

Appendix 1.0-V

MCA Engineering Ltd., Additional Electrical Backup Technical Information

Telkwa 25 kV Line Design Criteria

Rev 0 – Oct 29, 2018

Voltage

The line voltage will be 25kV, 3 phase, with multigrounded neutral. The line will be an extension of circuit 25F52, fed from Smithers substation.

Wire Size

The wire size will be #2 ACSR. This is the existing wire size at the tap point. The ampacity of #2 ACSR is 184 amps Conductor temperature of 75°C, ambient temperature 25°C, emissivity 0.5, wind 2 ft./sec., in sun. This corresponds to a load of $1.73 \times 25 \times 184 = 8000$ kVA.

Plant Load

The Plant Load is expected to be 4000 kVA ultimate, therefore well within the line design capacity.

Standards

The electrical supply system into the mine will be designed according to the following standards:

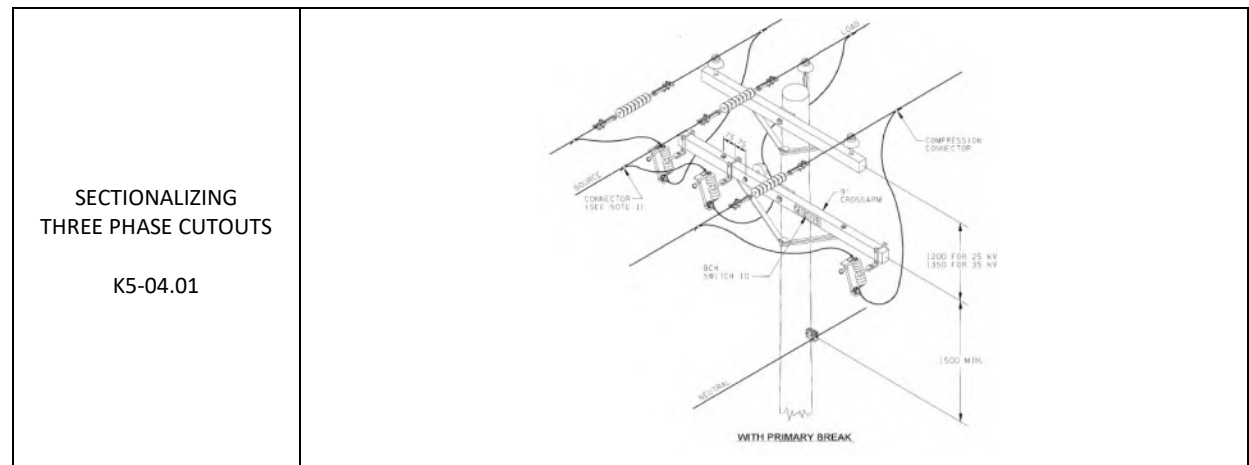
- CSA C22.1 - Canadian Electrical Code
- M421 – Standard for the Use of Electricity in Mines
- ES43 – BC Hydro Technical Standards and Guides
- C22.3 No.1-15 - Overhead Systems

Poles

Poles will be Western Red Cedar (WRC), minimum Class 3 for straight line, and Class 2 for angles, 50 foot, treated. Other, less expensive options include Douglas Fir and Pine, but WRC is recommended for its superior strength and life in heavy snow areas.

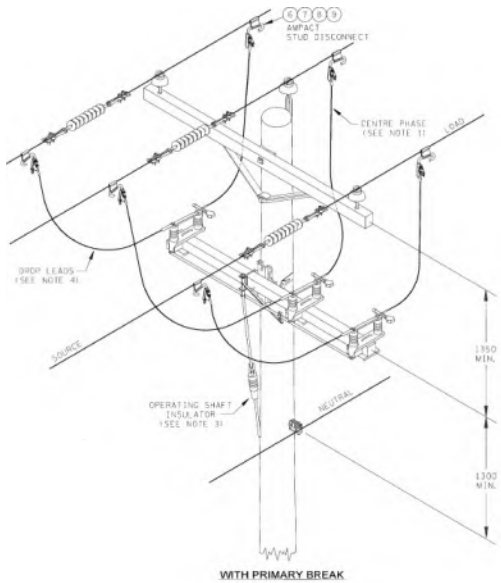
Structures

The following structures will be utilized:



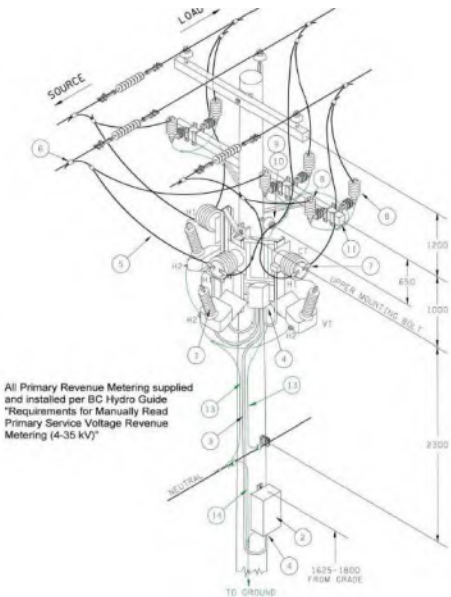
SECTIONALIZING
THREE PHASE WITH
GOLB SWITCH

K5-06.01



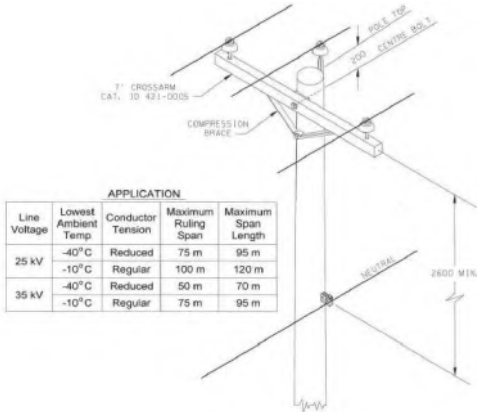
PRIMARY REVENUE
METERING THREE PHASE
FOUR WIRE

J7-01.01



THREE PHASE TANGENT
SKYPIN

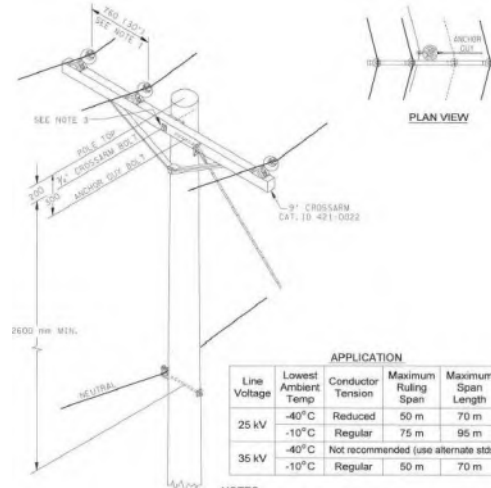
G4-02.01



Line Voltage	Lowest Ambient Temp.	Conductor Tension	Maximum Ruling Span	Maximum Span Length
25 kV	-40°C	Reduced	75 m	95 m
	-10°C	Regular	100 m	120 m
35 kV	-40°C	Reduced	50 m	70 m
	-10°C	Regular	75 m	95 m

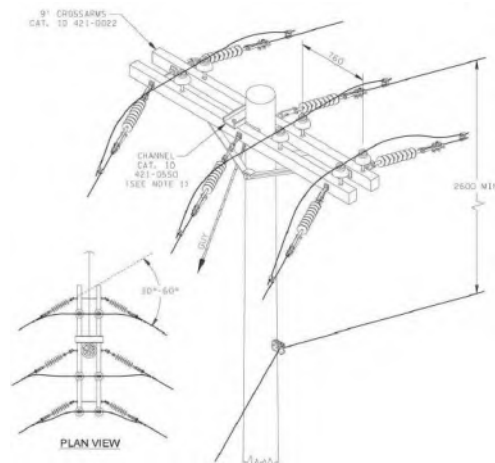
BASIC LINE STRUCTURES
THREE PHASE
ANGLE 5°-25°, FLAT

G4-10.02



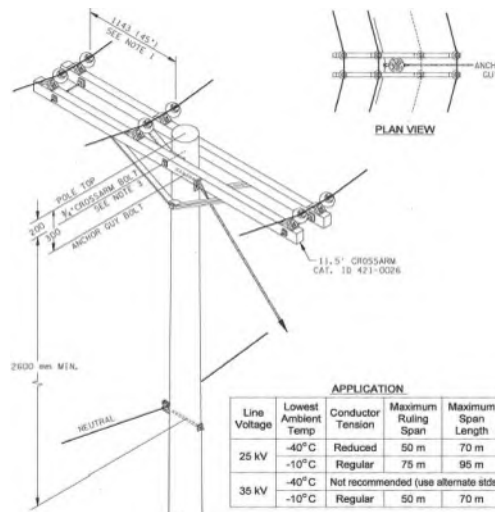
THREE PHASE HORIZONTAL
ANGLE 30°-60° CROSSARM

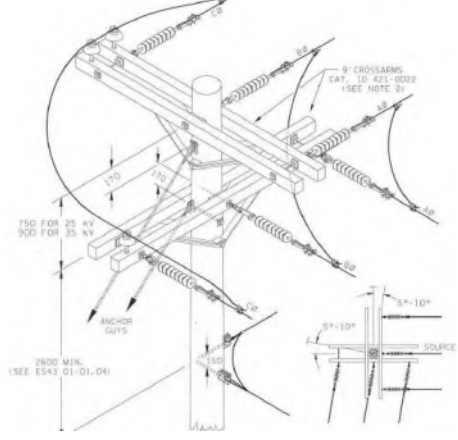
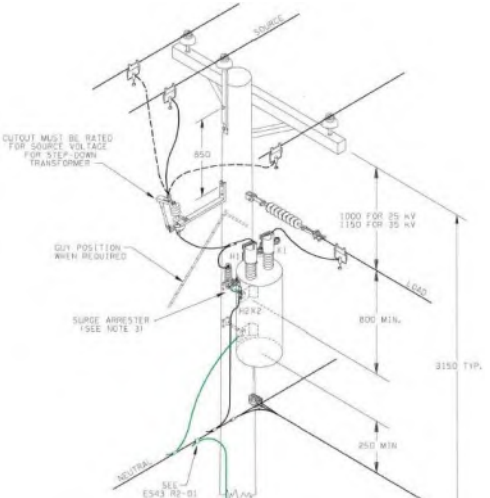
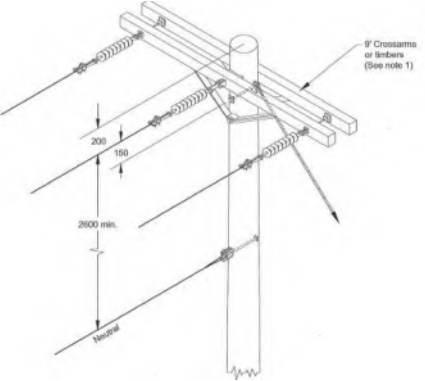
G4-09.01



BASIC LINE STRUCTURES
THREE PHASE
ANGLE 25°-45°, FLAT

G4-10.03



THREE PHASE CORNER 45°-90° G4-11.01	
SINGLE PHASE TRANSFORMER FRAMING STEP-DOWN TAP, POLE MOUNTED J2-09.01	
THREE PHASE DEAD END G4-05.01	

Pole Spacing

Poles will be conservatively spaced in order to reduce snow/wind loading, and associated tension, sag and sway. The average span will be 65 meters.

Surge Arresters

Surge Arresters will be installed at both ends of the line, and at the 1/3 and 2/3 intervals. A total of 4 sets of surge arresters will be installed.

Phase Spacing

Phase Spacing will be minimum 760mm, using 7 and 9 ft. crossarms, and 1143mm, using 11.5 ft. crossarms.

Grounding

The neutral of the 25kV system will be grounded at both ends in addition to at least 3 ground electrodes per kilometer. (Line length is 3.7 km, so 11 electrodes).

Source End Protection

The tap from BC Hydro would consist of a set of BC Hydro fused disconnects, followed by a customer owned gang operated disconnect and recloser. The recloser would provide automatic reclosing upon temporary shorts (ie tree branches, birds etc), but could be replaced by a set of fused disconnects, if the budget dictates.

Plant End Protection

The Plant End Protection would consist of a recloser (identical to Source End). The settings on the recloser would be programmed to protect the pad mounted step down transformer. As the recloser can be remotely operated, it would eliminate the need for an incoming breaker on the switchgear.

High Voltage Cable

The overhead line would extend partly onto the plant site, and terminate at the recloser. From the recloser pole, there would be a high voltage cable extending down the pole, into a trench, then on to the main step down transformer, at the east end of the process building (a distance of approximately 150 meters). The high voltage cable would be direct buried, except for high traffic areas, where it would be encased in concrete, and PVC duct.

Main Transformer

The main transformer will be rated 3000/4000 kVA, 25kV-600V, ONAN/ONAF, with 4-2.5% taps (2@FCAN and 2@FCBN), with low flammability oil. The transformer will have sidewall mounted bushings for high and low voltage connections. The bushings will be enclosed in compartments with ample room for terminations, stress cones etc. High and low voltage cables will enter from below.

The transformer will be mounted on a foundation with spill containment.

Decision Note 1

Raw Water Power Source

The Raw Water Pond will be approximately 500 m from the Main Process Building. The pump at the Raw Water Pond will be 37 kW.

There are three options to feed the pump:

1. Extend the 25 kV line, install a step down transformer bank.
2. Install a 600V, direct buried Teck cable from the Main Process Building MCC.
3. Install a local generator.

These options are evaluated on an Net Present Cost (NPC) basis, as well as a Pro's/Con's basis. Costs common to all 3 options are ignored (eg, the motor starter at the pond).

In order to evaluate the NPV, the following assumptions apply:

1. The load is continuous, 24/7.
2. The generator size required would be 125 kW. The generator would cost \$30,000 with enclosure.
3. The average motor load would be 37 kW.
4. The generator power cost (using diesel) would be \$0.30/kWh.
5. The average BC Hydro power cost would be \$0.084/kWh.
6. Discount factor is 10%.
7. Life of Mine is 15 years.

Option 1 – Extend the 25kV line.

The per-pole cost of the 25kV line is estimated at \$15,000/pole installed. As 10 poles are required, the capital cost is estimated at \$150,000.

The annual power cost would be $37\text{kW} \times 8760\text{h} \times \$0.084/\text{kWh} = \$27,226$.

The NPC of \$27,226 for 15 years, discounted at 10% is \$207,083.

Hence total NPC = $\$150,000 + \$207,083 = \$357,083$.

Option 2 – Install a 600V cable.

The cable cost is \$20/m, hence total cable cost is \$10,000. Labor cost is minimal as the cable would be buried in the same trench as the water pipe. Let's allow \$7000 for labor. Hence total capital cost is \$17,000.

The annual power cost would be $37\text{kW} \times 8760\text{h} \times \$0.084/\text{kWh} = \$27,226$.

The NPC of \$27,226 for 15 years, discounted at 10% is \$207,083.

Hence total NPC = \$17,000 + \$207,083 = \$224,083.

Option 3 – Install a generator.

The generator cost is \$30,000

The annual fuel cost would be $37\text{kW} \times 8760\text{h} \times 0.30/\text{kWh} = \$97,236$.

The NPC of \$97,236 for 15 years, discounted at 10% is \$739,584.

Discussion

Options 1 and 2 are both secure. Option 1 would be ready before the plant, but there is probably no need for that.

Option 3 becomes more attractive as the demand falls (ie no need for pond water). On the other hand, it could never become more competitive with Option 2. In addition, there are other problems with a local generator including:

- No permanent lighting (lack of security and safety)
- No permanent heating (possibility of freeze-up)
- Ongoing generator maintenance

Recommendation

Option 2 is recommended, based on cost and reliability.

This recommendation has been **approved / not approved**.

Allegiance Coal Representative _____

Date: _____

MCA Engineering Representative _____

Date: _____

DRAFTER: DM R. 2- REDONE. NEW PAGE NO. JUNE 2000 DY R. 3- MOVED CONCRETE POLE INFORMATION TO ES43 D4-01. NOV'12 PY

SIZES AND TYPES OF POLES

The common pole lengths used for distribution lines and services are 30', 35', 40', 45', 50' and 55'. BC Hydro stocks wood poles in these sizes which are graded according to strength into six classes (1 to 6). These poles are purchased and inspected in accordance with strict specifications which limit characteristics such as knots, straightness, twist, mechanical damage, decay, etc. The class of a wood pole simply determines its rated strength based on established circumference and length measurements for each given species. Therefore all poles of the same class have the same strength regardless of species or length.

In order to provide a satisfactory service life, wood poles are full-length treated with preservative to resist attack by fungi and insects.

Note: For pole data and selection details see Section Y.

HANDLING AND STORAGE

Wood poles shall be handled carefully to avoid breakage or cracking, especially in cold weather. When off-loading from a flatbed truck, they shall be eased off to avoid sharp impact. Poles in storage shall be stacked in such a way as to permit adequate ventilation in an area that is kept free of vegetation. If peaveys are used, they must be applied only above the ground line, and used with care to minimize damage.

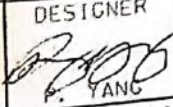
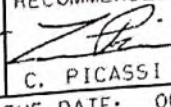
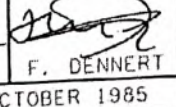
SETTING

The minimum standard setting depths for poles are given in the table below:

POLE LENGTH	SETTING DEPTH IN SOIL	SETTING DEPTH IN ROCK
30 ft.	5 ft. (1.5 m)	4 ft. (1.2 m)
35 ft.	5 1/2 ft. (1.7 m)	4 1/2 ft. (1.4 m)
40 ft.	6 ft. (1.8 m)	4 1/2 ft. (1.4 m)
45 ft.	6 1/2 ft. (2.0 m)	5 ft. (1.5 m)
50 ft.	7 ft. (2.1 m)	5 ft. (1.5 m)
55 ft.	7 1/2 ft. (2.3 m)	5 1/2 ft. (1.7 m)

The minimum standard setting depths in ordinary (Class 4 and 5) soil (see Section E for soil classifications) will provide sufficient overturning resistances to counteract the expected wind force on unguyed poles. In Class 6 to 8 soils, local experience is the best way of determining which of several methods will provide satisfactory pole stability and overturning resistance. Increasing the depth setting by 2 ft. (600 mm) provides some improvement. More effective is a breast log (ES43 E3-14), a foundation drum (ES43 D3-12), or a piling (ES43 D3-13). Note that on slopes or hills, the setting depth is measured from the lowest side of the hole opening. On steep slopes or near ditches where soil stability is doubtful, special consideration should be given to increasing the setting depth.

Poles shall be set, backfilled, and guyed before conductors are strung. Where possible, all crossarms and most other hardware should be attached before erecting the pole.

DESIGNER	RECOMMENDED	APPROVED
		
P. YANG	C. PICASSI	F. DENNERT

ORIGINAL ISSUE DATE: OCTOBER 1985

POLES GENERAL NOTES

BC Hydro  DISTRIBUTION STANDARDS

PAGE 1
OF 2

ES43 D1-01.01

R. 3

Preframed poles must be checked to ensure that, when set, the two top holes will be parallel to the line. Unguyed poles should be set absolutely vertical both for aesthetic appearance and to avoid axial load bending moments on the pole. For best appearance, adjacent poles should normally face in the opposite directions (i.e. setting gains on opposite sides). Dead end poles should always face the anchor.

At angles and dead-ends, the pole must be erected slightly off vertical with the rake against the line tension to compensate for movement from conductor tensioning. The rake shall be approximately 300 mm (see ES43 E1-01.04).

DIGGING AND BACKFILLING

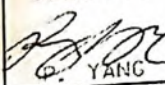
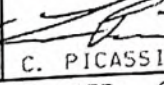
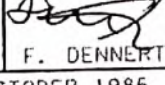
In digging and excavating pole holes, the hole diameters shall be kept to the minimum necessary to admit and erect the pole with sufficient space left to permit the use of a tamping bar on all sides of the pole over the full depth of the hole. Prior to setting the pole, any loose soil at the bottom of the pole hole must be removed or thoroughly tamped to prevent subsequent downward movement of the pole. This is of particular importance for guyed angle and dead-end structures. To prevent subsequent leaning of poles, backfill must also be thoroughly tamped during backfilling until the hole is completely filled. When available, small sized rocks should be used in the backfilling. Earth shall be mounded to a height of 150 mm around the pole to allow for settlement. Poles set in frozen ground shall be backfilled with "drainage course" material as specified by BC Hydro's Class of Work Specification No. 1322.

Backhoe digging of pole holes will often prove to be both convenient and economical. The backhoe shovel should be just slightly larger than the pole butt and the operator must be skilled to create three straight sides with a minimum amount of excavation. The length of the hole should be aligned with the pole line.

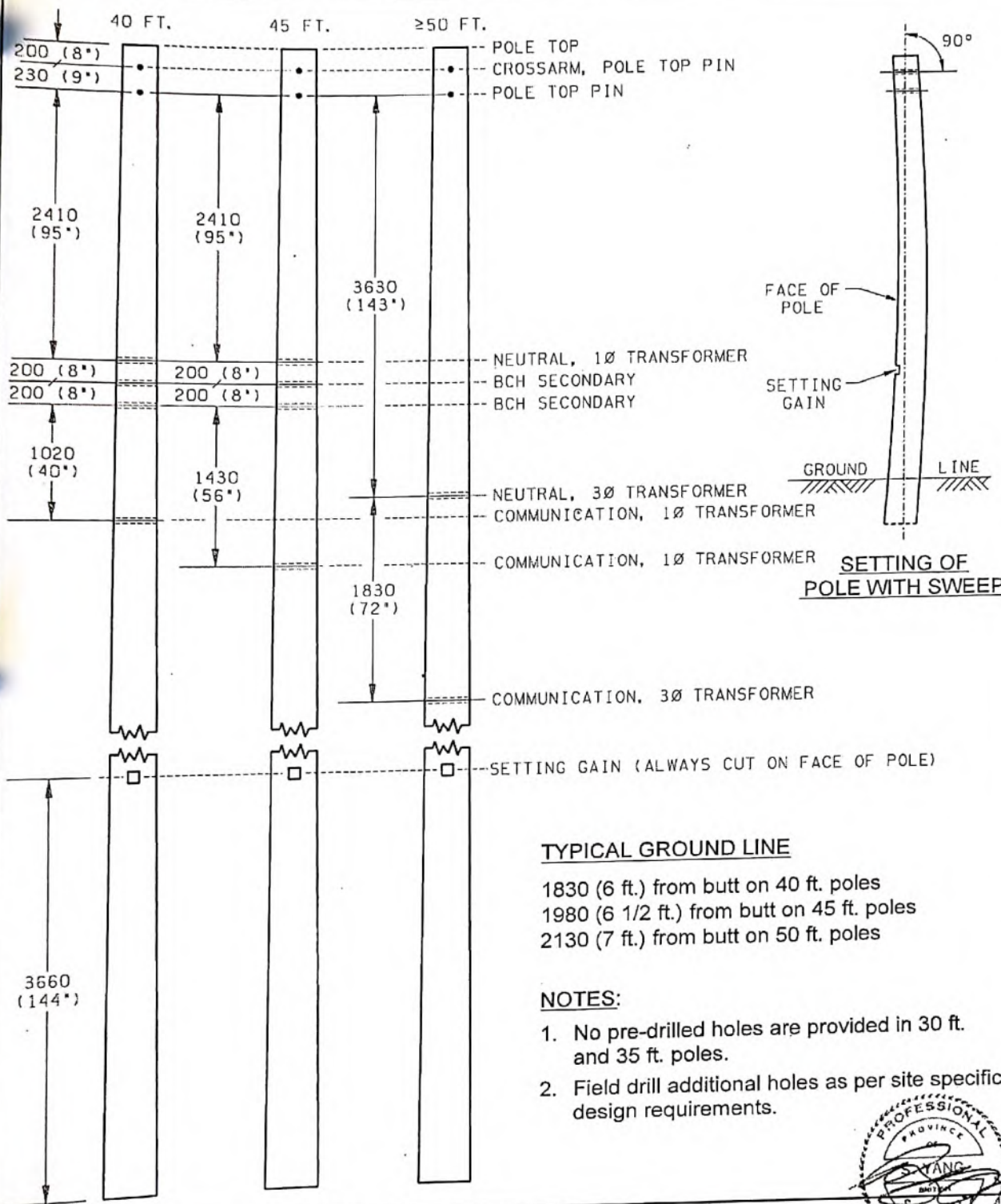
In solid rock locations, special pole mounts should be considered. For marshy or unstable (Class 7 to 8) soil locations, refer to ES43 D3-12. Contact Distribution Standards for more information.

FRAMING

Wood poles are purchased and preframed with a setting gain and bolt holes as shown on page ES43 D2-04. They are also stamped with the manufacturer's name or brand, the species, the treatment, the class, the length and the year of manufacture. Additional framing, as required, must be done in the field.

DRAFTER: DM	DESIGNER	RECOMMENDED	APPROVED	POLES GENERAL NOTES		
						
	C. YANG	C. PICASSI	F. DENNERT			
	ORIGINAL ISSUE DATE: OCTOBER 1985					
BChydro  DISTRIBUTION STANDARDS				PAGE 2 OF 2	ES43 D1-01.02	R. 3

DRAFTER: DM R. 5- REDRAWN & REVISED. NOV. '00 DY R. 6- TITLE BLOCK CHANGE. NOV. '12 PY R. 7- ADDED POLE DRILLING SECTION

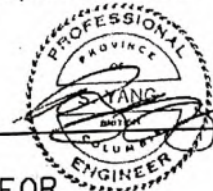


TYPICAL GROUND LINE

1830 (6 ft.) from butt on 40 ft. poles
1980 (6 1/2 ft.) from butt on 45 ft. poles
2130 (7 ft.) from butt on 50 ft. poles

NOTES:

1. No pre-drilled holes are provided in 30 ft. and 35 ft. poles.
2. Field drill additional holes as per site specific design requirements.



DESIGNER	RECOMMENDED	APPROVED
P. YANG	C. PICASSI	F. DENNERT
ORIGINAL ISSUE DATE: SEPTEMBER 1981		

STANDARD FRAMING FOR
WOOD DISTRIBUTION POLES

BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 2

E543 D2-04.01

R. 7

FIELD DRILLING

There have been cases where numerous holes have been drilled in the critical zone illustrated in FIG 1, where poles have a tendency to break due to bending moment stresses. To prevent this, field drilled holes in the critical zone shall be spaced no closer than 64mm (2 1/2") from each other. This spacing shall be adhered to for holes drilled perpendicular or parallel to each other.

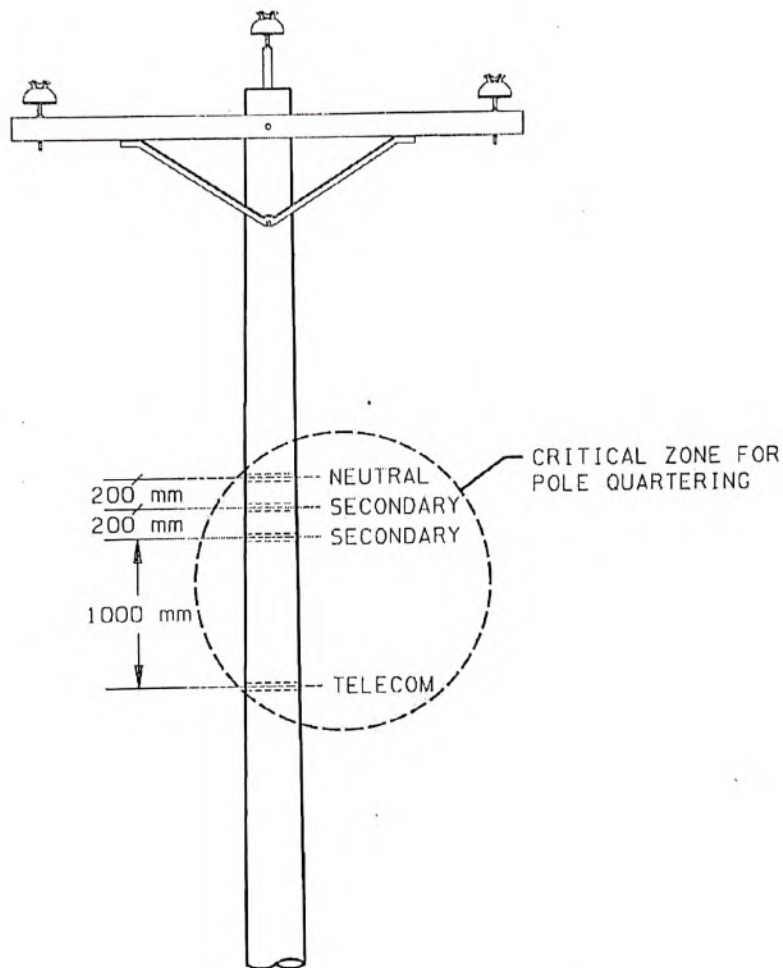


FIG 1



DRAFTER: UM

K. S. ALUMINUM & STEEL INDUSTRIES

DESIGNER	RECOMMENDED	APPROVED
P. YANG	C. PICASSI	F. DENNERT

ORIGINAL ISSUE DATE: SEPTEMBER 1981

STANDARD FRAMING FOR WOOD DISTRIBUTION POLES

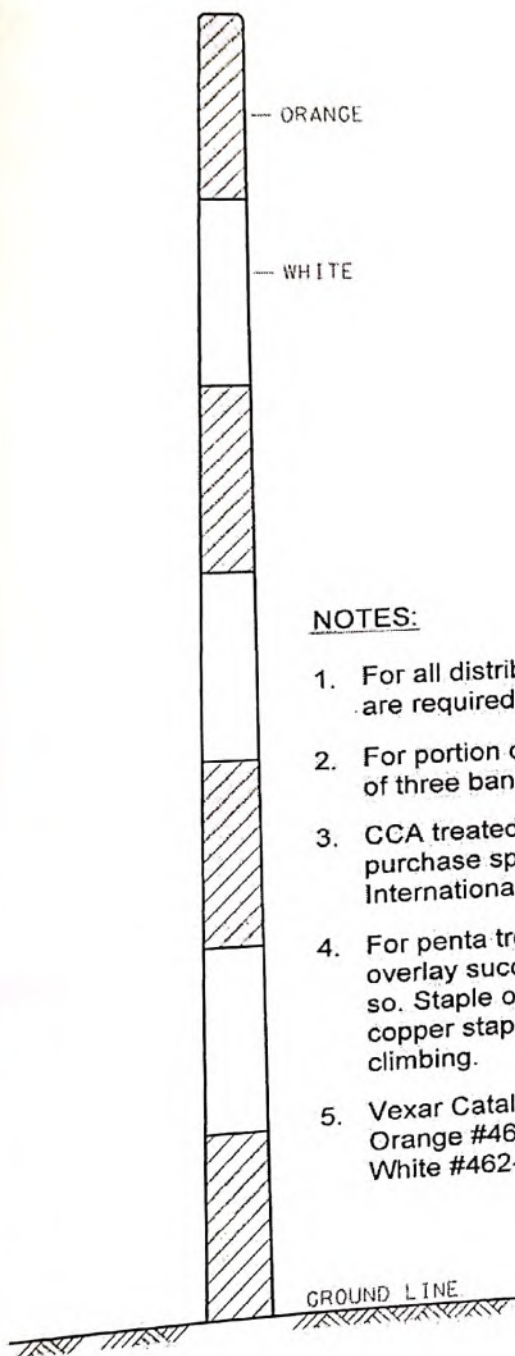
BChydro DISTRIBUTION STANDARDS

PAGE 2
OF 2

ES43 D2-04.02

R. 7

DRAFTER: DC/JW R.5- TITLE BLOCK, TRANSPORT CANADA MARKING, MAY'10 FK



NOTES:

1. For all distribution poles, seven painted bands of equal widths ~10% are required. Top and bottom bands must be orange.
2. For portion of pole that is shielded by terrain or other object, minimum of three bands must be displayed above shielded portion.
3. CCA treated poles are painted with an exterior latex paint. For direct purchase specify FED-STD-595B: International Orange 12197; White 17875.
4. For penta treated poles apply vexar netting as a double thickness and overlay successive strips by one inch. Staple each edge every inch or so. Staple other areas every six inches in both directions. Use 9/16" copper staples, or other secure method that will not interfere with climbing.
5. Vexar Catalogue ID's:
Orange #462-0013
White #462-0014

DESIGNER 		RECOMMENDED 		APPROVED 		FRAMING OF POLES SAFETY MARKING OF DISTRIBUTION POLES					
C. YANG		C. PICASSI		F. DENBERT							
ORIGINAL ISSUE DATE: SEPTEMBER 1981						PAGE 1 OF 1		ES43 D2-05		R. 5	
BChydro DISTRIBUTION STANDARDS											

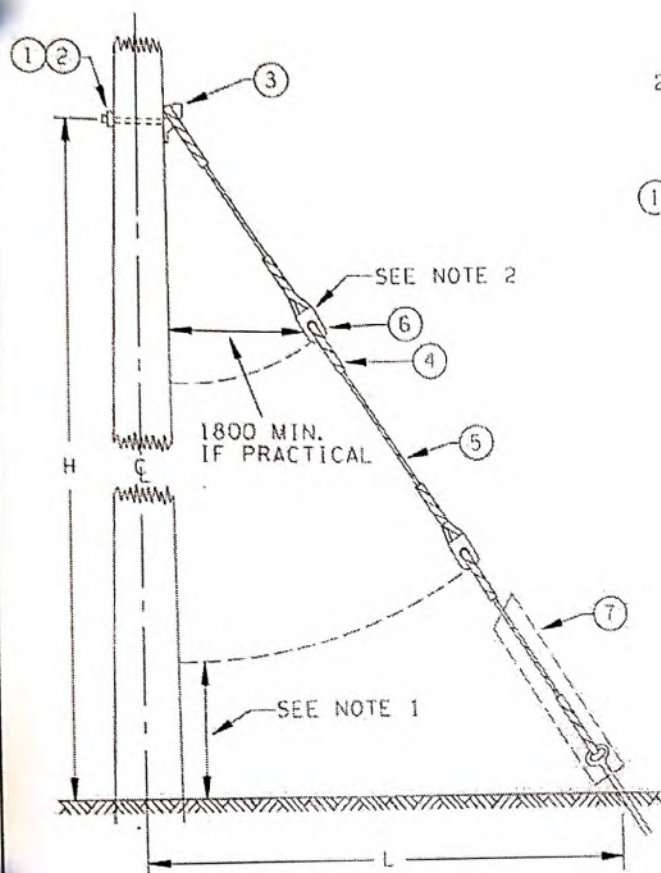


FIGURE A
ASSEMBLY ABOVE SECONDARY LEVEL

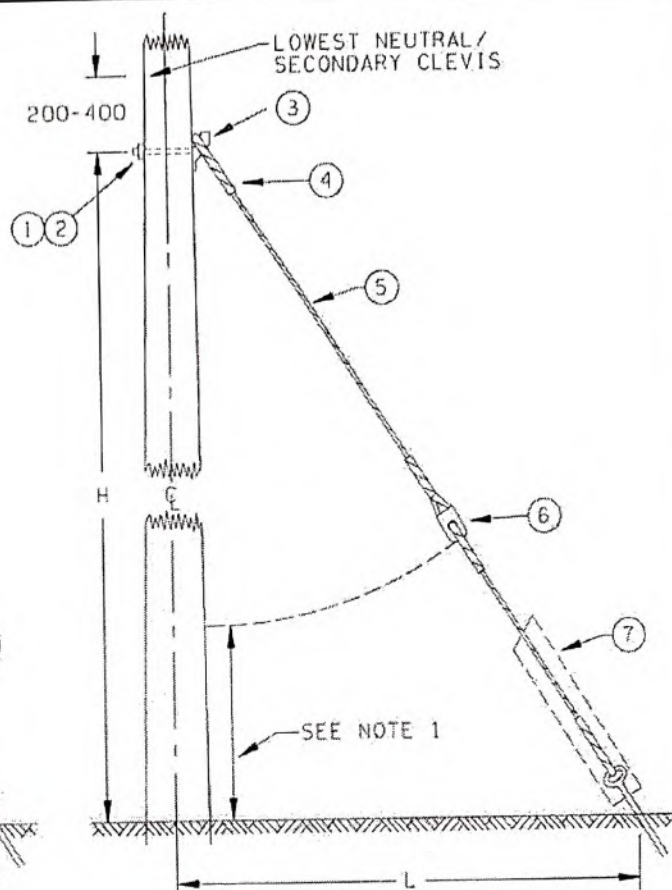


FIGURE B
ASSEMBLY AT SECONDARY LEVEL

NOTES:

1. Place lower strain insulator to swing to 2500 min. above ground.
2. Place upper strain insulator to swing above highest neutral or secondary conductor.
3. For dead end extensions, ensure that neutral, secondary and communication wires running past the guy strand are separated from it by 150 mm min.

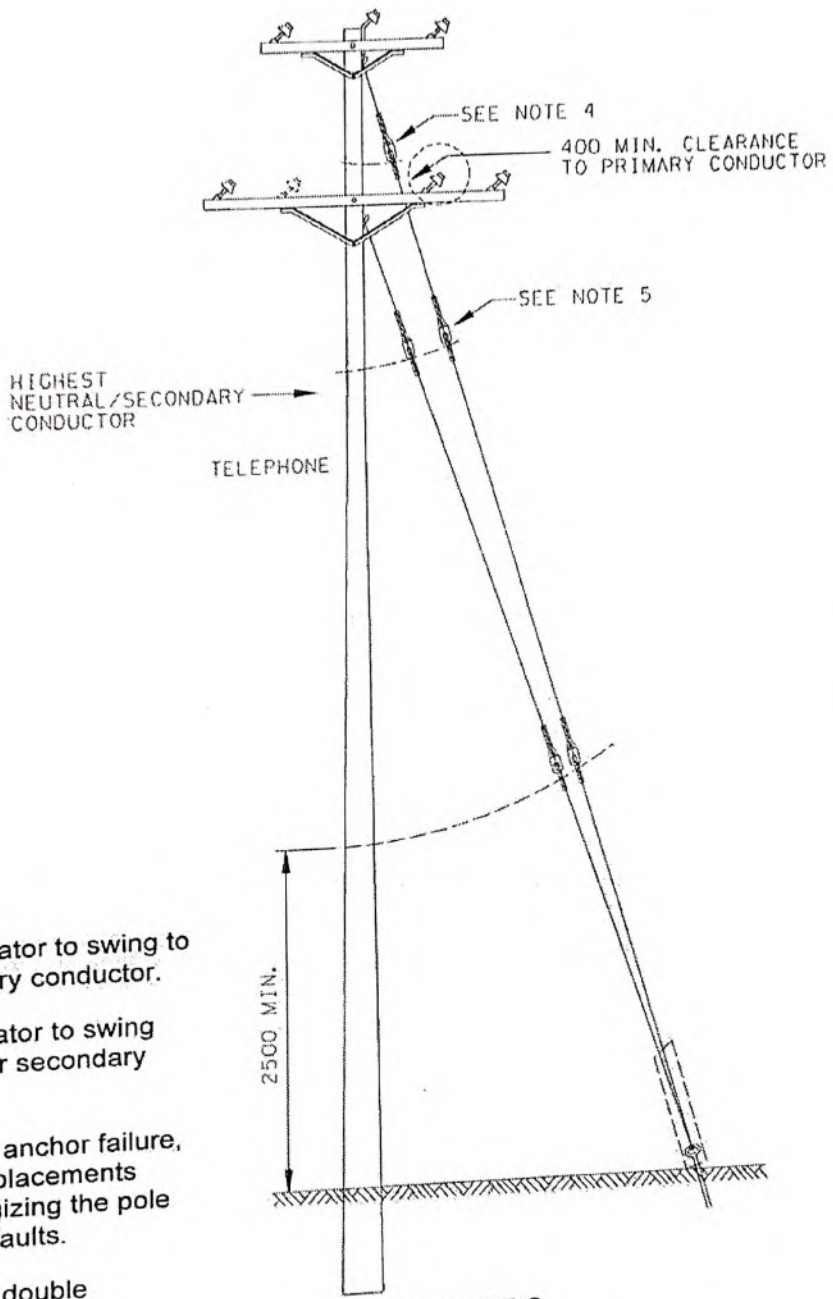
ES43 E2-21 Guy Grip Installation
 ES43 E2-22 Strain Insulator Installation
 ES43 E2-20 Pole Attachments
 REFERENCE DRAWINGS

BILL OF MATERIAL

Item No.	Description	Catalogue ID	Quantity	
			Fig. A	Fig. B
1	3/4" Machine Bolt	100-21XX	1	1
2	Square Washer, 75 x 75	420-1525	1	1
3	Guy Attachment	420-0766	1	1
4	Preformed Guy Grip:		6	4
	For Size 8 Guy	420-0973		
	For Size 10 guy	420-0975		
5	Guy Strand:		As Req'd	As Req'd
	For size 8 Guy	382-4233		
	For Size 10 Guy	382-4235		
6	Strain Insulator	410-1208	2	1
7	Guy Guard	420-0910	1	1

DESIGNER: [Signature]
 RECOMMENDED: [Signature]
 APPROVED: [Signature]
 C. PICASSI F. DENNERT
 ORIGINAL ISSUE DATE: AUGUST 1964

**GUYING
DOWNHAUL GUY ASSEMBLIES**



NOTES:

4. Place upper strain insulator to swing to above underbuild primary conductor.
5. Place lower strain insulator to swing above highest neutral or secondary conductor.
6. In the event of a guy or anchor failure, correct strain insulator placements reduce the risk of energizing the pole or causing inter-circuit faults.
7. For all anchor leads on double circuit structures, these must be calculated per ES43 Y3-01.

FIGURE C
DOUBLE CIRCUIT ANGLE ASSEMBLY

DRAFTER: DM/DC	DESIGNER	RECOMMENDED	APPROVED	GUYING DOWNHAUL GUY ASSEMBLIES		
	P. XAHG	C. PICASSI	F. DENNERT			
	ORIGINAL ISSUE DATE: AUGUST 1964			PAGE 2 OF 2	ES43 E2-10.02	R. 7

DOUBLE CIRCUITS

Double circuits on a pole line usually add significant structural stress and complexity for maintenance activities; therefore, they should be avoided if possible. Where double circuits must be constructed, see ES43 H8-01. Where more than two circuits may be required in the future, undergrounding is the preferred option.

NEUTRAL LOCATION

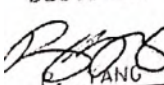
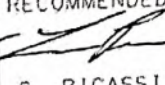
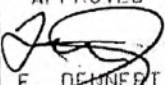
The neutral clevis and conductor shall be installed on the road-side of the pole.

The neutral is normally placed on the pole at a specified distance below the primary phase conductor(s) using the upper primary framing bolt hole on the pole as a convenient reference point. In line design, the determination of this distance on a pole by pole basis should take into consideration the following:

- (a) Minimum phase to neutral spacing of 2600 mm is designed to accommodate bucket access. Where no bucket access is required over the life of the installation, this may be reduced to 1800 mm.
- (b) Present and future space requirements for the equipment configurations shown in Sections J, K and M, which have been simplified in the following table for the purpose of determining pole height.

Typical Framing Configuration	Phase to Neutral Spacing /Separation (mm)
No bucket access, no equipment (No arborist traversing between phase and neutral)	1800 min.
Bucket access, no equipment	2600 min.
Single phase skypin with transformer 50 kVA or less	2600 min.
Single phase apparatus or dip	3200 typ.
Single phase lateral	3300 typ.
Three phase lateral	3350 typ.
Three phase transformer bank (no secondary open bus)	3600 min.
Three phase dip	3800 typ.
Three phase transformer bank with secondary bus	4200 typ.

- (c) Consistent wire spacing for line aesthetics.

DESIGNER  R. YANG	RECOMMENDED  C. PICASSI	APPROVED  F. DENNEFT
ORIGINAL ISSUE DATE: SEPTEMBER 1985		

BASIC LINE STRUCTURES: GENERAL NOTES

R. 5- FIG. NO. & BOLT ORIENTATION CHANGE.
 R. 6- ADDED HEX NUTS & TUBULAR V-BRACE. NOV. 15 PY
 ADDED NOTE 4 & RELABELLED DIAGRAMS. NOV. 12 PY

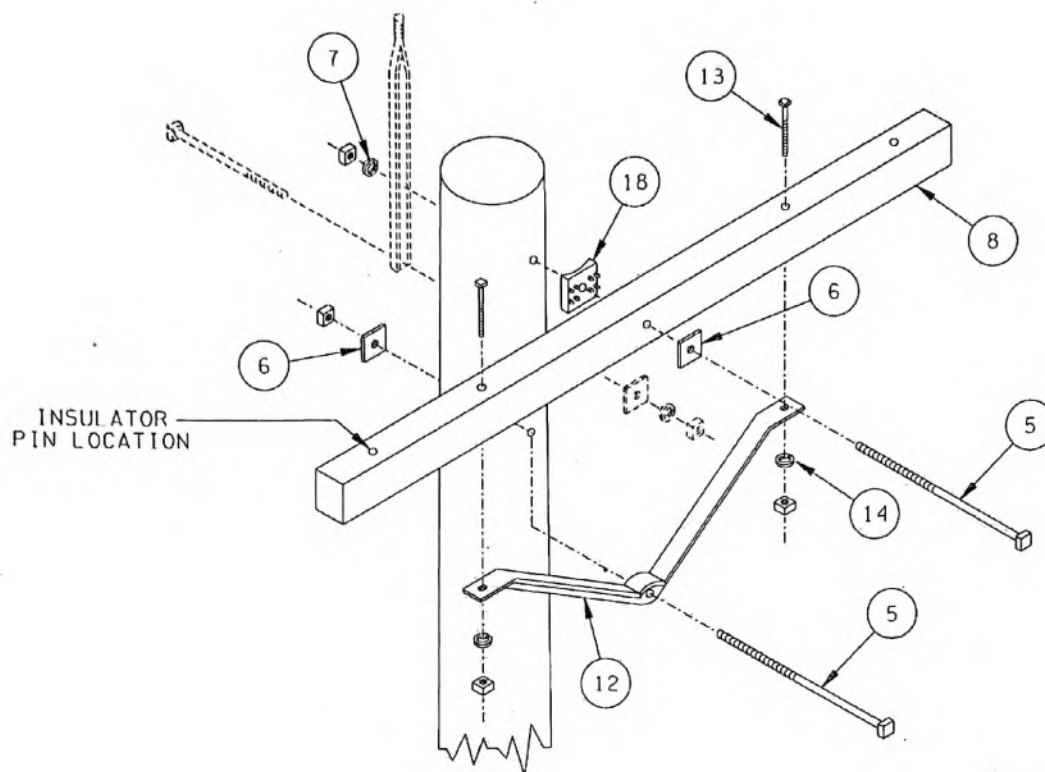
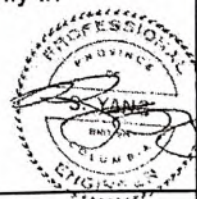


FIG. A
 7' Crossarm with Compression Brace

NOTES:

1. Instead of square nuts, hex nuts Cat ID 102-0124 may be used with 1/2" carriage bolts to fasten angle iron v-brace to cross arm.
2. Instead of square nuts, hex nuts Cat ID 102-0126 may be used with 5/8" bolts to fasten angle iron v-brace to pole.
3. Tubular (pipe) braces Cat ID 97000512 and Cat ID 97000513 are to be used only in areas that experience significant tree falls during storm events.



