between Conductors Bounding the Climbing Space

For 34.5/ 20 kV lines = 1000 mm

Climbing Space





Approach Distance to Energized Parts

For 34.5/ 20 kV lines only

Phase-to-Ground = 720 mm

Phase-to-Phase = 770 mm

For Outdoor Substation:
Minimum Required Distance

For 34.5/ 20 kV lines
Vertical & Horizontal
Clearance from Buildings = 3048 mm
Center-to-center phase spacing for buses = 915 mm
Center-to-center phase spacing for switching = 1219 mm
Phase-to-Ground = 610 mm
Between lines of different voltages = 1067 mm

Source: PEC 2009 Vol. 1 Part 1
Article 1.10.3.1 to 1.10.3.6

Approach Distance

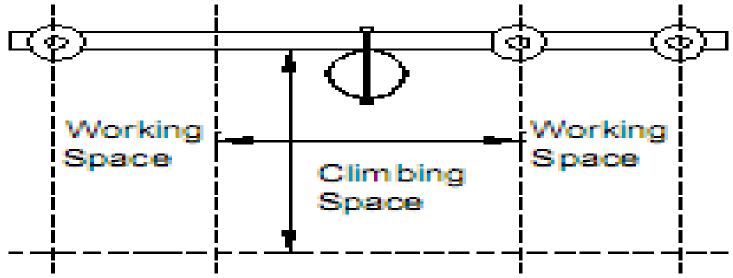
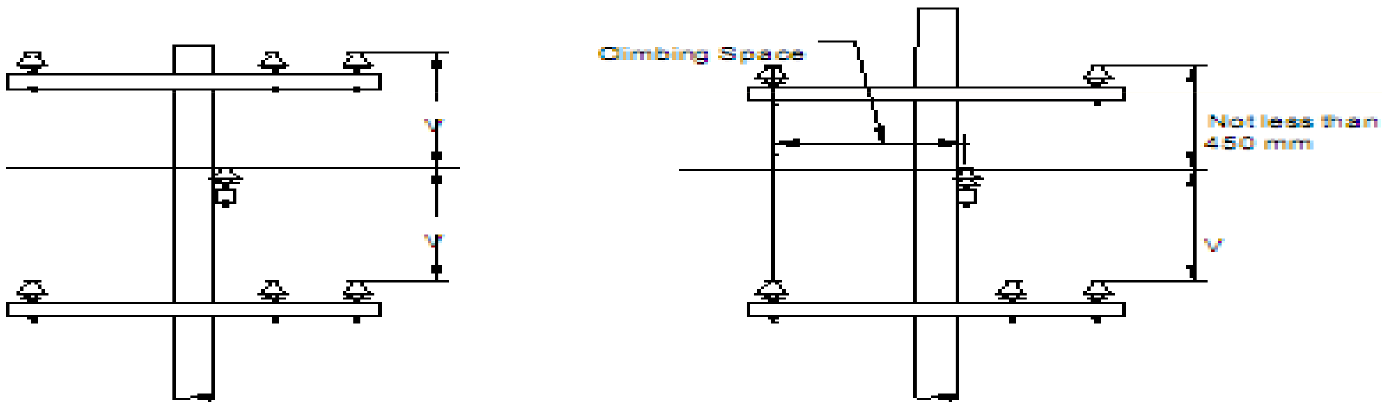


Fig. 4.2.12.1: Working Space



STANDARD HEIGHT OF WORKING SPACE

REDUCED HEIGHT OF WORKING SPACE

Determining Electrical Clearance with Existing or Affected Facilities

General Guidelines

Measurement of Clearances and Spacings

- **Unless otherwise specified, clearances shall be measured from surface to surface and spacings shall be measured center to center.**
- **For clearance purposes, live metallic hardware electrically connected to line conductors shall be considered part of the line conductors shall be considered part of the line conductors.**
- **Metallic bases of surge arresters, cutouts and other similar devices shall be considered as part of the supporting structure.**

Determining Electrical Clearance with Existing or Affected Facilities

General Guidelines

Covered Conductors

- **Covered conductors (including tree wires) shall be considered as bare conductors for all clearance requirements**