DRAFTER: DM	DESIGNER F. YANU	RECOMMENDED C. PICASSI	APPROVED F. DENNERT	BASIC LINE STRUCTURES 25 kV AND 35 kV SUB-ASSEMBLIES POLE-TOP PIN AND CROSSARM
	ORIGINAL ISSUE DATE: OCTOBER 1985			
	BChydro DISTRIBUTION STANDARDS			
PAGE 1 OF 5				ES43 G2-01.01
				R. 6

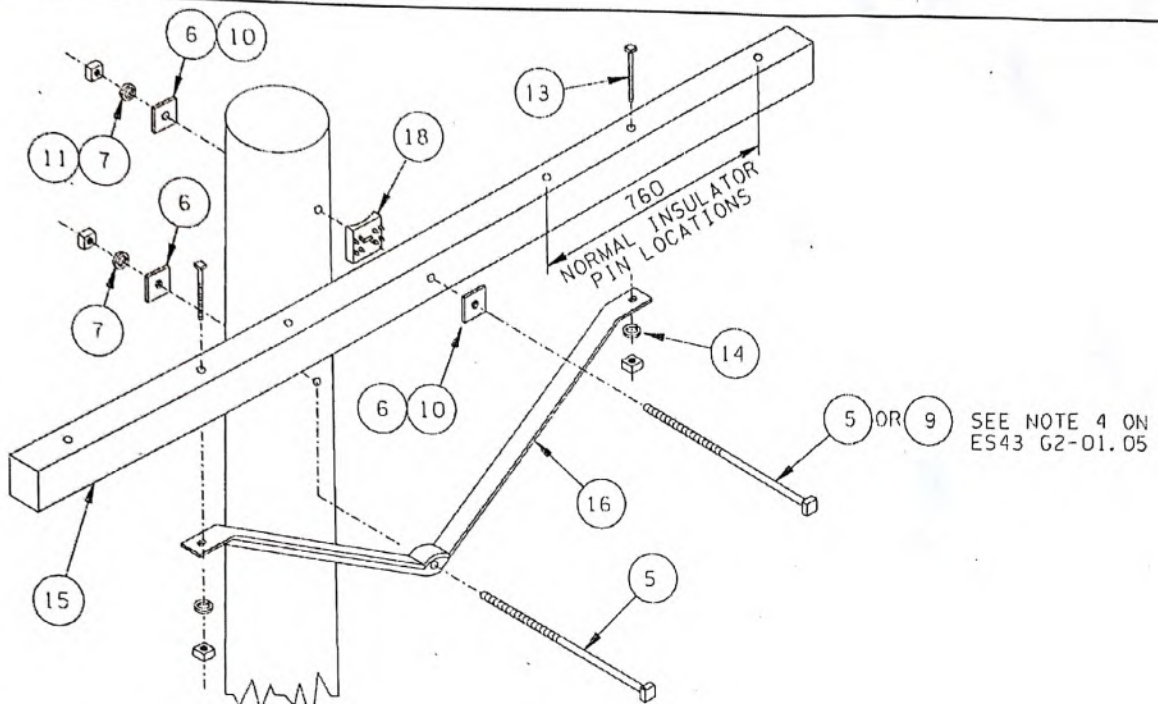


FIG. B

9' Crossarm with Compression Braces

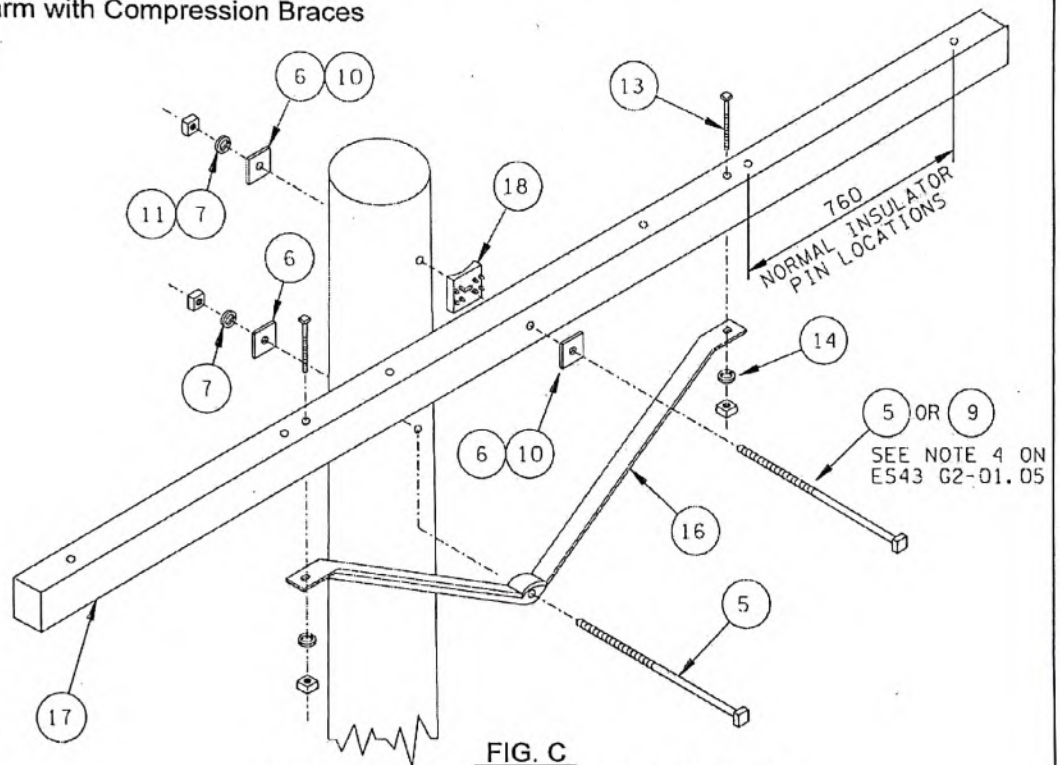


FIG. C

11'-6" Crossarm with Compression Braces



DRAFTER: DM

DESIGNER	RECOMMENDED	APPROVED
<i>[Signature]</i> D. YANG	<i>[Signature]</i> C. PICASSI	<i>[Signature]</i> F. DENNERT

ORIGINAL ISSUE DATE: OCTOBER 1985

BASIC LINE STRUCTURES
25 kV AND 35 kV SUB-ASSEMBLIES
POLE-TOP PIN AND CROSSARM

BChydro DISTRIBUTION STANDARDS

PAGE 2
OF 5

ES43 G2-01.02

R. 6

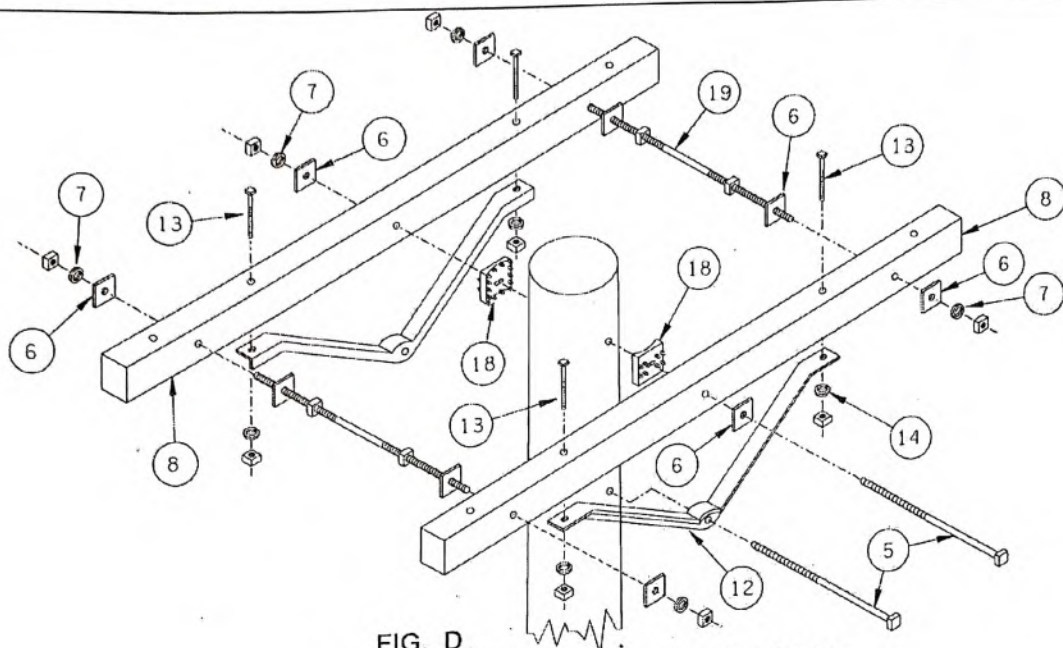


FIG. D
7' Double Crossarms with Compression Braces

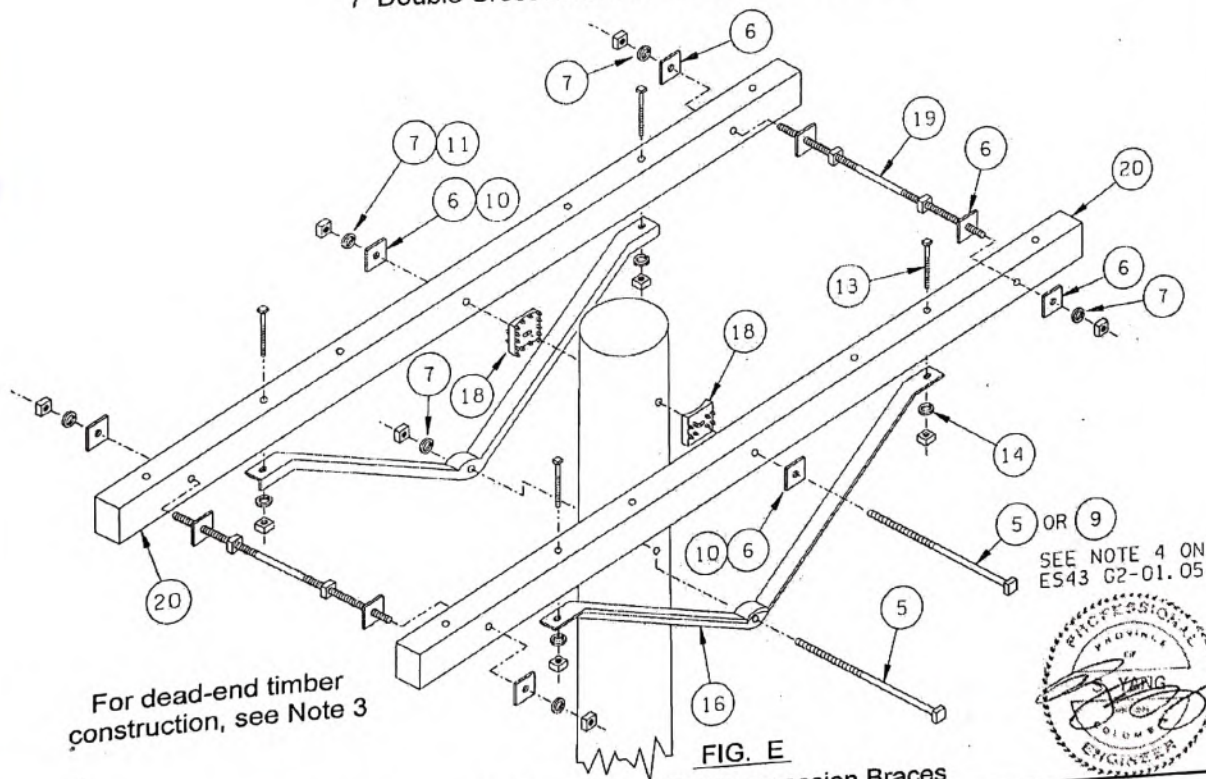


FIG. E
9' or 11'-6" Double Crossarms with Compression Braces

DRAFTER: DM/DC	DESIGNER	RECOMMENDED	APPROVED	BASIC LINE STRUCTURES 25 kV AND 35 kV SUB-ASSEMBLIES POLE-TOP PIN AND CROSSARM	
	P. YANG	C. PICASSI	F. DENNERT		
	ORIGINAL ISSUE DATE: OCTOBER 1985			PAGE 3 OF 5	ES43 G2-01.03
	BCHydro  DISTRIBUTION STANDARDS			R. 6	

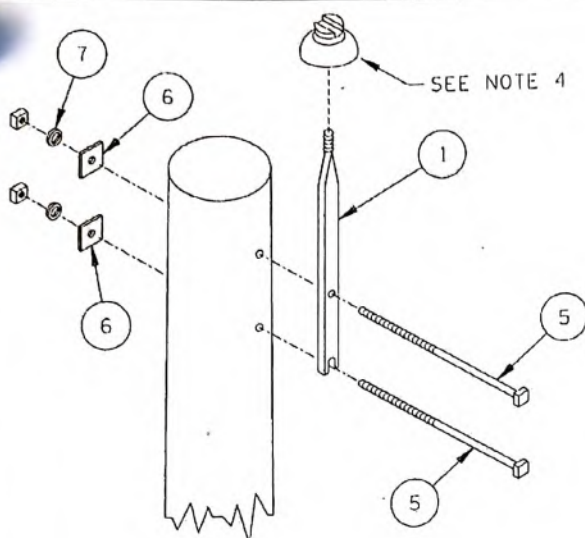


FIG. F
Pole Top Straight Pin

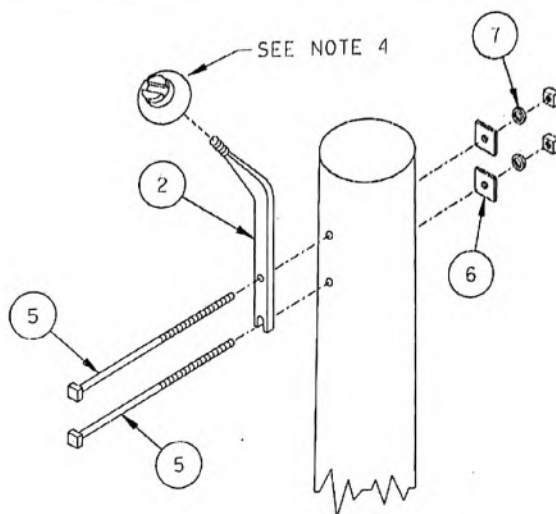


FIG. G
Pole Top Angle Pin

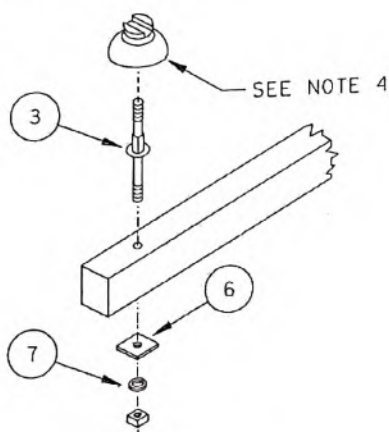


FIG. H
Crossarm Straight Pin

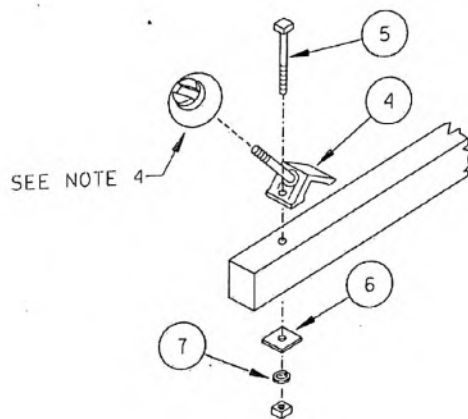


FIG. I
Crossarm Angle Pin

NOTES: 4. Pin Insulator selection schedule:

Voltage	Environment	Catalogue ID
7.2/12 kV	All	410-0649
14.4/25 kV	Clean	410-0649
14.4/25 kV	Moderate Contamination	410-0650
14.4/25 kV	Heavy Contamination	96012592
19.5/35 kV	All	96012592

5. The number of turns required to install pin insulators varies with the manufacturer. Therefore as a rule screw-on the insulator until it is snug. Then do one final, partial turn to properly line up the insulator with the conductor.



DRAFTER: DM	DESIGNER <i>[Signature]</i>	RECOMMENDED <i>[Signature]</i>	APPROVED <i>[Signature]</i>
	R. YANG	C. PICASSI	F. DENNERT
ORIGINAL ISSUE DATE: OCTOBER 1985			

BASIC LINE STRUCTURES
25 kV AND 35 kV SUB-ASSEMBLIES
POLE-TOP PIN AND CROSSARM

BChydro **DISTRIBUTION STANDARDS**

PAGE 4
OF 5

ES43 G2-01.04

R. 6

NOTES: (Cont.)

6. For double timber construction, build as per Fig. E using 9' timbers Cat. ID 211-0360 and carriage bolts Cat. ID 100-0552 to fasten brace to timber.
7. 3/4" bolts are used in ES43 G4-10.02, G4-10.03 and G4-12.02, angle structures.

BILL OF MATERIAL

ITEM NO.	DESCRIPTION	Catalogue ID	QUANTITY								
			Figures:								
			A	B	C	D	E	F	G	H	I
1	Pole Top Straight Pin	421-0410	-					1	-	-	-
2	Pole Top Angle Pin	421-0405	-	-	-	-	-	-	1	-	-
3	Crossarm Straight Pin	421-0307	-	-	-	-	-	-	-	1	-
	or Timber Straight Pin	421-0306	-	-	-	-	-	-	-	-	-
4	Crossarm Angle Pin	421-0351	-	-	-	-	-	-	-	-	1
5	Machine Bolt (5/8" x length)	100-20XX	2	1/2	1/2	2	1/2	2	2	-	1
6	Square Washer (50 mm x 50 mm)	420-1521	2	1/3	1/3	10	8/10	2	2	1	1
7	Helical Spring Washer (5/8")	102-4158	2	1/2	1/2	6	5/6	2	2	1	1
8	7' Crossarm	421-0005	1	-	-	2	-	-	-	-	-
9	Machine Bolt (3/4" x length)	100-21XX	-	1	1	-	1	-	-	-	-
10	Square Washer (75 mm x 75 mm)	420-1525	-	2	2	-	2	-	-	-	-
11	Helical Spring Washer (3/4")	102-4160	-	1	1	-	1	-	-	-	-
12	Compression Brace (1065 mm) Angle Iron Style or Tubular (Pipe) Style	421-0120 97000512	1	-	-	2	-	-	-	-	-
13	Carriage Bolt (1/2" x 150 mm) or Carriage Bolt (1/2" x 205 mm)	100-0547 100-0552	2	2	2	4	4	-	-	-	-
			-	-	-	-	-	-	-	-	-
14	Helical Spring Washer (1/2")	102-4156	2	2	2	4	4	-	-	-	-
15	9' Crossarm	421-0022	-	1	-	-	-	-	-	-	-
16	Compression Brace (1525 mm) Angle Iron Style or Tubular (Pipe) Style	421-0121 97000513	-	1	1	-	2	-	-	-	-
			-	-	1	-	-	-	-	-	-
17	11' - 6" Crossarm	421-0026	-	-	-	-	-	-	-	-	-
18	Crossarm Gain	421-0207	1	1	1	2	2	-	-	-	-
19	Double Arming Bolt (5/8" x length)	420-XXXX	-	-	-	2	2	-	-	-	-
20	9' Crossarm or	421-0022	-	-	-	-	-	-	-	-	-
	11' - 6" Crossarm or	421-0026	-	-	-	-	2	-	-	-	-
	9' Timber	211-0360	-	-	-	-	-	-	-	-	-

DRAFTER: DM/SG

DESIGNER

RECOMMENDED

APPROVED

E. YANG

C. PICASSI

F. DENNERT

ORIGINAL ISSUE DATE: OCTOBER 1985

BASIC LINE STRUCTURES
25 kV AND 35 kV SUB-ASSEMBLIES
POLE-TOP PIN AND CROSSARM

PAGE 5
OF 5

ES43 G2-01.05

R. 6

BChydro  DISTRIBUTION STANDARDS

R. 5- TITLE BLOCK, NOV'12 PY
 R. 2- POLYMERIC INSULATORS ADDED '00-11-07 FLK
 DRAFTER: JW

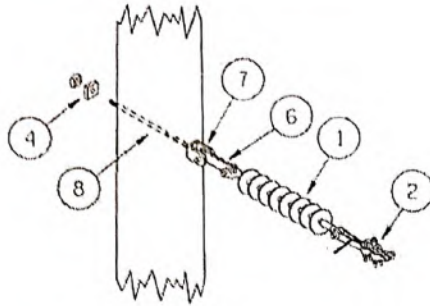


FIG.A DEAD-END TO POLE
(BOLT MAY ALSO SUPPORT CROSSARMS OR TIMBERS PROVIDED CONDUCTOR AT RIGHT ANGLE TO CROSSARM $\pm 5^\circ$)

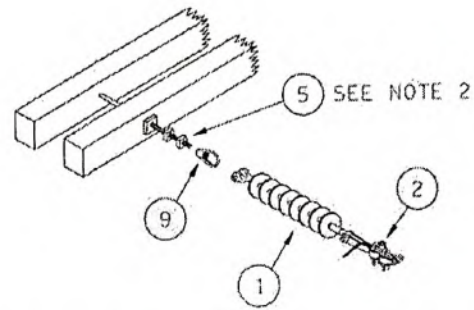


FIG.D DEAD-END TO CROSSARMS OR TIMBERS
WHERE CONDUCTOR AT RIGHT ANGLE TO CROSSARM $\pm 5^\circ$

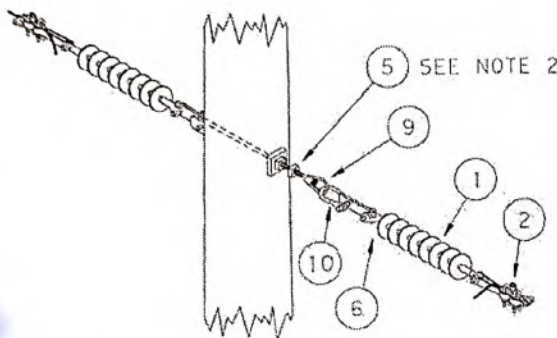


FIG.B DEAD-END TO EXISTING BOLT ON POLE

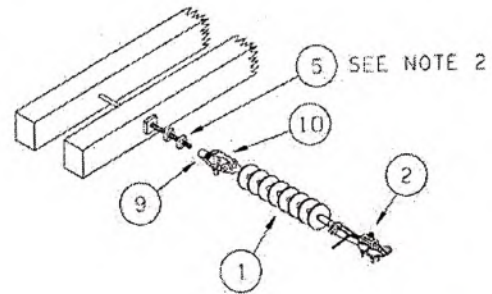


FIG.E DEAD-END TO CROSSARMS OR TIMBERS
WHERE CONDUCTOR NOT AT RIGHT ANGLES TO CROSSARMS

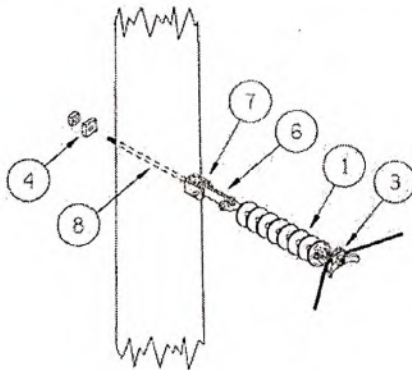


FIG.C ANGLE ATTACHMENT TO POLE.
 $15^\circ - 60^\circ$ LINE ANGLE

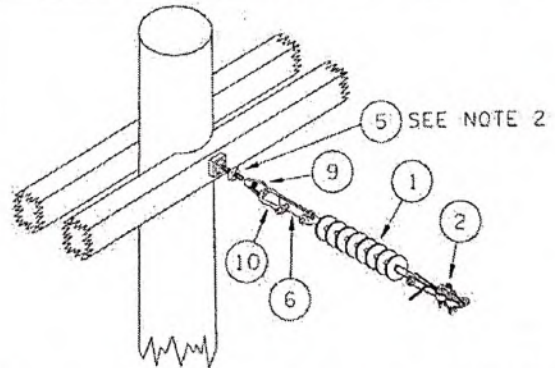


FIG.F DEAD-END OF CENTRE PHASE TO EXISTING
BOLT ON POLE WHERE CONDUCTOR
NOT AT RIGHT ANGLE TO CROSSARM

ES43 G2-01.03 Crossarm Assembly
REFERENCE DRAWINGS

DESIGNER	RECOMMENDED	APPROVED
<i>[Signature]</i> R. YANG	<i>[Signature]</i> C. PICASSI	<i>[Signature]</i> F. DENNERT

ORIGINAL ISSUE DATE: SEPTEMBER 1985

**25 kV AND 35 kV PRIMARY
SUSPENSION INSULATOR
SUB-ASSEMBLIES**

BCHydro  **DISTRIBUTION STANDARDS**

PAGE 1
OF 2

ES43 G2-04.01

R. 5

BILL OF MATERIAL

Item No.	Description	Catalogue ID	Quantity					
			A	B	C	D	E	F
1	Suspension Insulator: Polymeric (See Note 1)	410-1027	X	X	X	X	X	X
2	Dead End Clamp: #2 to 1/0 ACSR 3/0 ACSR to 336.4 ASC (See Note.3)	413-0579 413-0580	1	1	-	1	1	1
3	Angle Clamp (See Note 4)	413-0706	-	-	1	-	-	-
4	Square Washer (50 mm x 50 mm)	420-1521	1	-	1	-	-	-
5	Nut (5/8") (See Note 2)	102-0126	-	1	-	1	1	1
6	Extension Strap (125 mm)	420-1009	1	1	1	-	-	1
7	Dead End Clevis	413-0130	1	-	1	-	-	-
8	Machine Bolt (5/8" x length)	100-XXXX	1	-	1	-	-	-
9	EyenuT (5/8")	420-1400	-	1	-	1	1	1
10	Shackle	420-1500	-	1	-	-	1	1

NOTES:

1. Applications:

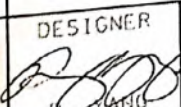
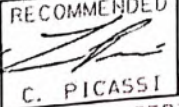
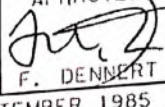
- (a) 1 x DS-35 Polymeric (410-1027):
 - for all applications at/below 14.4/25 kV.
 - for 19.9/35 kV, up to medium contamination levels.
 - for 19.9/35 kV, heavy contamination levels - contact Distribution Standards.

- (b) Porcelain (410-1019) - now obsolete
 - existing 2 x Porcelain need not be upgraded to polymeric when converting to 14.4/25 kV in clean environment areas.

Medium Contamination: Sea winds but a few km away from sea.
 Not subject to air-borne particulate matter from industries, or pulp mill effluent.

Heavy Contamination: Subject to salt-spray, air-borne particulate matter from industries, or pulp mill effluent.

2. TIGHTEN NUT AGAINST EYENUT TO PREVENT ROTATION.
 3. Not suitable for copper conductors. For copper conductors use Cat. ID 413-0573 and Cat. ID 413-0581.
 4. Not suitable for copper conductors. For copper conductors use Cat. ID 96000894.

DRAFTER: DM	DESIGNER 	RECOMMENDED 	APPROVED 	PRIMARY 25 kV AND 35 kV SUSPENSION INSULATOR SUB-ASSEMBLIES
	K. TANG	C. PICASSI	F. DENNERT	
	ORIGINAL ISSUE DATE: SEPTEMBER 1985			
BCHydro  DISTRIBUTION STANDARDS				PAGE 2 OF 2
ES43 G2-04.02				R. 5

7' CROSSARM
CAT. ID 421-0005

COMPRESSION
BRACE

POLE TOP
200 CENTRE BOLT

APPLICATION

Line Voltage	Lowest Ambient Temp	Conductor Tension	Maximum Ruling Span	Maximum Span Length
25 kV	-40°C	Reduced	75 m	95 m
	-10°C	Regular	100 m	120 m
35 kV	-40°C	Reduced	50 m	70 m
	-10°C	Regular	75 m	95 m

NEUTRAL

2600 MIN.

NOTES:

1. This structure is suitable for angle 0° to 5°, with guy as required.
2. For 35 kV insulate accordingly.
3. A 9' crossarm, Cat. ID 421-0022 may be used instead of the 7' crossarm in places where the additional conductor spacing mitigates wildlife electrical contact. See ES43 W2-02.
4. See ES43 G4-12.01 for 9' crossarm.

ES43 N2-01.01 Neutral Assembly ✓
 ES43 G2-01.04 Primary Pin Assembly ✓
 ES43 G2-01.01 Crossarm Assembly ✓
 ES43 G1-01.04 Neutral Location ✓

REFERENCE DRAWINGS

DESIGNER	RECOMMENDED	APPROVED
<i>P. YAND</i>	<i>C. PICASSI</i>	<i>F. DENNERT</i>
P. YAND	C. PICASSI	F. DENNERT

ORIGINAL ISSUE DATE: MARCH 1964

THREE PHASE TANGENT
SKYPIN

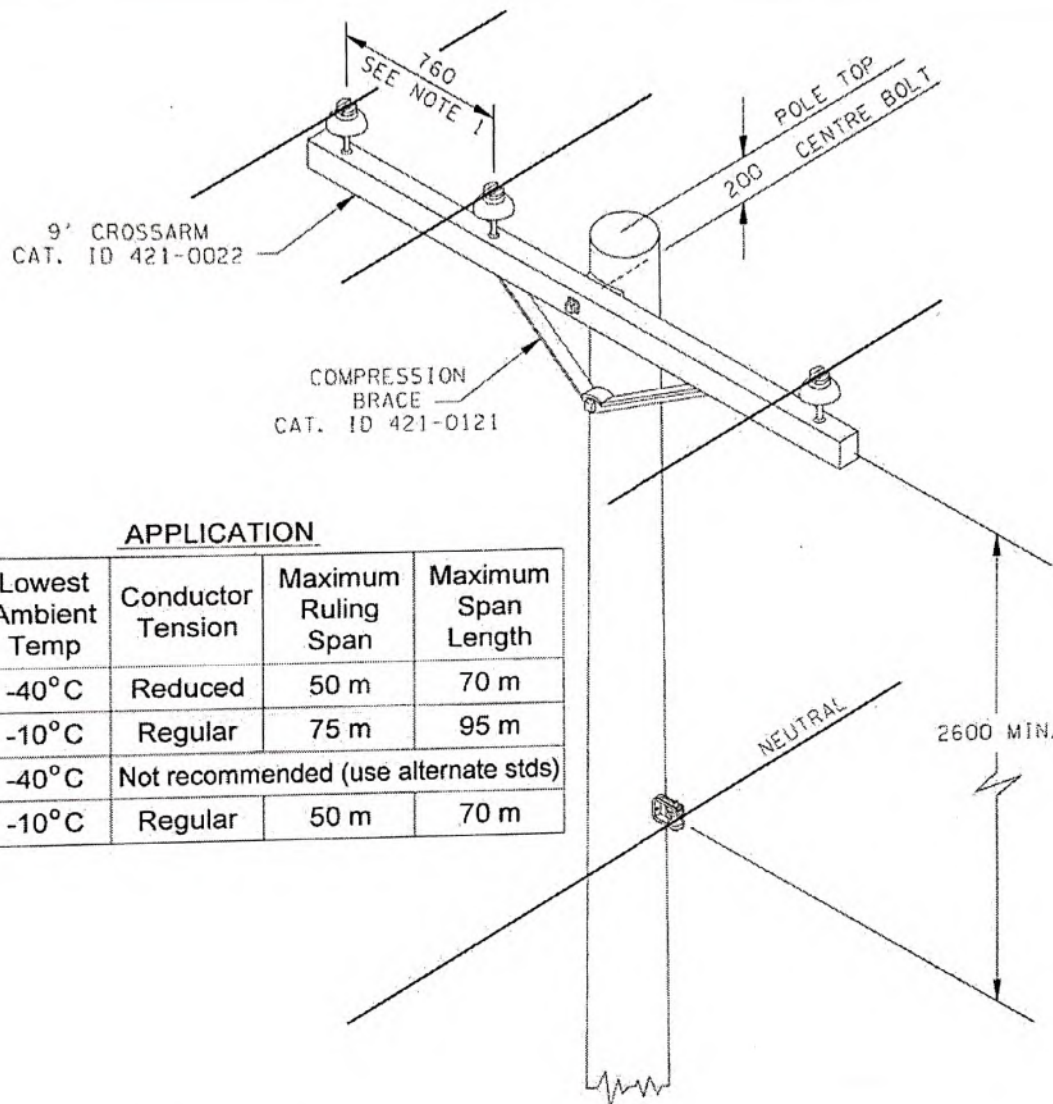
BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 2

ES43 G4-02.01

R. 9

DRAFTER: DM/DC R. 5- INCREASED PHASE TO NEUTRAL SPACING MAY. '10 CP R. 6- ADDED TABLE FOR SPAN & TENSION, NOV '12 PY



APPLICATION

Line Voltage	Lowest Ambient Temp	Conductor Tension	Maximum Ruling Span	Maximum Span Length
25 kV	-40°C	Reduced	50 m	70 m
	-10°C	Regular	75 m	95 m
35 kV	-40°C	Not recommended (use alternate stds)		
	-10°C	Regular	50 m	70 m

NOTES:

1. For additional phase spacing, centre pin may installed 200 minimum from side of pole for 25 kV: 420 minimum for 35 kV.
2. This structure is also suitable for angles 0° to 5°, with guy as required. See Section E.
3. For 35 kV, insulate accordingly.

ES43 N2-01.01 Neutral Assembly
 ES43 G2-01.02 Crossarm Assembly
 ES43 G1-01.04 Neutral Location
 ES43 G1-01.01 Phase Spacing

REFERENCE DRAWINGS

DESIGNER <i>[Signature]</i> P. WANG	RECOMMENDED <i>[Signature]</i> C. PICASSI	APPROVED <i>[Signature]</i> F. DENNETT
---	---	--

ORIGINAL ISSUE DATE: MARCH 1980

THREE PHASE TANGENT
FLAT

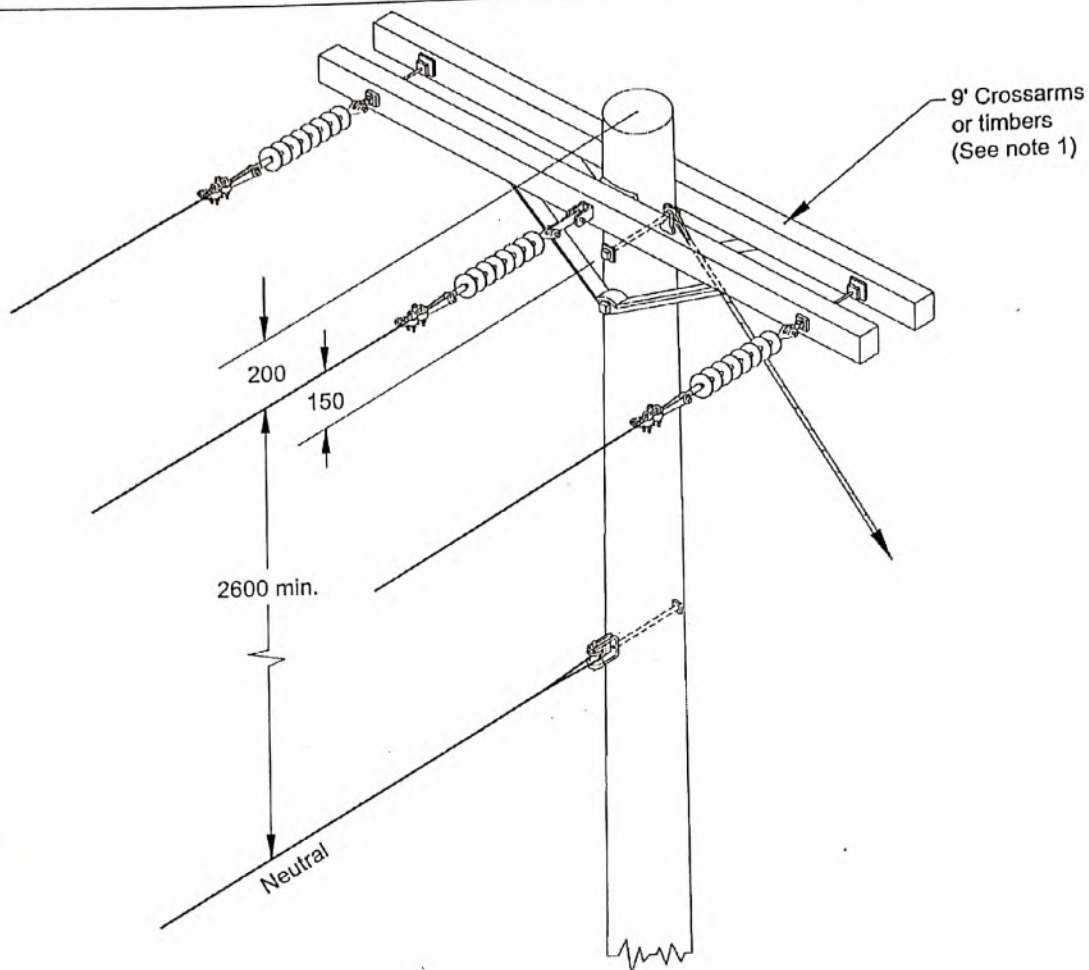
BChydro DISTRIBUTION STANDARDS

PAGE 2
OF 2

ES43 G4-02.02

R. 6

(Not used)



Notes

1. 5" x 7" timbers required when conductors are larger than 2/0 unless crossarm guys are used. See ES43 E2-12.
2. For 35 kV insulate accordingly.

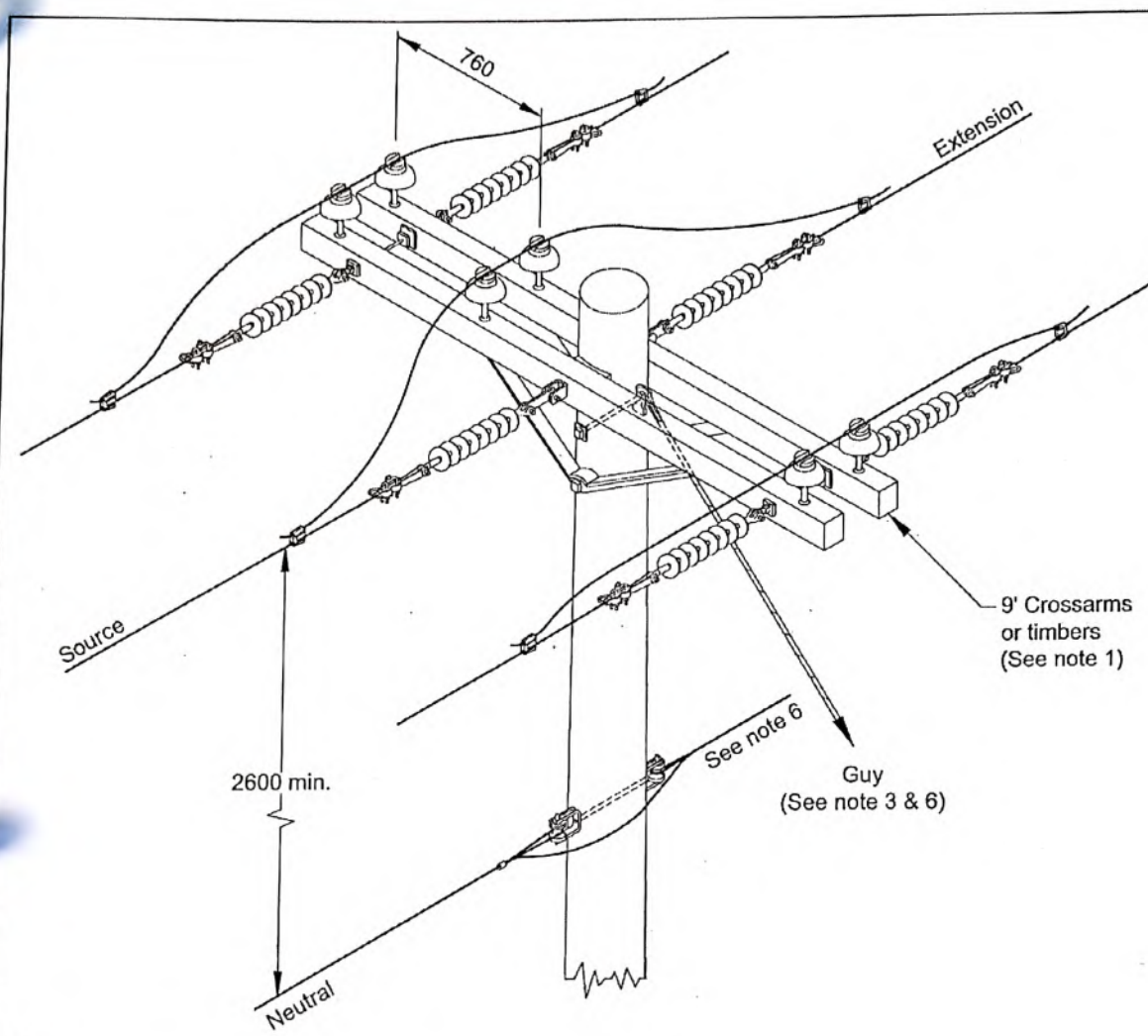
Reference Standards

ES43 N2-01.01	Neutral Dead-End
ES43 G2-04.01	Primary Dead-End
ES43 G2-01.03	Crossarm Assembly
ES43 G1-01.04	Neutral Location
ES43 E2-10	Guy Assembly

DESIGNED <i>P. Yang</i> P. YANG	RECOMMENDED <i>C. Picassi</i> C. PICASSI	ACCEPTED <i>F. Dennert</i> F. DENNERT	ENGINEER OF RECORD <i>P. S. Yang</i> P. S. YANG ENGINEER	THREE-PHASE DEAD END	
DISTRIBUTION STANDARDS BC Hydro		ISSUED: MAY 2017 REPLACES: NOV 2012 ORIGINALLY ISSUED: MAR 1964		PAGE 1 OF 3	ES43 G4-05.01 R 10

REVISIONS: R.9 - REVISED TITLE, NOV '12 PY, R.10 - ADDED PAGE THREE, REDRAWN, MAY '17 PY

REVISIONS: R.10 - REVISED NOTE 1 TO ACCOMMODATE SLACK SPAN AND LOW TENSION DESIGN. JUNE '15 P.Y. R.11 - ADDED PAGE THREE, REDRAWN. MAY '17 P.Y.



Notes

1. This construction used where tension in extension is less than source tension. 5" x 7" timbers are required when conductors are larger than 2/0 and final loaded tension difference per conductor is 6 kN or greater.
2. For sectionalizing, see section K.
3. Guy may be required at railway crossings as per section E, or if tension changes due to different conductor sizes.
4. For 35 kV insulate accordingly.
5. Maximum allowable line angle is 5°.
6. Provide neutral/secondary to guy separation of 150 mm minimum. If necessary, offset guy or neutral/secondary.

Reference Standards

ES43 N2-01.01	Neutral Dead End
ES43 G2-04.01	Primary Dead End
ES43 G2-01.03	Crossarm Assembly
ES43 G1-01.04	Neutral Location
ES43 E2-10	Guy Assembly

DESIGNED <i>P. Yang</i> P. YANG	RECOMMENDED <i>C. Picassi</i> C. PICASSI	ACCEPTED <i>F. Dennert</i> F. DENNERT	ENGINEER OF RECORD <i>P. Yang</i> P. YANG
DISTRIBUTION STANDARDS BC Hydro			
ISSUED: MAY 2017 REPLACES: JUN 2015 ORIGINALLY ISSUED: NOV 1981			

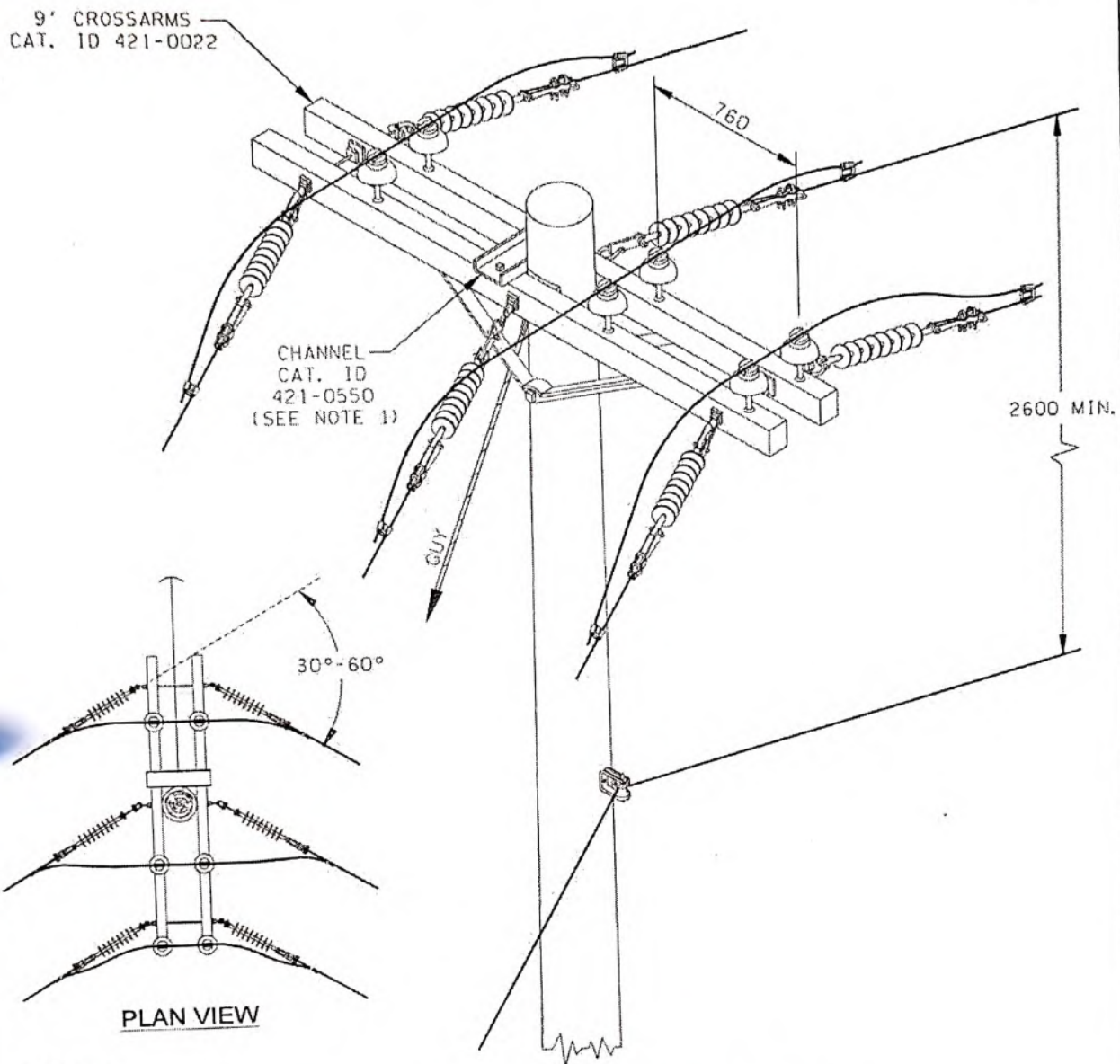
**THREE-PHASE
DEAD END EXTENSION**

PAGE 2
OF 3

ES43 G4-05.02

R
11

R. 3- INCREASED PHASE TO NEUTRAL SPACING. MAY. '10 CP | R. 4-REVISED PHASE JUMPERS. NOV' 12 PY



NOTES:

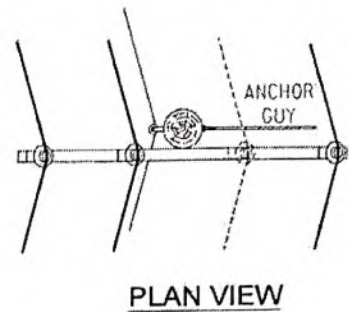
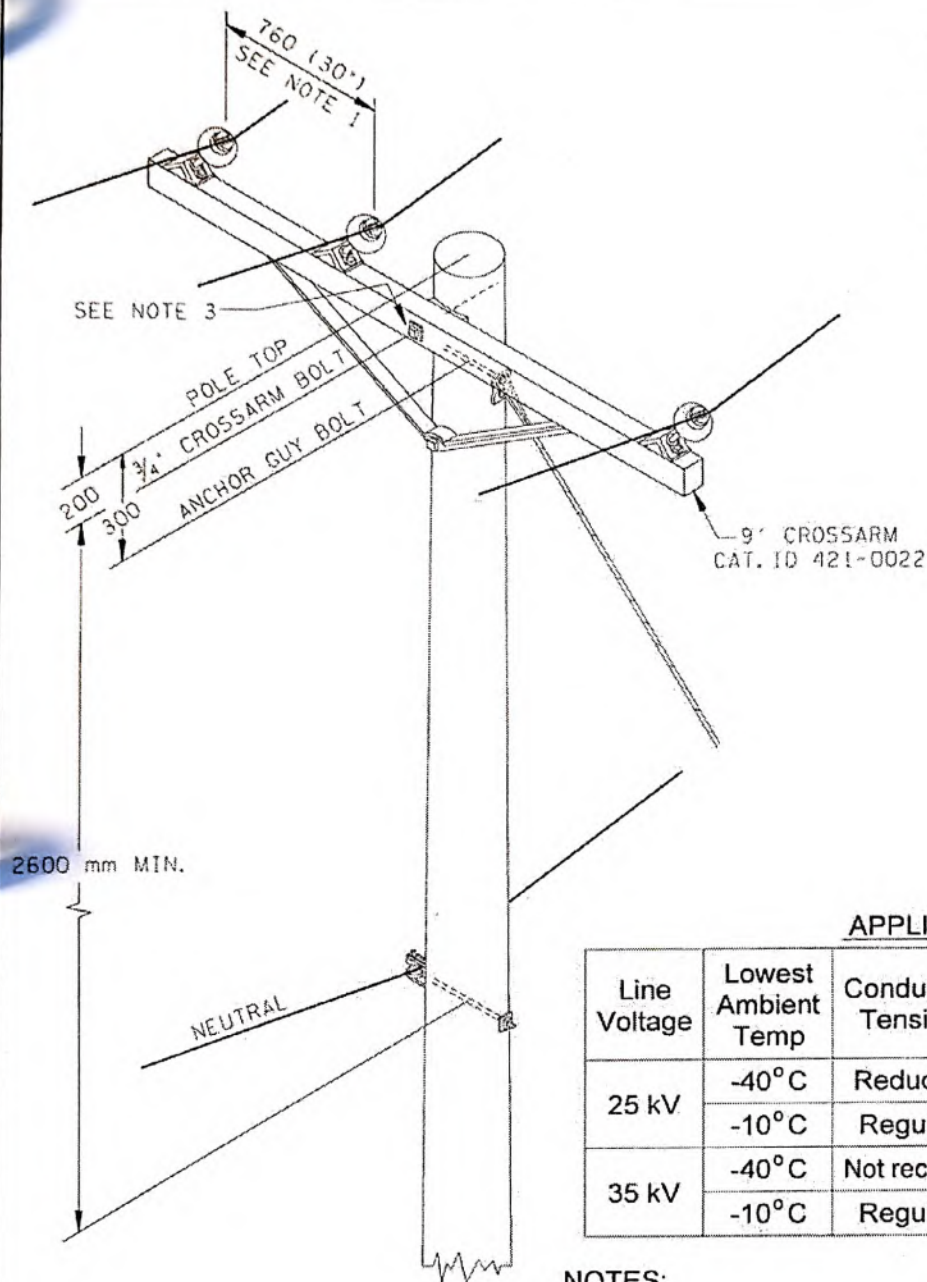
1. Mount channel to crossarms using 5/8" bolts and butt up against pole.
2. For 35 kV insulate accordingly.

- ES43 N2-01.01 Neutral Assembly
 ES43 G2-04.01 Primary Dead-End
 ES43 G2-01.03 Crossarm Assembly
 ES43 G1-01.04 Neutral Location
 ES43 E2-10 Guy Assembly
 REFERENCE DRAWINGS

PPA

DRAFTER: DM/DC	DESIGNER <i>[Signature]</i> P. YANGL	RECOMMENDED <i>[Signature]</i> C. PICASSI	APPROVED <i>[Signature]</i> F. DENNERT	THREE PHASE HORIZONTAL ANGLE 30° - 60° CROSSARM	
	ORIGINAL ISSUE DATE: SEPTEMBER 1985				
	Bchydro DISTRIBUTION STANDARDS				
			PAGE 1 OF 2	ES43 G4-09.01	R. 4

DRAFTER: DM/DC R. 9- INCREASED PHASE TO NEUTRAL SPACING, MAY '10 CP R. 10- ADDED APPLICATION TABLE, NOV. '12 PY



APPLICATION

Line Voltage	Lowest Ambient Temp	Conductor Tension	Maximum Ruling Span	Maximum Span Length
25 kV	-40°C	Reduced	50 m	70 m
	-10°C	Regular	75 m	95 m
35 kV	-40°C	Not recommended (use alternate stds)		
	-10°C	Regular	50 m	70 m

NOTES:

1. For additional phase spacing, centre pin may be installed 300 minimum from side of pole for 25 kV, 420 minimum for 35 kV.
2. For 35 kV insulate accordingly.
3. Use 3/4" crossarm bolt with 3" washers.
4. For AWG #2 conductor, maximum allowable line angle is 45°.

ES43 N2-01.01	Neutral Assembly	✓
ES43 G2-01.02	Crossarm Assembly	✓
ES43 G1-01.04	Neutral Location	✓
ES43 G1-01.01	Phase Spacing	✗
ES43 E2-10	Guy Assembly	✓

REFERENCE DRAWINGS

DESIGNER	RECOMMENDED	APPROVED
P. YANG	C. PICASSI	F. DEHART
ORIGINAL ISSUE DATE: MARCH 1964		

BASIC LINE STRUCTURES
THREE PHASE
ANGLE 5° - 25°, FLAT

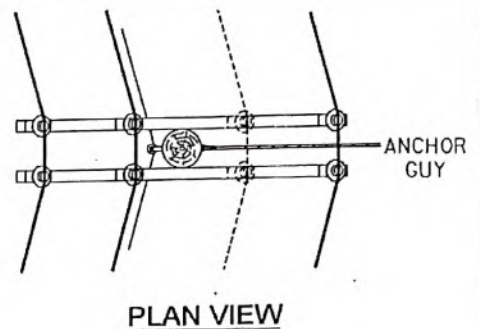
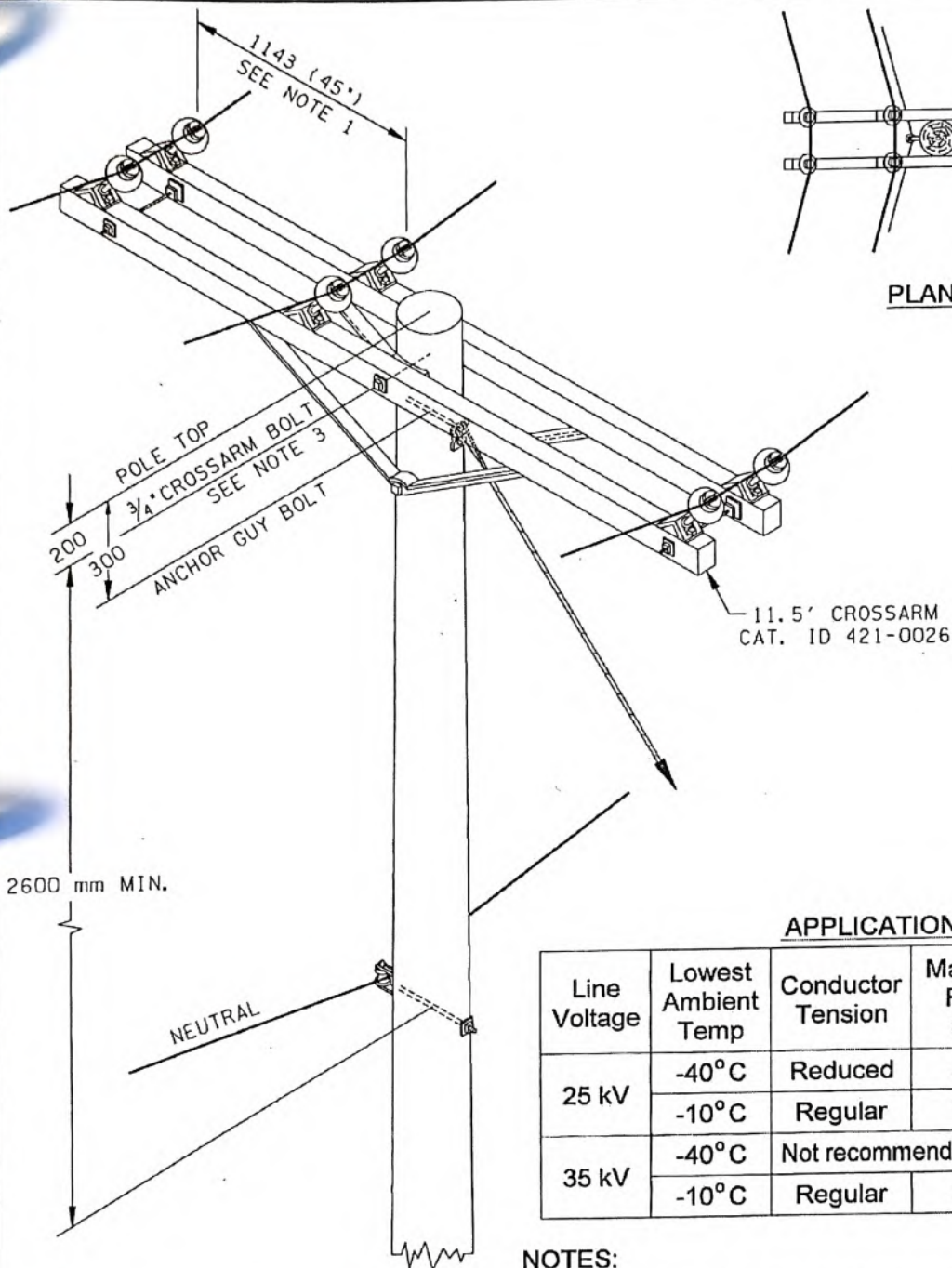
BChydro DISTRIBUTION STANDARDS

PAGE 2
OF 3

ES43 G4-10.02

R.10

R. 0- 11.5' DOUBLE CROSSARM ANGLE, NOV'12 PY R. 1- DRAW BEHIND V-BRACE, FEB'14 PY



APPLICATION

Line Voltage	Lowest Ambient Temp	Conductor Tension	Maximum Ruling Span	Maximum Span Length
25 kV	-40°C	Reduced	50 m	70 m
	-10°C	Regular	75 m	95 m
35 kV	-40°C	Not recommended (use alternate stds)		
	-10°C	Regular	50 m	70 m

NOTES:

1. For additional phase spacing, centre pin may be installed 300 minimum from side of pole for 25 kV, 420 minimum for 35 kV.
2. For 35 kV insulate accordingly.
3. Use 3/4" crossarm bolt with 3" washers.

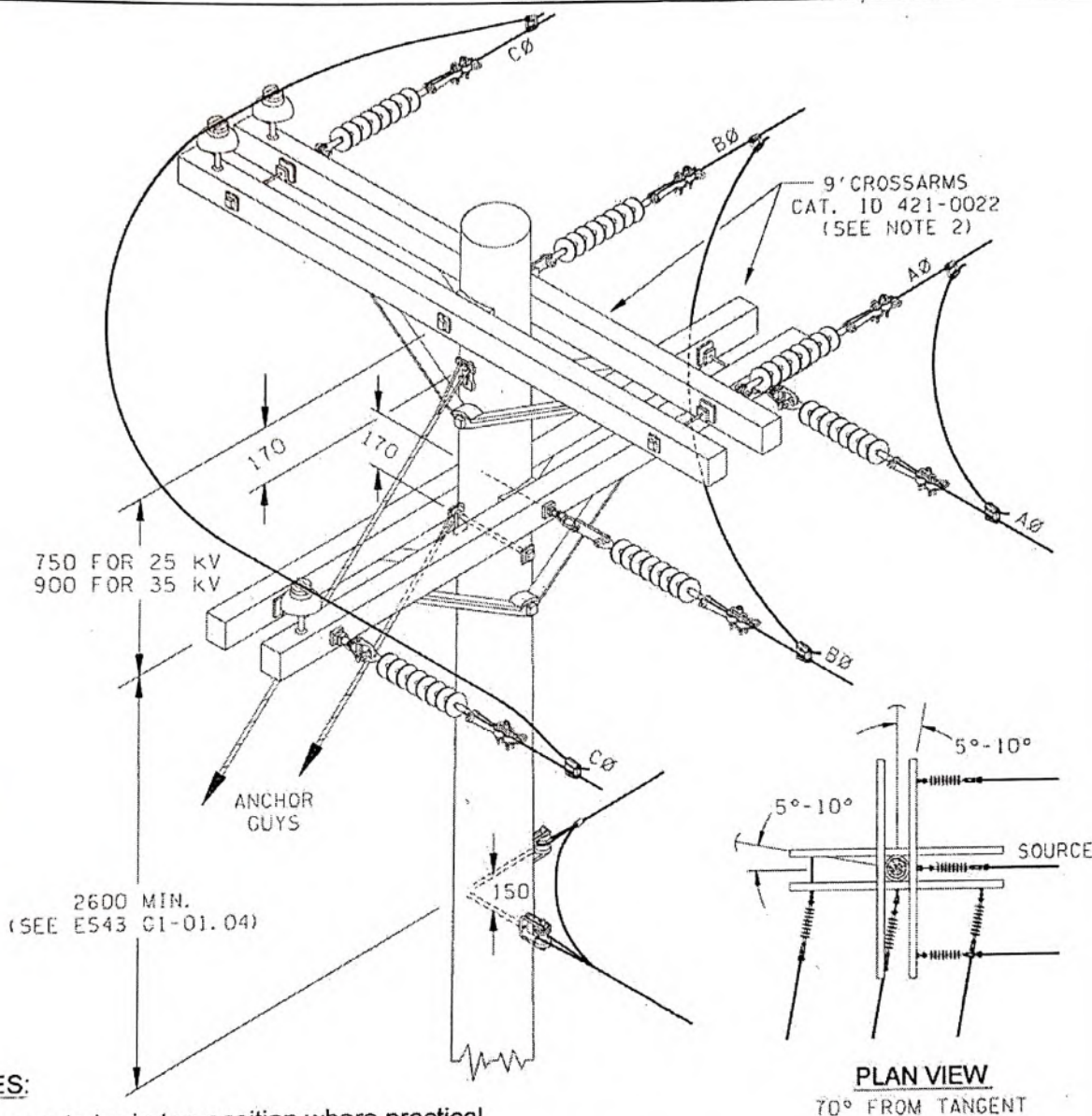
- REFERENCE DRAWINGS
- ES43 N2-01.01 Neutral Assembly ✓
 - ES43 G2-01.03 Crossarm Assembly ✓
 - ES43 G1-01.04 Neutral Location ✓
 - ES43 G1-01.01 Phase Spacing ✗
 - ES43 E2-10 Guy Assembly ✓

DESIGNER P. YANG	RECOMMENDED C. PICASSI	APPROVED F. DENNERT
ORIGINAL ISSUE DATE: NOVEMBER 2012		



BASIC LINE STRUCTURES
THREE PHASE
ANGLE 25° - 45°, FLAT

R.12- ANCHOR LOCATION REV. FEB. '05 FLK R.13- PHASE TO NEUTRAL SPACING, NOV'12 PY



NOTES:

1. Source to be in top position where practical.
2. 5" x 7" timbers required when dead-ending larger than 2/0.
3. Refer to ES43 G2-04.01 for dead-end shackle requirement.
4. See ES43 G4-11.02 for alternate phasing.
5. "A" phase normally to be located on north and east sides of pole.
6. For 35 kV insulate accordingly.
7. For road crossings, span from lower arm position to lower arm position maintains same elevation.

N2-01-01 NEUTRAL ASSEMBLY
 ES43 G2-01.03 Crossarm Assembly ✓
 ES43 G1-01.04 Neutral Location ✓
 ES43 E2-10 Guy Assembly ✓
 ES43 N2-01.01 Neutral Dead-End ✓
 ES43 G2-04.01 Primary Dead-End ✓

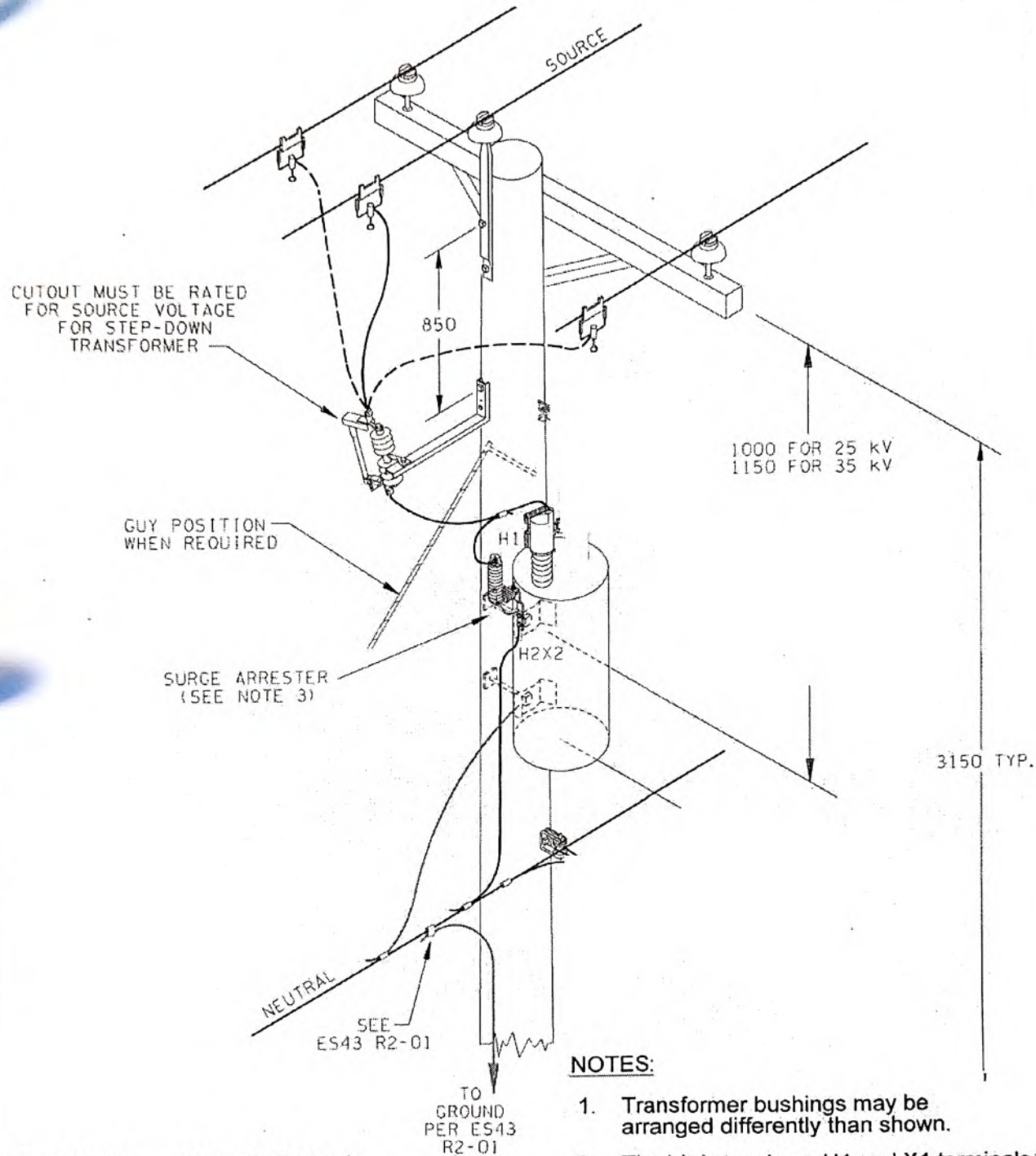
REFERENCE DRAWINGS

DESIGNER	RECOMMENDED	APPROVED
<i>[Signature]</i>	C. PICASSI	F. DENHART

ORIGINAL ISSUE DATE: MARCH 1964

THREE PHASE CORNER
 45° - 90°

R. 2- ADDED DIMENSION, JAN. '01 FLK
 R. 3- ADDED SURGE ARRESTER, REVISED GROUNDING & CLEARANCES, FEB. '10 AJ
 R. 4- REV. CLEARANCE TO NEUTRAL, NOV. '12 AJ



ES43 R2-01 Ground Electrode
 ES43 R3-01 Tank Grounding
 ES43 K6-01 Fusing Schedule
 ES43 K2-05 Single Phase Tap

REFERENCE DRAWINGS

DESIGNER <i>A. Jacob</i> A. JACOB	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Dennert</i> F. DENNERT
---	--	---

ORIGINAL ISSUE DATE: DEC 1991

SINGLE PHASE TRANSFORMER FRAMING STEP-DOWN TAP, POLE MOUNTED

BChydro DISTRIBUTION STANDARDS

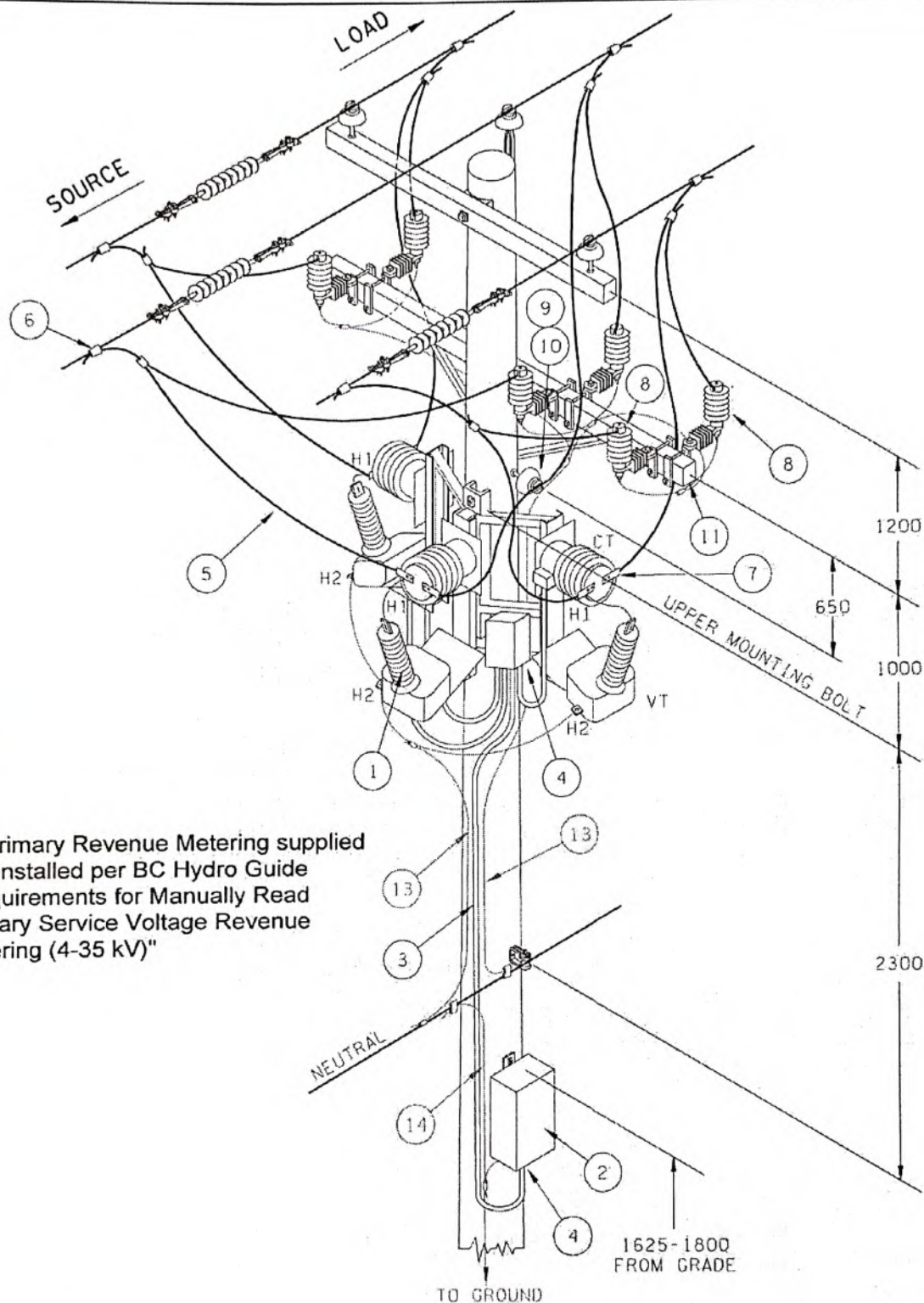
PAGE 1
OF 2

ES43 J2-09.01

R. 4

R. 2- GENERAL REVISION. WAS SHEET 2. MAY '01 SC R. 3- GRND. WIRE CHANGE. NOV '12 MK

All Primary Revenue Metering supplied and installed per BC Hydro Guide "Requirements for Manually Read Primary Service Voltage Revenue Metering (4-35 kV)"



DRAFTER: DM

DESIGNER
M. KELVIN

RECOMMENDED
C. PICASSI

APPROVED
F. DENHART

ORIGINAL ISSUE DATE: JULY 1998

PRIMARY REVENUE METERING THREE PHASE FOUR WIRE

BC Hydro  DISTRIBUTION STANDARDS

PAGE 1
OF 4

ES43 J7-01.01

R. 3

ITEM #	DESCRIPTION	STOCK NO.	QUANTITY
1	METERING KIT		1
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 10-5	362-6037	
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 25-5	362-6330	
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 50-5	362-6039	
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 100-5	362-6031	
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 200-5	362-6032 ←	
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 300-5	362-6033	
	25kV class, 3Ph., 4 wire, VT: 14,400-120, CT: 400-5	362-6034	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 10-5	362-5037	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 25-5	362-5330	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 50-5	362-5039	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 100-5	362-5031	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 200-5	362-5032	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 300-5	362-5033	
	15kV class, 3Ph., 4 wire, VT: 7,200-120, CT: 400-5	362-5034	
	15kV class, 3Ph., 3 wire, VT: 12,500-120, CT: 400-5	Contact RMSM	
	25kV class, 1Ph., 2 wire, VT: 14,400-120, CT: 10-5	362-6117	
	25kV class, 1Ph., 2 wire, VT: 14,400-120, CT: 25-5	362-6110	
	15kV class, 1Ph., 2 wire, VT: 7,200-120, CT: 10-5	362-5117	
	15kV class, 1Ph., 2 wire, VT: 7,200-120, CT: 25-5	362-5110	
2	METER CABINET	372-9204	1
3	TECK CABLE		10m
	11 conductor, for 3 ph	380-4545	
	4 conductor, for 1 ph	380-4555	
4	CABLE FITTING		2
	11 conductor, for 3 ph	390-1125	
	4 conductor, for 1 ph	390-1122	
5	POLYETHYLENE COVERED CONDUCTOR		As required
	200 amps and less: #2 Cu	380-0256	
	201 to 400amps: 4/0 Cu	380-0261	
6	AMPACT CONNECTORS		$\frac{3 \text{ Ph } 1 \text{ Ph}}{9 \quad 3}$
	#2 ACSR TO #2 Cu	388-0531	
	366.4 ASC TO 4/0 Cu	388-0825	
7	COMPRESSION SPADE CONNECTORS		$\frac{3 \text{ Ph } 1 \text{ Ph}}{6 \quad 2}$
	#2 Cu	388-1030	
	4/0 Cu	388-1035	
8	SURGE ARRESTERS		$\frac{3 \text{ Ph } 1 \text{ Ph}}{6 \quad 2}$
	9kV rating, for 7.2 / 12.5kV system	351-0013	
	18kV rating, for 14.4 / 25kV system	351-0016	
9	PIN INSULATOR 14.4 / 25kV	410-0649	1
10	DROP LEAD INSULATOR PIN	421-0311	1
11	9' CROSS ARM	421-0022	1
12	INSULATOR, HORIZONTAL LINE POST, 25kV	410-0681	1
13	#4 AWG PE COVERED Cu CONDUCTOR	380-5051	As required
14	THEFT DETERRENT GROUNDING WIRE	96006427	As required

DESIGNER

M. KELVIN

RECOMMENDED

C. PICASSI

APPROVED

F. DENNERT

PRIMARY REVENUE METERING
BILL OF MATERIAL

ORIGINAL ISSUE DATE: JUNE 2001

BChydro  DISTRIBUTION STANDARDSPAGE 4
OF 4

ES43 J7-01.04

R. 3

DRAFTER: DM

IMPORTANT:

Machine bolt **must** be installed in upper bracket hole. Install cutout and arrester **after** the bracket has been mounted. Bottom machine bolt may be replaced with fetter drive screw (101-0258).

EQUIPMENT MOUNTING BRACKET
CAT. ID 350-5295 OR CAT. ID 350-5297
SEE NOTES 1 AND 2

5/8" MACHINE BOLT
CAT. ID 100-20XX

SEE NOTE 2

ARRESTER LOCATION
SEE NOTE 1

CUTOUT LOCATION
SEE NOTE 1

CROSSARM MOUNT

NOTES:

1. Bracket (Cat. ID 350-5295) has two 1/2" mounting bolts. The outermost bolt is to be used for cutout mounting, the innermost bolt for mounting of surge arrester. Bracket (Cat. ID 350-5297) has only one 1/2" bolt for either cutout or arrester.
2. On concrete poles use stainless steel band (Cat. ID 240-0203) in the lower hole position to prevent bracket rotation.

CUTOUT OR ARRESTER LOCATION

5/8" HELICAL
SPRINGWASHER
CAT. ID
102-4158

50 mm x 50 mm
SQUARE WASHER
CAT. ID 420-1521

POLE MOUNT

CROSSARM

75
MIN.

EQUIPMENT MOUNTING
BRACKET CAT. ID 350-5296

R.2- NEW TITLE BLOCK, REPLACE FETTER
DRIVE SCREW W/ MACHINE BOLT, NOV. 12 MW

R.1- REDRAWN, MAY 2000 FLK

DRAFTER: DM

DESIGNER
M. WYNDHAM

RECOMMENDED
C. PICASSI

APPROVED
F. DENNERT

ORIGINAL ISSUE DATE: DECEMBER 1985

TAP FUSING AT TAP POLE
CUTOUT AND ARRESTER MOUNTING
BRACKET SUB-ASSEMBLIES

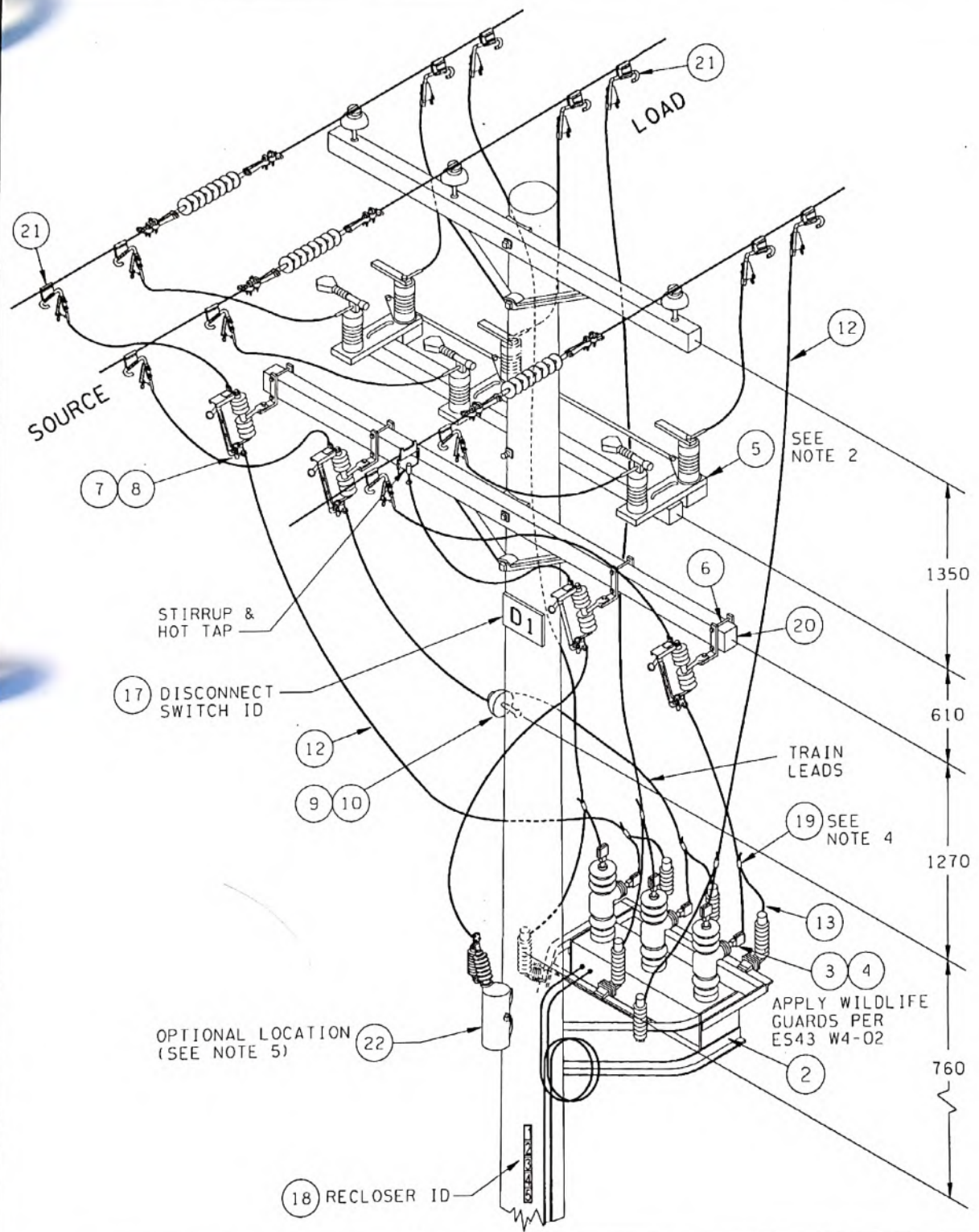
BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 1

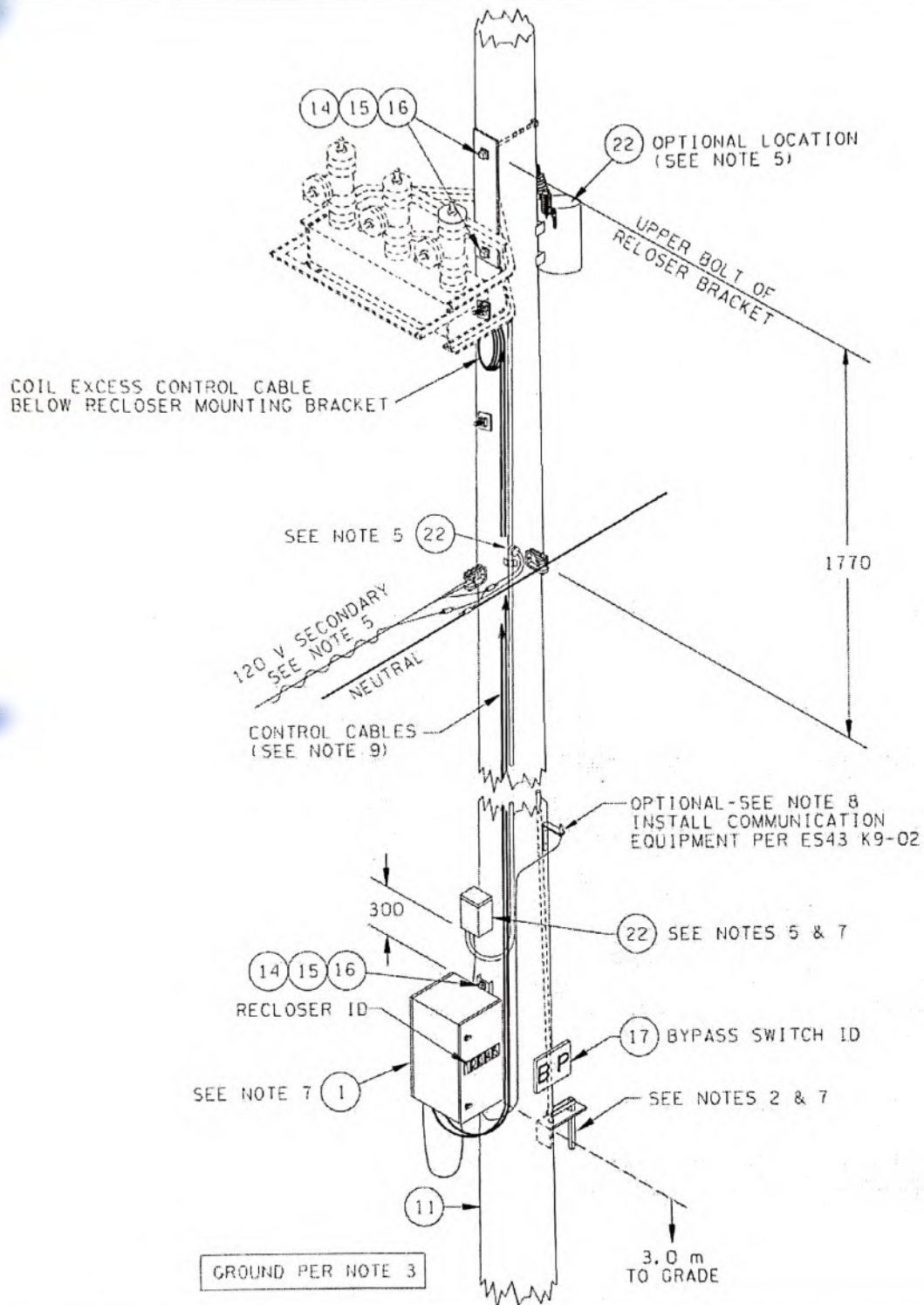
ES43 K2-01

R. 2

DRAFTER: DM/DC R.1- ADDED AMPACT DISCONNECTS, NOV'12 PF



DESIGNER <i>Phil</i> P. FOUND	RECOMMENDED <i>CGB</i> C. BEFUS	APPROVED <i>[Signature]</i> F. DENNERT	RECLOSERS 3PH GANGED 12.5 kV, 25 kV GOLB SWITCH BYPASS & CUTOUT DISCONNECTS		
ORIGINAL ISSUE DATE: NOVEMBER 2010					
BChydro  DISTRIBUTION STANDARDS			PAGE 1 OF 4	ES43 K3-06.01	R. 1



DRAFTER: DM/DC

DESIGNER
Paul
P. FOUND

RECOMMENDED
CJB
C. BEFUS

APPROVED
F. DENNERT
F. DENNERT

ORIGINAL ISSUE DATE: NOVEMBER 2010

RECLOSERS
3PH GANGED 12.5 kV, 25 kV
GOLB SWITCH BYPASS & CUTOUT DISCONNECTS

BChydro  DISTRIBUTION STANDARDS

PAGE 2
OF 4

ES43 K3-06.02

R. 1

NOTES:

1. This configuration is intended for 12.5 kV and 25 kV installations on three phase lines with load currents less than 300 A. This standard may also be used where bucket truck access is limited and GOLB bypass is preferred. For lines greater than 300 A load, see ES43 K3-05. Contact CPC Technologists for site commissioning.
2. Hookstick GOLB switch preferred for bucket operation only. Where ground access to GOLB bypass is required, install pipe operated GOLB switch (350-8078) and install operating rod insulator above neutral and below all primary voltage conductors. Consult field crews to determine choice of switch.
3. Install bonding and grounding per ES43 R3-04. For neutral to ground rod conductor use theft deterrent galvanized steel conductor per ES43 R2-01.
4. Surge arresters to be installed on both sides of recloser, and on the source transformer only if mounted one pole span away. Connect arrester to recloser drop leads using #4 Cu poly-covered conductor and a 2-bolt connector (item 19), covered with mastic tape (394-0296) and then two half-lapped layers of PVC tape (394-0306).
5. All power supply associated equipment to be installed per ES43 K9-01. Preference is to install a source transformer one pole span away to avoid congestion on the recloser pole. Test the transformer with the secondary wiring connected before energization. Power supply must be dedicated to the recloser.
6. Use poly-covered drop leads schedule per ES43 K1-01.01.
7. Install locks on control box, AC breaker box, and GOLB handle to prevent public access. Mount at height shown.
8. Refer to ES43 K9-02 for detail on mounting BC Hydro remote communications equipment. Carefully apply moisture seal and mount the antenna in the pole quadrant as shown in ES43 K9-02.
9. Connect PT supply cable to pole with P-clamps. Tie-wrap the control cables to armored cable. Coil excess control cable at the recloser mounting bracket.
10. A minimum 50 ft class 3 pole is required with flat tangent construction recommended. See ES43 G4-02.02. For clearances over highways or with additional shared services, a class 2 55 ft minimum height pole may be required.
11. If the recloser head is rotated 90 deg counter-clockwise to accommodate a different source/road side configuration, it must be properly re-attached to the tank. Centre the module over the tank lip and tighten the 4 securing bolts to 34-38 N·m (25-28 ft·lbs). Perform site survey and consult field crews to determine the ideal location for ladder and bucket access to the recloser control.

DRAFTER: DM/DC	DESIGNER <i>Paul</i> P. FOUND	RECOMMENDED <i>CB</i> C. BEFUS	APPROVED <i>[Signature]</i> F. DENNERT	RECLOSERS 3PH GANGED 12.5 kV, 25 kV GOLB SWITCH BYPASS & CUTOUT DISCONNECTS		
	ORIGINAL ISSUE DATE: NOVEMBER 2010					
	BChydro  DISTRIBUTION STANDARDS			PAGE 3 OF 4	ES43 K3-06.03	R. 1

BILL OF MATERIAL

Item No.	Description	Cat ID	Quantity
1	3 Ph Cooper Form 6 Control	96004906	1
2	3 Ph Cooper Nova - Recloser Head w/18 kV MCOV Application Surge Arresters	96004903	1
3	Wildlife Guard - vertical bushing	96006524	3
4	Wildlife Guard - horizontal bushing	96006525	3
5	25 kV, 600 A GOLB Switch, w/hookstick mech.	96005871	1
or	25 kV, 600 A GOLB Switch, w/pipe handle mech.	350-8078	1
6	Crossarm Cutout Mounting Bracket	350-5296	3
7	14.4/25 kV Cutout, Polymer body	96005747	3
8	Blade, Disconnect, Solid, 300 A	350-5271	3
9	Crossarm Insulator Pin	421-0307	1
10	Pin Insulator, 14.4/25 kV	410-0649	1
11	Pole, Pwr, 50 ft., CL3, Dist (see note 10)	960XXXXX	1
12	Wire/cable, 2/0 AWG, soft, 19 Str., PE cover (see note 6)	380-0259	as req'd
13	Wire/cable, #4 AWG, 1C, Copper, Stranded, PE cover	380-5051	as req'd
14	Machine Bolt (3/4" x Length)	100-XXXX	4
15	Square Washer (75 mm x 75 mm)	420-1525	4
16	Helical Spring Washer (3/4")	102-4160	4
17	Plate, Pocket Panel, Horizontal, 2 spaces, 110 mm long, 120 mm wide	96006326	2
18	Plate, Pocket Panel, Vertical, 6 spaces, 65 mm long, 600 mm wide	96005904	1
19	Connector, 2 Bolt, 4/0 Run, #6 - 4/0 Tap, w/Separator (see note 4)	388-0353	6
20	Crossarm, 9'	421-0022	1
21	Ampact Stud Disconnect	F5-11.02	12
or	suitably rated connector	K1-01.02	12
22	Power Supply (see note 5)	K9-01	1

ES43 K5-06 GOLB Switch Sectionalizing
 ES43 K1-01.02 Connector Selection
 ES43 K1-01.01 Drop Leads
 ES43 G2-01 Crossarm Assemblies
 ES43 G1-11 Equipment Boxes on Poles
 ES43 F6-04 Installation of Wedge-Tap Connectors
 ES43 F5-11 Ampact Stud Disconnect

ES43 K9-01 Power Supply Transformer
 ES43 K9-02 Remote Communication
 ES43 W4-02 Cooper Recloser Guard
 ES43 R3-07 GOLB Switch Handle Grounding
 ES43 R3-04 Recloser Grounding
 ES43 R2-01 Ground Electrode Installation

REFERENCE DRAWINGS

DESIGNER <i>Paul</i> P. FOUND	RECOMMENDED <i>CB</i> C. BEFUS	APPROVED <i>[Signature]</i> F. DENNETT
-------------------------------------	--------------------------------------	--

ORIGINAL ISSUE DATE: NOVEMBER 2010

RECLOSERS
 3PH GANGED 12.5 kV, 25 kV
 GOLB SWITCH BYPASS & CUTOUT DISCONNECTS

BChydro  DISTRIBUTION STANDARDS

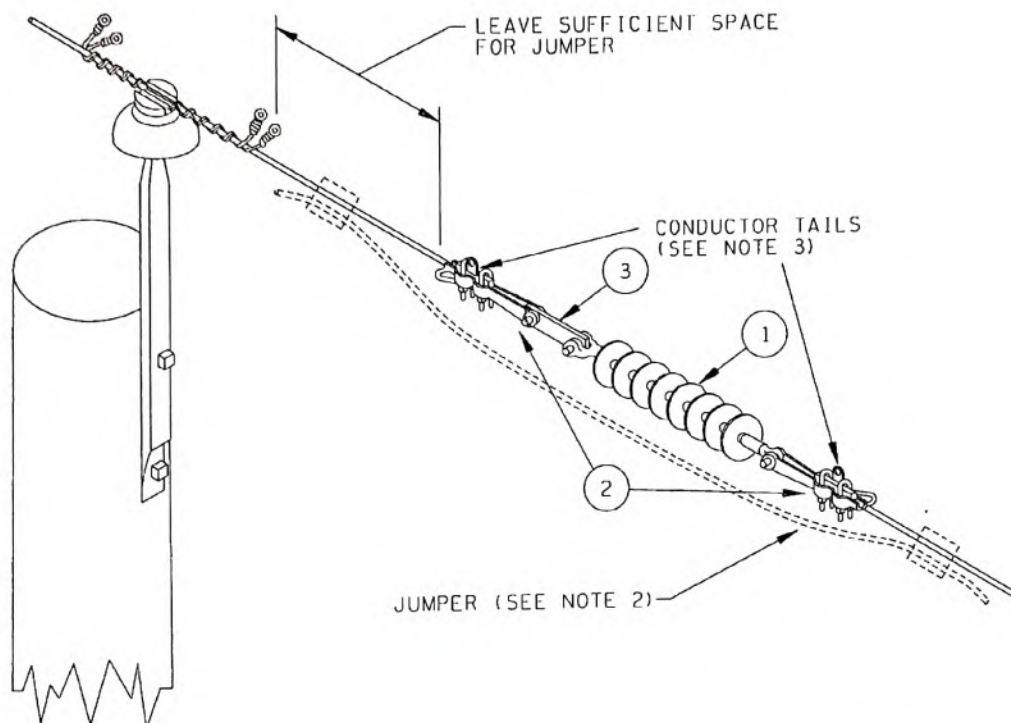
PAGE 4
OF 4

ES43 K3-06.04

R. 1

DRAFTER: DM/DC

R.2- REDRAWN '00-03-01 FLK R3- MOVED FROM ES43 K3-01, MATERIALS. NOV' 12 GR
 DRAFTER: DM/DC



NOTES:

1. This insulator is applicable for voltages up to 19.9/35 kV with medium contamination levels. For 19.9/35 kV with heavy contamination levels, contact Distribution Standards.
2. To temporarily jumper the line break, use same conductor as line conductor and wedge-tap connectors.
3. Conductors shall not extend beyond the dead-end clamp and tails should be kept short. Jumpers and leads must be attached to the primary conductor as shown.