Determining Electrical Clearance with Existing or Affected Facilities

General Guidelines

Reduction in Clearance Requirements

- **The clearances shown in this guideline may be reduced particularly in cases where the PEC specifically allows or where the requirements are physically impossible to attain.**
- **All reductions in clearances shall conform to allowable limit set by PEC.**

Determining Electrical Clearance with Existing or Affected Facilities

Specific Guidelines

Horizontal Clearance of Supporting Structure from other Objects

- **Poles, support arms and equipment attached thereto, and braces shall have the following clearances from other objects. The clearances shall be measured between the nearest parts of the objects concerned.**

Determining Electrical Clearance with Existing or Affected Facilities

Specific Guidelines

Horizontal Clearance of Supporting Structure from other Objects

Along streets, roads and highways

- **Where there are no curbs, supporting structures should be located at a sufficient distance from the street, road or highway right-of-way to avoid contact with ordinary vehicles.**
- **Location of overhead utility installations on highways with narrow right-of-way or on urban streets with closely abutting improvements are special cases which must be resolved in a manner consistent with prevailing limitations and conditions (PEC Part 2 – 2000, Sect. 3.4.2.1 [b][1]).**

Determining Electrical Clearance with Existing or Affected Facilities

Specific Guidelines

Horizontal Clearance of Supporting Structure from other Objects

From Railroad Tracks

- **For overhead lines crossing or in parallel with railroad tracks, all portions of the supporting structure, support arms, anchor guys, and equipment attached thereto that are less than 6700 mm above track rail shall be located not less than 3600 mm from the said track rail. At industrial sidings (i.e., short railroad tracks connected to the main track), a clearance of not less than 2130 mm is permitted (Fig. 3)**

Determining Electrical Clearance with Existing or Affected Facilities

Specific Guidelines

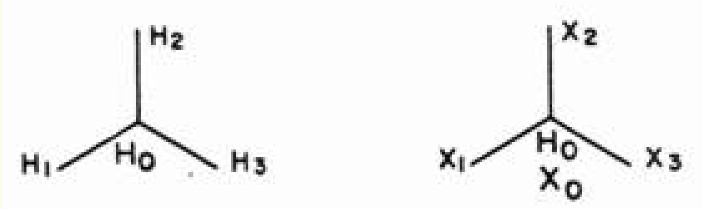
Overhead Line Clearance

Vertical Clearance of Conductors above Ground or other Surfaces

- **The vertical clearances specified for conductors above ground are as shown in Tables 4.2.1.1 and Figs. 4.2.1.1 (a) & (b) and shall be applied at any point in the span. These clearances shall be maintained considering the maximum span and highest temperature that can be attained by the conductors during operation.**

Addendum 2
Other Transformer Connections

Case II. Grounded Wye – Grounded Wye



Provided Transformers are:

A. Single-Phase Type)
B. Three (3) Phase – Shell Type) Why?
C. Three (3) Phase – Five (5) – legged Core-Type)

Advantages:

A. 1. It provides two different values of secondary voltages instead of one. (20 KV-139/278V or 34.5 KV-240/480V)

2. Availability of single phase (1ø) circuits with only one conductor run (1 to N voltage)

3. Economical in terms of insulation.

4. Provides path for ground current, sufficient for protective devices to detect and operate.

5. Suited to systems having high line voltages and relatively low currents.

6. Best connection to minimize if not totally illuminate the occurrence of ferroresonance.

Single phase sequential switching at the fuse disconnects does not produce a ferroresonant condition since transformer magnetizing reactance are not energized in series with the cable capacitance. The cable capacitance is merely a load on one phase to neutral and is not in series with the transformer magnetizing reactance.

7. It makes it possible to ground all three phases symmetrically at a common point thus associating each phase load with phase source, making it almost fool proof.

8. Low KV rating of LA's together with discharge spark over voltage which is consonant with BIL requirement of transformer as well as other associated equipment thus economy in design of the system is achieved.

Additional four (4) oscillograph studies showed that with sine wave voltages between lines, the line to neutral voltages of the Y-Y banks about 60% third harmonic component.

9. Three phase – Shell Type & 5 legged Core Type

In a 3ø transformer of shell-type or 5-legged core- type, react in the same manner as a (3) - 1ø distribution transformers connected Y-Y both primary & secondary neutral connected to system neutral. The recommended connection is free from ferroresonant overvoltage conditions.