BILL OF MATERIAL

Item No.	Description	Catalogue ID	Quantity
1	DS-35 Polymeric Suspension Insulator*	410-1027	1
2	Dead-End Clamp: #2 AWG Al to 2/0 ACSR	413-0579	2
or	Dead-End Clamp 3/0 ACSR to 336.4 ASC	413-0580	2
or	Dead-End Clamp #6 to 1/0 AWG Cu	413-0581	2
or	Dead-End Clamp 1/0 to 4/0 AWG Cu	413-0573	2
3	Extension Link (125 mm)	420-1009	1

* See note 1

ES43 G2-04.02 Suspension Insulator
REFERENCE DRAWINGS

DESIGNER <i>G. Rincham</i> G. RINCHAM	RECOMMENDED <i>C. Befus</i> C. BEFUS	APPROVED <i>F. Dement</i> F. DEMENT
ORIGINAL ISSUE DATE: DECEMBER 1985		

SECTIONALIZING
IN-LINE (FLYING) PRIMARY
BREAK SUB-ASSEMBLY

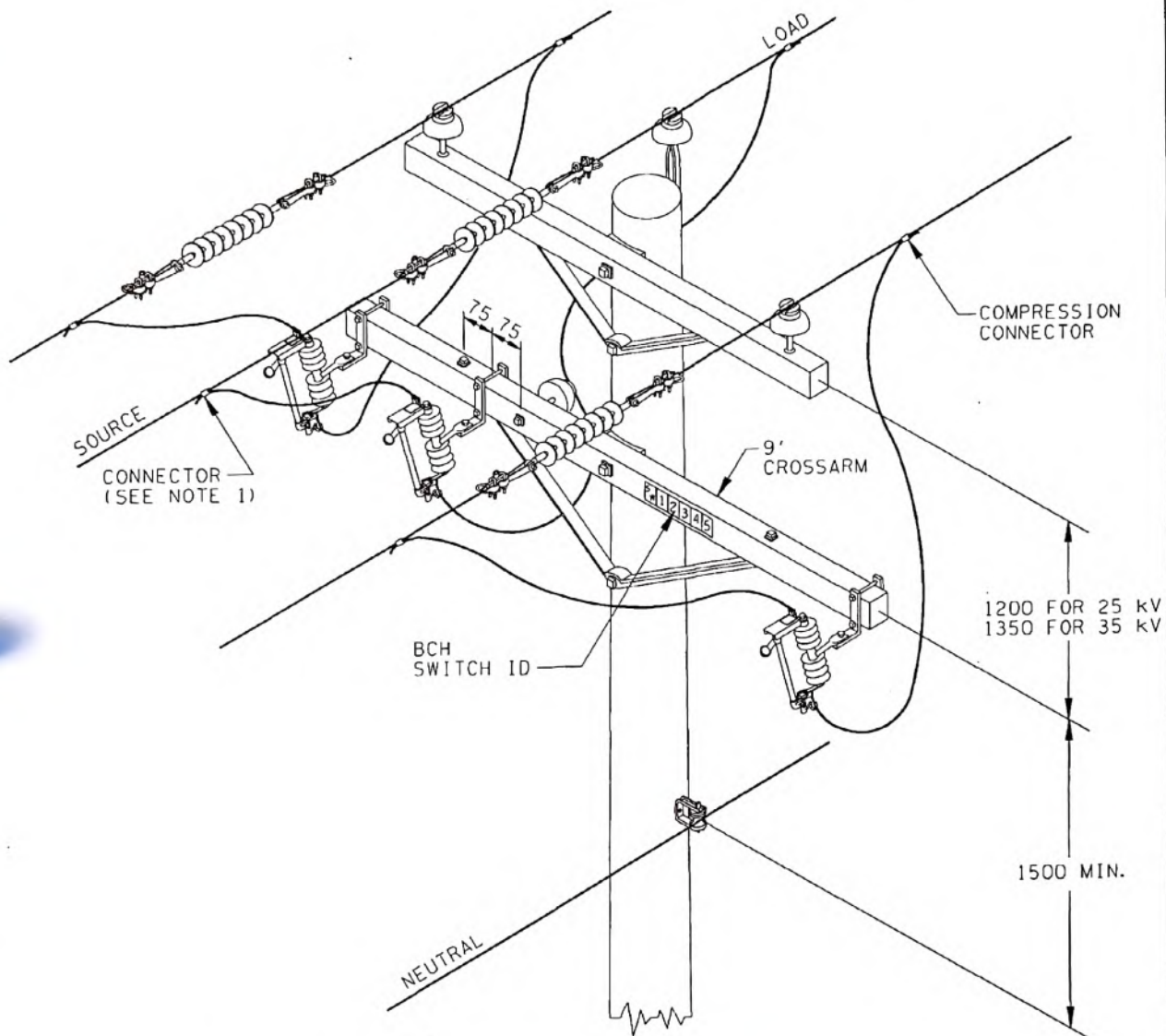
BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 K5-01

R. 3

DRAFTER: DM/DC R.4- INCREASED PHASE TO NEUTRAL SPACING. MAY '10 CP R.5- FORMAT, SPACING, NOV '12 GR



ES43-K5-01 SECTIONALIZING IN LINE WITH PRIMARY BREAK
 ES43-K2-01 CUTOUT BRACKET

DESIGNER <i>G. RINGHAM</i> G. RINGHAM	RECOMMENDED <i>C. BEFUS</i> C. BEFUS	APPROVED <i>F. DENHART</i> F. DENHART
---	--	---

SECTIONALIZING
THREE PHASE WITH CUTOUTS

ORIGINAL ISSUE DATE: DECEMBER 1985

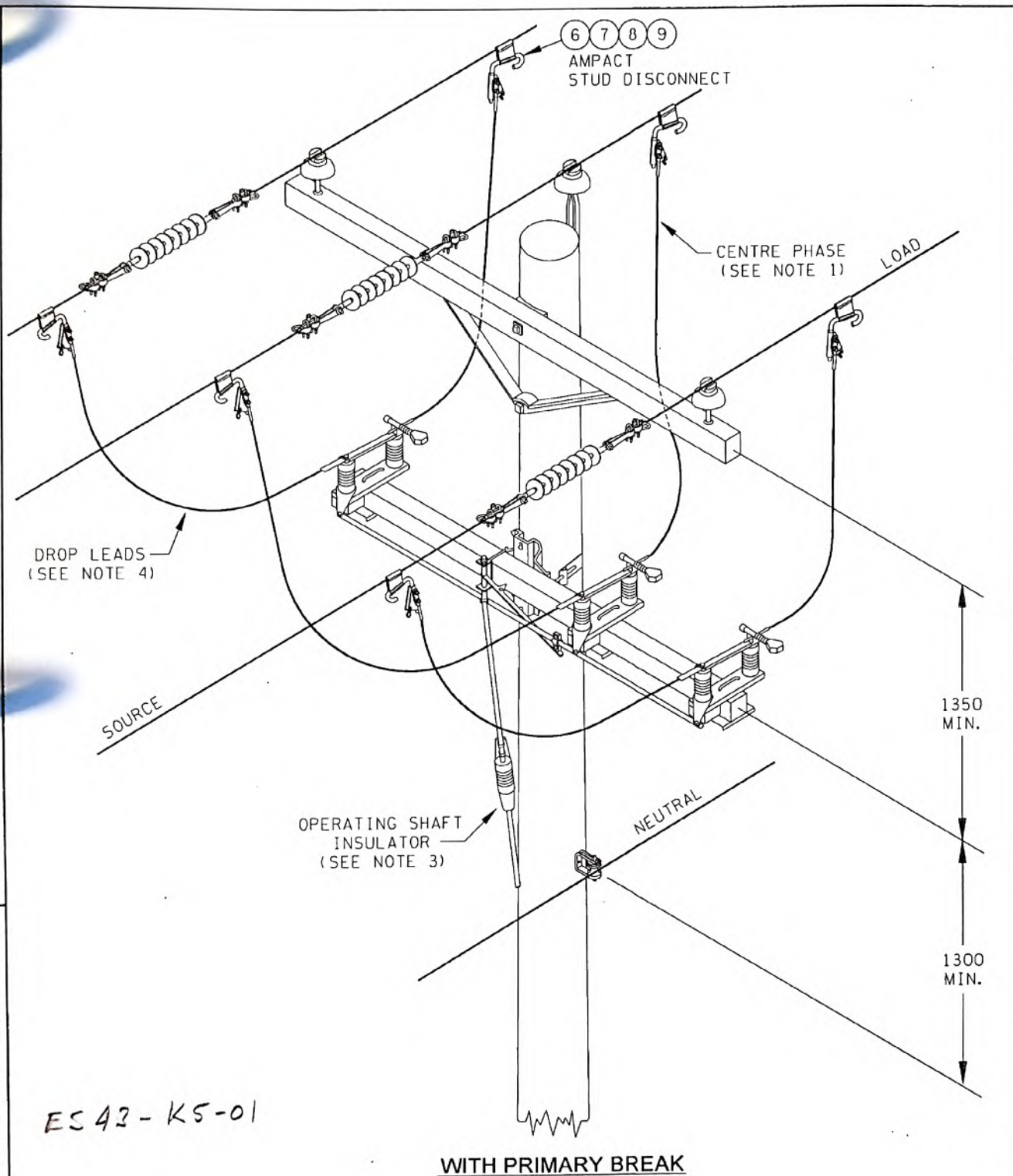
BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 2

ES43 K5-04.01

R. 5

DRAFTER: DM/DC R. 3- REVISED SWITCH, MAY '09 KM R. 4- AMPACT CONNECTORS, SHEETS COMBINED, SPACING, NOV '12 GR



DESIGNER G. RINGHAM	RECOMMENDED C. BEFUS	APPROVED F. DENNERT	SECTIONALIZING THREE PHASE WITH GOLB SWITCH	
ORIGINAL ISSUE DATE: DECEMBER 1985			PAGE 1 OF 4	ES43 K5-06.01 R. 4
BChydro DISTRIBUTION STANDARDS				

R.2- MEDIUM ANGLE & NOTE 2, NOV. '01 BF R.3- ADDED NEW FIG. C & B of M. NOV. '12 PY

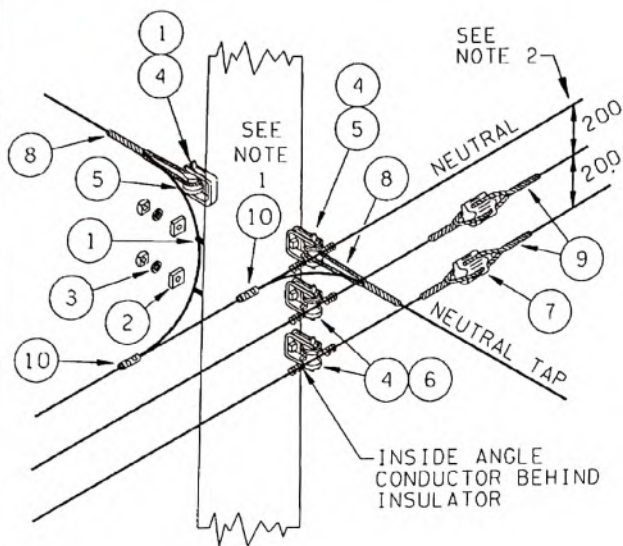


FIG. A
Secondary Tangent, Neutral Tap
and Secondary Cut

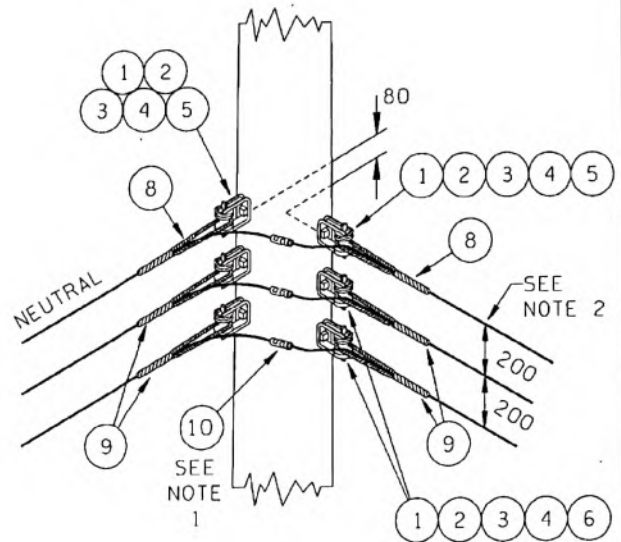


FIG. B
Secondary Heavy Angle

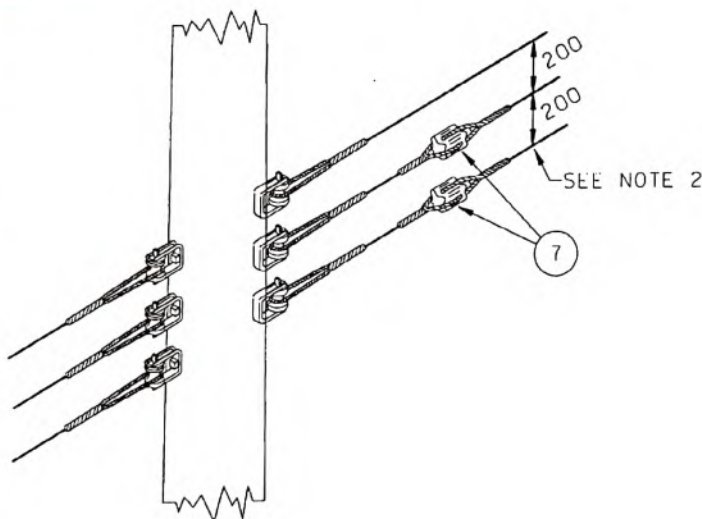


FIG. C
Secondary Dead-End and Cut

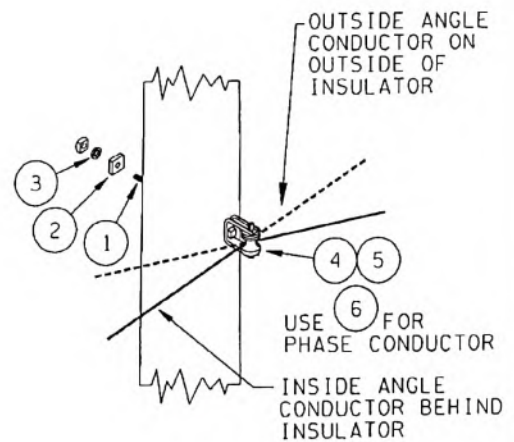


FIG. D
Small-Medium Angle Neutral

DESIGNER	RECOMMENDED	APPROVED
<i>[Signature]</i> P. YANG	C. PICASSI	<i>[Signature]</i> F. DENNERT

ORIGINAL ISSUE DATE: NOVEMBER 1985

SERVICE CONNECTIONS TYPICAL SECONDARY/NEUTRAL STRUCTURES

BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 3

ES43 N2-01.01

R. 3

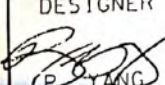
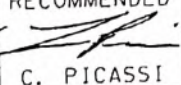
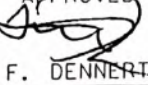
NOTES:

1. See Section F for compression connector selection.
2. Ensure 200 mm clevis spacing for 60m maximum span and 250 mm for 75 m maximum span.
3. See ES43 N2-01.01 for typical construction/material details.
4. 2nd/3rd Voltage: Split Phase 120/240 V, 3 Phase 120/208 V, or 347/600 V.
5. 120/240 V phase conductors must be below the neutral. Three phase voltages must be above the neutral, with the highest voltage at the highest level. A service taken directly from the transformer(s) per Figure E may be treated as an exception.
6. Don't mix non-standard and standard, grounded and ungrounded system.

BILL OF MATERIAL

Item No.	Description	Catalogue ID	Quantity			
			A	B	C	D
1	Machine bolt (5/8" x length)	100-XXXX	3	6	3	1
2	Square Washer (50mm x 50mm)	420-1521	3	6	-	1
3	Lock Washer (5/8")	102-4158	3	6	-	1
4	Secondary Clevis	413-0051	4	6	6	1
5	Neutral Spool Insulator (White)	410-0500	2	2	2	1
6	Phase Spool Insulator (Brown)	410-0501	2	4	4	-
7	Strain Insulator	410-1208	2	-	2	-
8	Grip for Bare Neutral	413-054X	2	2	2	-
9	Grip for Insulated Secondary	413-05XX	4	4	4	-
10	Compression Connector	388-XXXX	2	3	-	-

ES43 Section F Conductors and Connectors
ES43 N1-01.02 General Secondary Ties
ES43 N1-01.01 General-Secondary Voltages/Conductors, Neutral Conductors
REFERENCE DRAWINGS

DESIGNER  C. YANG	RECOMMENDED  C. PICASSI	APPROVED  F. DENNERT
--	--	---

ORIGINAL ISSUE DATE: NOVEMBER 1985

SERVICE CONNECTIONS
TYPICAL SECONDARY STRUCTURES
BILL OF MATERIAL AND NOTES

BChydro  DISTRIBUTION STANDARDS

PAGE 3
OF 3

ES43 N2-01.03

R. 3

DRAFTER: DM

SECTION R - BONDING AND GROUNDING

ES43 R1

DEFINITIONS AND PRACTICES

R1-01

ES43 R2

GROUND ELECTRODE INSTALLATIONS

R2-01

Ground Rods at Wood Poles and Multiple Ground Rods

R2-02*

Ground Rods at Concrete Poles

R2-03

Grounding Plates at Wood Poles

R2-04*

Grounding Plates at Concrete Poles

R2-06

Pole Ground Retrofit in Rocky Areas - Vertical Plate Method

R2-07

Pole Ground Retrofit in Rocky Areas - Horizontal Plate Method

R2-08

List of Components and Notes

ES43 R3

EQUIPMENT

R3-01.01

Polemounted Transformers

.02

Platform Transformers

R3-02

Shunt Capacitors

R3-03

Voltage Regulators

R3-04.01

Reclosers - Supply One Span Away

.02

Reclosers - Supply on Pole

R3-05.01

Three Phase Primary Metering

.02

Single Phase Primary Metering

R3-06

Surge Arresters

R3-07

Air Break Switch Handles

R3-08

Street Light Bracket

R3-09*

Bonding of Concrete Poles

R3-10

Connection Details

R3-11

List of Components

ES43 R5

SYSTEM NEUTRAL GROUNDING

R5-01

ES43 R6

GROUNDING IN HIGH CORROSION AREAS

R6-01

ES43 R7

OTHER UTILITIES

R7-01

Grounding Connections

* Not included with printed edition - see DSwiki at <http://edmbchwiki1/ES43.html>

DESIGNED

RECOMMENDED

APPROVED

M. WYNDHAM

C. PICASSI

F. DENNERT

ORIGINAL ISSUE DATE: MAY 1986

BONDING AND GROUNDING: TABLE OF CONTENTS

BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 R0-01

R. 3

DRAFTER: DM R. 2- REDONE & REVISED, DEC. '00 BF R. 3- REDONE & REVISED, NOV '12 MW

R. 1-BONDING DEFINITION, DEC. '01 BF R. 2- PAGE 2 JOINT USE GROUNDS, JAN. '02 FLK R. 3- JOINT USE GROUNDS, A. '14 MS

DEFINITION, EXAMPLES AND PURPOSE

BONDING: the interconnection of metallic and semi-conductive parts which are not energized under normal operating conditions. The tying together of transformer tanks and capacitor mounting brackets, the connection of those tanks and brackets to the neutral, and the interconnection of cable neutrals at terminal poles are some examples.

GROUNDING: the connection of a metallic part or a group of metallic parts to a ground electrode.

GROUND ELECTRODE: a conducting part or parts in intimate contact with the earth for the purpose of connections to the earth. Ground rods, grounding plates and ground mats are some examples.

NEUTRAL: a conductor which returns the unbalanced load current back to the source. See ES43 R5-01 for more details.

PURPOSE OF BONDING:

Bonding eliminates voltage differences between metallic parts that are not intended to be energized. Voltage differences can cause equipment damage, danger to personnel, pole fires, and radio and television interference.

PURPOSE OF GROUNDING:

Grounding limits the voltage rise on metallic parts when they become energized inadvertently. As well, it provides a path back to the source for fault currents, thus enabling protective equipment to detect and clear faults more quickly.

Multiple grounding of the neutral will limit the voltage rise of the neutral for most line-to-ground and all line-to-neutral faults. It also provides multiple paths back to the source for fault currents, increasing the probability of detection and reducing clearing times.

TYPES OF GROUND ELECTRODES AND WHERE TO USE EACH

GALVANIZED STEEL GROUND ROD:

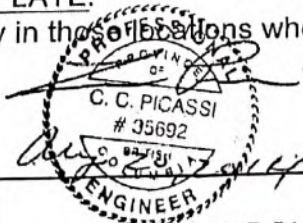
This is the general purpose ground rod and is to be used for most installations. It is also the least costly. NOTE: Except as specified in ES43 R6-01, copper ground rods must be avoided where possible as they may cause galvanic corrosion of adjacent anchor rod and steel ground rods.

COPPERCLAD STEEL GROUND ROD:

This ground rod is to be used in high corrosion areas ONLY as per ES43 R6-01.

GALVANIZED STEEL GROUNDING PLATE:

The grounding plate is to be used only in those locations where it is difficult or impossible to drive a ground rod.



DESIGNER	RECOMMENDED	APPROVED
M. SCHAEFER	C. PICASSI	F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING DEFINITIONS AND PRACTICES

SIZE OF BONDING AND GROUNDING CONDUCTORS

All bonding conductors shall be #4 AWG Copper minimum except those that are required to carry neutral currents. Any conductor that is to carry neutral currents must be selected for the expected maximum imbalance condition. See ES43 Section Y1 for ampacities of conductors.

All grounding conductors shall be theft deterrent grounding wire as shown in ES43 R2-01.

WHERE TO GROUND

A ground electrode shall be installed and connected to neutral at the following locations:

1. Along the line at sufficient frequency to satisfy the requirement of ES43 R5-01.
2. At all primary dead-ends.
3. At all poles with transformers, capacitors, regulators, reclosers, arresters, airbreak switches, metering outfits, and any other metal enclosure containing energized parts.

In addition, specific instructions on bonding luminaire brackets, terminal poles, casings, enclosures, etc. are contained in ES43 Section R3.

PROXIMITY OF DISTRIBUTION GROUND ELECTRODE TO TRANSMISSION STRUCTURE

In order to prevent a hazardous ground potential rise (GPR) on the distribution neutral during a phase to ground fault on a transmission structure, distribution ground electrodes must be installed a minimum of 10 m away from the base of a transmission structure.

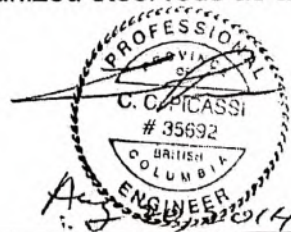
SAFETY TO THE PUBLIC AND OPERATING PERSONNEL

The standards in this section are designed to protect the public and operating personnel, when proper work methods and procedures are used, from excessive step and touch potentials.

JOINT USE COMMUNICATION GROUNDS

Ground electrodes installed by TELUS and BC Hydro third party communication licensees at joint use poles shall be installed in accordance with ES43 R2-01, leaving a coil of ground wire banded to the pole below the system neutral for subsequent connection to the system neutral by BC Hydro. At every pole ground electrode location, all non-current carrying metallic communication components must be bonded to the ground wire. Ground electrodes installed by Telus may use 3/4" diameter, 10' long, galvanized steel rods as an acceptable alternative to BC Hydro ground rods (Cat. ID 420-1093).

ES43 R6-01 High Corrosion Areas
ES43 R5-01 System Neutral Grounding
REFERENCE DRAWINGS



BONDING AND GROUNDING DEFINITIONS AND PRACTICES

DESIGNER	RECOMMENDED	APPROVED
M. SCHAEFER	C. PICASSI	F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

BChydro  DISTRIBUTION STANDARDS

PAGE 2
OF 2

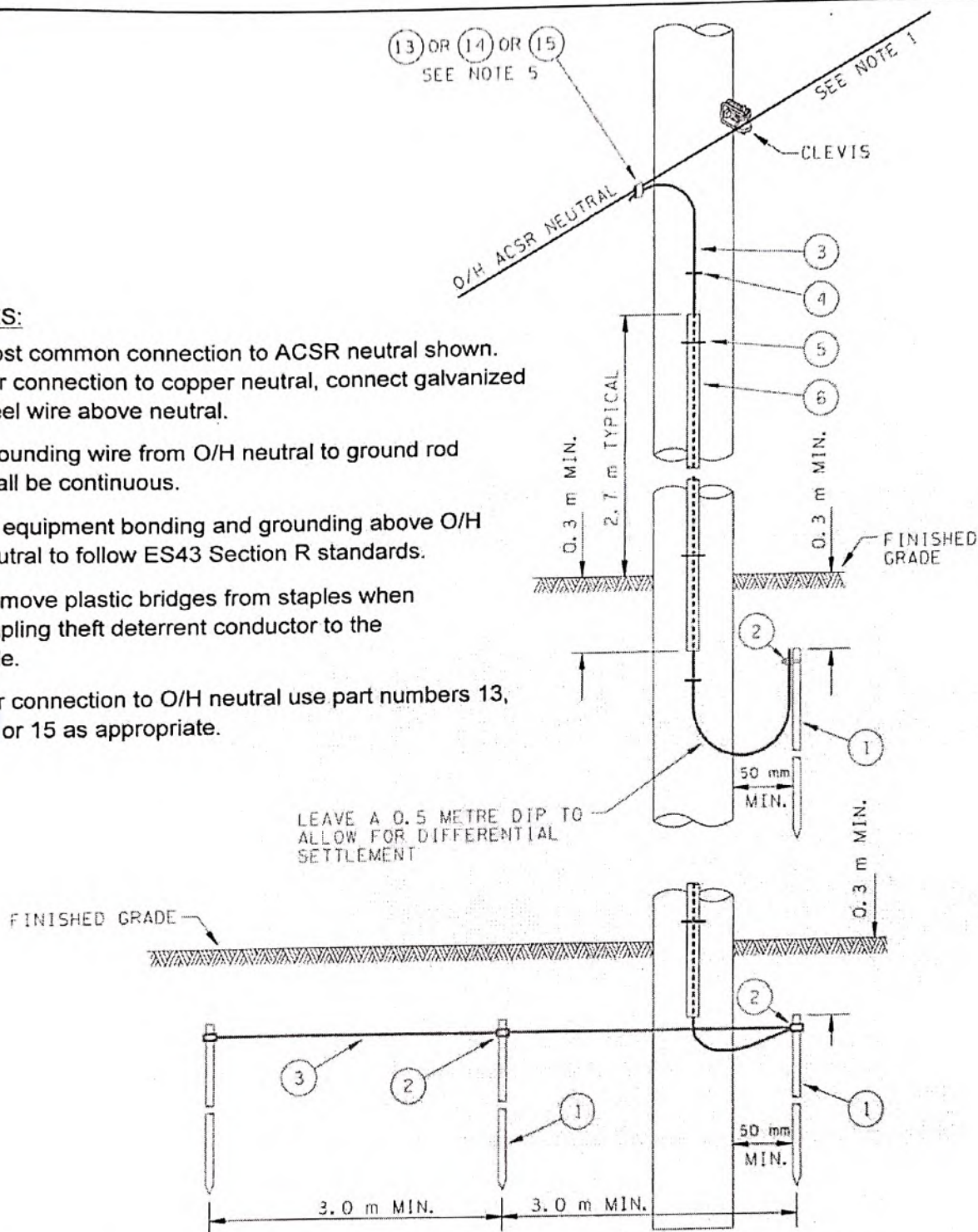
ES43 R1-01.02

R. 3

DRAFTED M

NOTES:

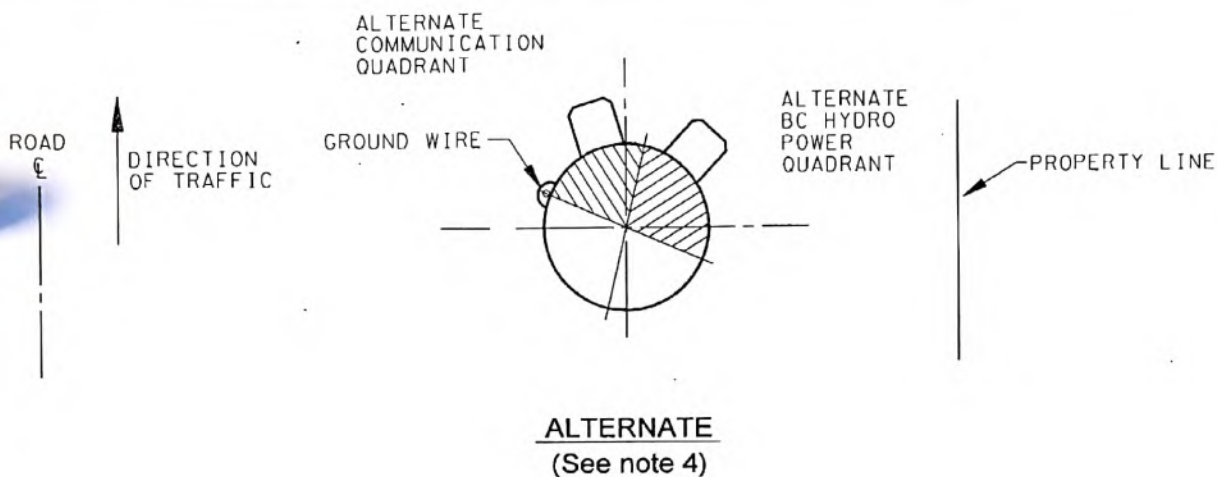
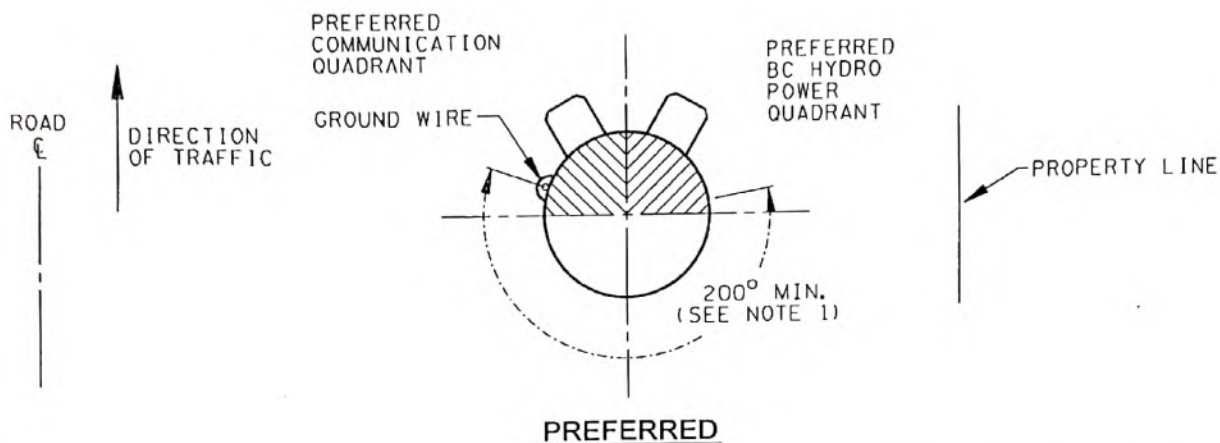
1. Most common connection to ACSR neutral shown. For connection to copper neutral, connect galvanized steel wire above neutral.
2. Grounding wire from O/H neutral to ground rod shall be continuous.
3. All equipment bonding and grounding above O/H neutral to follow ES43 Section R standards.
4. Remove plastic bridges from staples when stapling theft deterrent conductor to the pole.
5. For connection to O/H neutral use part numbers 13, 14 or 15 as appropriate.



ES43 R2-08 List of Components and Notes
REFERENCE DRAWINGS

DESIGNER	RECOMMENDED	APPROVED
M. WYNDHAM	C. PICASSI	F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

**BONDING AND GROUNDING
GROUND ELECTRODE INSTALLATIONS
GROUND RODS AT WOOD POLES
AND MULTIPLE GROUND RODS**



NOTES:

1. 200° min. of free pole space required at ground line to facilitate possible future pole replacement.
2. The placing of communication risers and power risers on the same pole should be avoided where practicable.
3. Communication cables and power cables are not permitted to share the same quadrant.
4. Use alternate location where communication pilaster is not permitted to project past road side of pole. Rotate quadrants accordingly.

DRAFTER: JW/DC

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Denney</i> F. DENNEY
---	--	---

ORIGINAL ISSUE DATE: JANUARY 1986

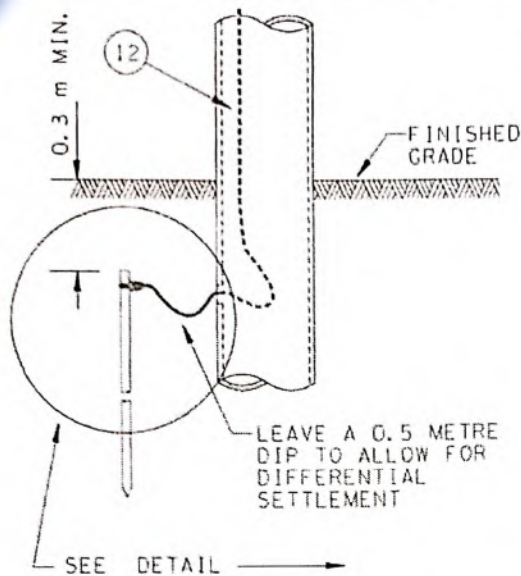
BONDING AND GROUNDING
GROUND ELECTRODE INSTALLATIONS
GROUND RODS AT WOOD POLES
AND MULTIPLE GROUND RODS

BChydro  DISTRIBUTION STANDARDS

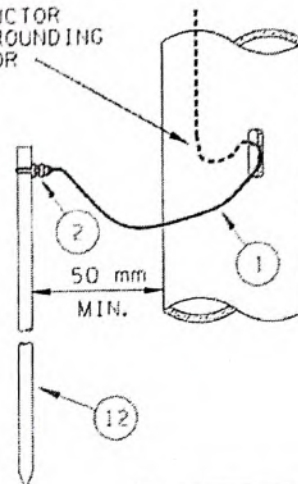
PAGE 2
OF 2

ES43 R2-01.02

R. 4

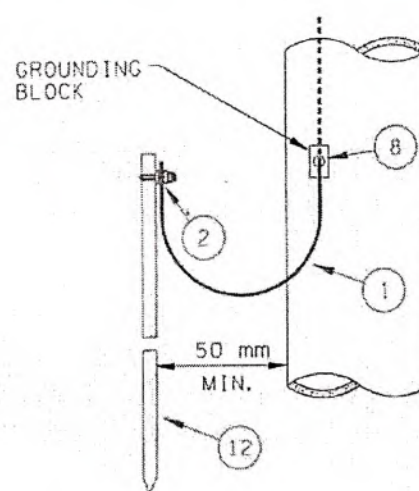
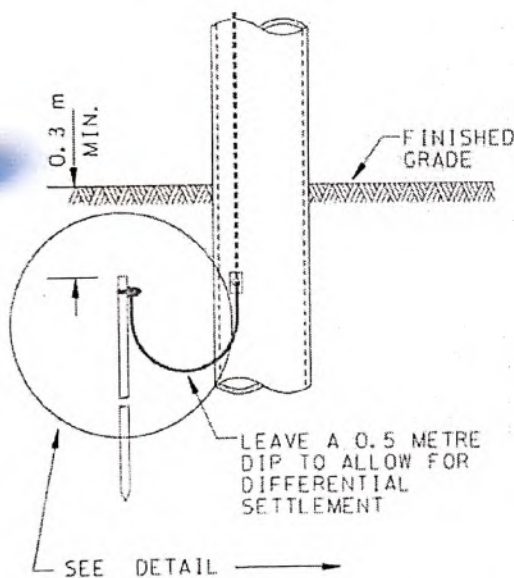


LEAVE ENOUGH CONDUCTOR SLACK FOR TELUS GROUNDING CONDUCTOR CONNECTOR



REMEDIAL STDS
Not to be used for new construction.

CONCRETE POLES WITH HANDHOLES



CONCRETE POLES WITH GROUNDING BLOCKS

NOTE:

1. For proper connection of theft deterrent wire to neutral, see ES43 R2-01.

ES43 R3-09 Bonding of Concrete Poles
ES43 R2-08 List of Components and Notes
ES43 R2-01 Ground Rods at Wood Poles and Multiple Ground Rods
REFERENCE DRAWINGS

DRAFTER: JW

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picasso</i> C. PICASSI	APPROVED <i>F. Denney</i> F. DENNEY
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING GROUND ELECTRODE INSTALLATIONS GROUND RODS AT CONCRETE POLES

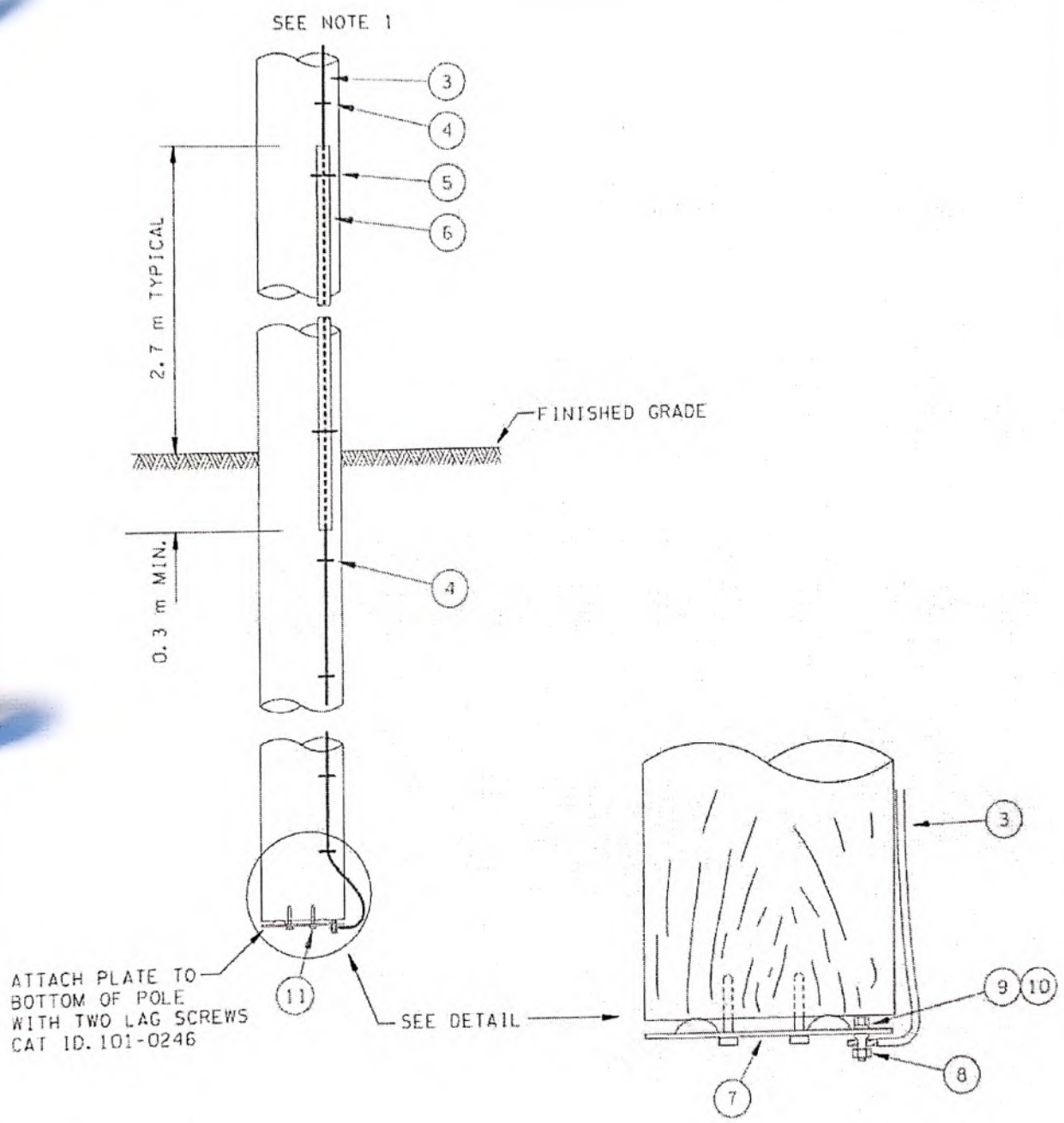
BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 R2-02

R. 4

R. 2-UPDATED FOR THEFT DET. GROUNDING. MAY '09 MP R. 3- ADDED NOTE 1. JULY '10 MW R. 4-MINOR EDITS. NOV '12 MW



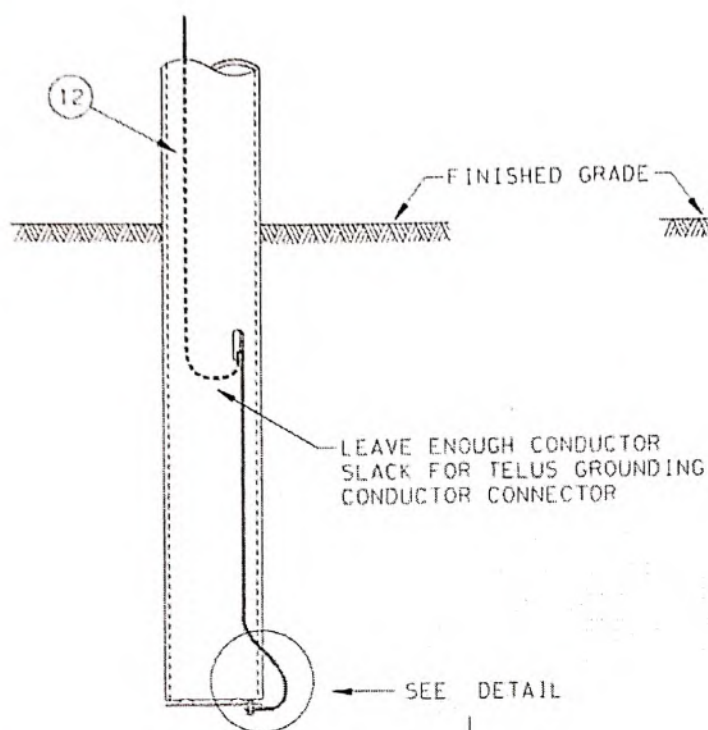
NOTE:

1. For proper connection of theft deterrent wire to neutral, see ES43 R2-01.

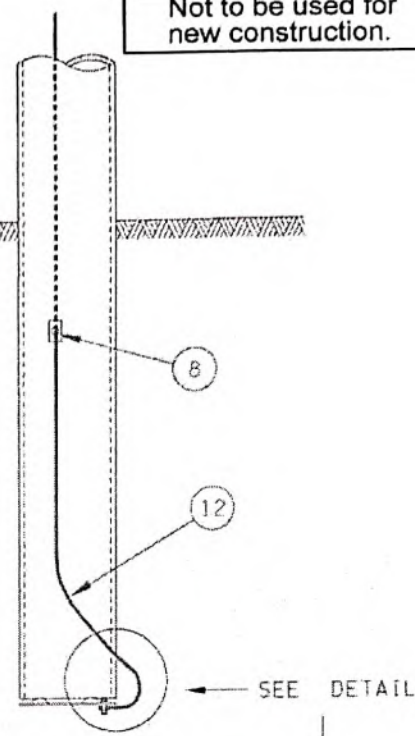
ES43 R2-08 List of Components and Notes
ES43 R2-01 Ground Rods at Wood Poles and Multiple Ground Rods
REFERENCE DRAWINGS

DRAFTER: JW	DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Dennert</i> F. DENNERT	BONDING AND GROUNDING GROUND ELECTRODE INSTALLATIONS GROUNDING PLATES AT WOOD POLES		
	ORIGINAL ISSUE DATE: MAY 1986					
	BChydro  DISTRIBUTION STANDARDS				PAGE 1 OF 1	ES43 R2-03

R. 3- CHANGED BACK TO #4 CU FOR GROUND WIRE. ADDED REM. STD BLOCK. JULY '10 MW R. 4-MINOR EDITS. NOV '12 MW



WITH HANDHOLES

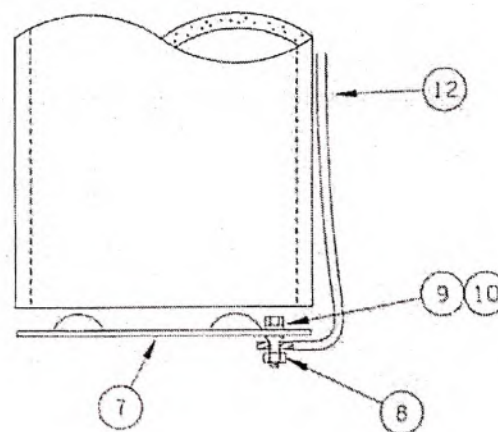


WITH GROUNDING BLOCKS

NOTE:

1. For proper connection of theft deterrent wire to neutral, see ES43 R2-01.

NOTE: PLATE IS NOT FASTENED TO POLE



ES43 R2-08 List of Components and Notes
REFERENCE DRAWINGS

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Denhart</i> F. DENHART
ORIGINAL ISSUE DATE: MAY 1986		

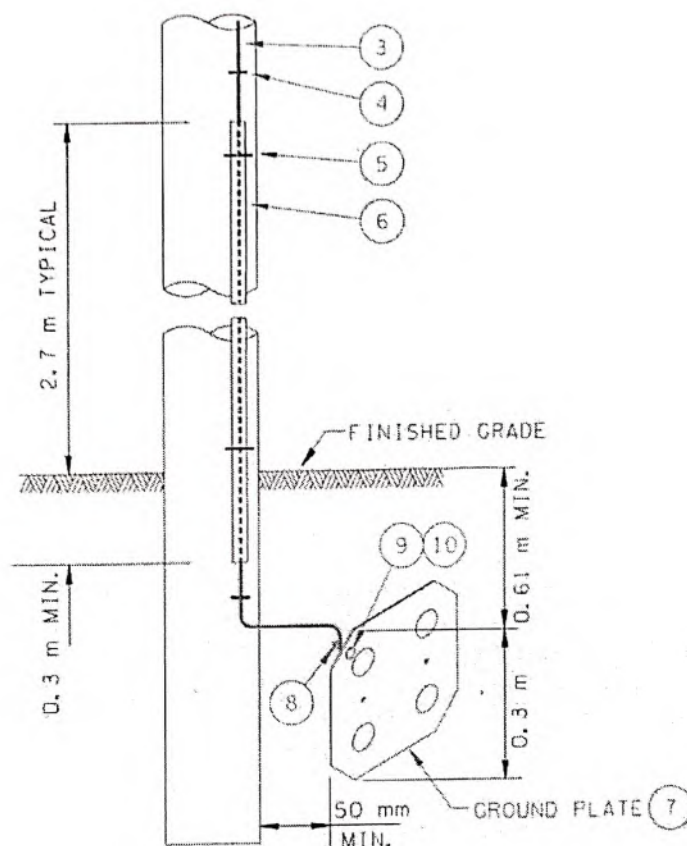
**BONDING AND GROUNDING
GROUND ELECTRODE INSTALLATIONS
GROUNDING PLATES
AT CONCRETE POLES**

BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 R2-04

R. 4



NOTES:

1. This standard is only to be used where the ground is rocky and the original pole set did not include grounding.
2. If this installation is not possible, please refer to the alternate installation ES43 R2-07.
3. For proper connection of theft deterrent wire to neutral, see ES43 R2-01.

ES43 R2-08 List of Components and Notes

ES43 R2-08 List of Components and Notes
ES43 R2-01 Ground Rods at Wood Poles and Multiple Ground Rods

REFERENCE DRAWINGS

DESIGNER <i>M. Wyndham</i> M. WYNDHAM		RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>J. Denhart</i> F. DENHART	BONDING AND GROUNDING GROUND ELECTRODE INSTALLATIONS POLE GROUND RETROFIT IN ROCKY AREAS VERTICAL PLATE METHOD
ORIGINAL ISSUE DATE: AUGUST 2006				
BChydro  DISTRIBUTION STANDARDS			PAGE 1 OF 1	ES43 R2-06
				R. 4

LIST OF COMPONENTS

Item No.	Description	Catalogue ID
1	Ground Rod (See note 6 and 7)	420-1093
2	Ground Rod Connector (See note 6)	420-1158
3	Theft Deterrent Galvanized Grounding Wire	96006427 or 96006428
4	Staple, Ground Conductor	103-0224
5	Staple, Conductor Moulding	103-0228
6	Moulding, Ground Conductor	388-5221
7	Ground Plate	420-1080
8	Split Stud Connector	388-2103
9	3/8" Nut Hex Galvanized	102-0122
10	3/8" Washer, Spring, Galvanized	102-4154
11	1/4" X 50 mm Lag Screw Galvanized	101-0246
12	#4 AWG Cu Conductor PE Covered	380-5051
13	Miniwedge, Erico - #1/0 ACSR	96006696
14	Miniwedge, Erico - #2 ACSR	96006695
15	Miniwedge, Erico - #4 Str Cu	96006667

NOTES:

1. Install ground conductor on pole as per ES43 R2-01.02.
2. Staple ground conductor approximately every metre on wood pole.
3. Multiple ground rods shall be installed in areas with high ground resistivity. Ground rods shall be spaced min. 3.0 metres apart and shall be approximately in line with the pole line.
4. Ground conductors should not be spliced.
5. Grounding plates shall be used only in areas where ground rods cannot be driven to full depth.
6. For items 1 and 2 see drawing ES43 R6-01 for material substitutions in high corrosion areas.
7. Ground electrodes installed by Telus may use 3/4" diameter, 10' long, galvanized steel rods as an acceptable alternative to BC Hydro ground rods (Cat-ID 420-1093).