10. Distribution Utility recommends 5-legged core type and not 3-legged core type to avoid problems of tank heating due to unbalances loading condition, or secondary faults which cause a primary fuse to open.

Disadvantages:

1. Necessitates tertiary windings to stabilize the neutral potential in the primary wye and to suppress third harmonic currents.

2. Severe induction voltages to telephone lines in case of line to ground fault.

3. Three-legged core type transformer experiences tank heating, specially during unbalanced loading.

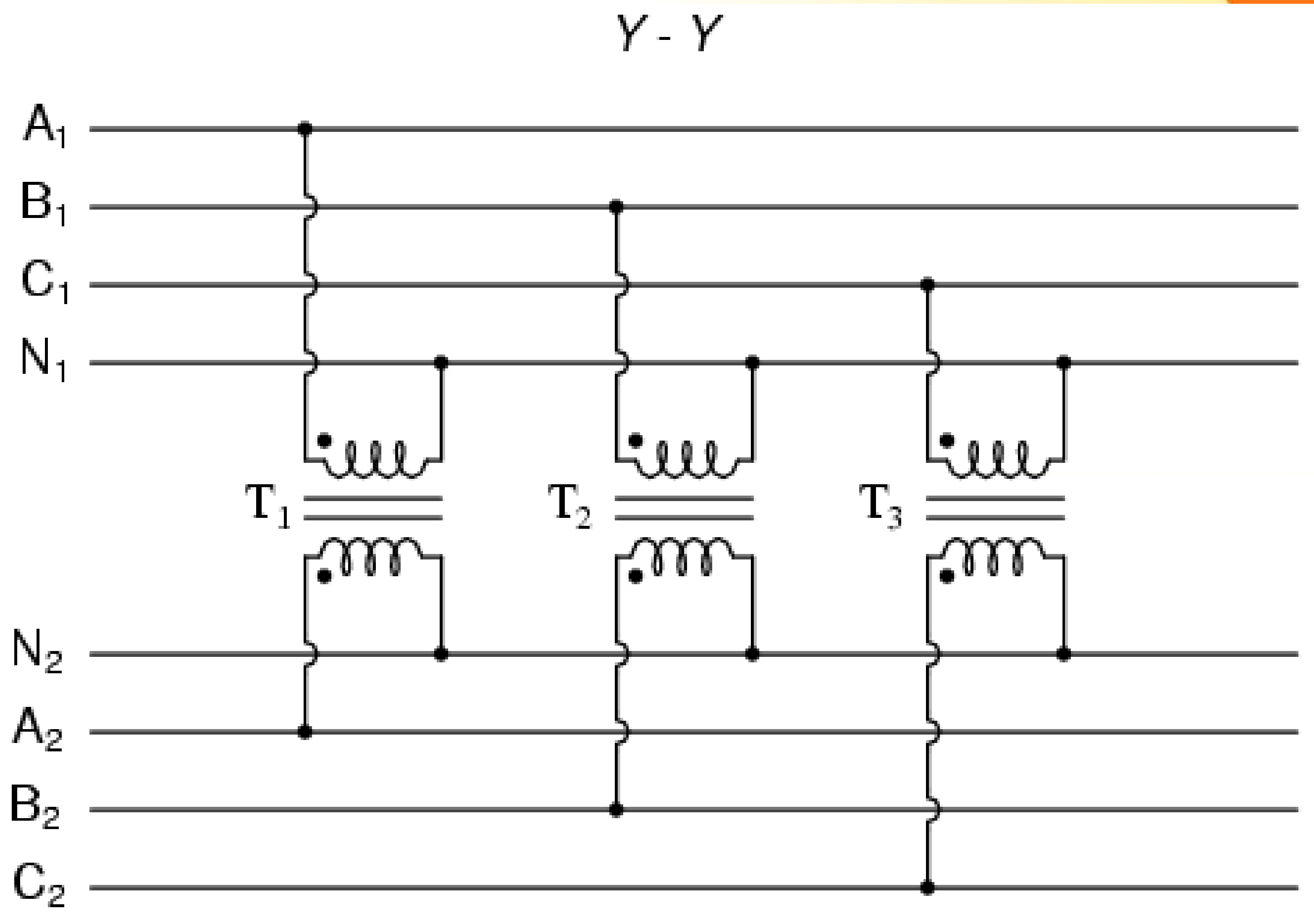
   Remedy: With the use of five-legged core type transformer, shell type transformers or to provide with a low resistance lines installed in a 3-legged core type will act as a path for the magnetic flux.