ES43 R6-01 Grounding in High Corrosion Areas
REFERENCE DRAWINGS



DESIGNER	RECOMMENDED	APPROVED
M. SCHAEFER	C. PICASSI	F. DENERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING GROUND ELECTRODE INSTALLATIONS LIST OF COMPONENTS AND NOTES

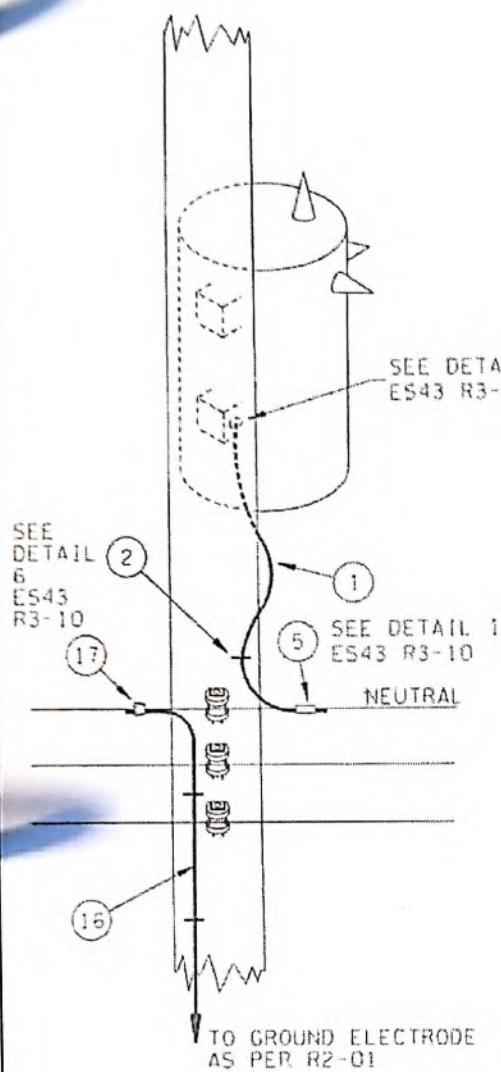
BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 1

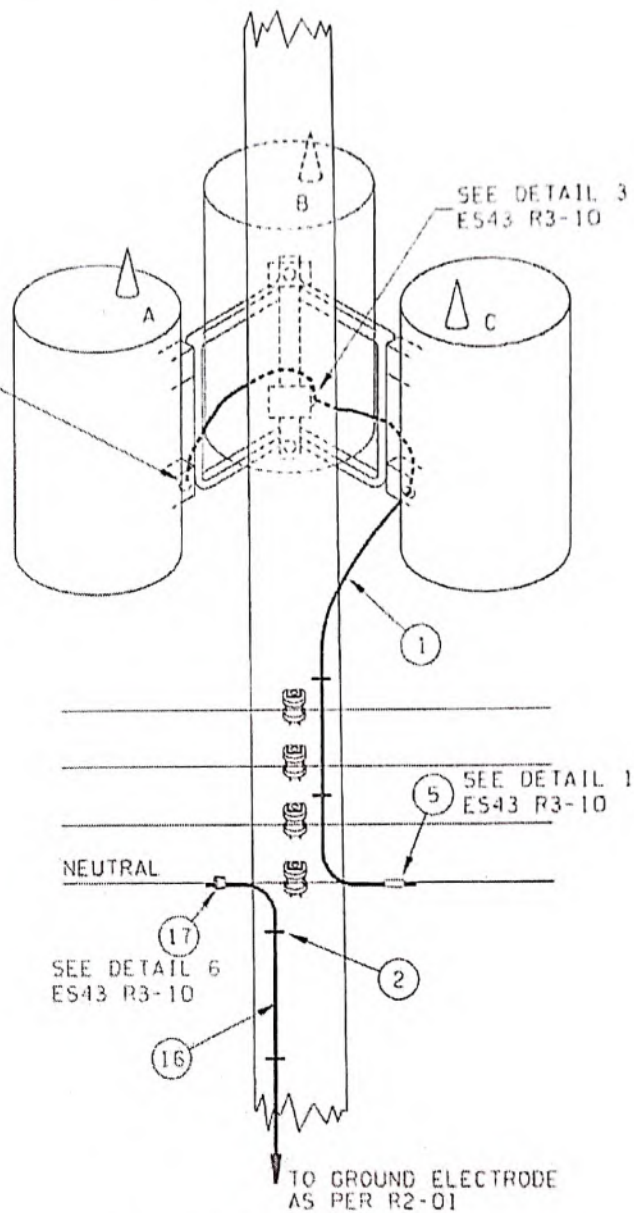
ES43 R2-08

R. 4

DRAFTED BY: R. 2- ADDED ALL MINIWEDGE CONNECTORS/#4 CU POLY, JULY '10 MW R. 3- MINOR R. 4- ADDED NOTE 7, AUG '14 MS



SINGLE PHASE TRANSFORMER



THREE PHASE TRANSFORMER

ES43 R3-11 List of Components
ES43 R3-10 Connection Details
ES43 R2-01 Ground Rods at Wood Poles and Multiple Ground Rods
REFERENCE DRAWINGS

DESIGNER <i>A. Jacob</i> A. JACOB	RECOMMENDED <i>C. Picasso</i> C. PICASSI	APPROVED <i>F. Dendert</i> F. DENDERT
---	--	---

BONDING AND GROUNDING POLEMOUNTED TRANSFORMERS

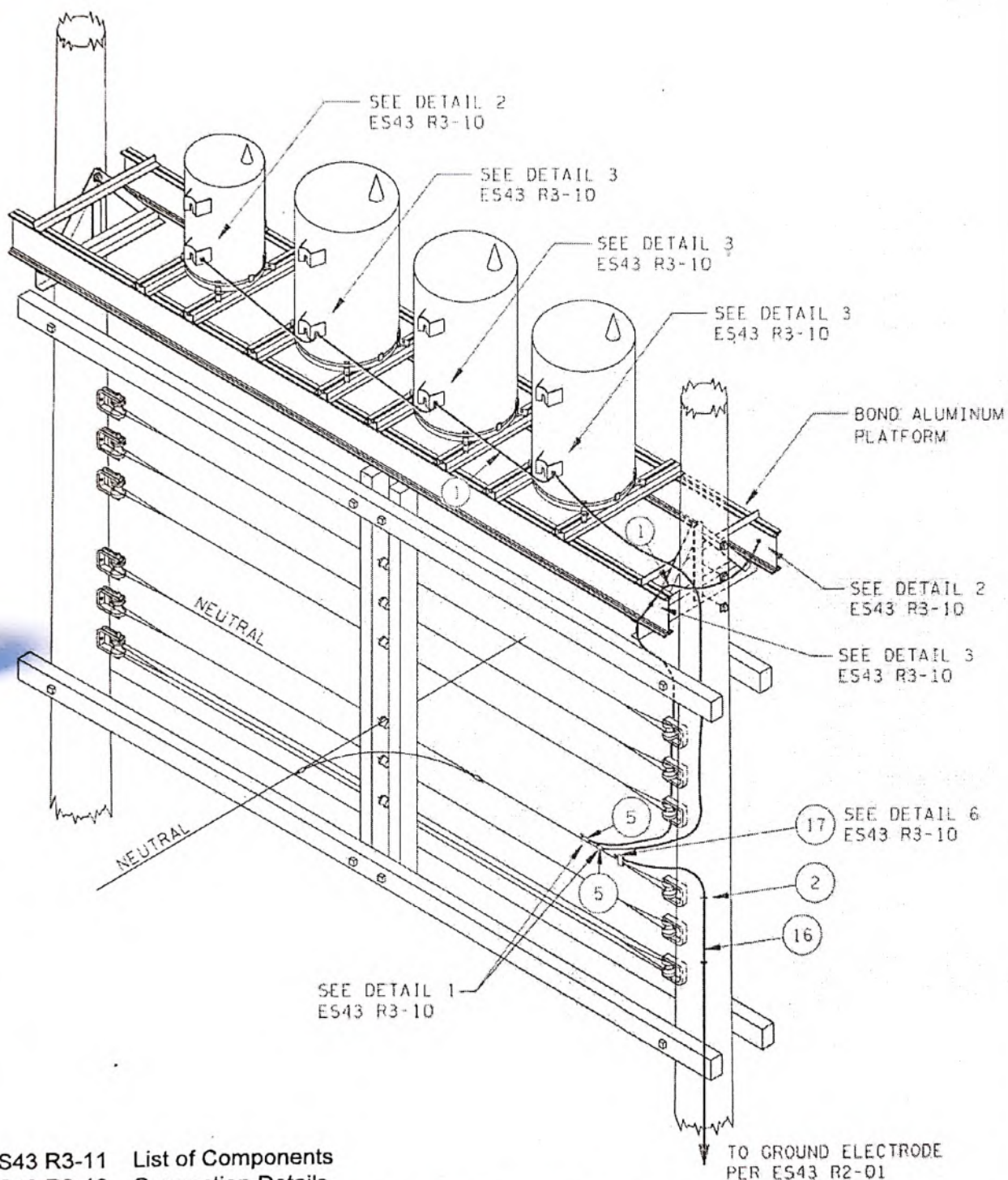
ORIGINAL ISSUE DATE: MAY 1986

BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 2

ES43 R3-01.01

R. 2



ES43 R3-11 List of Components
 ES43 R3-10 Connection Details
 ES43 R2-01 Ground Rods at Wood Poles and Multiple Ground Rods
 REFERENCE DRAWINGS

DRAFTER: DM R.1- REVISED CONNECTOR, NOV'12 AJ

DESIGNER <i>Aol 2</i> A. JACOB	RECOMMENDED <i>[Signature]</i> C. PICASSI	APPROVED <i>[Signature]</i> F. DENNETT
ORIGINAL ISSUE DATE: FEBRUARY 1982		

BONDING AND GROUNDING PLATFORM TRANSFORMERS

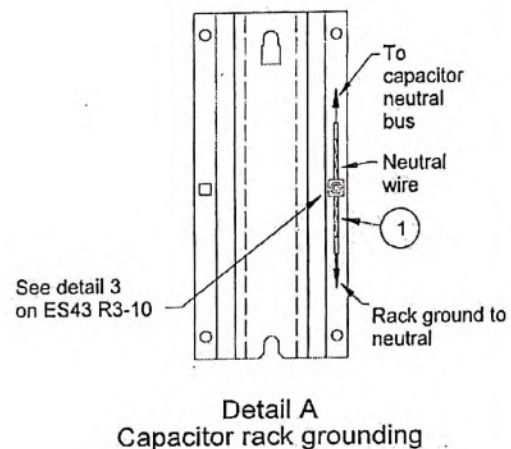
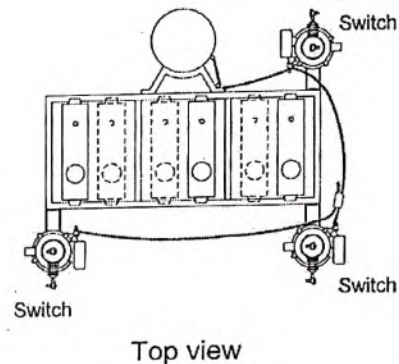
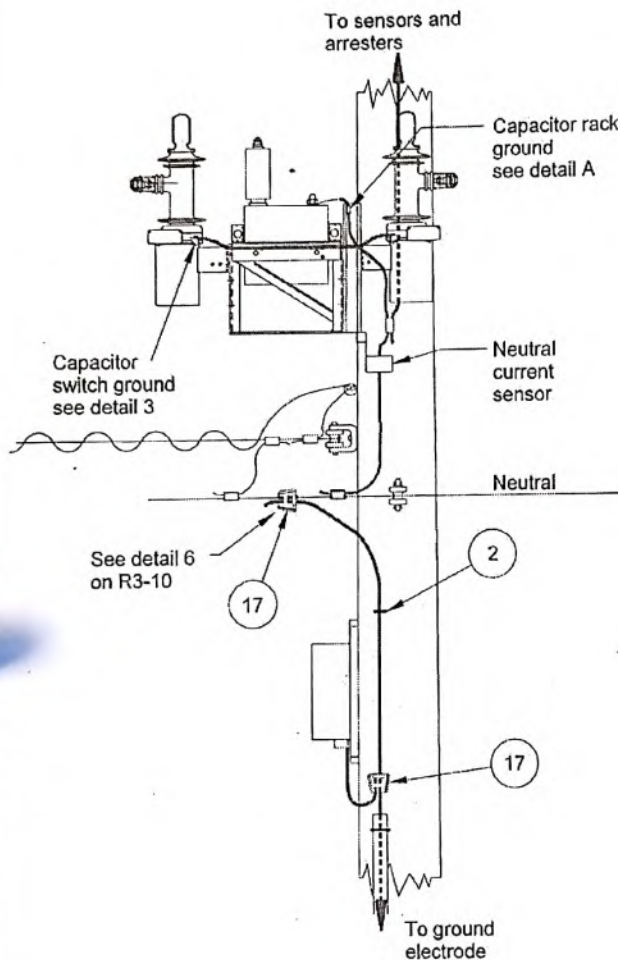
BChydro  DISTRIBUTION STANDARDS

PAGE 2
OF 2

ES43 R3-01.02

R. 1

REVISED: R.4 - MAJOR REVISION REDRAWN AND SIMPLIFIED. ISOMETRIC ELIMINATED. NOV '12 MP | R.5 - NEW CONTROL. JULY '16 MP |

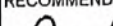
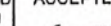


Notes

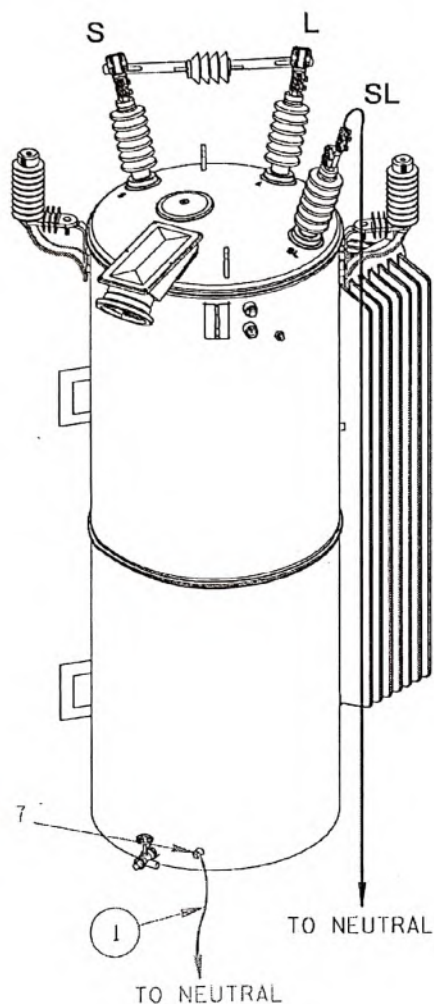
1. For surge arrester bonding/grounding see ES43 R3-06.
2. Capacitor switches may not be mounted exactly as shown.

Reference Drawings

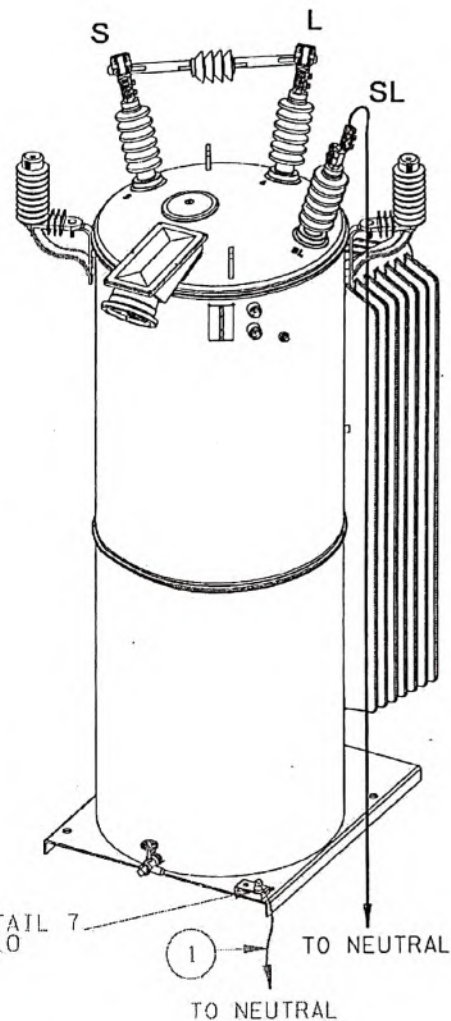
- ES43 R3-11 List of Components
- ES43 R3-10 Connection Details
- ES43 R3-06 Surge Arresters
- ES43 R2 Ground Electrode Installations

DESIGNED  M. PEDLEY	RECOMMENDED  P. FOUND	ACCEPTED  F. DENNERT	 ENGINEER OF RECORD PAUL A. DENNERT # 36485 BRITISH COLUMBIA ENGINEER JULY 8, 2016	BONDING AND GROUNDING EQUIPMENT SHUNT CAPACITORS		
DISTRIBUTION STANDARDS  BC Hydro			ISSUED: JULY 2016 REPLACES: NOV 2012 ORIGINALLY ISSUED: NOV 2012	PAGE 1 OF 1	ES43 R3-02	R 5

July 8, 2016



WITHOUT SUBSTATION BASE

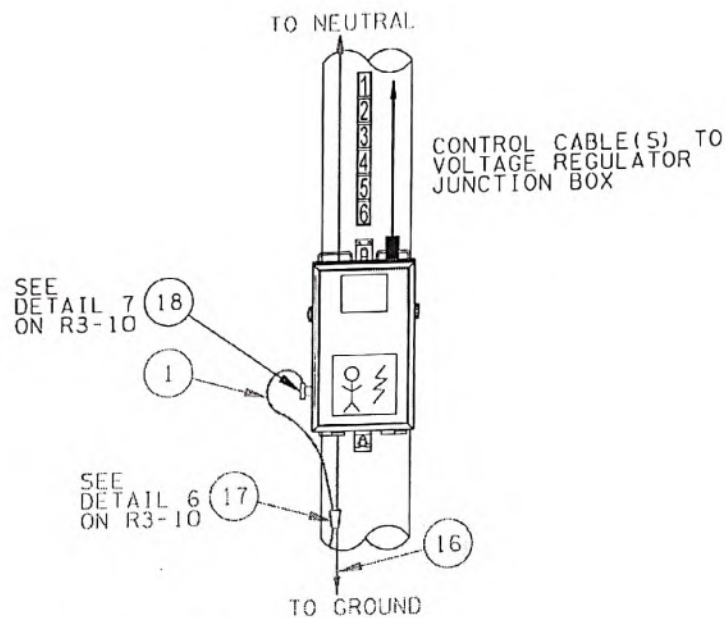


WITH SUBSTATION BASE



DESIGNER <i>M. Pedley</i> M. PEDLEY	RECOMMENDED <i>P. Found</i> P. FOUND	APPROVED <i>F. Dennert</i> F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING
EQUIPMENT
VOLTAGE REGULATORS

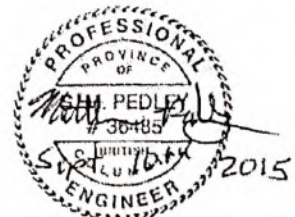


Pole Mounted Controls

NOTES:

1. Grounding and bonding shown above applies to all voltage regulator installations regardless of number of phases.
2. Ground electrode installation per ES43 R2 required at all voltage regulator installations.
3. For details indicated see drawing ES43 R3-10.

ES43 R3-11 List of Components
 ES43 R3-10 Connection Details
 ES43 R2 Ground Electrode Installations
 REFERENCE DRAWINGS



DESIGNER <i>M. Pedley</i> M. PEDLEY	RECOMMENDED <i>Paul</i> P. FOUND	APPROVED <i>F. Dennert</i> F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

VOLTAGE REGULATORS
 THREE-PHASE
 PLATFORM-MOUNTED

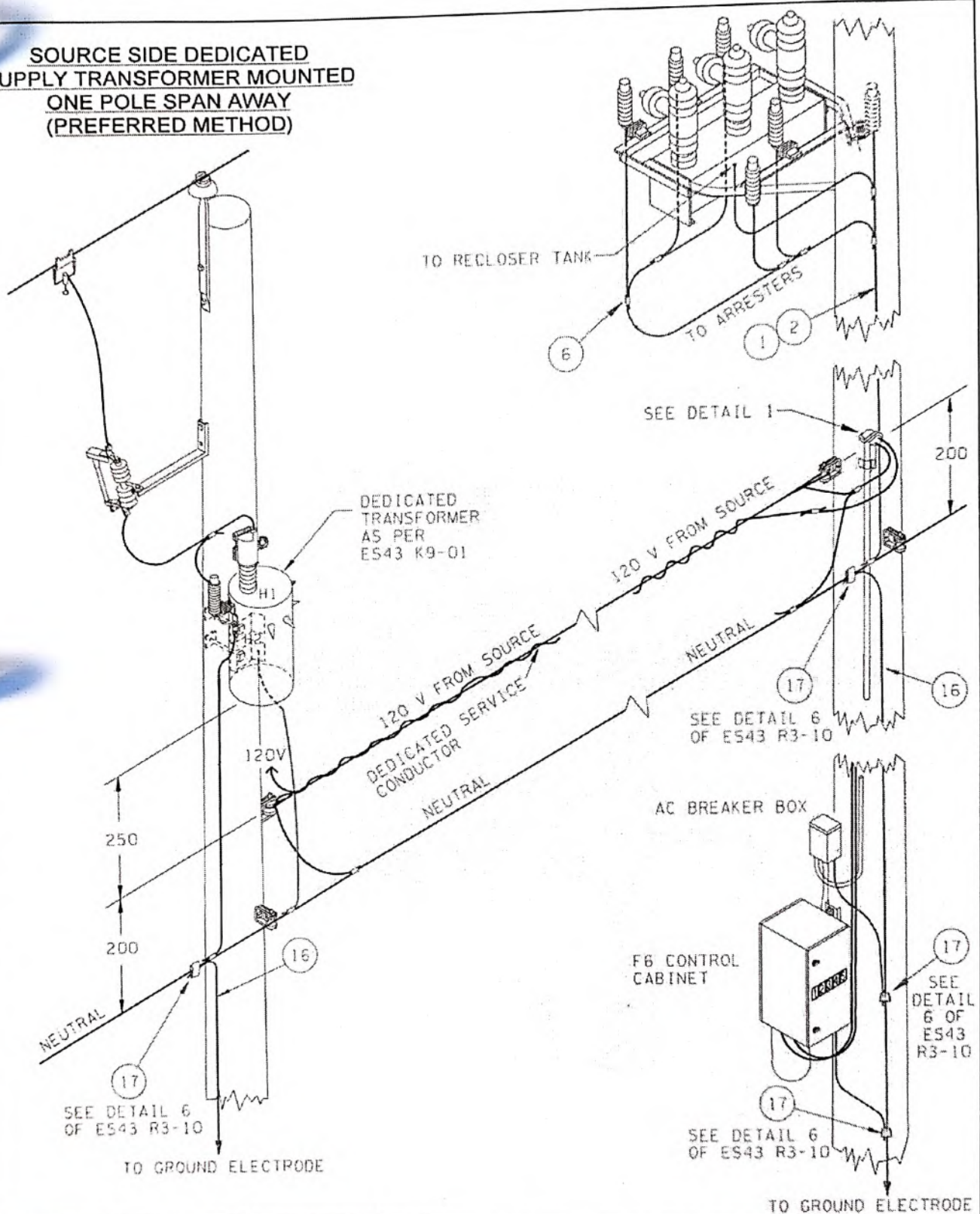
BCHydro DISTRIBUTION STANDARDS

PAGE 2
 OF 2

ES43 R3-03.02

R. 5

**SOURCE SIDE DEDICATED
SUPPLY TRANSFORMER MOUNTED
ONE POLE SPAN AWAY
(PREFERRED METHOD)**



DRAFTER: DM R. 3- NEW GROUNDING STDS. NOV. 12 PF

DESIGNER <i>Paul</i> P. FOUND	RECOMMENDED <i>GB</i> C. BEFUS	APPROVED <i>[Signature]</i> F. DEMERT
-------------------------------------	--------------------------------------	---

ORIGINAL ISSUE DATE: DECEMBER 2007

**BONDING AND GROUNDING
EQUIPMENT
RECLOSERS-SUPPLY ONE SPAN AWAY**

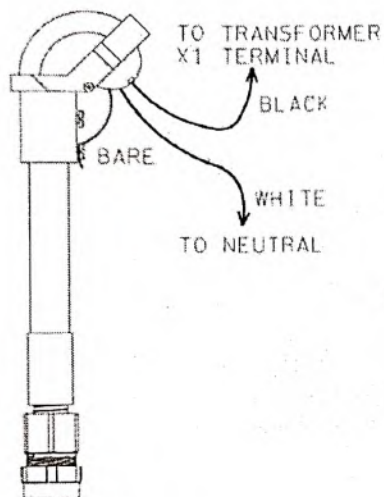
BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 2

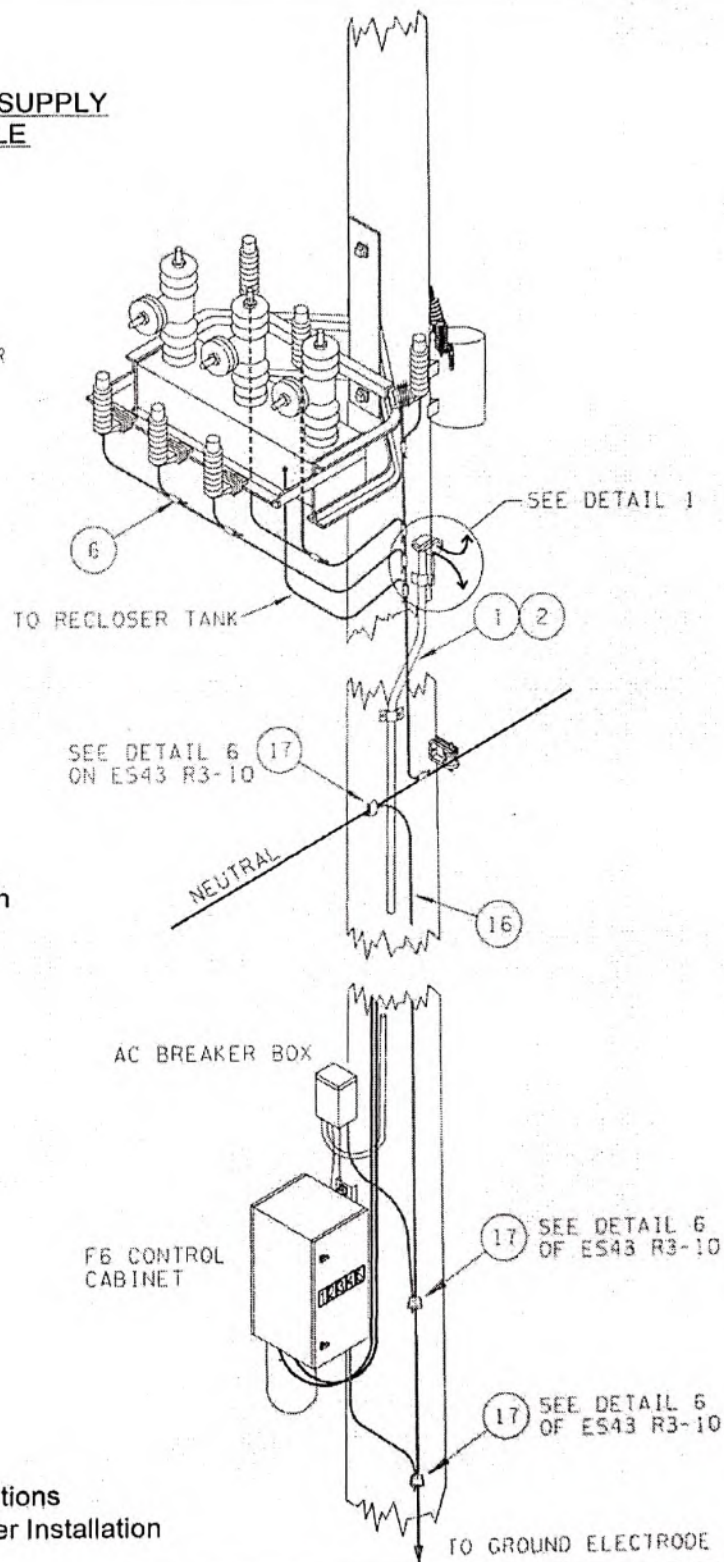
ES43 R3-04.01

R. 3

**SOURCE SIDE DEDICATED POWER SUPPLY
MOUNTED ON RECLOSER POLE
(OPTIONAL METHOD)**



DETAIL 1
Weatherhead Grounding Connection



- ES43 R3-11 List of Components
ES43 R3-10 Connection Details
ES43 R2-01 Ground Electrode Installations
ES43 K9-01 Power Supply Transformer Installation
- REFERENCE DRAWINGS

DRAFTER: DM	DESIGNER <i>Paul</i> P. FOUND	RECOMMENDED <i>CGB</i> C. BEFUS	APPROVED <i>[Signature]</i> F. DEWERT	BONDING AND GROUNDING EQUIPMENT RECLOSERS-SUPPLY ON POLE		
	ORIGINAL ISSUE DATE: DECEMBER 2007					
	BChydro  DISTRIBUTION STANDARDS			PAGE 2 OF 2	ES43 R3-04.02	R. 3

R. 2- NOTES ADDED, NOV '12 MK

DEC. '01

R. 1- NEW 3Ø METERING KIT, SC

DRAFTER: DM

ES43 R3-06 Surge Arrester Grounding
 ES43 R3-05.03 Primary Meter Cabinet Grounding
 ES43 R3-11 List of Components
 REFERENCE DRAWINGS

DESIGNER <i>[Signature]</i> M. KELVIN	RECOMMENDED <i>[Signature]</i> C. PICASSI	APPROVED <i>[Signature]</i> F. DEINERT
---	---	--

ORIGINAL ISSUE DATE: MAY 1986

BONDING AND GROUNDING EQUIPMENT THREE PHASE PRIMARY METERING

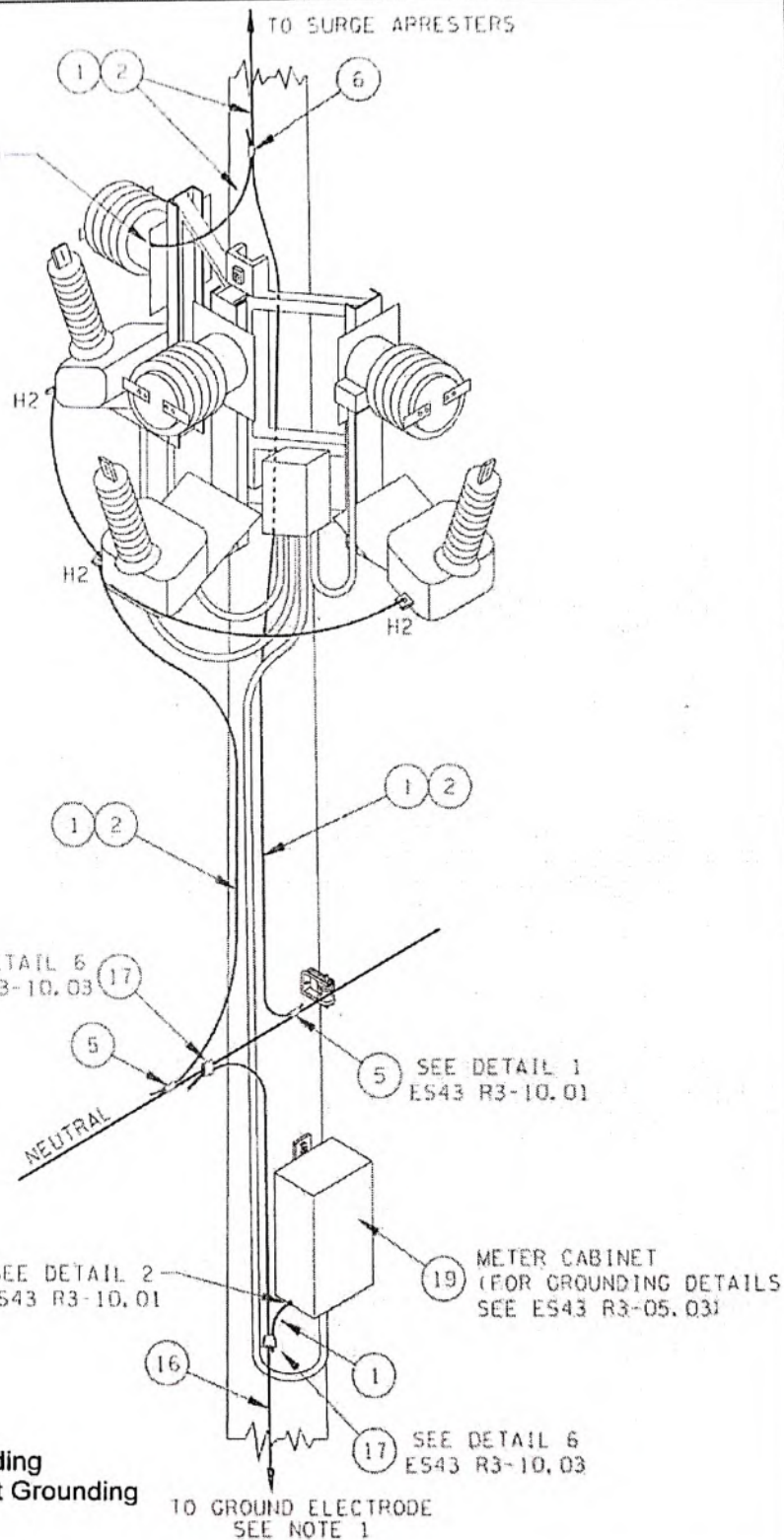
BChydro  DISTRIBUTION STANDARDS

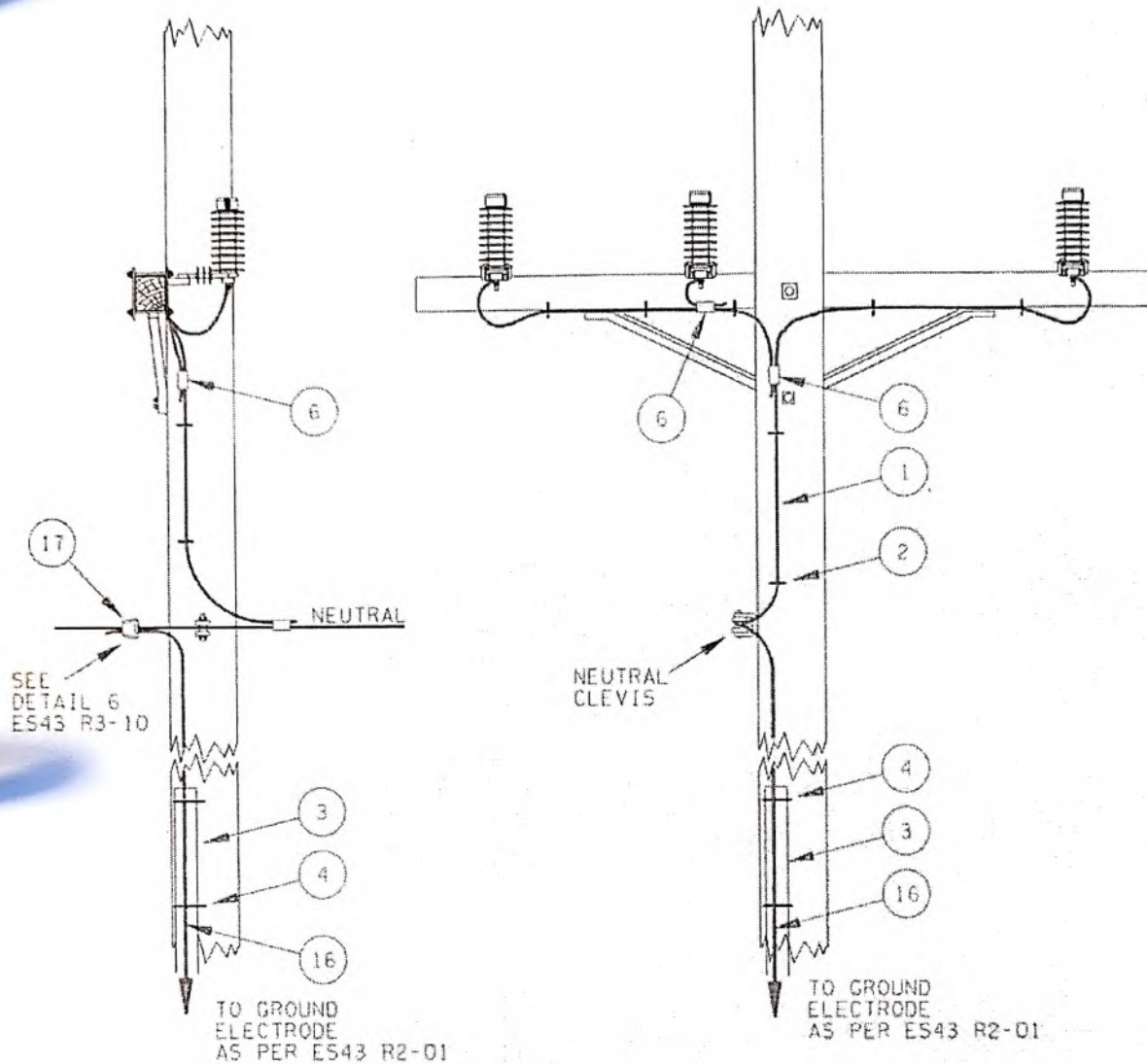
PAGE 1
OF 3

ES43 R3-05.01

R. 2

METER KIT GROUND
 SEE DETAIL 2
 ES43 R3-10.01





NOTES:

1. The ground conductor shall be installed with no sharp bends to avoid flashovers.
2. For surge arresters at terminal poles see ES53 R4-01.

ES43 R3-11 List of Components
 ES43 R3-10 Connection Details
 ES43 R2-01 Ground Electrode Installations
 ES53 R4-01 Bonding and Grounding at Terminal Pole Structures
 REFERENCE DRAWINGS

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Denfert</i> F. DENFERT
ORIGINAL ISSUE DATE: MAY 1986		

**BONDING AND GROUNDING
EQUIPMENT
SURGE ARRESTERS**

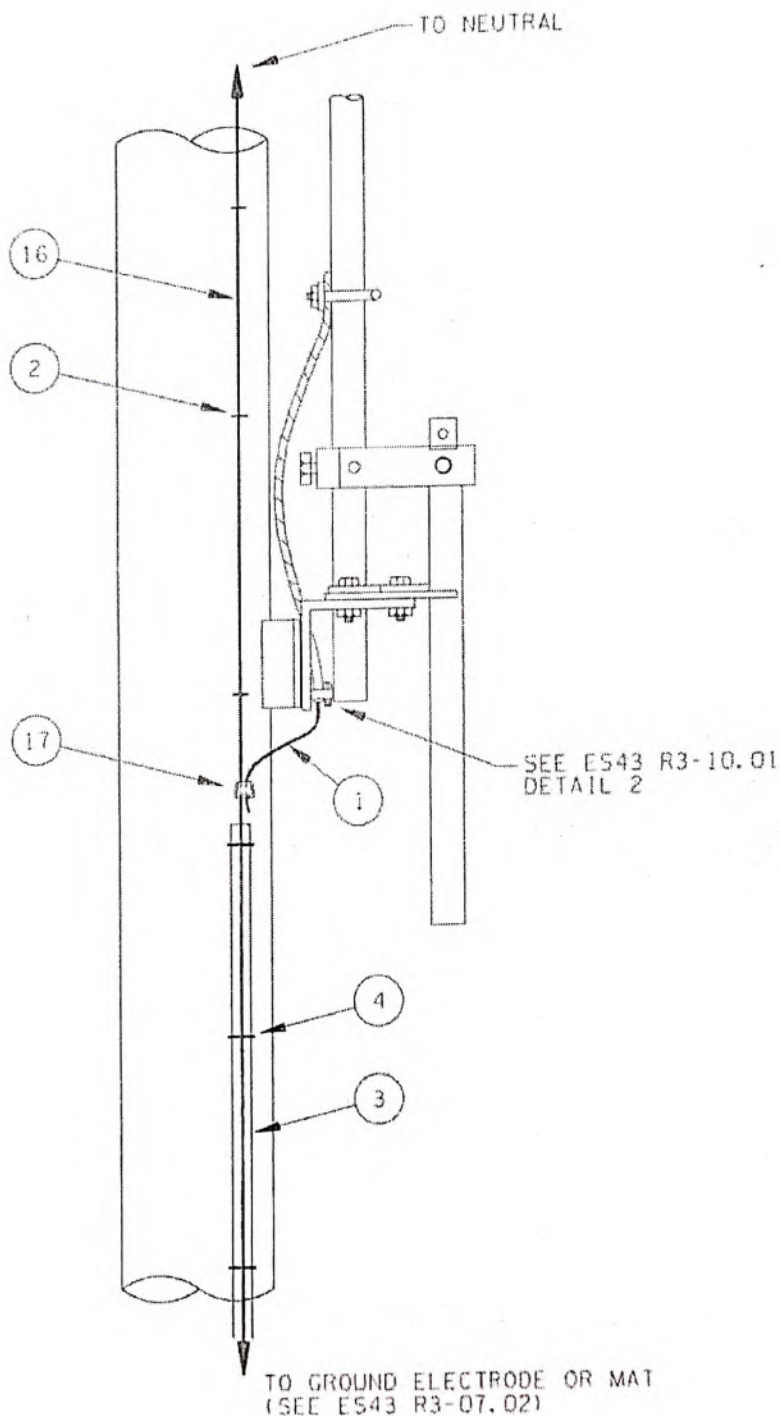
BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 R3-06

R. 2

R.2- REDRAWN '00-09 VF R.3- CONNECTORS REVISED/REMOVED RECIPROCATING HANDLE. NOV '12 CR



DRAFTER: JW

DESIGNER

G. RINGHAM

RECOMMENDED

C. BEFUS

APPROVED

F. DENNERT

ORIGINAL ISSUE DATE: MAY 1986

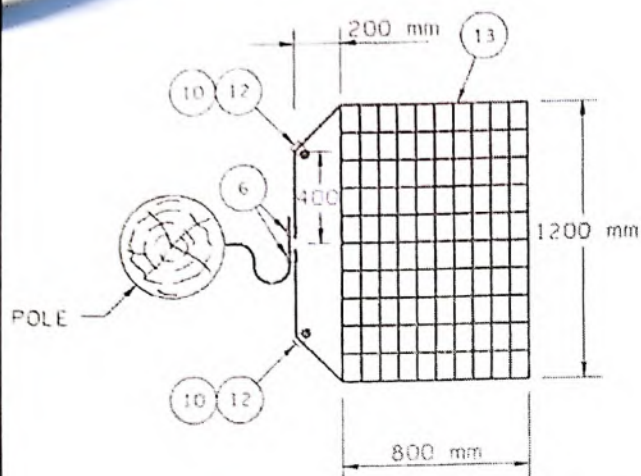
BONDING AND GROUNDING EQUIPMENT LOAD BREAK SWITCH HANDLES

BChydro  DISTRIBUTION STANDARDS

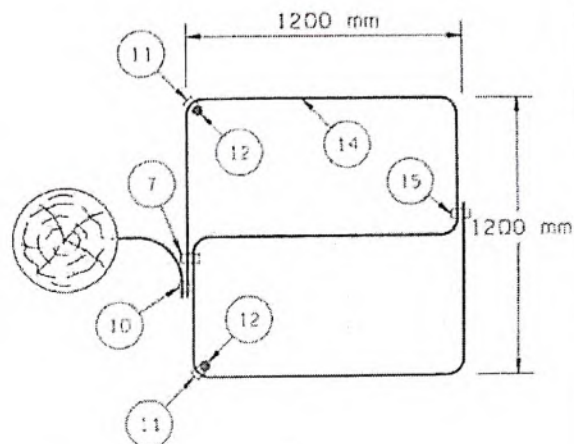
PAGE 1
OF 2

ES43 R3-07.01

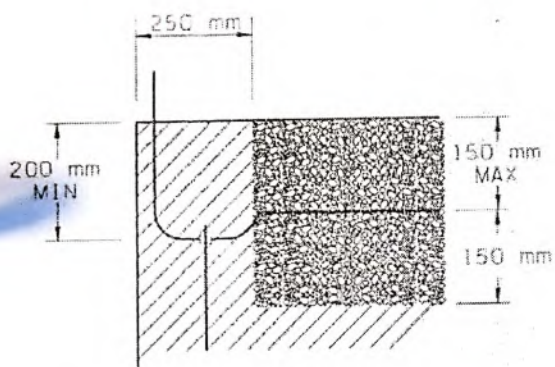
R. 3



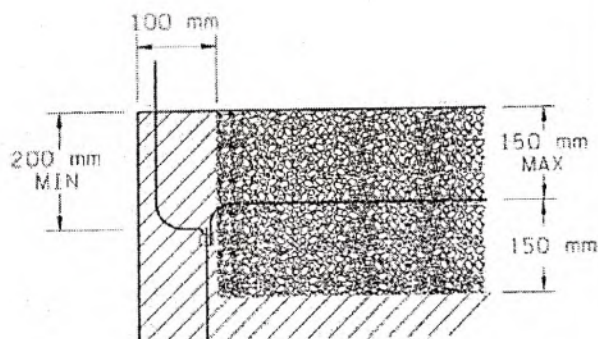
METHOD A - MAT PLAN VIEW



METHOD B - WIRE ROPE PLAN VIEW



METHOD A - MAT PROFILE



METHOD B - WIRE ROPE PROFILE

NOTES:

1. If handle is three metres above ground, omit ground mat and retain one ground rod, installed per ES43 R2-01. Otherwise, install ground mat or wire rope as shown above.
2. Set mat using crushed stone; 150 mm below, covering min 50 mm (including stone, concrete and asphalt) but not to exceed 150 mm.
3. Bury ground rods at a depth of 200 mm minimum.