4. Deviation of ø voltage from the theoretical one during unbalanced load condition.

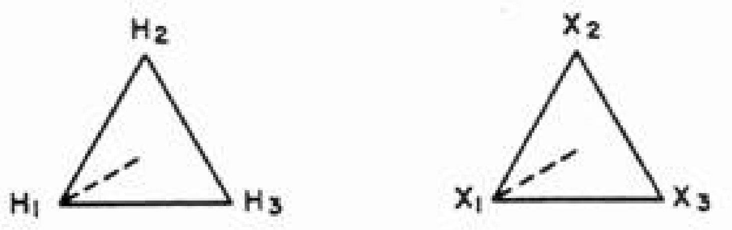
NOTES:

a) If the primary neutral is not connected to the source, unbalanced load causes a roving neutral. (Roving neutral – not stable neutral)

b) If the neutral wire is connected from the source to the neutral of the primaries, each phase can work independently of the other; any unbalanced in current is then carried by the neutral.


Y - Y
A1
B1
C1
N1
T1
T2
T3
N2
A2
B2
C2

Case III. Delta – Delta Connection



Advantages:

1. No third harmonic current will occur.

2. Failure of one phase can still operate as an open delta.

3. Sharing of load according to the impedance of he phases. A small transformer in one of the phases usually has a high impedance, therefore, it tends to take a smaller share of the load.

4. Availability of balanced symmetrical voltage and currents with load or at no load.

5. Tank heating is minimized.

Disadvantages:

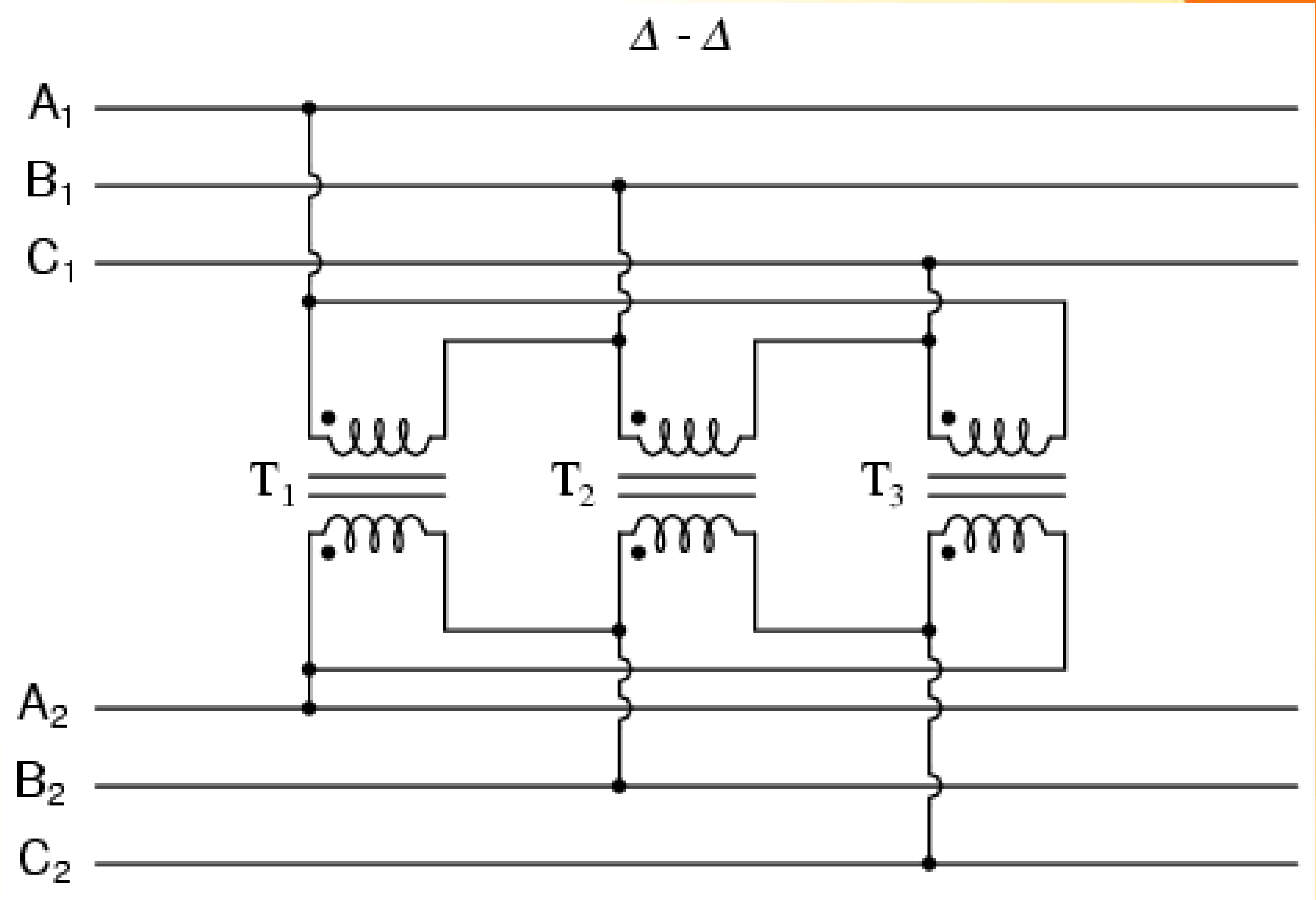
1. Higher KV rating of arrester needed thereby increase in investment of equipment is necessary.