ES43 R3-11 List of Components
 ES43 R3-10 Connection Details
 ES43 R2-01 Ground Electrode Installations
 REFERENCE DRAWINGS

DESIGNER <i>C. RINGHAM</i>	RECOMMENDED <i>C. BEYUS</i>	APPROVED <i>F. DENNERT</i>
ORIGINAL ISSUE DATE: MAY 1986		

**BONDING AND GROUNDING
 EQUIPMENT
 LOAD BREAK SWITCH HANDLES**

BChydro DISTRIBUTION STANDARDS

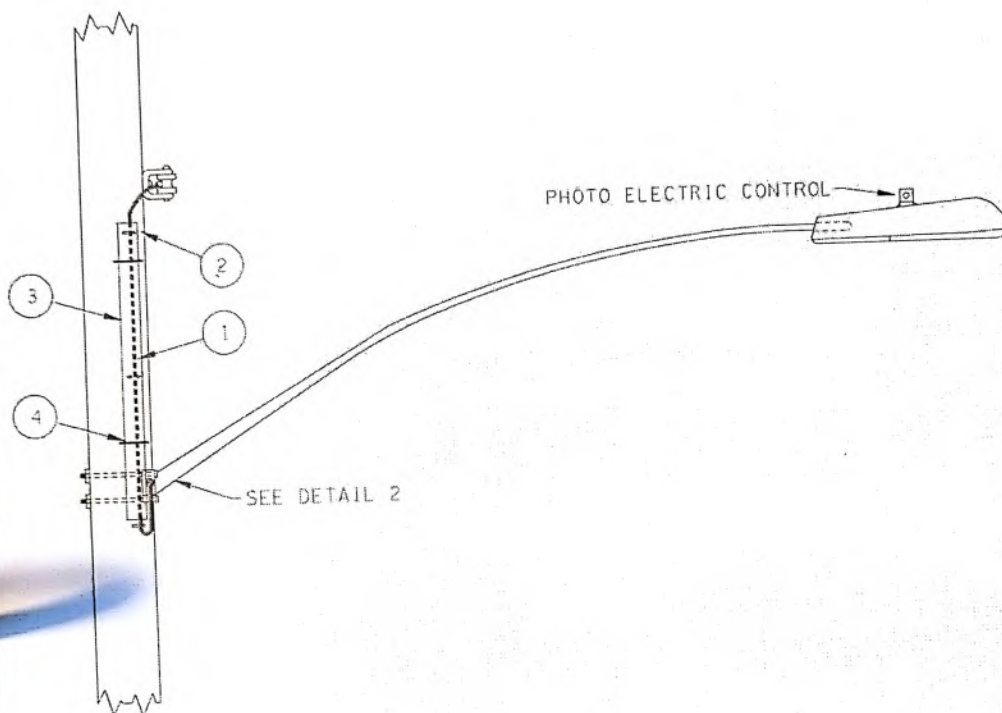
PAGE 2
 OF 2

ES43 R3-07.02

R. 3

DRAFTER: JW

R. 1- REDRAWN '00-09 MF R. 2- LUMINAIRE TO FLAT GLASS BRACKET, NOV '12 MW



NOTES:

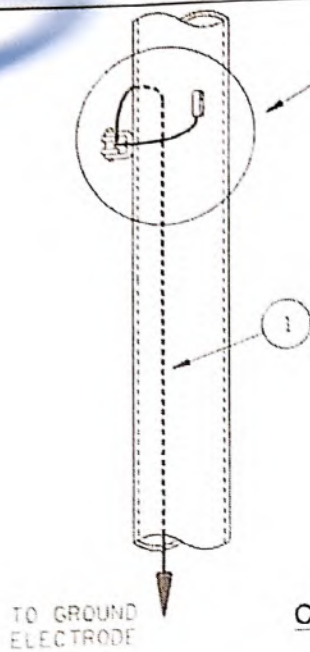
1. For details indicated see ES43 R3-10.
2. See ES43 L2-02 for locations requiring grounding of bracket.

ES43 R3-11 List of Components
 ES43 R3-10 Connection Details
 ES43 L2-02 Luminaire Installation on Level Ground
 REFERENCE DRAWINGS

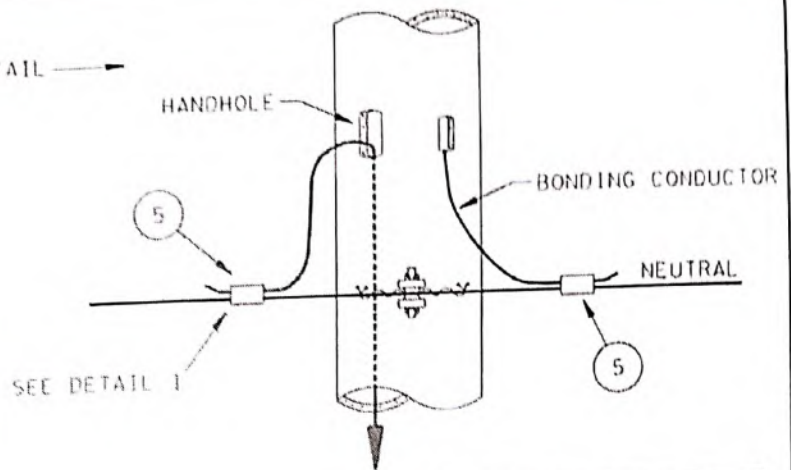
DRAWN: DM	DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Denvert</i> F. DENVERT	BONDING AND GROUNDING EQUIPMENT STREET LIGHT BRACKET
	ORIGINAL ISSUE DATE: MAY 1986			
	Bchydro DISTRIBUTION STANDARDS			
PAGE 1 OF 1				ES43 R3-08
				R. 2

R.1- REDRAWN'00-09 MF | R.2- CONNECTORS REVISED NOV'12 MW

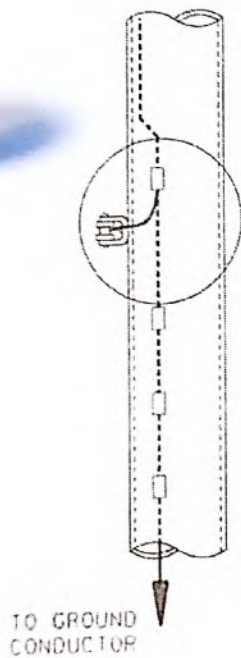
DRAWN: JW



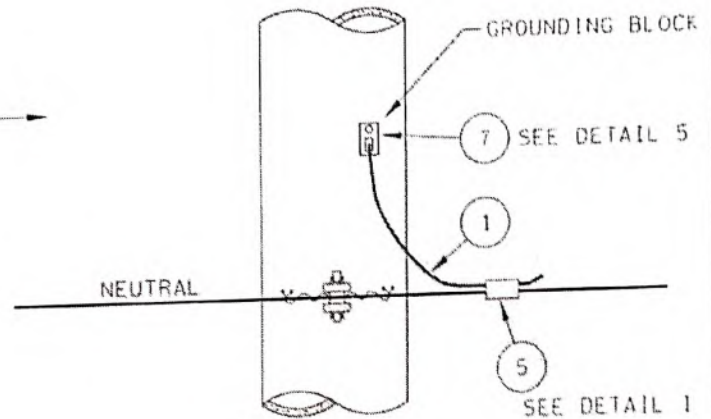
CONCRETE POLES WITH HANDHOLES



REMEDIAL STDS
Not to be used for
new construction.



CONCRETE POLES WITH GROUNDING BLOCKS



ES43 R3-11 List of Components
ES43 R3-10 Connection Details
ES43 R2 Ground Electrode Installations
REFERENCE DRAWINGS

NOTES:

1. For details indicated see ES43 R3-10.

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Dennert</i> F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

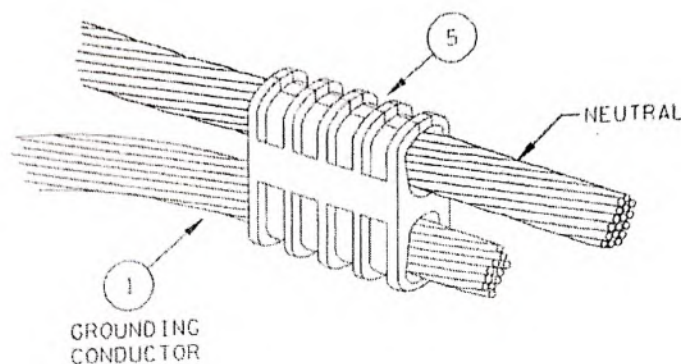
BONDING AND GROUNDING
EQUIPMENT
BONDING OF CONCRETE POLES

BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 1

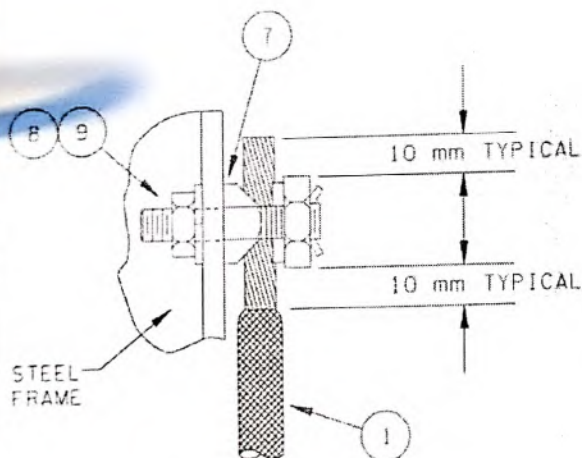
ES43 R3-09

R. 2



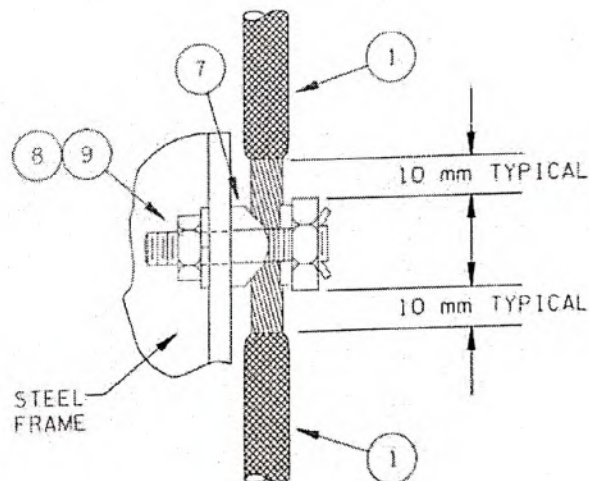
DETAIL 1

Ensure the grounding conductor is placed below the neutral if the neutral is aluminum.



DETAIL 2

Installation of grounding conductor to steel frame (end type connection). If manufacturer supplied equipment is furnished with a proper ground connector, omit items 7, 8 and 9



DETAIL 3

Installation of grounding conductor to steel frame (through type connection). If manufacturer supplied equipment is furnished with a proper ground connector, omit items 7, 8 and 9

R.1- REDRAWN '00-09 MF R.2- NEW DETAILS, UPDATE, NOV '12 MW DRAFTER: DM/JW

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picasso</i> C. PICASSI	APPROVED <i>F. Denbert</i> F. DENBERT
ORIGINAL ISSUE DATE: MAY 1986		

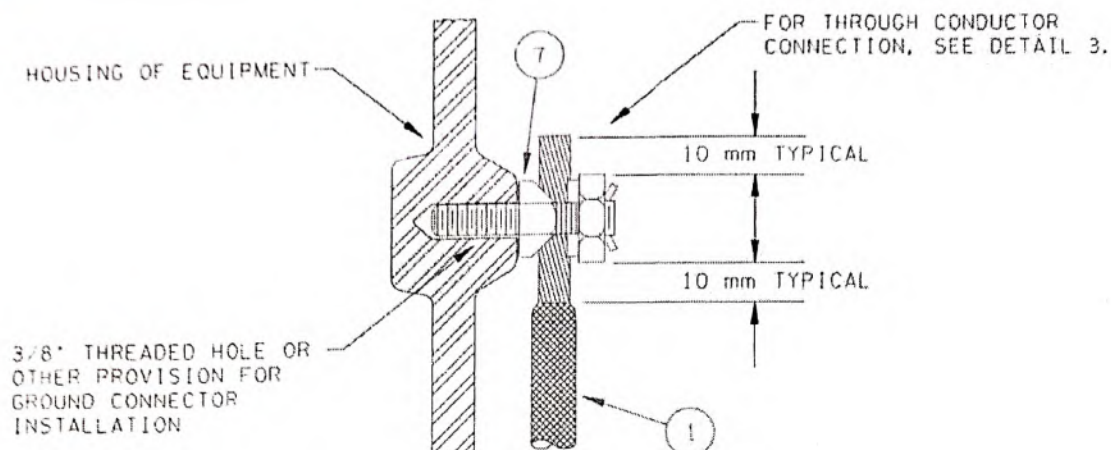
BONDING AND GROUNDING EQUIPMENT CONNECTION DETAILS

BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 3

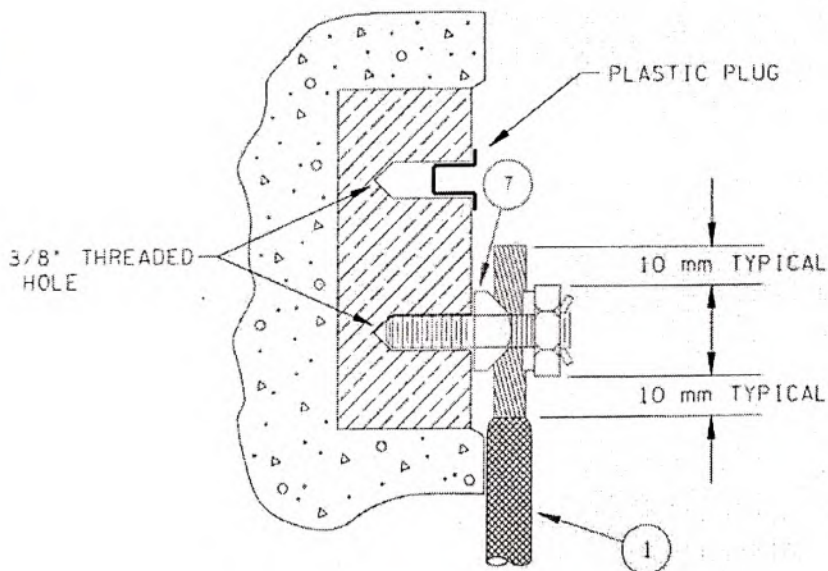
ES43 R3-10.01

R. 2



DETAIL 4

Ground Connector Installation on Pole Mounted Equipment
If manufacturer supplied equipment is furnished with a proper ground connector, omit item 7



DETAIL 5

Ground Connector Installation
on Concrete Pole with Ground Blocks

DRAFTED DM/JW

DESIGNER	RECOMMENDED	APPROVED
<i>M. Wyndham</i>	<i>C. Picassi</i>	<i>F. Dennert</i>
M. WYNDHAM	C. PICASSI	F. DENNERT

ORIGINAL ISSUE DATE: MAY 1986

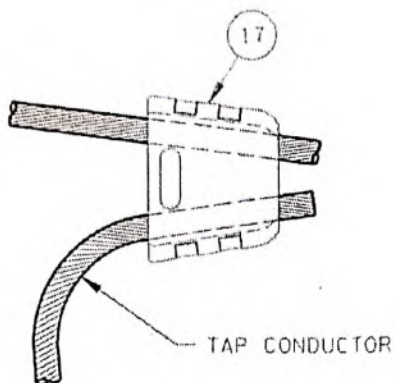
BONDING AND GROUNDING EQUIPMENT CONNECTION DETAILS

BChydro  DISTRIBUTION STANDARDS

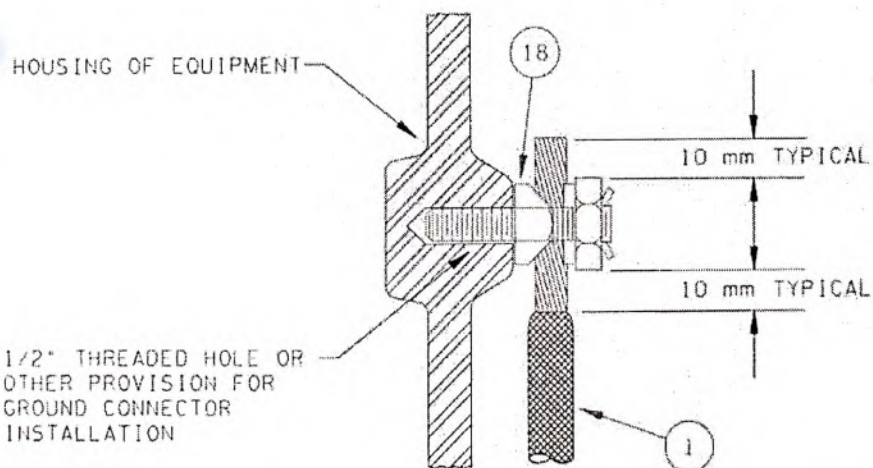
PAGE 2
OF 3

ES43 R3-10.02

R. 2



DETAIL 6
Miniwedge Connector Installation



DETAIL 7
Ground Connector Installation on Pole Mounted Equipment
If manufacturer supplied equipment is furnished with a proper
ground connector, omit item 18

DRAFTER: DM/DC

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Denner</i> F. DENNER
ORIGINAL ISSUE DATE: MAY 1986		

**BONDING AND GROUNDING
EQUIPMENT
CONNECTION DETAILS**

BChydro  DISTRIBUTION STANDARDS

PAGE 3
OF 3

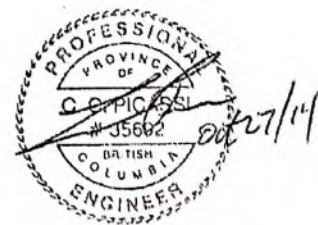
ES43 R3-10.03

R. 2

LIST OF COMPONENTS

Item No.	Description	Catalogue ID
1	#4 Awg Cu Gnd.Conductor P. E. Covered	380-5051
2	Staple, Ground Conductor	103-0224
3	Moulding, Ground Conductor	388-5221
4	Staple, Conductor Moulding	103-0228
5	Compression Connector H-Type	388-0514
6	Compression Connector C-Type	388-0453
7	Split Stud Connector	388-2103
8	3/8" Nut, Hex, Galvanized	102-0122
9	3/8" Washer, Spring, Galvanized	102-4154
10	Ground Rod/Ground Wire Connector	420-1158
11	Ground Rod/Counterpoise Connector	420-1157
12	Ground Rod	420-1093
13	Ground Mat (800 mm x 1200 mm)	350-8810
14	Wire Rope Counterpoise (7 m)	106-2510
15	U-Bolt Clamp	420-0965
16	Theft Deterrent Galvanized Grounding Wire	96006427 or 96006428
17	Miniwedge, Erico	96006696, 96006695, or 96006667 as per ES43 R2-01
18	1/2" Split Stud Connector	97000053
19	Meter Cabinet	372-9204

ES43 R3-10 Connection Details
ES43 R2-01 Ground Electrode Installations
REFERENCE DRAWINGS



DESIGNER <i>M. Schaefer</i> M. SCHAEFER	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Denner</i> F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING EQUIPMENT LIST OF COMPONENTS

BChydro DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 R3-11

R. 3

R.2- ITEM 16, 17, 18 & 19 ADDED. NOV'12 MW R.3- ITEM 18 UPDATED. NOV'14 MS

DRAWING: DC

PURPOSE OF A NEUTRAL

The neutral returns the unbalanced load current to the transformer under normal operating conditions. During faults it will generally provide a lower impedance path to the transformer than ground electrodes thus allowing easier detection and faster clearing.

SIZE OF A NEUTRAL

The neutral shall meet the minimum size requirements as defined in ES43 Section N, and be sized to carry the maximum expected unbalanced load currents under normal operating conditions, as well as the maximum expected fault currents. See ES43 Section Y1 for ampacities of conductors.

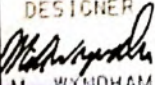
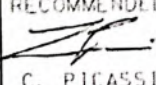
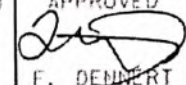
NEUTRAL-TO-GROUND RESISTANCE AND VOLTAGE

The system neutral-to-ground resistance should not exceed 6 ohms. This will limit overvoltages during faults to tolerable limits and will enable fuses, circuit breakers and reclosers to operate more quickly.

A minimum of three ground electrodes per kilometre should be installed. In many areas this should be sufficient to achieve the 6 ohms. However, if this value can not be attained, then additional electrodes should be installed. NOTE: Irrespective of how many ground electrodes there are per kilometre, one must be installed at every transformer, switch handle, recloser, etc. location as detailed in ES43 Section R3. Under normal conditions, grounding to these standards should be sufficient to limit the neutral to ground voltage to less than 10 volts; however, corrective action should be taken if this value is found to be exceeded. Where this voltage limit has been met, but customers require further reduction to 1 volt or less for farm applications, arrangements may be made with BC Hydro's Agricultural Specialist.

R.1- NEUTRAL VOLTAGE, NOV. '01 BF R.2- PAGE 2 ADDED & MINOR UPDATES, NOV '12 MW

DRAFTER: JW

DESIGNER  M. WYNDHAM	RECOMMENDED  C. PICASSI	APPROVED  F. DENBERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING SYSTEM NEUTRAL GROUNDING

BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 2

ES43 R5-01.01

R. 2

LOWERING THE NEUTRAL-TO-GROUND RESISTANCE

The resistance may be lowered, in order of preference, by selecting a more suitable location, by installing electrodes more often, by installing multiple rods, or by using sectional rods.

A more suitable location is one that is a low lying, moist area within 4 or 5 metres of the pole. The grounding conductor must be trenched in at a minimum depth of 0.5 m and be routed such that it cannot be disturbed by road widening, road maintenance, or ditch cleaning.

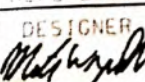
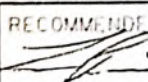
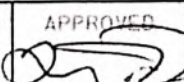
Multiple rods can be used if a more suitable location is not available and if installing electrodes more often is not possible or practical. Multiple rods are to be installed in accordance with drawing ES43 R2-01. The expected reduction in resistance at a location is:

<u>No. of Rods</u>	<u>Relative Resistance %</u>
1	100
2	55
3	41
4	35
5	30

Sectional rods may also be used and can sometimes be more effective than multiple rods if a permanent moisture layer can be reached. They are not a Distribution item but are used by Transmission and Substations.

ES43 Y1 Engineering Data
ES43 R3 Equipment
ES43 R2-01 Ground Rods at Wood Poles and Multiple Ground Rods
ES43 N2-11 Neutral Isolation Device
ES43 F Conductors and Connectors

REFERENCE DRAWINGS

DESIGNER	RECOMMENDED	APPROVED
 M. WYNDHAM	 C. PICASSI	 F. DENHART
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING SYSTEM NEUTRAL GROUNDING

BChydro  DISTRIBUTION STANDARDS

PAGE 2
OF 2

ES43 R5-01.02

R. 2

A. PARAMETERS DEFINING CORROSIVE SOILS

The corrosiveness of soils is based roughly on three parameters: pH, soil resistivity and chloride ion content. Table 1 lists the value ranges of the parameters for which a copper grounding system should be used.

Table 1

CRITERIA FOR SELECTING COPPER GROUNDING SYSTEM		
Soil Parameter	Value Range	Comments
pH	< 6	Occurs in peaty, marshy areas
soil resistivity	< 25 Ω -m	Occurs in loamy or clay soils with > 20% moisture content. (This type of permanent soil condition is extremely rare).
chloride ion	> 50 ppm	Occurs in areas at or within a few metres of sea level.

If one or more of the soil parameters fall within the value range of Table 1, and the sulfide ion is not present, then a copper grounding system should be used. If the sulfide ion is present (occurs in soils holding swamp water or polluted brackish water), then the general purpose galvanized steel grounding system should be used.

B. PROCEDURE FOR DETERMINING SOIL PARAMETERS

If an area is suspected of having corrosive soils or if there has been a history of corrosion problems with ground rods, anchor rods, etc. then a soil sample should be taken using the following procedure:

Remove the top 0.3 m of soil cover and fill a one (1) 5 gallon bucket 1/2 way up. For clay, undisturbed soil sample should be taken. Care should be taken to ensure that the soil retains any water it may contain.

Copy form on page ES43 R6-01.03, complete Section A and send with the soil sample (suitably packaged for mailing) to:

O.C.S.
Powertech Labs
Surrey
Attention: Nick Dominelli

Powertec Labs Inc.
Applied Chemistry Business Unit
Attention: Nick Dominelli
12388 - 88th Avenue
Surrey, B.C., V3W 7R7

DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Dennert</i> F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING
GROUNDING IN HIGH CORROSION AREAS

BChydro  DISTRIBUTION STANDARDS

PAGE 1
OF 3

ES43 R6-01.01

R. 3

C. DOCUMENTATION AND RESPONSIBILITY

The designer shall be responsible for recognizing possible corrosive soil conditions. However, soil samples should be routed through local Field Service Engineers who should act as central coordinators mapping potential corrosive soil areas.

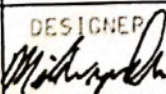
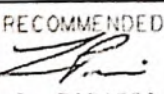
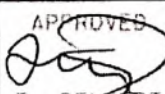
D. REVISED BILL OF MATERIAL

The following details the revisions to the Bill of Material for those areas where high corrosion levels are found.

Ground Rod Installation at Poles (Refer to ES43 R2-06)

Item No.	Description	Catalogue ID
1	Ground Rod, 5/8" x 9' copperclad steel	420-1104
2	Connector, Counterpoise/Gnd Conductor to Gnd Rod, in copper bronze	420-1159

DRAFTER: DM

DESIGNER  M. WYNDHAM	RECOMMENDED  C. PICASSI	APPROVED  F. DENNERT
ORIGINAL ISSUE DATE: MAY 1986		

BONDING AND GROUNDING
GROUNDING IN HIGH CORROSION AREAS

BChydro  DISTRIBUTION STANDARDS

PAGE 2
OF 3

ES43 R6-01.02

R. 3

FORM FOR SUBMITTING SOIL SAMPLE FOR CORROSION ANALYSIS

SECTION A (To be filled in by designer)

1. Location of sample:
2. Date sample was taken:
3. General weather conditions:
4. Return Address:

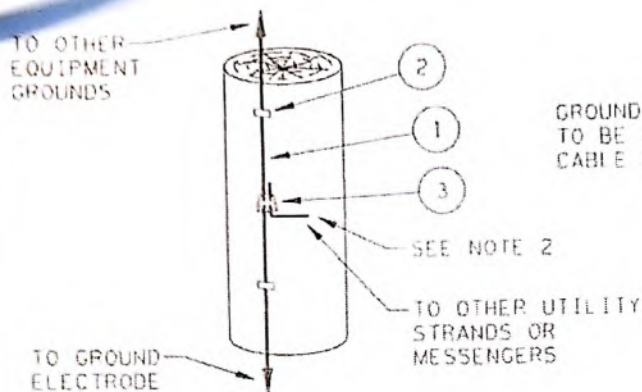
SECTION B (To be filled in by Powertech Labs)

<u>Soil Parameter</u>	<u>Value</u>
pH	
soil resistivity	Ω -m
chloride ion	ppm
Sulfide Ion present: (check appropriate one)	Yes No

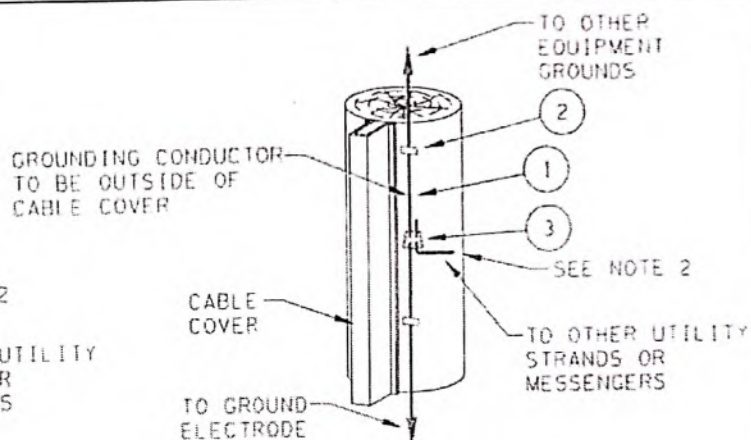
COMMENTS: (if any)

NOTE: Completed copy to be returned to originator, who should forward a copy to the local Field Services Engineer.

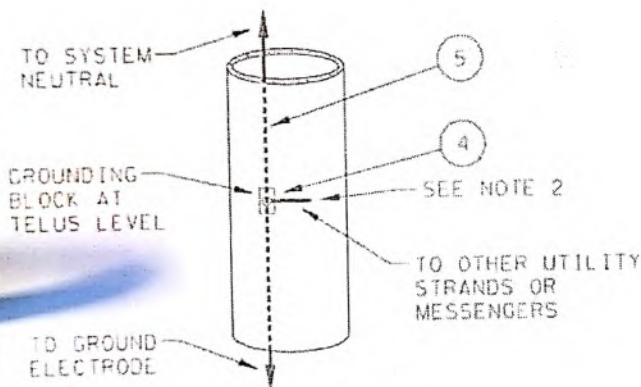
DRAFTER: DN	DESIGNER <i>M. Wyndham</i> M. WYNDHAM	RECOMMENDED <i>C. Picassi</i> C. PICASSI	APPROVED <i>F. Dennert</i> F. DENNERT	BONDING AND GROUNDING GROUNDING IN HIGH CORROSION AREAS		
	ORIGINAL ISSUE DATE: MAY 1986					
	BChydro  DISTRIBUTION STANDARDS				PAGE 3 OF 3	ES43 R6-01.03



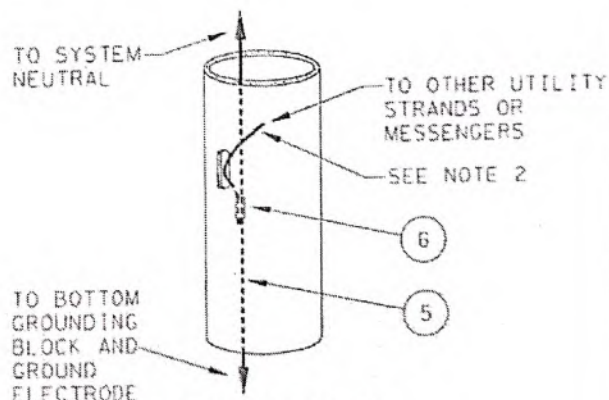
WOOD POLE



**TERMINAL POLE
(WOOD)**



**CONCRETE POLE
WITH GROUNDING BLOCKS**



**CONCRETE POLE
WITH HAND HOLES**

NOTES:

1. Other utilities such as TELUS, cable tv, etc, shall ground their messengers or support strands to BC Hydro's grounding conductors as shown above.
2. Other utility grounding on BC Hydro terminal poles shall be done as shown above.
3. For connection to ground electrodes see Section ES43 R2.
4. For bonding on concrete poles see drawing ES43 R3-09.

ES43 R3-09 Bonding of Concrete Poles
ES43 R2 Ground Electrode Installations
REFERENCE DRAWINGS

Item No.	Description	Catalogue ID
1	Theft Deterrent Galvanized Grounding Wire	96006427 or 96006428
2	Staple, Ground Conductor	103-0224
3	Miniwedge Connector	See ES43 R2-01
4	Connector, Split Stud	388-2103
5	#4 AWG Cu Gnd Conductor P.E. covered	380-5051
6	Compression Connector C-type	388-0453

DESIGNER: M. WYNHAM
RECOMMENDED: C. PICASSI
APPROVED: F. DENNERT

ORIGINAL ISSUE DATE: MAY 1986

**BONDING AND GROUNDING
OTHER UTILITIES
GROUNDING CONNECTIONS**

Structure No.	BCH Drawing	X	Y	Horiz Dist (m)	Cummulative (m)	Elev	Line Angle Ded	No. of Poles	Pole Species	Pole Class	Pole Height (ft)	Guy
0		620,450	6,055,326	50					WRC			
1		620,437	6,055,250	77	50	688		1	WRC	2	50	
2	K5-04.01	620,432	6,055,225	26	76	690		1	WRC	3	50	
3	K5-06.01	620,427	6,055,198	27	103	684		1	WRC	3	50	
4	K3-06.01	620,422	6,055,170	28	131	682		1	WRC	3	50	
5	J7-01.01	620,418	6,055,143	28	159	678		1	WRC	3	50	
6	G4-02.01	620,411	6,055,107	36	195	675		1	WRC	3	50	
7	G4-10.02	620,406	6,055,079	28	224	674	11	1	WRC	2	50	1
8	G4-02.01	620,407	6,055,023	56	280	673		1	WRC	3	50	
9	G4-02.01	620,407	6,054,964	59	338	672		1	WRC	3	50	
10	G4-02.01	620,408	6,054,913	51	390	671		1	WRC	3	50	
11	G4-02.01	620,409	6,054,858	55	445	671		1	WRC	3	50	
12	G4-02.01	620,410	6,054,801	57	502	671		1	WRC	3	50	
13	G4-02.01	620,410	6,054,741	61	562	672		1	WRC	3	50	
14	G4-02.01	620,411	6,054,680	60	622	672		1	WRC	3	50	
15	G4-02.01	620,412	6,054,626	55	677	672		1	WRC	3	50	
16	G4-02.01	620,412	6,054,566	59	737	673		1	WRC	3	50	
17	G4-10.02	620,413	6,054,512	55	791	675	11	1	WRC	2	50	1
18	G4-02.01	620,404	6,054,460	53	844	677		1	WRC	3	50	
19	G4-02.01	620,393	6,054,401	60	903	679		1	WRC	3	50	
20	G4-02.01	620,382	6,054,340	62	966	680		1	WRC	3	50	
21	G4-09.01	620,371	6,054,282	59	1,024	682		1	WRC	3	50	
22	G4-10.03	620,359	6,054,215	68	1,093	684	35	1	WRC	2	50	2
23	G4-02.01	620,390	6,054,148	74	1,166	686		1	WRC	3	50	
24	G4-02.01	620,426	6,054,071	86	1,252	688		1	WRC	3	50	
25	G4-02.01	620,462	6,053,995	83	1,335	690		1	WRC	3	50	
26	G4-02.01	620,497	6,053,918	85	1,420	692		1	WRC	3	50	
27	G4-11.01	620,537	6,053,833	94	1,514	692	95	1	WRC	2	50	2
28	G4-10.02	620,463	6,053,807	78	1,592	692	12	1	WRC	2	50	1
29	G4-11.01	620,413	6,053,800	51	1,643	693	55	1	WRC	2	50	2
30	G4-02.01	620,357	6,053,860	82	1,725	693		1	WRC	3	50	
31	G4-02.01	620,300	6,053,922	84	1,809	694		1	WRC	3	50	
32	G4-02.01	620,241	6,053,986	87	1,896	695		1	WRC	3	50	
33	G4-02.01	620,182	6,054,049	86	1,983	697		1	WRC	3	50	
34	G4-10.03	620,128	6,054,108	80	2,062	699	23	1	WRC	2	50	2
35	G4-02.01	620,050	6,054,144	86	2,149	705		1	WRC	3	50	
36	G4-02.01	619,965	6,054,182	93	2,241	725		1	WRC	3	50	
37	G4-02.01	619,887	6,054,217	85	2,327	735		1	WRC	3	50	
38	G4-02.01	619,810	6,054,251	84	2,411	750		1	WRC	3	50	
39	G4-11.01	619,728	6,054,288	90	2,501	765	49	1	WRC	2	50	2
40	G4-02.01	619,671	6,054,262	63	2,564	766		1	WRC	3	50	
41	G4-10.03	619,608	6,054,233	69	2,633	768	32	1	WRC	2	50	2
42	G4-02.01	619,564	6,054,165	81	2,714	770		1	WRC	3	50	
43	G4-02.01	619,526	6,054,107	70	2,784	772		1	WRC	3	50	
44	G4-11.01	619,490	6,054,051	66	2,850	775	47	1	WRC	2	50	2
45	G4-02.01	619,421	6,054,039	70	2,920	790		1	WRC	3	50	
46	G4-02.01	619,347	6,054,025	75	2,995	788		1	WRC	3	50	
47	G4-10.03	619,269	6,054,012	79	3,074	787	28	1	WRC	2	50	2
48	G4-02.01	619,211	6,053,966	74	3,148	787		1	WRC	3	50	
49	G4-02.01	619,151	6,053,919	77	3,224	787		1	WRC	3	50	2
50	G4-11.01	619,089	6,053,870	79	3,303	787	53	1	WRC	2	50	2
51	G4-02.01	619,090	6,053,775	96	3,399	792		1	WRC	3	50	
52	G4-11.01	619,092	6,053,683	92	3,491	798	46	1	WRC	2	50	2
53	G4-02.01	619,058	6,053,643	52	3,543	801		1	WRC	3	50	
54	G4-11.01	619,007	6,053,598	68	3,611	801	95	1	WRC	2	50	2
55	K5-06.01	619,019	6,053,587	16	3,627	802		1	WRC	3	50	
56	J2-09-01A	619,032	6,053,577	17	3,644	803		1	WRC	3	50	
57	K3-06.01-04	619,045	6,053,566	17	3,661	790		1	WRC	3	50	1
58	G4-02.01	619,113	6,053,947	47	47	800		1	WRC	3	50	
59	G4-02.01	619,043	6,053,998	87	134	800		1	WRC	3	50	
60	G4-02.01	618,972	6,054,049	87	221	800		1	WRC	3	50	
61	G4-02.01	618,905	6,054,098	83	304	800		1	WRC	3	50	
62	G4-02.01	618,835	6,054,149	87	391	800		1	WRC	3	50	
63	G4-02.01	618,765	6,054,200	87	478	800		1	WRC	3	50	
64	G4-02.01	618,687	6,054,257	96	574	800		1	WRC	3	50	
65	G4-10.03	618,613	6,054,311	91	665	800	27	1	WRC	2	50	2
66	G4-02.01	618,592	6,054,390	82	747	800		1	WRC	3	50	
67	G4-02.01	618,574	6,054,463	75	822	800		1	WRC	3	50	1

Telkwa Power Costs

Oct 11 2018
by: MMC

Oct 11 2018
by: MMC

Load		
BC Hydro Tariff		Eff Apr 1, 2018
Assumed annual average load	MW	2.0
Hours per year operation		8,600.0
Annual Energy Usage	MWh	17,200
Assumed Load Factor	factor	0.85
Assumed corrected Power Factor	factor	0.96
Peak Load	MVA	2

		Eff Apr 1, 2018
		0.5
		8,600.0
		4,300
		0.85
		0.96
		1

Shaded numbers are user entered

Rates		
Energy Charge	\$/MWh	57.20
Demand Charge	\$/MVA-mo	\$ 11,440

	57.20
\$	11,440

Annual Utility Charges		
Energy	\$	\$ 983,840
Demand	\$	\$ 336,471
Total Charges	\$	\$ 1,320,311

	245,960
\$	84,118
\$	330,078

Rider	factor	1.00
Total Charges including Rider	\$	\$ 1,320,311

	1.00
\$	330,078

Total Charges per MWh	\$/MWh	\$ 76.8
Total Charges per kWh	\$/kWh	\$ 0.0768

	76.8
\$	0.0768

Cost of Line Losses		
Line Loss	MW	0.01
Cost of Line Losses	\$	\$ 6,706
Additional Cost per MWh	\$/MWh	\$ 0.39
Additional Cost per kWh	\$/kWh	\$ 0.0004

	0.01
\$	6,706
\$	1.56
\$	0.0016

Total Net Charges to Mine per MWh	\$/MWh	\$ 77.15
Total Net Charges to Mine per kWh	\$/kWh	\$ 0.0772

	78.32
\$	0.0783

Included Line Losses

Cost of Transformer/E-House/Switchgear Maintenance		
Estimated at	\$/yr	\$ 15,000
Converted to cost per MWh		\$ 0.87
Converted to cost per kWh		\$ 0.0009

	15,000
\$	3.49
\$	0.0035

Cost of Line Maintenance		
Estimated at	\$/yr	\$ 25,000
Converted to cost per MWh		\$ 1.45
Converted to cost per kWh		\$ 0.0015

	25,000
\$	5.81
\$	0.0058

Total Cost of Electricity at Mine Site before tax		
Cost per MWh	\$/MWh	\$ 79.48
Cost per kWh	\$/kWh	\$ 0.0795

\$	87.62
\$	0.0876

Includes Line Losses and Line Maintenance

Incl GST at 5%	1.05
Incl PST at 7%	1.07

	1.05
	1.07

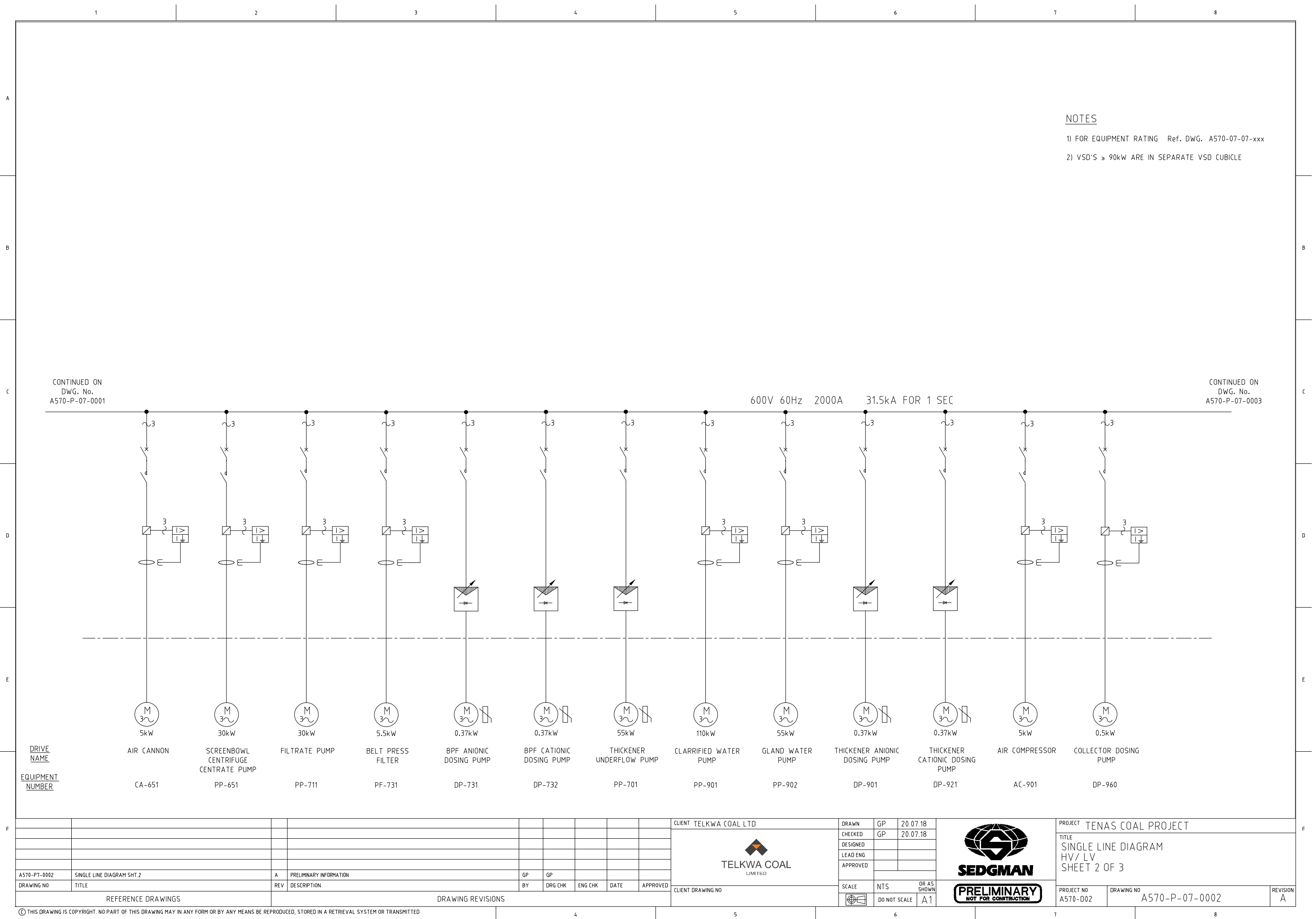
Total Cost of Electricity at Mine site all in		
Cost per MWh	\$/MWh	\$ 89.02
Cost per kWh	\$/kWh	\$ 0.0890

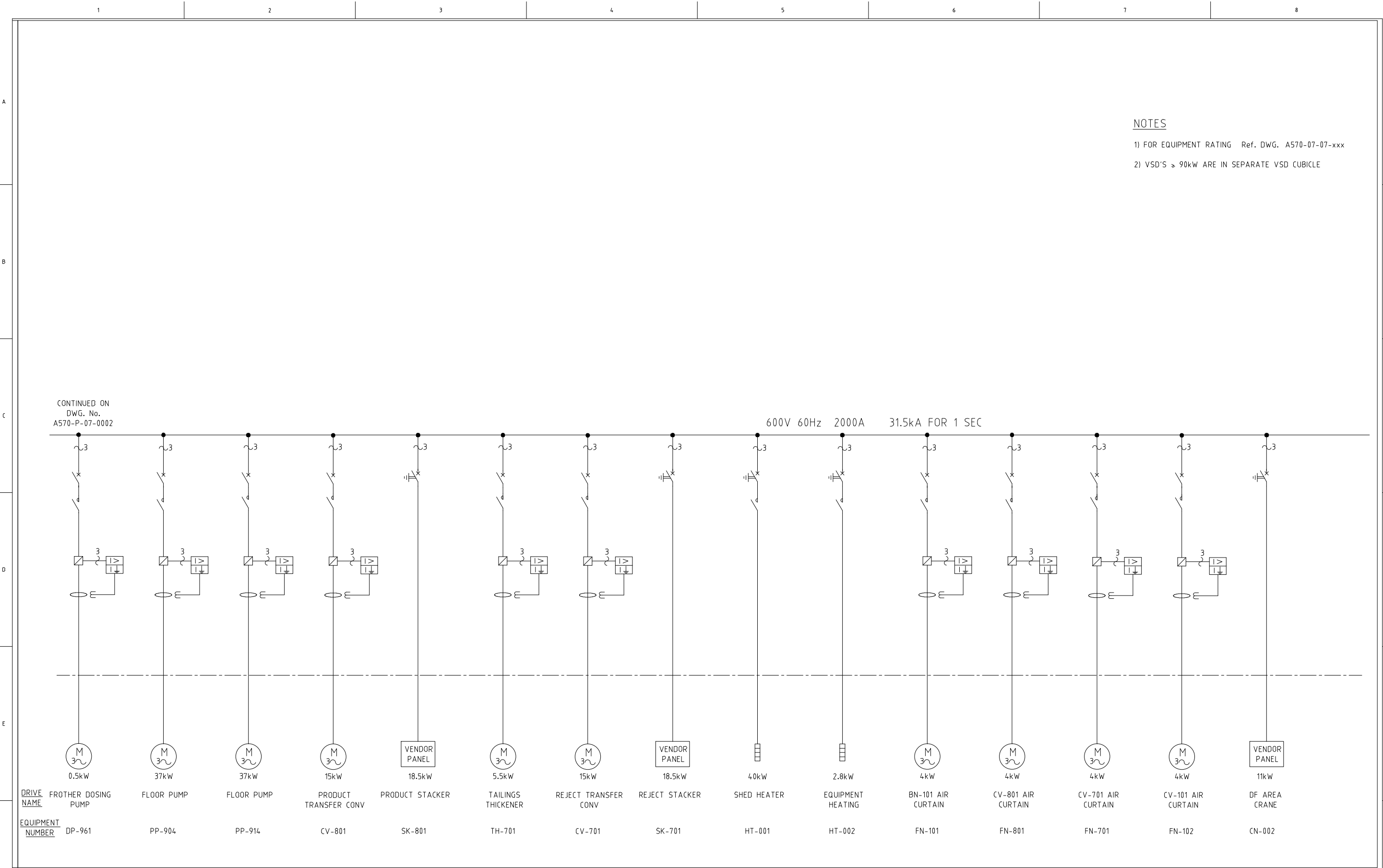
	98.14
\$	0.0981

Includes Line Losses, Line Maintenance and GST

Total Cost of Electricity at Mine Site all in (tax, maintenance, losses)	\$	1,531,059
---	----	-----------

\$	421,998
----	---------





NOTES

- 1) FOR EQUIPMENT RATING Ref. DWG. A570-07-07-xxx
- 2) VSD'S ≥ 90kW ARE IN SEPARATE VSD CUBICLE

F																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

R. 1- REDONE & REVISED. MAY'01 BF
R. 2- REVISED & TITLE BLOCK CHANGE. MAY'10 FK
DRAFTER: DM

SECTION B - CLEARANCES

ES43 B1

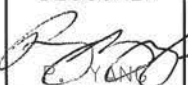
CLEARANCES: GENERAL NOTES

B1-01	Clearances - General Notes
B1-02	Standard Vertical Sag Criteria for Wires and Conductors above Ground and Roads
B1-03	Vertical Design Clearances of Wires and Conductors above Ground
B1-11	Clearances above Ground for Low Voltage Services
B1-12	Clearances over Railway Crossings
B1-13	Vertical Spacing of Power Conductors and Communication Lines Attached to the Same Pole
B1-15.01	Minimum Clearances - Buildings and Streetlights
.02	Canadian Electrical Code Clearance Requirements
B1-16	Vertical Separation between Conductors Carried on Separate Supports

DESIGNER

RECOMMENDED

APPROVED

 P. YANG
 C. PICASSI
 F. BENNERT

ORIGINAL ISSUE DATE: OCTOBER 1985

CLEARANCES TABLE OF CONTENTS

BCHydro  DISTRIBUTION STANDARDS

PAGE 1
OF 1

ES43 B0-01

R. 2

1. Mandatory Minimum Clearances:

The following pages give the mandatory minimum clearances, separations, and spacing that must be maintained between electric power conductors, communication lines, span guys, foreign objects, and the ground under specified conditions. To ensure that these minimum values are met under maximum specified loading and service conditions, additional day-to-day clearance must be obtained to allow for varying operating, weather, and other conditions on or around the pole. Allowances should also be made for anticipated future changes such as distribution or communication plant additions, changes to road grades, new buildings adjacent to the pole line, etc.

2. Vertical Clearances:

Vertical clearances shown are, in general, those specified in CSA Standard C22.3 No. 1-10, and apply under conditions of maximum specified design sag due to either ice-loading or thermal expansion, whichever is larger. Vertical clearances apply to any point of the span, so allowances must be made for the profile of the terrain. To calculate the clearance of inclined spans, see ES43 Y1-04.

3. Horizontal Clearances:

Horizontal clearances shown are, in general, those specified in CSA Standard C22.3 No. 1-10, and apply under conditions of maximum specified design swing for the conductor or wire. To calculate conductor swing, see ES43 Y1-06.

4. Private Property:

For conductors over private property, clearances must conform with the requirements of the Canadian Electrical Code (CSA Standard C22.1, Canadian Electrical Code Part 1).

5. Highways:

For conductors crossing or alongside highways, clearances shown are those specified in the B.C. Ministry of Transportation & Infrastructure (MoTI) Utility Policy Manual, and apply within MoTI rights-of-way.

6. Navigable Waters:

Clearances over navigable waters are not included in this section. Such clearances are subject to the regulations of Transport Canada and are shown on the individual crossing permits.

DRAFTER: DM

DESIGNER  P. YANG	RECOMMENDED  C. PICASSI	APPROVED  F. DENNERT
ORIGINAL ISSUE DATE: SEPTEMBER 1985		

CLEARANCES GENERAL NOTES

7. Gas / Propane Tanks:

Conductors are not to pass over gasoline pumps or propane tanks over 7600 litres capacity. Primary conductors, including the system neutral, are to be kept 7.6 m horizontal distance from gasoline pumps or propane tanks.

8. Secondary Conductors:

The practical clearance of secondary and neutral conductors may be dictated by pole attachment heights needed to attain required service clearances (see ES43 B1-11).

9. Joint Use Poles:

On joint use poles, minimum clearances and attachment heights of conductors are dictated by Provincial and National Regulations, by the BC Hydro/TELUS Joint Use Agreement, and by variations established from time-to-time by the Joint Use Coordinating Committee (JUCC). (See ES43 C2-01).

10. Over-Height Vehicle Clearances:

For line construction through farmland, consideration must be given to the likelihood of large farm machinery being moved about. Near machinery depots, dumping areas, and logging areas, additional vertical clearances may be required by local agreement to allow passage of vehicles and machinery in excess of 4.15 m in height. Where combined height of vehicle plus load exceeds 4.15 m, clearances must be increased by the amount by which the height exceeds 4.15 m. (See ES43 B1-03)

11. Transmission Line Clearances:

Transmission Engineering must be consulted for clearances to transmission conductors, as sags may change significantly under extreme operating conditions (see ES43 B1-16).

12. Horizontal Separation from Other Buried Services:

Minimum separation of 0.6 m is required between the edge of the base of a pole and the nearest face of other buried service, in order to permit pole replacement without damage to other services.

DESIGNER

RECOMMENDED

APPROVED

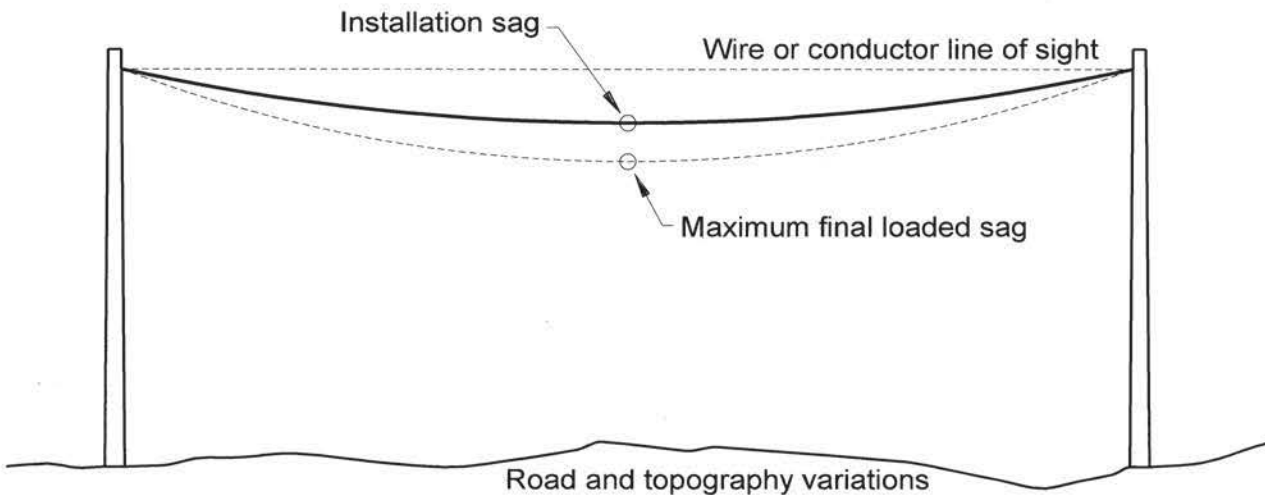

P. YANG


C. PICASSI


F. DENNERT

ORIGINAL ISSUE DATE: SEPTEMBER 1985

CLEARANCES GENERAL NOTES



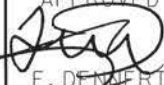
NOTES:

1. Minimum wire and conductor clearances above ground and roads are mandated by road authorities and CSA Standards. Minimum vertical clearances are based on maximum final design sag conditions.
2. For service placing heights see ES43 B1-11.
3. For clearances over railway crossings see ES43 B1-12.

ES43 F2-02
ES43 F1-04
ES43 F1-01

REFERENCE DRAWINGS

DRAFTER: DM	DESIGNER	RECOMMENDED	APPROVED	STANDARD VERTICAL SAG CRITERIA FOR WIRES AND CONDUCTORS ABOVE GROUND AND ROADS
	C. YANG	C. PICASSI	F. DENNERT	
ORIGINAL ISSUE DATE: NOVEMBER 2012				
BChydro DISTRIBUTION STANDARDS				PAGE 1 OF 1
				ES43 B1-02
				R. 0

LOCATIONS OF WIRES OR CONDUCTORS	SPAN GUYS, COMMUNICATION WIRES	SYSTEM VOLTAGE	
		0 - 750 V Phase-Gnd	750 V - 22 kV Phase-Gnd
	Minimum vertical clearances at maximum final design sag		
Over B.C. freeways, expressways and signalized intersections as approved under MoTI jurisdiction	5.5 m	6.1 m	6.7 m
Over or alongside B.C. MoTI highways. Greater clearance may be required for highway maintenance and construction equipment as determined by the District Highways Manager	5.0 m	6.1 m	6.7 m
Over roads, streets, lanes, driveways (other than: residential driveways); over the right-of-way of underground pipelines, and land not likely to be travelled by high road vehicles or high farm machinery	4.42 m	4.42 m	4.75 m
Alongside roads and within 1.5 m of the limit of the right-of-way. (These are generally adjacent to fences and accessible to small vehicles but are not likely to be travelled by high road vehicles or high farm machinery)	3.0 m	3.4 m	4.15 m
Over walkways or ground normally accessible only to pedestrians, snowmobiles, and personal-use all-terrain vehicles. (Seasonal conditions may require additional clearances)	2.5 m	3.1 m	3.4 m
NOTES: - Clearances shown are <u>absolute minimum clearances under maximum final design sag conditions</u>. To ensure these clearances are met, additional clearance is required over and above the normal ambient operating conditions. - Add the amount by which vehicle heights are permitted to exceed 4.15 m. - For neutral and secondary conductors, maximum sags will occur under ice-loading. - For primary conductors, maximum sag may occur under ice-loading or thermal expansion. - To calculate clearance of inclined spans, see ES43 Y1-04.			
DESIGNER  P. YANG	RECOMMENDED  C. PICASSI	APPROVED  F. DEMERT	VERTICAL DESIGN CLEARANCES OF WIRES AND CONDUCTORS ABOVE GROUND
ORIGINAL ISSUE DATE: SEPTEMBER 1985			
BChydro  DISTRIBUTION STANDARDS		PAGE 1 OF 1	ES43 B1-03 R. 3

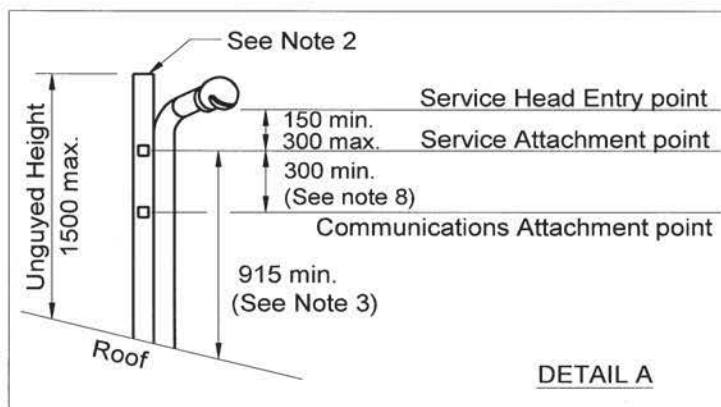
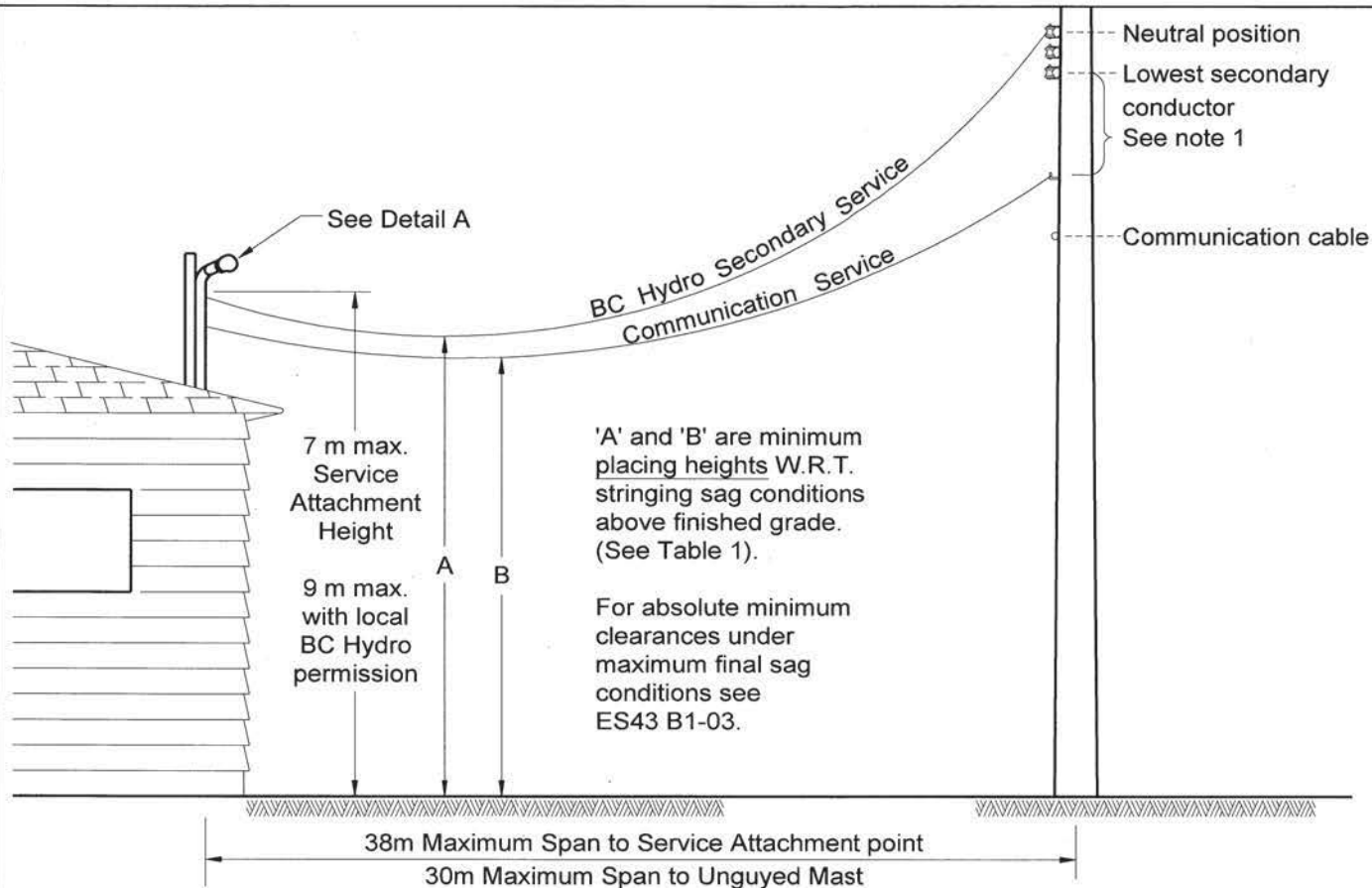


TABLE 1		
LOCATION	A (Hydro)	B (TELUS)
Across MoTI Freeways, Expressways	7.1 m	6.4 m
Across MoTI Highways	7.1 m	5.9 m
Across Streets, Lanes, Pipeline Row	5.5 m	5.3 m
Across Residential Driveways	4.5 m	4.3 m
Across Commercial and Industrial Driveways	5.5 m	5.3 m
Across Ground only Accessible to Pedestrians	3.5 m	3.0 m

NOTES:

1. For Joint Use spacing on Pole see ES43 C2-01.
2. Mast and Service Head to comply with clause 6-112 and 6-116 of the Canadian Electrical Code, Part 1, 2009.
3. Drip Loop clearance to roof 600 mm minimum.
4. Services must also meet the requirements of Distribution Instruction S10-2.
5. All clearances shown apply to services attached directly to the side of buildings. See ES43 N2-02, N2-05 and N2-06.
6. On Joint Poles ensure that sufficient clearance is available to allow for communication service placing height.
7. All dimensions in mm except where noted.
8. Telus requires 600 mm separation on commercial buildings.

R.3- TITLE BLOCK, NOTES REVISED, MAR'10 FK

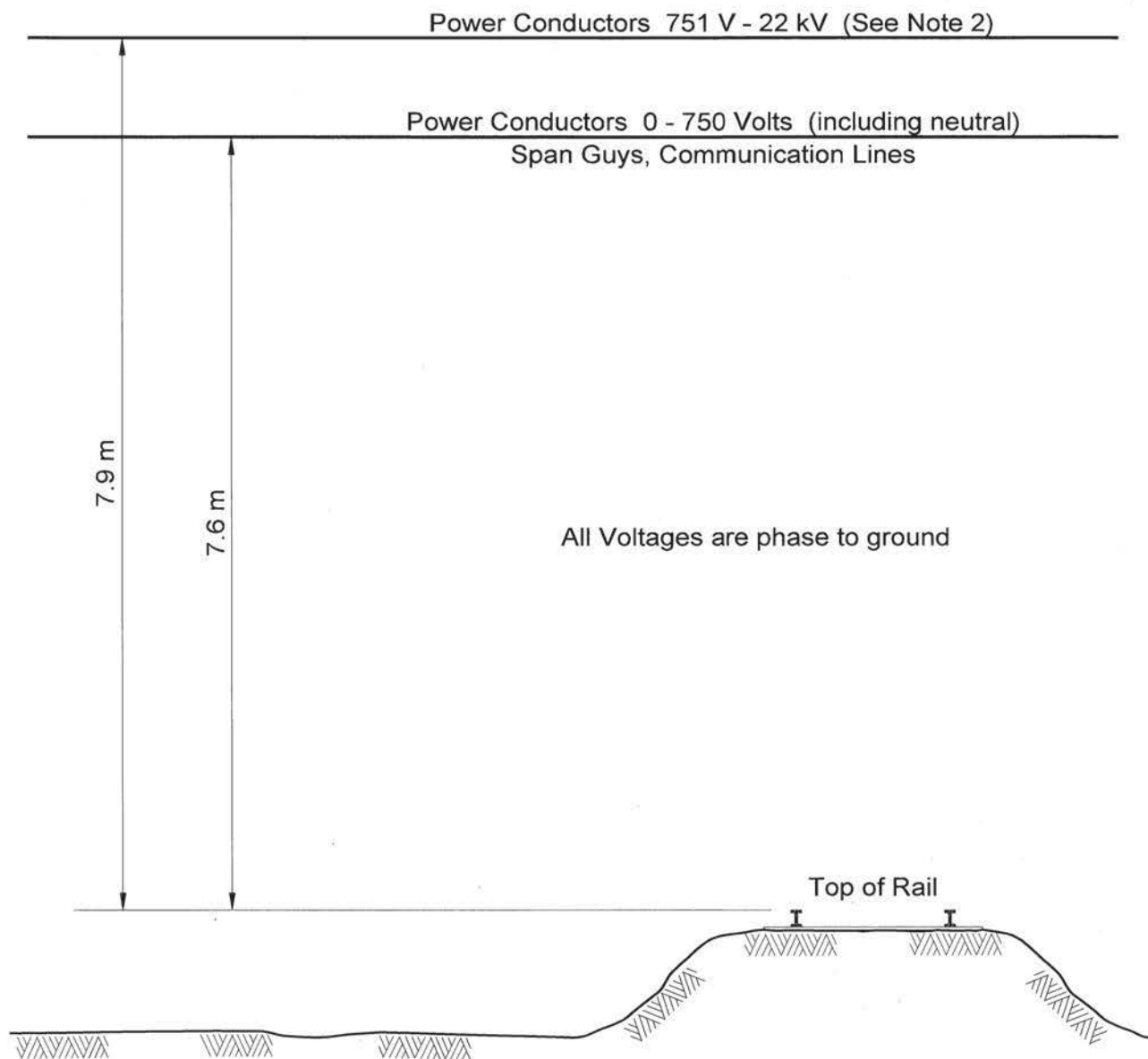
DRAFTER: DM

DESIGNER	RECOMMENDED	APPROVED
 R. YANG	 C. PICASSI	 F. DENNERT

ORIGINAL ISSUE DATE: SEPTEMBER 1985

CLEARANCES ABOVE GROUND FOR LOW VOLTAGE SERVICES

R. 3- TITLE BLOCK, CSA C22.3 NO. 1-10, MAR. '10 FK
DRAFTER: DM



NOTES:

1. Clearances shown are absolute minimum under any and all conditions of sag and loading as specified in CSA C22.3, No.1-10.
2. Clearances include 0.3 m allowance for future ballast lift.
3. Clearances are measured from the top of the rail to the sag point directly over the rail.
4. Transmission Engineering must be consulted for clearances to transmission conductors, as sags may change significantly under extreme operating conditions.

DESIGNER	RECOMMENDED	APPROVED
 R. YANG	 C. PICASSI	 F. DEHNERT

ORIGINAL ISSUE DATE: SEPTEMBER 1985

**CLEARANCES
OVER RAILWAY CROSSINGS**

MINIMUM VERTICAL SEPARATION
(All Voltages are phase to ground)

Power Conductors/ Communication Lines at Lower Level	Power Conductors at Upper Levels	
	0 - 750 volts	0.75 - 22 kV
Communications At the Pole Mid-span	1.0 m (see Note 2)	1.2 m (see Note 3)

NOTES:

1. At the pole these spacings conform with Table 23 of CSA Standard C22.3 No.1-10, but may, in some cases, be less than the framing dimensions shown in this manual. Standard framing dimensions, if larger, will always supersede the spacings given above.
2. For communication service drops at the pole, separation may be reduced to 0.6 m. (See ES43 C2-01).
3. A multi-grounded neutral is considered to be 0 - 750 volts. For single phase flat construction, see ES43 G3-10, 11, 12 and 13 for communication spacing.
4. Minimum in-span vertical clearances between supply and communications conductors are measured from the line of sight of the highest communication wire or cable as follows:

0 - 750 V with WP covering	- 2 mm
0.75 kV - 15 kV	- 300 mm
15 kV - 22 kV	- 380 mm

(Per Table 24 CSA Standard C22.3 No. 1-10)

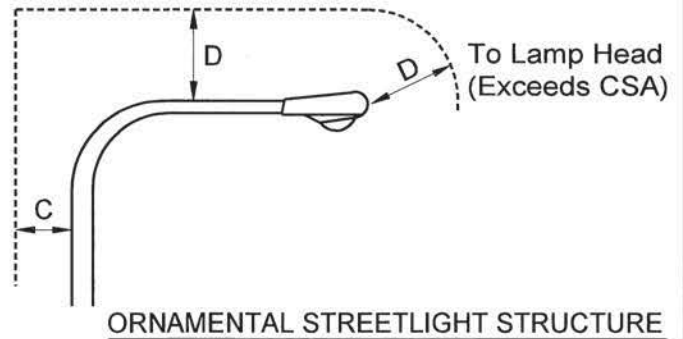
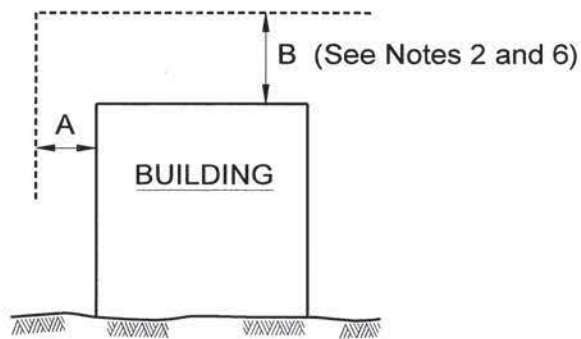
5. For spans over 75 m, the neutral may sag below the line-of-sight of the communication attachments, but not lower than 300 mm above the communication line in the span (per CSA Standard C22.3 No. 1-10 Clause 5.10.3.3).

R.3- TITLE BLOCK, CSA 22.3 No.1-10, MAR'10 FK

DRAFTER: DM

DESIGNER  P. YANG	RECOMMENDED  C. PICASSI	APPROVED  F. DENNERT
ORIGINAL ISSUE DATE: SEPTEMBER 1985		

**VERTICAL SPACING OF POWER
CONDUCTORS AND COMMUNICATION
LINES ATTACHED TO THE SAME POLE**



VOLTAGE PHASE TO GROUND	BUILDING SURFACE		SIGNS, BILLBOARDS, LAMP & TRAFFIC STRUCTURES	
	A Horizontal (See Note 3)	B Vertical (See Note 2)	C Horizontal (See Note 3)	D Vertical (See Note 2)
0 - 750 V	1.0 m (See Note 4)	2.5 m	1.0 m	1.0 m
0.75 - 22 kV	2.0 m	3.0 m	3.0 m	3.0 m

NOTES:

- Clearances apply to any part of the building or streetlight standard.
- Vertical clearances for conductors are absolute minimum under maximum design loading conditions. Conductors over 750 volts should not pass over buildings.
- Horizontal clearances for conductors are in addition to maximum conductor design swing.
- Conductor clearance shall be increased to 1.5 m where conductors pass in front of windows or other openings, unless satisfactorily guarded.
- All clearances meet or exceed CSA Standard C22.3 No. 1-10, Table 9 where applicable.
- Where practical, clearances greater than the minimum specified values should be provided for enhanced safety to persons in or on buildings, workers maintaining streetlights, and firefighters.
- Refer to ES43 B1-15.02 for Canadian Electrical Code requirements of supply plant.

R. 3- TITLE BLOCK, CSA C22.3 No. 1-10, PAGE 2 ADDED. MAR. '10 FK

DRAFTER: DM

DESIGNER  P. YANG	RECOMMENDED  C. PICASSI	APPROVED  F. DENNERT
ORIGINAL ISSUE DATE: SEPTEMBER 1985		

MINIMUM CLEARANCES BUILDINGS AND STREETLIGHTS

NOTES, cont.

Verbatim Rules from the 2012 Edition of the Canadian Electrical Code, Part 1 are listed below. Compliance with the Code edition adopted in the Province of British Columbia is required.

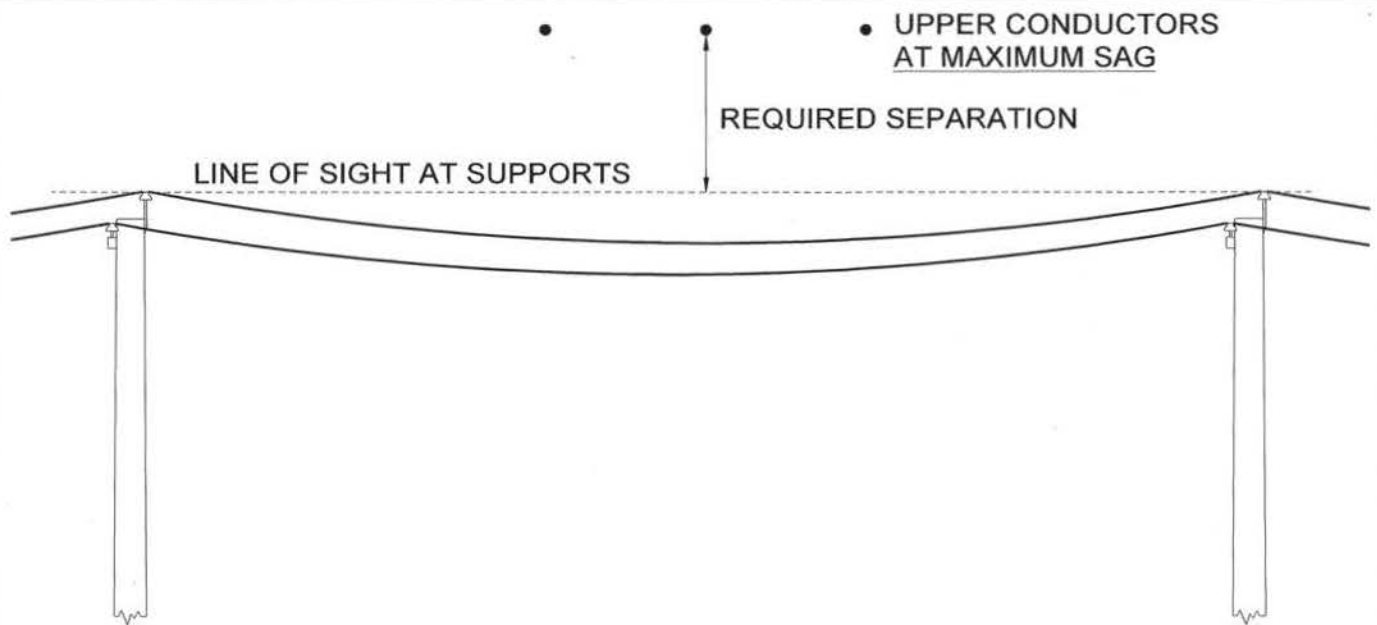
8. Rule 26-014 Dielectric liquid-filled equipment - Outdoors (see Appendix B)

- (1) Except as permitted by Subrule (3), dielectric liquid-filled electrical equipment containing more than 46 L in one tank, or 137 L in a group of tanks, and installed outdoors shall not be located within 6m of:
 - (a) any combustible surfaces or material on a building
 - (b) any door or window
 - (c) any ventilation inlet or outlet
- (2) The dimension referred to in Subrule (1) shall be the shortest line-of-sight distance from the face of the container containing the liquid to the building or part of the building in question.
- (3) Notwithstanding the requirements of Subrule (1), the equipment shall be permitted to be installed within 6m of any item listed in Subrule (1) (a), (b), and (c), provided that a wall or barrier with non-combustible surfaces or material is constructed between the equipment and that item.
- (4) Where dielectric liquid-filled electrical equipment containing more than 46 L in one tank, or 137 L in a group of tanks, is installed outdoors it shall
 - (a) be inaccessible to unauthorized persons;
 - (b) not obstruct firefighting operations;
 - (c) if installed at ground level, be located on a concrete pad draining away from structures or be in a curbed area filled with coarse crushed stone; and
 - (d) not have open drains for the disposal of the liquid in the proximity of combustible constructions or materials.

9. Rule 12-310 Clearance of conductors

The conductors shall be located or guarded so that they cannot be reached by a person standing on a fire escape, flat roof, or other portion of a building, and they shall be at least 2.5 m above the highest point of a flat roof or roof that can be readily walked upon and at least 1 m above peaked roofs or the highest point of roofs that cannot be readily walked upon, except that where a deviation has been allowed in accordance with Rule 2-030, they shall be permitted to be less than 2.5 m but not less than 2 m above the highest point of a flat roof or roofs that can be readily walked upon.

DRAFTER: DM	DESIGNER	RECOMMENDED	APPROVED	CANADIAN ELECTRICAL CODE CLEARANCE REQUIREMENTS		
	 F. YANG	 C. PICASSI	 F. DENNERT			
	ORIGINAL ISSUE DATE: SEPTEMBER 1985					
BChydro  DISTRIBUTION STANDARDS				PAGE 2 OF 2	ES43 B1-15.02	R. 3



CONDUCTORS AND SPAN GUYS AT LOWER LEVEL (PHASE TO GROUND)	POWER CONDUCTORS AT UPPER LEVEL (PHASE TO PHASE)							
	(m)		(SEE NOTES 1 & 4) (m)					
	750 V	25 kV	60 kV	138 kV	230 kV	287 kV	360 kV	500 kV
COMMUNICATION	0.3	2.1	2.1	2.1	2.6	3.1	3.5	4.2
SPAN GUYS	0.2	0.5	1.4	2.0	2.6	3.1	3.5	4.2
0 - 750 VOLTS, A.C.	0.3	0.5	1.4	2.0	2.6	3.1	3.5	4.2
751 - 22,000 VOLTS	---	0.6	1.4	2.0	2.6	3.1	3.5	4.2
TROLLEY 0 - 750 V, D.C. (SEE NOTE 5)	0.6	0.9	1.4	2.0	2.6	3.1	3.5	4.2

NOTES:

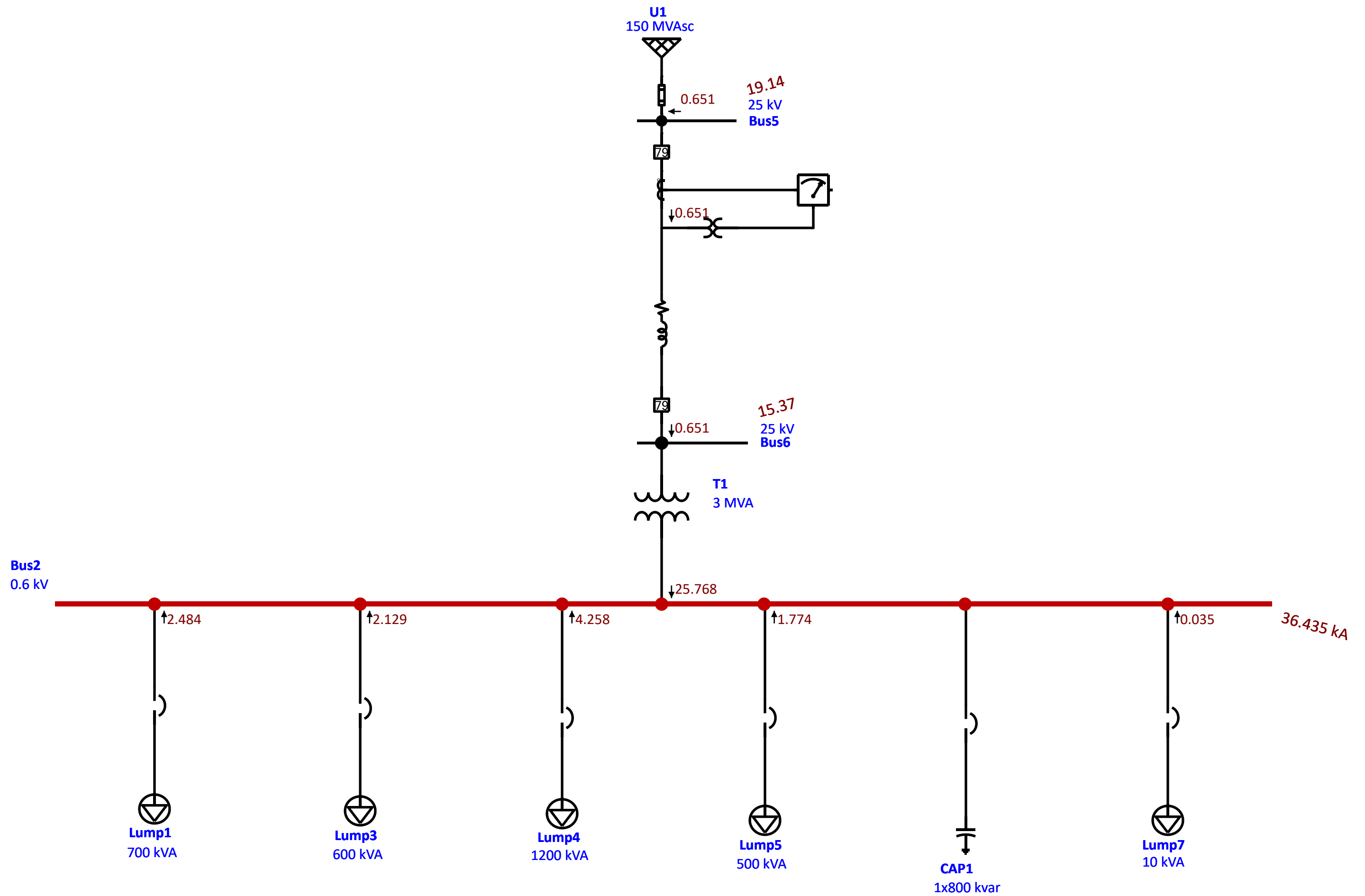
1. Agreement must be obtained from Transmission Engineering before distribution lines are designed or constructed, or clearances are altered beneath transmission lines, as sags may change significantly under extreme operating conditions. Transmission line elevations at maximum sag must be obtained from Transmission Engineering, as normal survey methods will not determine maximum sag conditions.
2. These minimum separations meet or exceed CSA Standard C22.3 No. 1-10 Table 13, and apply when the top conductors are at maximum sag.
3. A multigrounded neutral is considered to be less than 750 volts.
4. Minimum separations to conductors above 25 kV meet or exceed Transmission Engineering Standard 41 K March 2008, Table 3.
5. Where the trolley pick up arm is not prevented from de-wiring, the clearance shall be increased to meet the specified clearance in the de-wired position.

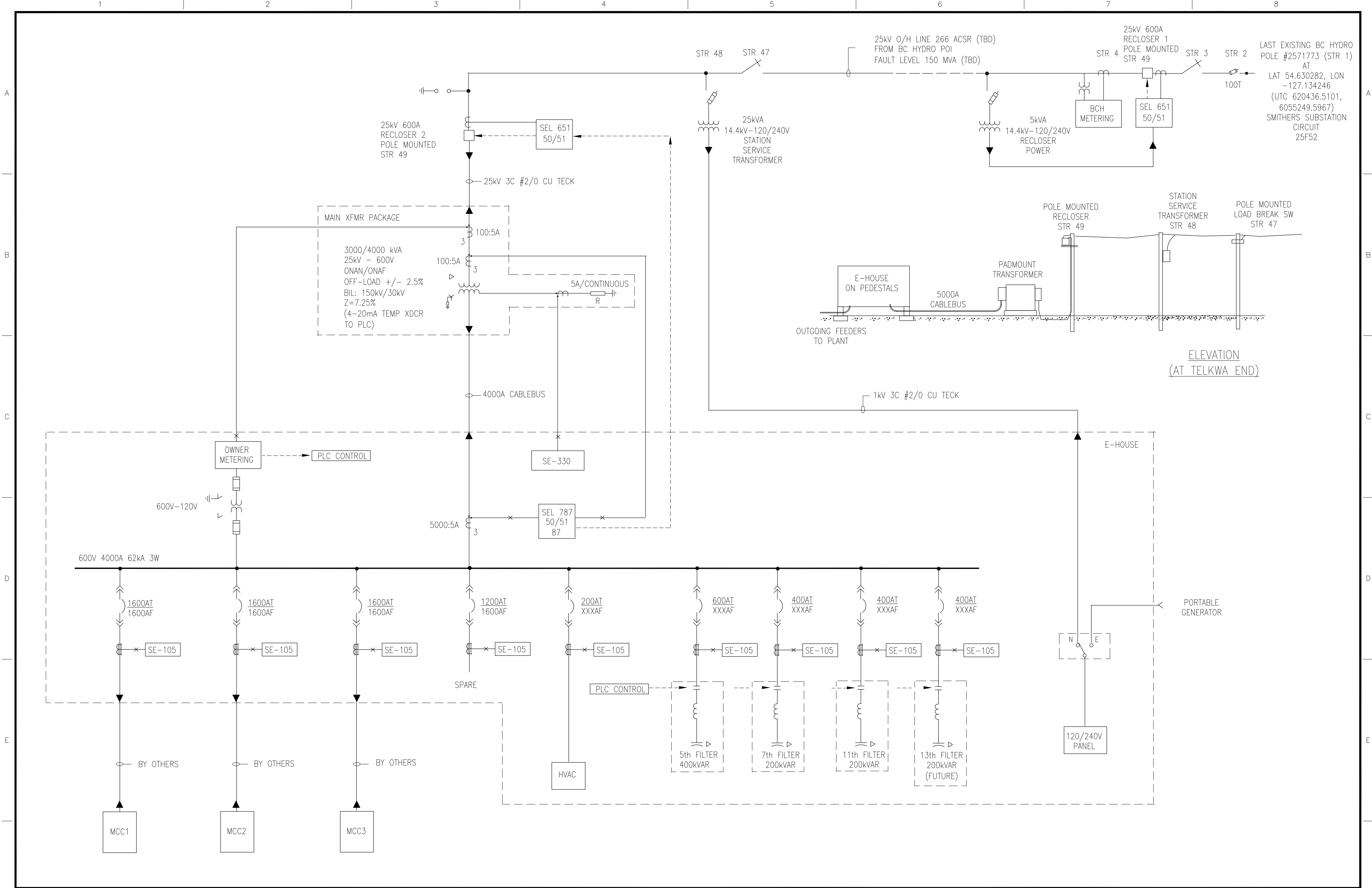
DESIGNER  P. YAM	RECOMMENDED  C. PICASSI	APPROVED  F. DENNERT
ORIGINAL ISSUE DATE: SEPTEMBER 1985		

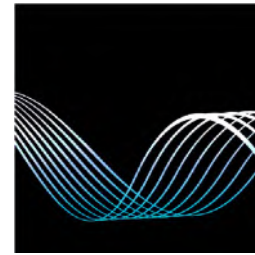
VERTICAL SEPARATION BETWEEN CONDUCTORS CARRIED ON SEPARATE SUPPORTS

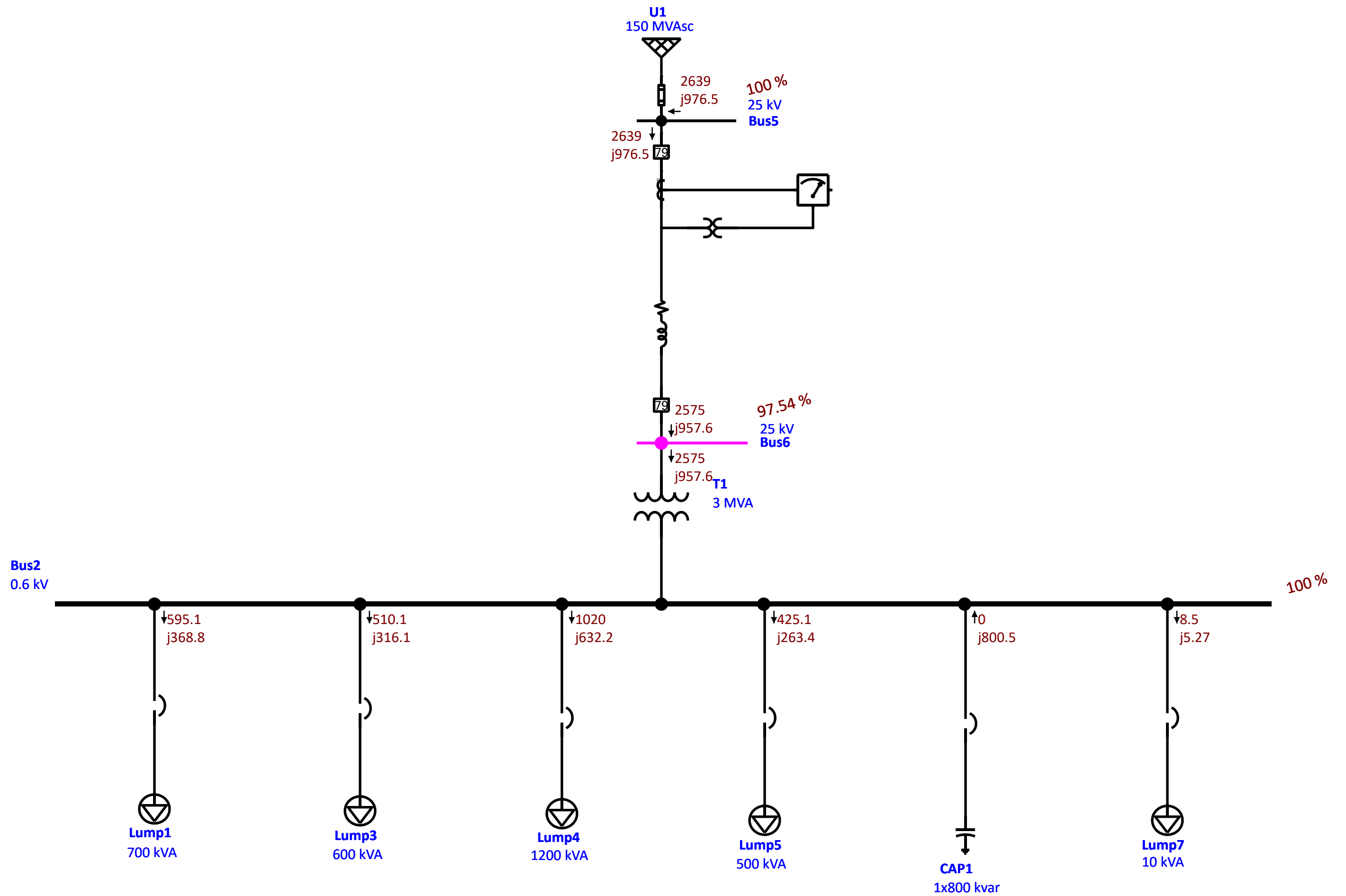


Area	Equipment Tag	Sub-Item	Description	Equipment Type	Motor Power (kW)
Raw Coal Handling	FB-101		Raw Coal Reclaim Breaker	Feeder - Chain	
Raw Coal Handling	FB-101	a	Breaker Drive	Feeder	150
Raw Coal Handling	FB-101	b	Chain Drive	Feeder	220
Raw Coal Handling	FB-101	c	Cooling Fan	Feeder	5
Raw Coal Handling	CV-101		Raw Coal Conveyor	Conveyor	15
Raw Coal Handling	SK-101		Raw Feed Radial Stacker	Conveyor	37
CPP	CR-401		Secondary Sizer	Crusher	75
CPP	CR-402		Tertiary Sizer	Crusher	90
CPP	SC-401		Desliming Screen	Screen	30
CPP	PP-402		Desliming Cyclone Feed Pump	Pump	75
CPP	PP-401		DMC Feed Pump	Pump	132
CPP	SC-402		Product Drain & Rinse Screen	Screen	22
CPP	CF-401		Coarse Coal Centrifuge	Centrifuge - Fine/Coarse	
CPP	CF-401	a	- Rotation Drive	Centrifuge - Fine/Coarse	45
CPP	CF-401	b	- Vibration Drive	Centrifuge - Fine/Coarse	5.5
CPP	CF-401	c	- Vibration Drive	Centrifuge - Fine/Coarse	5.5
CPP	CF-401	d	- Oil Pump Drive	Centrifuge - Fine/Coarse	0.55
CPP	PP-403		Correct Medium Pump	Pump	18.5
CPP	PP-404		Dilute Medium Pump	Pump	45
CPP	MS-401		Magnetic Separators	Magnetic Separator - DM	5.5
CPP	SC-403		Reject Drain & Rinse Screen	Screen	22
CPP	CF-501		Fine Coal Centrifuge	Centrifuge - Fine/Coarse	
CPP	CF-501	a	- Rotation Drive	Centrifuge - Fine/Coarse	75
CPP	CF-501	b	- Oil Pump	Centrifuge - Fine/Coarse	1.1
CPP	PP-501		Fines Feed Pump	Pump	75
CPP	PP-502		Fines Effluent Pump	Pump - Centrifugal	45
CPP	PP-601		Ultrafine Feed Pump	Pump	65
CPP	PP-602		Secondary Flotation Feed Pump	Pump	65
CPP	PP-603		Screen Bowl Centrifuge Feed Pump	Pump	15
CPP	CF-651		Screenbowl Centrifuge	Centrifuge - Screenbowl	
CPP	CF-651	a	- Main Rotation Drive	Centrifuge - Screenbowl	400
CPP	CF-651	b	- Oil Pump Drive	Centrifuge - Screenbowl	2.2
CPP	CA-651		Air Cannon	Air Compressor	5
CPP	PP-651		Screenbowl Centrifuge Centrate Pump	Pump	30
CPP	SC-701		High Frequency Screen	Screen	
CPP	SC-701	a	- Drive A	Screen	3.7
CPP	SC-701	b	- Drive B	Screen	3.7
CPP	PP-711		Filtrate Pump	Pump	30
CPP	AG-731S		BPF Tank Agitator	Agitator	1.49
CPP	PF-731		Belt Press Filter	Filter	5.5
CPP	DP-731		BPF Anionic Dosing Pump	Pump	0.37
CPP	DP-732		BPF Cationic Dosing Pump	Pump	0.37
CPP	PP-704		BPF Feed Pump	Pump	15
CPP	PP-705		BPF Feed Pump	Pump	15
CPP	DP-733		BPF Anionic Dosing Pump	Pump	0.37
CPP	DP-734		BPF Cationic Dosing Pump	Pump	0.37
CPP	AG-732S		BPF Tank Agitator 2	Agitator	1.49
CPP	PF-732		Belt Press Filter 2	Filter	5.5
CPP	FL-701		Cloth Wash Water Filter	Filter	2.2
CPP Services	PP-701		Thickener Underflow Pump	Pump	55
CPP Services	PP-901		Clarified Water Pump	Pump	110
CPP Services	PP-902		Gland Water Pump	Pump	55
CPP Services	PP-903		Reflux Classifier Fluidising Water Pump	Pump	22
CPP Services	DP-901		Thickener Anionic Dosing Pump	Pump	0.37
CPP Services	DP-921		Thickener Cationic Dosing Pump	Pump	0.37
CPP Services	AC-901		Air Compressor	Air Compressor	5
CPP Services	PP-904		Floor Pump	Pump - Sump	37
CPP Services	PP-914		Floor Pump	Pump - Sump	37
Product Handling	CV-801		Product Transfer Conveyor	Conveyor	15
	SK-801		Product Stacker	Stacker	18.5
Product Handling	CV-802		Product Bin Feed Conveyor	Conveyor	22
Reject Handling	TH-701		Tailings Thickener	Thickener	5.5
Reject Handling	CV-701		Reject Transfer Conveyor	Conveyor	15
Reject Handling	CV-702		Reject Bin Feed Conveyor	Conveyor	15
	SK-701		Reject Stacker	Stacker	18.5
Infrastructure - On-Site	HT-001		Heating/HVAC	Heater	40
	HT-002		Heating/HVAC	Heater	2.8
	FN-101		Air Curtain		4
	FN-801		Air Curtain		4
	FN-701		Air Curtain		4
	FN-102		Air Curtain		4
	CN-002		Crane		11
CHPP Installed Power (KW)					2362.95
Infrastructure - Supporting	ST-901		CPP Workshop/Warehouse		120
Infrastructure - Supporting	ST-902		CPP Office & Control Room		30
Infrastructure - Supporting	ST-903		CPP Lab		20
CHPP Infrastructure Installed Power (KW)					170
Train Loadout					
Loadout	RC-801		Product Coal Reclaim Feeder	Feeder - Chain	
Loadout	RC-801	a	Breaker Drive	Feeder - Chain	150
Loadout	RC-801	b	Chain Drive	Feeder - Chain	220
Loadout	RC-801	c	Cooling Fan	Feeder - Chain	5
Loadout	CV-802		Train Load-out Conveyor	Conveyor	225
Loadout	SA-802		Train Loadout Sampler	Sampler - Cross Belt	11
Loadout	HY-801		TLO Hydraulic System		36
Loadout	DS-801		TLO Bin Dust System	Dust Extractor	10
Loadout	ST-803		Train Wagon Spray System	Structure/Station	
Loadout	ST-803	b	Anti-Freeze Dosing Pump	Pump	3
Loadout	ST-803	c	Water Pump	Pump	1.5
Loadout	ST-803	e	Dustbinder Dosing Pump	Pump	0.55
Loadout	ST-803	f	Compressor	Air Compressor	1.5
Loadout	PP-810		TLO Potable Water Pump	Pump	0.55
lights & GPO's			stockpile light towers		20
TLO Installed Power (kW)					684.1
Subtotal					3217





F	THE INFORMATION CONTAINED ON THIS DRAWING HAS BEEN PREPARED SOLELY FOR THE OWNER FOR USE ON THIS PROJECT AND IS COPYRIGHTED. ANY UNAUTHORIZED USE OF THIS INFORMATION IS A BREACH OF COPYRIGHT AND WILL BE PURSUED AS SUCH. USE OF THE INFORMATION ON THIS DRAWING IN WHOLE OR IN PART OTHER THAN FOR THE INTENDED PURPOSE IS AT THE SOLE RISK OF THE USER.										 MCA Engineering Ltd. 917 Columbia St., Lillooet BC V0K1V0 250-256-8008										<table><tr><td>CLIENT</td><td>PROJMAN</td><td>PROJENG</td><td>PROCESS</td><td>ELECTR</td><td>INSTR</td><td>PIPING</td><td>MECH</td><td>STRUCT</td><td>SERVICES</td><td>LAGOUT</td><td>REV.</td><td>ISSUE</td><td colspan="2"></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>A</td><td>B</td><td colspan="2"></td></tr><tr><td colspan="13"></td><td colspan="2">REDUCED MAIN TRANSFORMER SIZE</td><td colspan="2">5 AUG 18</td><td colspan="2">--</td></tr><tr><td colspan="13"></td><td colspan="2">ISSUED FOR QUOTES</td><td colspan="2"></td><td colspan="2">--</td></tr><tr><td colspan="13"></td><td colspan="2">DESCRIPTION</td><td colspan="2">DATE</td><td colspan="2">BY</td></tr><tr><td colspan="13"></td><td colspan="2">No.</td><td colspan="2"></td><td colspan="2"></td></tr><tr><td colspan="13"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr><tr><td colspan="13"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr><tr><td colspan="13"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr><tr><td colspan="13"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr></table>										CLIENT	PROJMAN	PROJENG	PROCESS	ELECTR	INSTR	PIPING	MECH	STRUCT	SERVICES	LAGOUT	REV.	ISSUE														A	B																REDUCED MAIN TRANSFORMER SIZE		5 AUG 18		--															ISSUED FOR QUOTES				--															DESCRIPTION		DATE		BY															No.																																																																																		<table><tr><td colspan="4">DISCIPLINE: PROCESS</td></tr><tr><td colspan="2">SCALE: NONE</td><td colspan="2">DATE</td></tr><tr><td colspan="2">DESIGNED BY: MMC</td><td colspan="2">SEP '17</td></tr><tr><td colspan="2">DRAWN BY: MMC</td><td colspan="2">SEP '17</td></tr><tr><td colspan="2">CHECKED BY:</td><td colspan="2"></td></tr><tr><td colspan="2">APPROVED BY:</td><td colspan="2"></td></tr></table>										DISCIPLINE: PROCESS				SCALE: NONE		DATE		DESIGNED BY: MMC		SEP '17		DRAWN BY: MMC		SEP '17		CHECKED BY:				APPROVED BY:				<table><tr><td colspan="4">TELKWA COAL</td></tr><tr><td colspan="4">ONE LINE DIAGRAM MAIN INCOMING AND E-HOUSE</td></tr><tr><td colspan="4">CLIENT PROJECT No. --</td></tr><tr><td colspan="2">FILENAME</td><td colspan="2">PROJECT NUMBER</td><td colspan="2">CLIENT DWG No. --</td><td colspan="2">DRAWING NUMBER</td><td colspan="2">REV.</td></tr><tr><td colspan="2">3177-E100.DWG</td><td colspan="2">3177</td><td colspan="2">3177-E100</td><td colspan="2"></td><td colspan="2">B</td></tr></table>										TELKWA COAL				ONE LINE DIAGRAM MAIN INCOMING AND E-HOUSE				CLIENT PROJECT No. --				FILENAME		PROJECT NUMBER		CLIENT DWG No. --		DRAWING NUMBER		REV.		3177-E100.DWG		3177		3177-E100				B		H																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
	CLIENT	PROJMAN	PROJENG	PROCESS	ELECTR	INSTR	PIPING	MECH	STRUCT	SERVICES	LAGOUT	REV.	ISSUE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
												A	B																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
														REDUCED MAIN TRANSFORMER SIZE		5 AUG 18		--																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
														ISSUED FOR QUOTES				--																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
														DESCRIPTION		DATE		BY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
														No.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
DISCIPLINE: PROCESS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
SCALE: NONE		DATE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
DESIGNED BY: MMC		SEP '17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
DRAWN BY: MMC		SEP '17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
CHECKED BY:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
APPROVED BY:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
TELKWA COAL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
ONE LINE DIAGRAM MAIN INCOMING AND E-HOUSE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
CLIENT PROJECT No. --																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
FILENAME		PROJECT NUMBER		CLIENT DWG No. --		DRAWING NUMBER		REV.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
3177-E100.DWG		3177		3177-E100				B																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
DWG. NO.										REFERENCE DRAWINGS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							



Statement to BC Hydro Regarding Primary Voltage Service Entrance Equipment

BC Hydro

The Customer, or representative, provides this Statement to BC Hydro knowing that BC Hydro intends to rely upon it.