2. No path for sufficient ground current could be provided thus preventing protection devices to be applicable.

3. Provides only a single value of secondary voltage (if not provided with neutral)

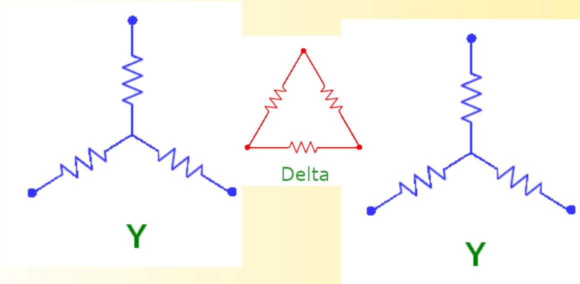
4. At least two conductors or ones could be made to supply single phase loads.

5. Higher cost, more insulation required.



Δ - Δ
A1
B1
C1
T1
T2
T3
A2
B2
C2

Case V. Ungrounded Primary Wye and Grounded Wye Secondary with Delta Tertiary:



1. This set-up eliminates the 3rd harmonic problems and simplifies adherence to the effectively grounded system.

2. The zero sequence reactance Xo, at the delta, provides the path for the zero sequence current, it has a very low Xo reactance in its grounded wye in a set-up.

Advantages to Distribution Utility – any unbalancing of load at the secondary will just be contained at the primary system neutral current will not be affected.

Advantages to customer of Grounded Wye secondary:

1. Smaller fault current.

2. Fault in any leg of the secondary will be readily – isolated. Does not need to wait for a fault on another leg as in delta connection.

3. Less insulation than DELTA connected.

Disadvantages:

1. Susceptible to ferroresonance

Advantages: Single Phase

1. Same as wye grounded secondary advantages to customer

2. Ferro resonance eliminated

3. Tank heating eliminated

4. Lower first cost

Three Phase

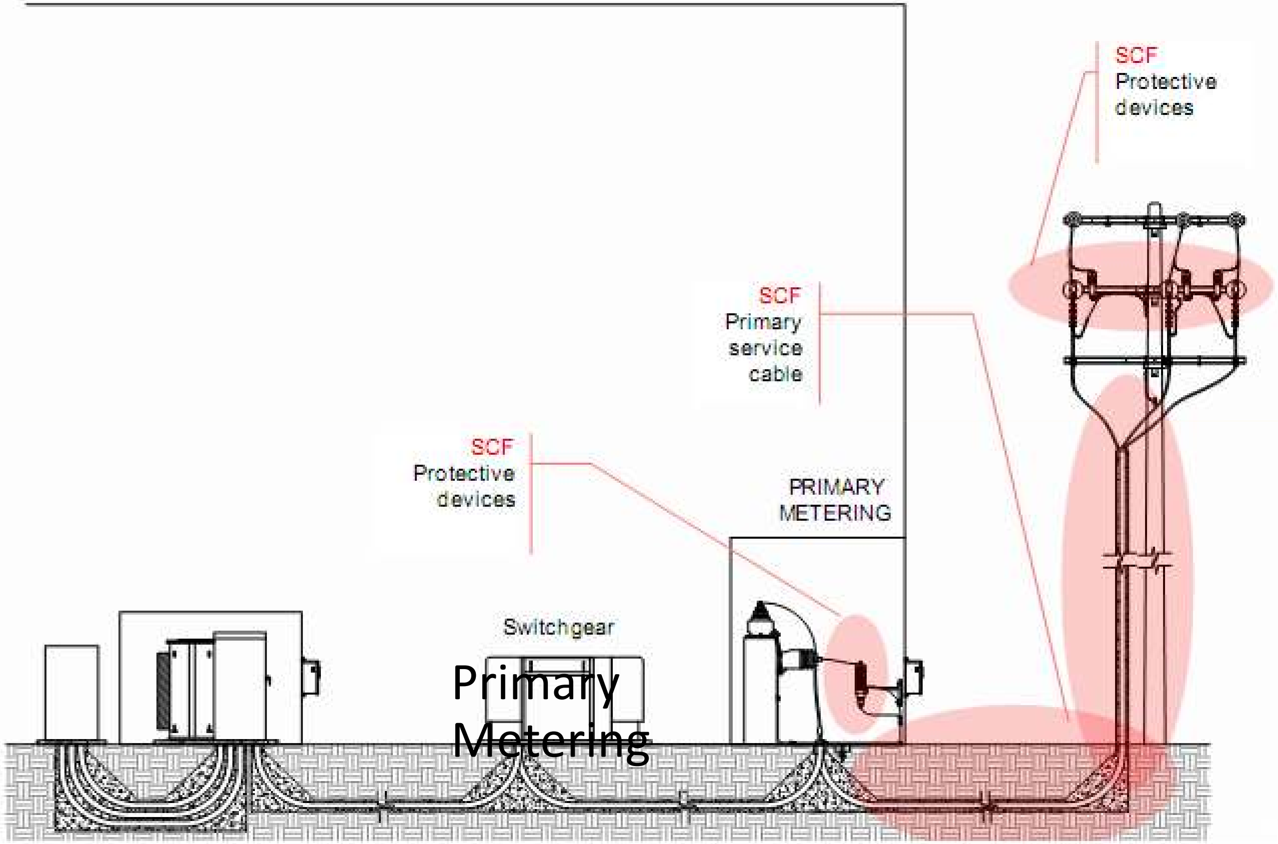
1. Must be shell type or 5 – legged core type to eliminate tank heating.

Addendum 3
Underground
Primary-Metered Service

Primary Metering Service
Underground Installation
Customer-Owned Transformer
(Optional)

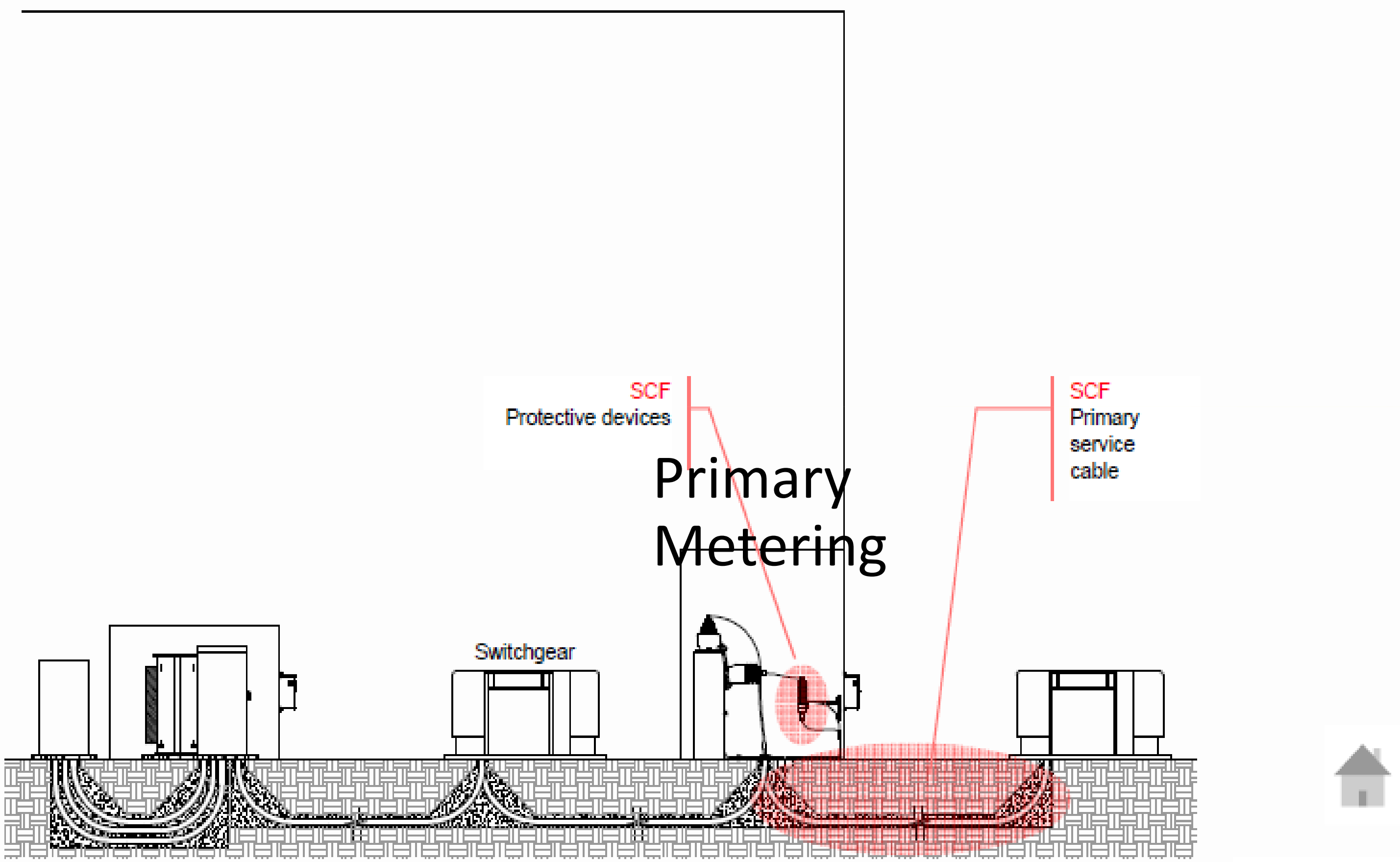
Primary Service, Underground Installation, Customer-Owned Transformer

Standard Connection Facilities (SCF)



Distribution-Voltage Service, Underground Installation, Non-Residential, Customer-Owned Transformer, Sourced from Overhead Distribution System

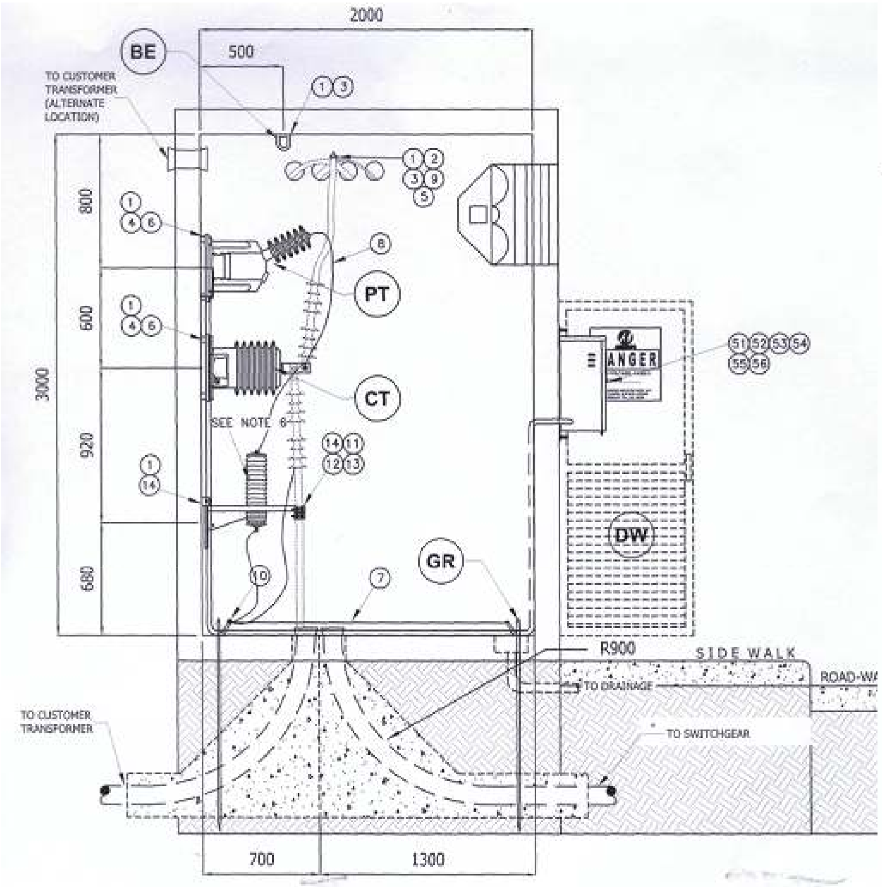
Primary Service, Underground Installation, Customer-Owned Transformer



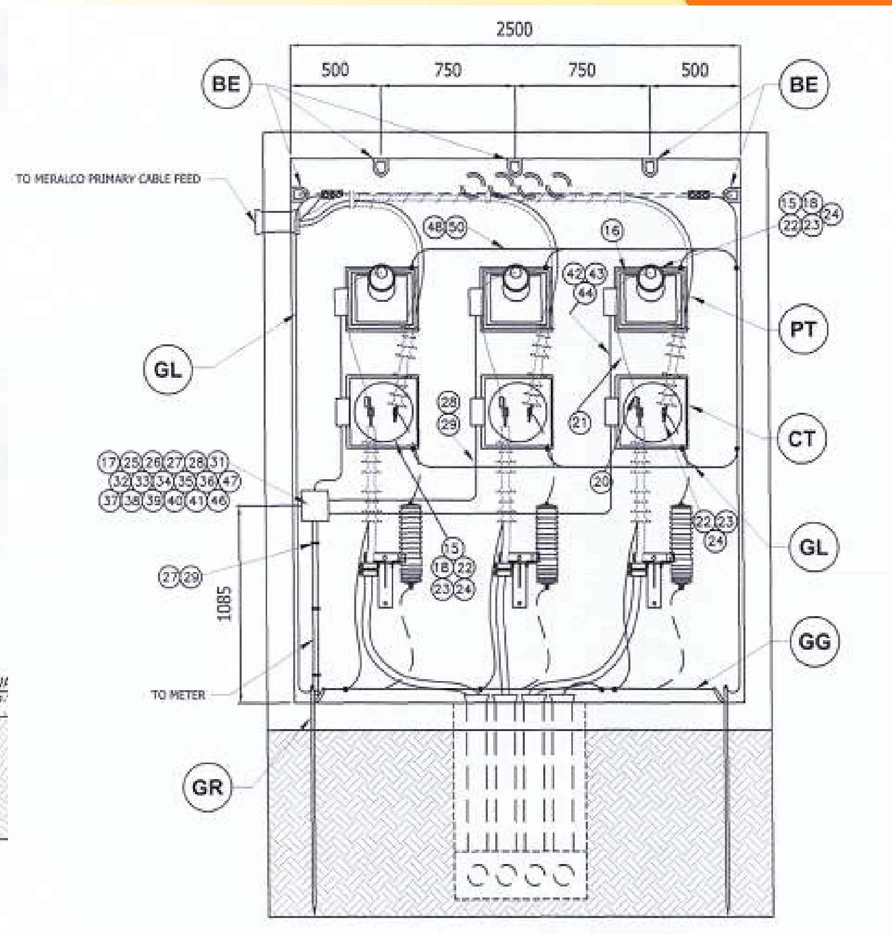
Distribution-Voltage Service, Underground Installation, Non-Residential, Customer-Owned Transformer, Sourced from Underground Distribution System

20 / 34.5 kV
Indoor Primary Metering Installation on Loopfeed Line
(3 P.T.'S./3 C.T.'S.)

Primary Metering Vault



SECTION A-A
SCHEME I



Primary Metering Vault

20 / 34.5 kV
Indoor Primary Metering Installation on Loopfeed Line
(3 P.T.'S./3 C.T.'S.)