BC Hydro may refuse to supply Electricity to the Customer or suspend or discontinue the supply if, in BC Hydro's judgment, the Equipment is not compatible with or suitable for the BC Hydro electrical system.

The judgment by BC Hydro of the Equipment shall not be construed by the Customer or others as an endorsement of the design or as a warranty by BC Hydro of the Equipment for the purpose of the Customer or others than BC Hydro.

Project Telkwa Coal Project		Location 4km SE of Telkwa BC		Owner/Developer Allegiance Coal Ltd										
Service: U/G ☐ O/H ☒		At 25 kV	Expected Service Date: June 2019											
Type of Service Equipment: O/H Structure ☒ Unit Sub. ☐ Outdoor ☒ Indoor ☐ Vault ☐														
Required Drawings: One-Line Drawing Number <u>3177-E100</u> Site Plan Drawing Number _____ Equipment Layout Drawing Number _____														
Transformers:														
Bank kV•A	H.V. Winding				L.V. Winding				High Voltage Taps				On-load Tap Changer ± <u>n/a</u> %	Impedance % <u>7.25</u> on bank kV•A base (ONAN)
	Volts	Δ	Y	Y	Volts	Δ	Y	Y	Above Rated Volt.		Below Rated Volt.			
				Grounded				Grounded	No.	%	No.	%		
3000/4000	25kV	X			600			Res Gnd	2	2 1/2 ea	2	2 1/2 ea		
Service Entrance: (Complete I or II)														
(I) Circuit Breaker:														
Voltage Rating 27 kV		Current Rating 600 Amps		Interrupting Rating 12.5 KA SYM RMS		Clearing Time 2 Cycles		Trip Coil - Current Trip tbd - or Shunt Trip		Amps (ac) Volts (dc)				
(II) Fuse Protection: Either Load Break Switch, or Disconnect Switch Interlocked with Secondary Breaker.														
(A) Switch (Specify Mounting): Pole ☐ Structure ☐ Cubicle ☐														
Voltage Rating kV	Load Interrupting Rating Amps		At % P.F.	Momentary Rating Amps		At % P.F.	Manufacturer (if known)		CSA Approval Yes ☐ No. ☐					
(B) Fusing														
Manufacturer		Manufacturer Type Designation		Rated Continuous Current		Rated Maximum Voltage		Fuse Characteristics						
Interconnection Protection:														
Protection		Manufacturer		Type/Style		Timed Element Setting Range		Inst. Element Setting Range						
Ground Overcurrent		SEL		651R		see TCC		see TCC						
Phase Overcurrent		SEL		651R		see TCC		see TCC						
☐ Over ☐ Under Voltage														
☐ Over ☐ Under Frequency														
Synchronizing Check														
Reverse Power														
Differential														
Under Frequency Load Shedding														
Are C.T.'s adequate to operate relays and current trip coils where applicable for all current magnitude from minimum trip to maximum fault duty?														
☒ Yes ☐ No based on maximum fault duty of <u>500</u> MV•A														

Metering:

Pole Metering. Yes ☒ No ☐
 Vault or Indoor Unit Sub. Yes ☐ No ☐
 Outdoor or Unit Sub Yes ☐ No ☐

Estimated Maximum Demand	
Initial	Future
2300 kW	3800 kW

Metered Voltage
25 kV
Rate Schedule
1211

Customer Generation:

- ☒ No Customer generation.
- ☐ Customer generation not parallel to BC Hydro supply, transfer switch type: _____
- ☐ Customer generation parallel to BC Hydro supply but with no agreement to sell electricity to BC Hydro. } If selected, complete Generators Section.
- ☐ Customer generation parallel to BC Hydro supply with intent to sell electricity to BC. Hydro.

Generators:

Type	Energy Source	Manufacturer	Rated Output in kW	Rated Output Voltage	Power Factor	3 PH or 1 PH	Total Harmonic Content Current	Voltage	Reactance in % Machine kV•A Base Xd	Xd'	Xd''	Machine Inertia Constant H

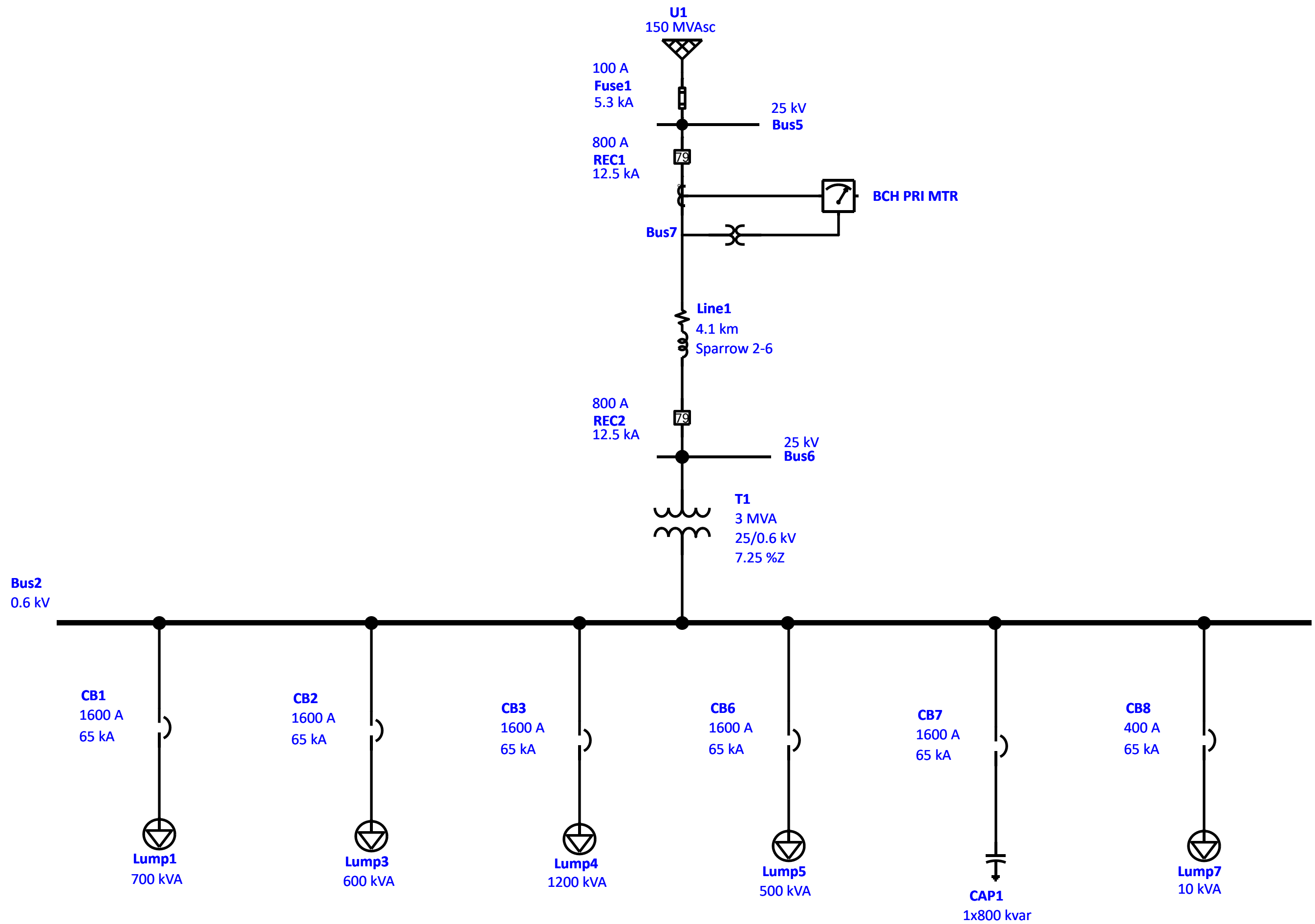
1. Hydraulic 2. Gas 3. Woodwaste 4. Diesel 5. Other: _____
 1. Synchronous Generator 2. Induction Generator 3. Other: _____

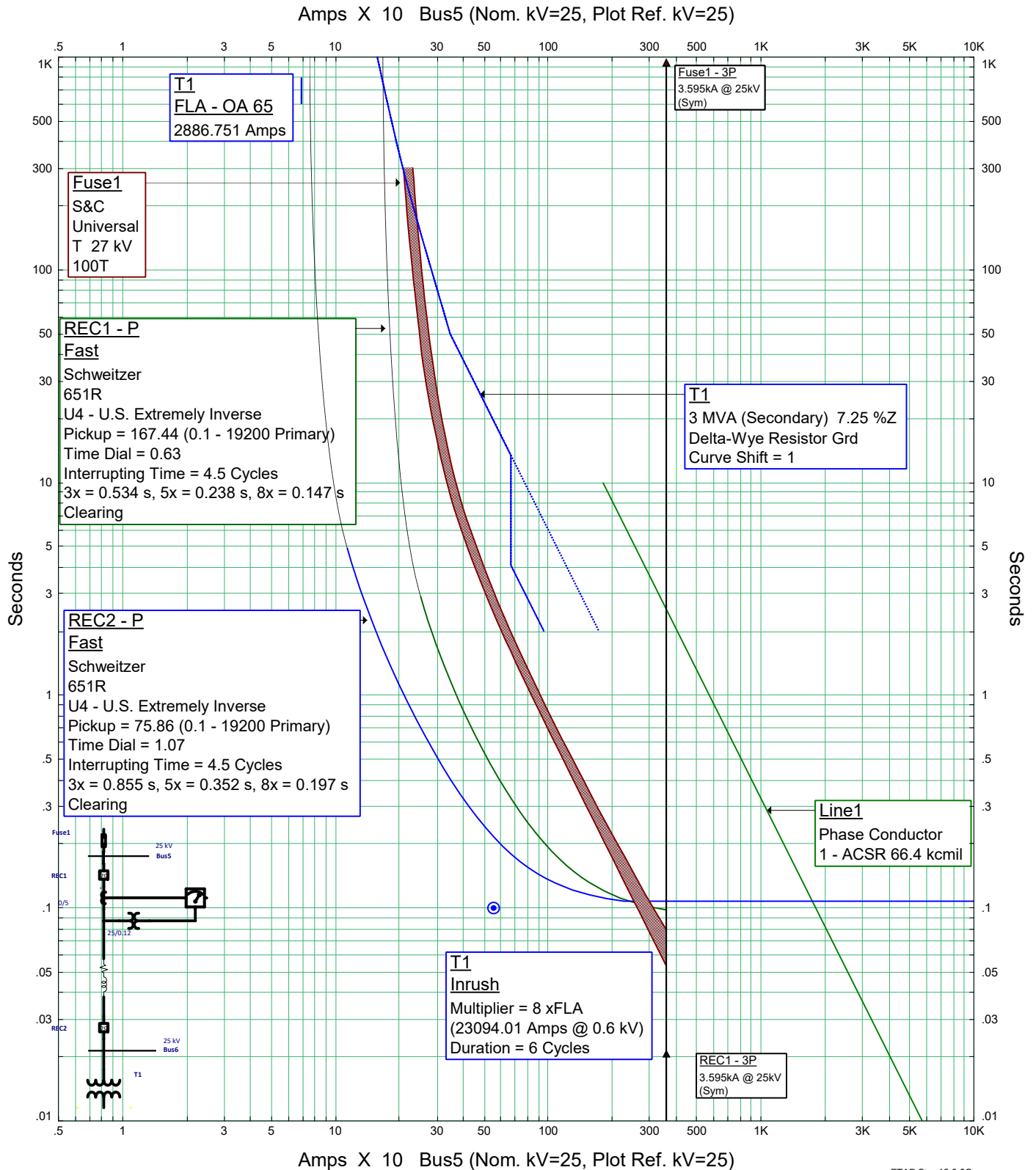
If the above space is insufficient for all generators, please provide remaining generator information separately.

Seal of
Professional
Engineer



MCA Engineering Ltd	BC Hydro
Company	
Signature <i>M. M. Cameron</i>	Received By
7 August 2018	
Date	Date





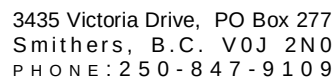
Amps X 10 Bus5 (Nom. kV=25, Plot Ref. kV=25)

ETAP Star 18.0.0C

Star1

Project:
Location:
Contract:
Engineer:
Filename: M:\MCA Engineering Files\Project Files\3177 Bulkley - Allegiance Coal\allegiance\allegi

Date: 07-28-2017
SN: MCA-ENGLTD
Rev: Base
Fault: Phase



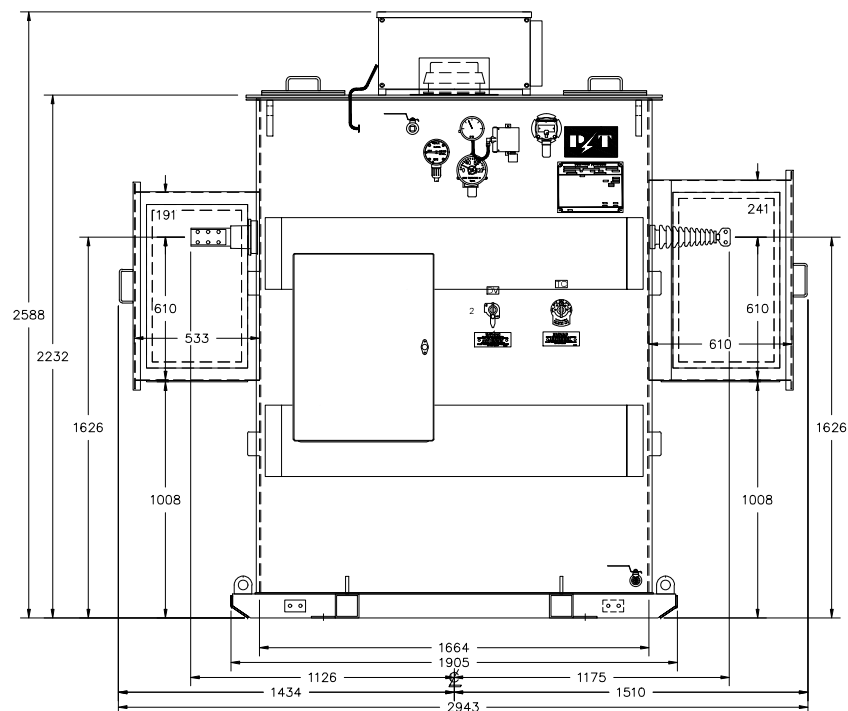
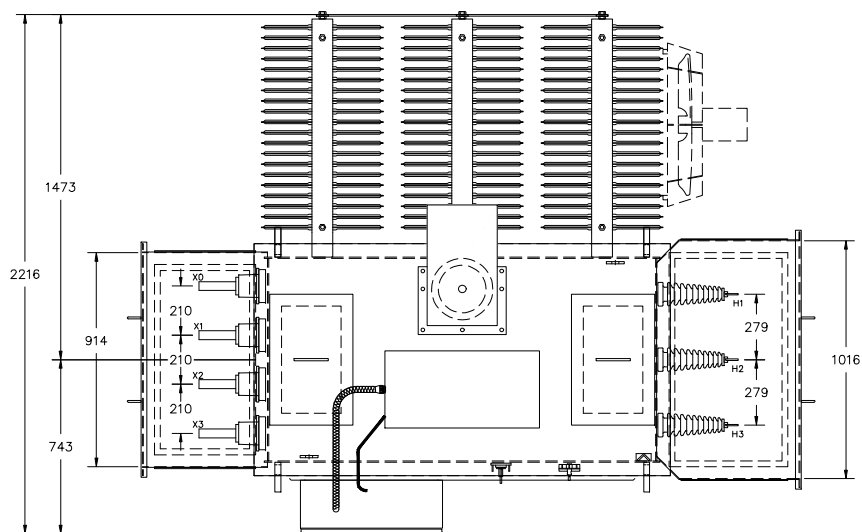
Quote

Customer

Contact:

Qty	Description	Total
	Right of way clearing, staking, surveying	150,000
	Supply and delivery of substation and switchgear	780,000
	Concrete work for pedestal on site	30,000
	Supply and delivery of e-house	180,000
	Install of e-house	25,000
	Supply of powerline, poles, wire, equipment, transport	738,000
	Install of powerline (69 structures)	653,600
	Install of construction power	100,000
	Commissioning	50,000
	Drawings - As-build design	25,000
	Install 3MVA Transformer, Cablebus, PDC,Filter,PLC	74,000
	Communications	45,000
	Grounding	10,000
	* BC Hydro fees by customer (Estimated)	25,000
	Total	2,885,600
This is a quotation on the goods named, subject to conditions noted below Pole plants and civil work by others, quotation valid for 30 days Waste management by others, Filling and patching by others Assumes existing equipment/materail in good working order		2,885,600
		2,885,600

TERMS: Payment in full within 30 days of invoice date. Overdue accounts subject to 1.5% interest per month (19.56% per annum).
Thank you Dave Krabbendam E:dave.krabbendam@bulkleyelectric.com C:2508779303



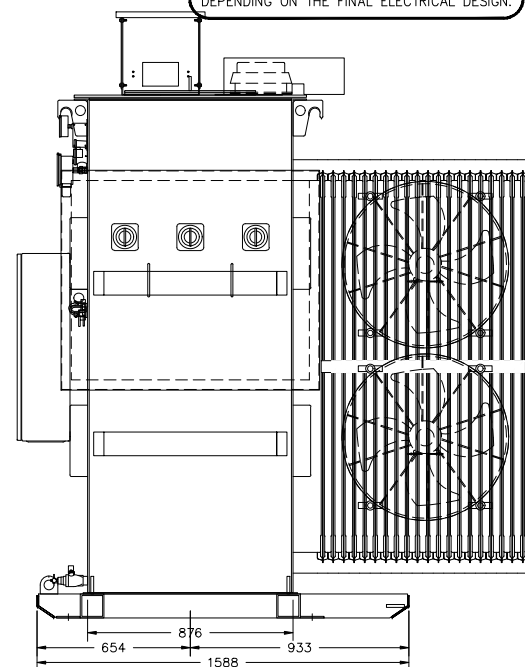
3.00/3.38/PROV. 4.00/4.50 MVA 3 PHASE 60 CYCLES ONAN/PROV. ONAF TYPE
12470 DELTA X 24940 DELTA H.V. 600Y/347 L.V. (+ 2500V (2000V) ON EACH VOLTAGE) TAPS 55/65°C TEMP.RISE

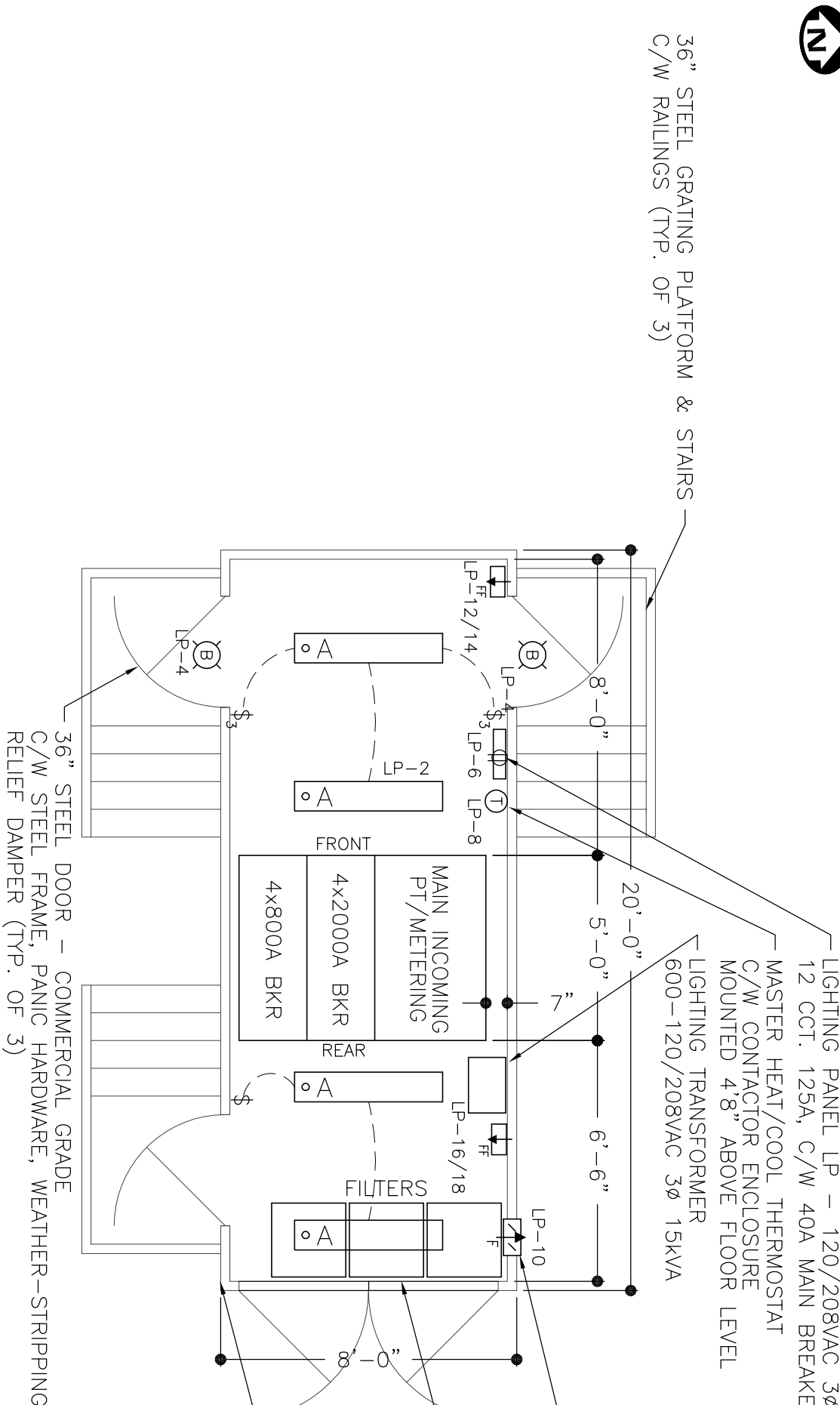
CALCULATED MASSES PER UNIT		
CORE & COILS	3350	kg.
TANK & FITTINGS	2510	kg.
2530 L NON-PCB, CLASS B, TYPE II, MINERAL OIL	2245	kg.
TOTAL	8105	kg.

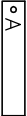
ANSI 70 GREY PAINT

**PRELIMINARY DRAWING :
NOT FOR CONSTRUCTION**

WEIGHT & DIMENSIONS ARE APPROXIMATE ONLY.
FINAL WEIGHT AND DIMENSIONS MAY VARY
DEPENDING ON THE FINAL ELECTRICAL DESIGN.





FIXTURE SCHEDULE	
ITEM	DESCRIPTION
	- LIGHT - SURFACE MOUNTED FLUORESCENT, 120VAC 2 x 32w T8 TUBES, HIGH EFFICIENCY BALLAST PVC WEATHERPROOF ENCLOSURE
	- EXTERIOR LIGHT - WALL MOUNTED LED, 120VAC 17w, C/W PHOTOCELL
	- RECEPTACLE - 15A 120VAC SINGLE POLE DUPLEX SURFACE MOUNTED 3'-0" ABOVE FLOOR LEVEL
\$ ₃	- LIGHT SWITCH - 20A 120VAC 3-WAY 4'2" ABOVE FLOOR LEVEL
\$	- LIGHT SWITCH - 20A 120VAC 4'2" ABOVE FLOOR LEVEL
	- FORCE FLOW HEATER - WALL MOUNTED, 1.5kW 208VAC 1ϕ C/W WALL MOUNTING BOX 1'-0" ABOVE FLOOR LEVEL
	- EXHAUST FAN - 120VAC 1ϕ, 1000CFM CONNECTED MASTER HEAT/COOL THERMOSTAT
①	- MASTER HEAT/COOL THERMOSTAT - 24VAC C/W CONTACTOR BOX

			DESIGN: CAC	TELKWA COAL LTD. TELKWA, B.C.		
			DRAWN: CAC			
			CHECK: .	TITLE: NEW 600V SWITCHGEAR LINE-UP PROPOSED BUILDING G.A.		
			SCALE: 1/4"=1'0"	DRAWING:		REV.
			DATE: 17/11/27	TK-C1		B
			PROJECT: 17L255			
A	CAC	ISSUED FOR CLIENT REVIEW				
REV.	BY	DESCRIPTION				
			Automation now AUTOMATING INDUSTRY THROUGH INNOVATION 1131 CENTRAL AVE SUITE A, THUNDER BAY, ONT.			



TRANSFORMATEURS L.TÉE
PIONEER
TRANSFORMERS LTD



Novus
#1110-1111 West Georgia Street
Vancouver, BC
V6E 4M3

December 4, 2017
Your Reference: Bralorne
Our Reference: 05-037-015

Attention: Malcolm Cameron
We are pleased to submit the following proposal:

Item:	100-TMR-101	100-TMR-102
Quantity:	1	1
Type:	Sub station	Sub station
kVA:	3000/prov/4000 @ 55C 3360/prov/4500 @ 65C	750/prov/1000 @ 55C 840/prov/1125 @ 65C
Temperature Rise:	55/65	55/65
# of Phases (60 Hz.):	3	3
Primary Voltage:	24940 X12470 Delta X Delta Junction Box	24940 X12470 Delta X Delta Junction Box
Secondary Voltage:	600Y/347 Junction Box	4160Y/2400 Junction Box
Taps:	4-2 ½ % 2fcan,2fcbn in both connections	4-2 ½ % 2fcan,2fcbn in both connections
Specification:	CSA C2	CSA C2
CSA Inspection & Decal:	See Below	See Below
* Delivery:	20-22	20-22
Unit Price:	\$ 94,000.	\$ 61,000.
Total	\$ 94,000.	\$ 61,000.

Units will come complete with:

- First filling of oil
- Sealed tank design c/w bolted cover
- Fan provision
- Hot dipped galvanized radiators
- Oil temperature gauge c/w contacts
- Oil level gauge c/w contacts
- Pressure vacuum gauge c/w bleeder and contacts
- Pressure relief device
- Rapid rise relay c/w contacts
- Neutral grounding resistor rated 347 v line to neutral, 5 amps continuous c/w STARTCO EFCT-26 and ER600VC in a NEMA 3R enclosure item 100-TMR-101
- Neutral grounding resistor rated 2400 V line to neutral, 25 amps for 60 seconds, c/w NGRS50 and T6A in a NEMA 3R enclosure
- STARTCO SE-325 monitor and RK-325 remote relay shipped separately
- Both items offered with a minimum impedance of 6.25%.
- Drain and sampling valve
- Filler plug
- Top filter press connection
- 4-2 ½ % 2fcan, 2fcbn taps
- 55/65 degree C temperature rise
- Standard accessories and built to CSA C2.



TRANSFORMATEURS L.TÉE
PIONEER
TRANSFORMERS LTD



Comments:

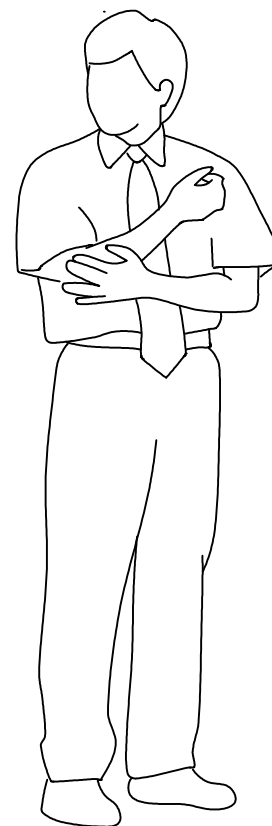
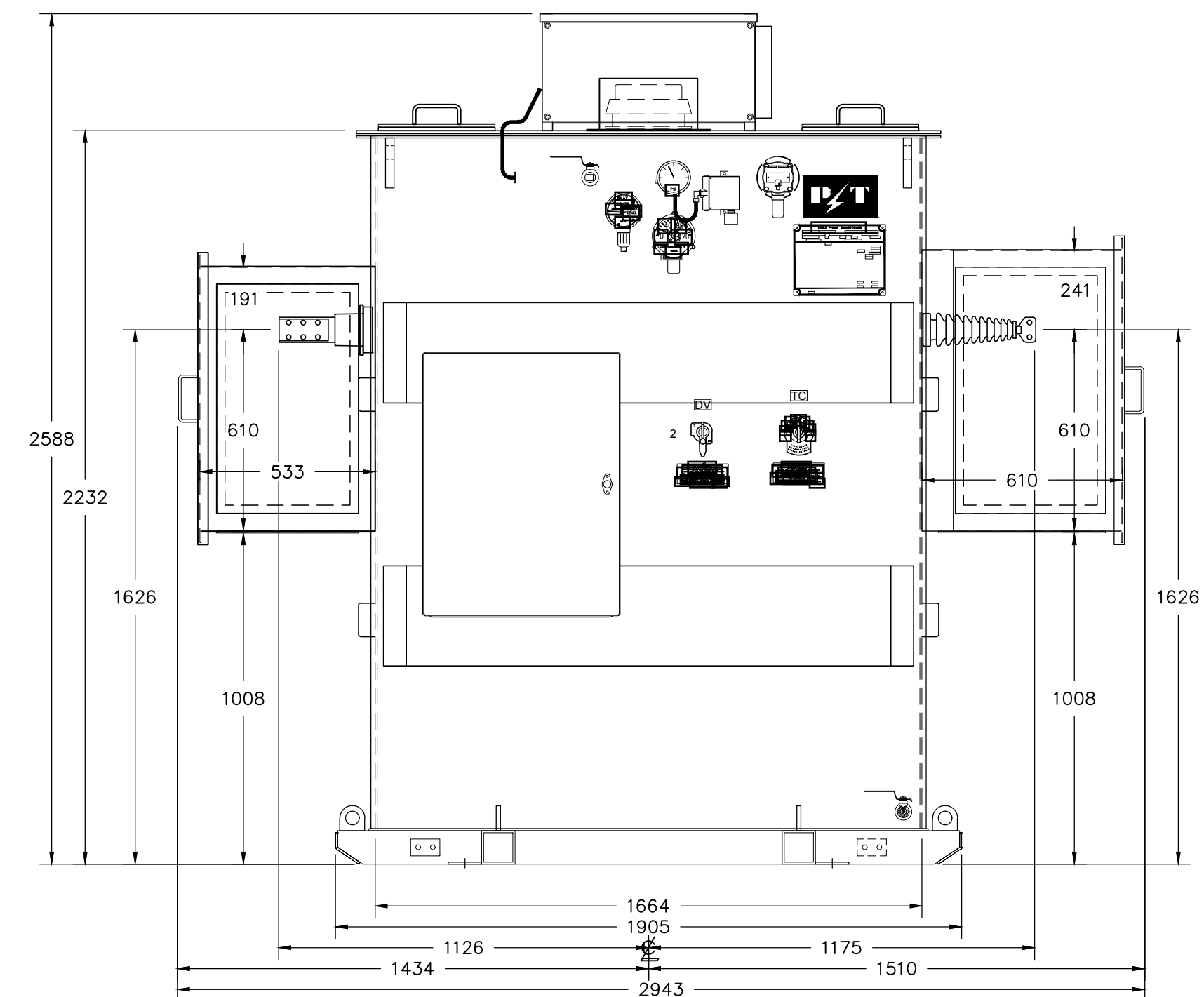
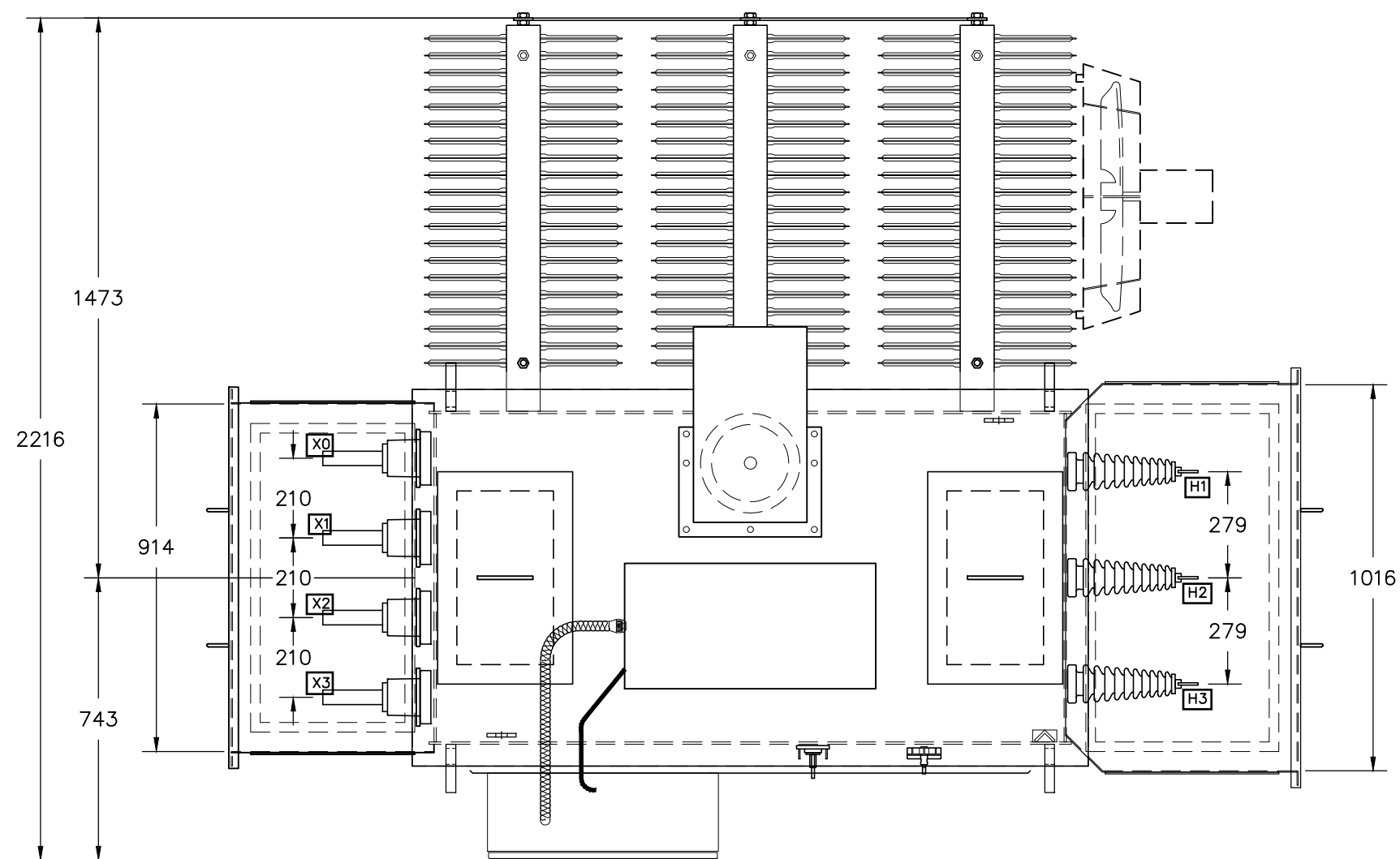
- 1) No HV or LV connectors are included.
- 2) These transformers will be built in accordance with the CSA specification as noted above, if you require a CSA inspection and decal please contact the local CSA office for pricing. Alternatively, Pioneer can hire a CSA official to visit the factory from Ottawa and provide this service for \$2,500 per visit.
- 3) No harmonic factors were not considered for item 100-TMR-102.
- 4) Unit will be painted per process attached.
- 5) 3000 KVA unit will be all copper, 750 KVA unit will be HV copper LV aluminum.
- 6) Freight for both units included at \$ 6500.

PRICES: Canadian funds.

F.O.B.: our plant freight allowed Barlorne, BC. Off-Loading is not included.

DELIVERIES: Deliveries are quoted in approximate weeks from receipt of an order, subject to confirmation at the time of an order.

NOTES: Taxes are not included. Quotation is valid for 90 days. Terms of Payment are Net 30 Days.



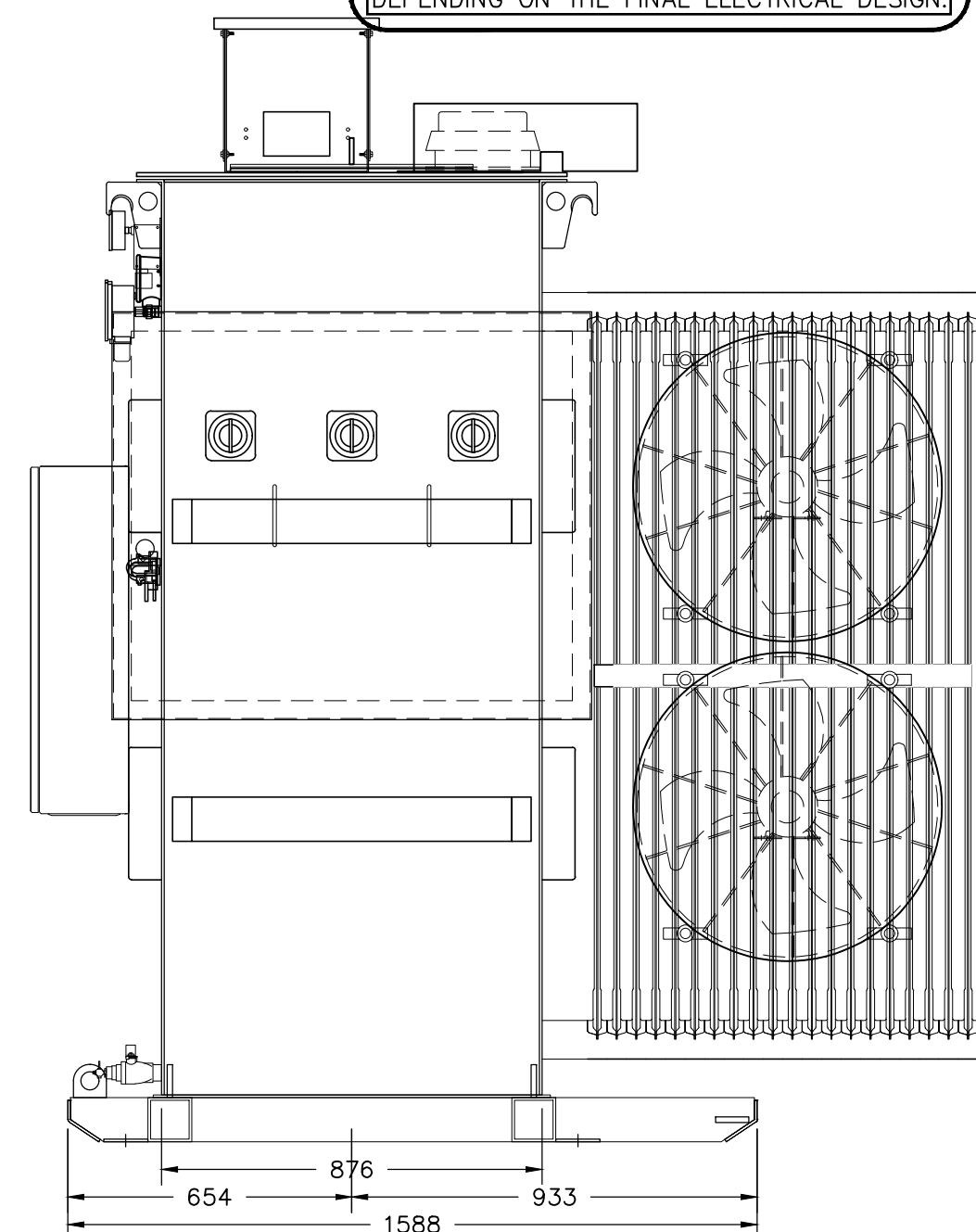
[3.00/3.38/PROV. 4.00/4.50] MVA [3] PHASE [60] CYCLES [ONAN/PROV. ONAF] TYPE
 [12470 DELTA X 24940 DELTA] H.V. [600Y/347] L.V. [4- 2500% (2FCAN,2FCBN) ON EACH VOLTAGE] TAPS [55/65°C] TEMP.RISE

CALCULATED MASSES PER UNIT		
CORE & COILS	3350	kg.
TANK & FITTINGS	2510	kg.
2530 L NON-PCB, CLASS B, TYPE II, MINERAL OIL	2245	kg.
TOTAL	8105	kg.

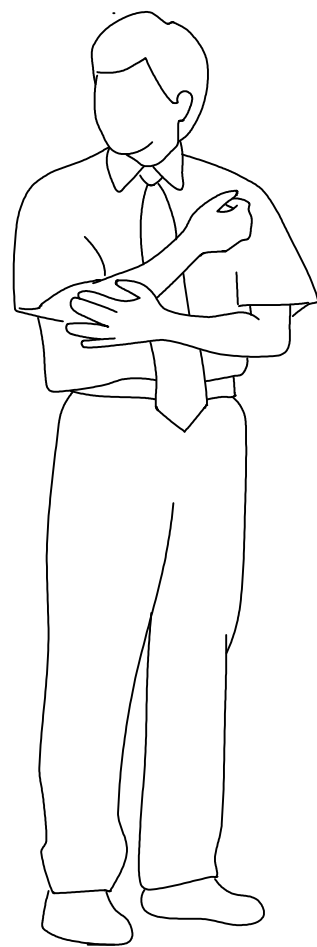
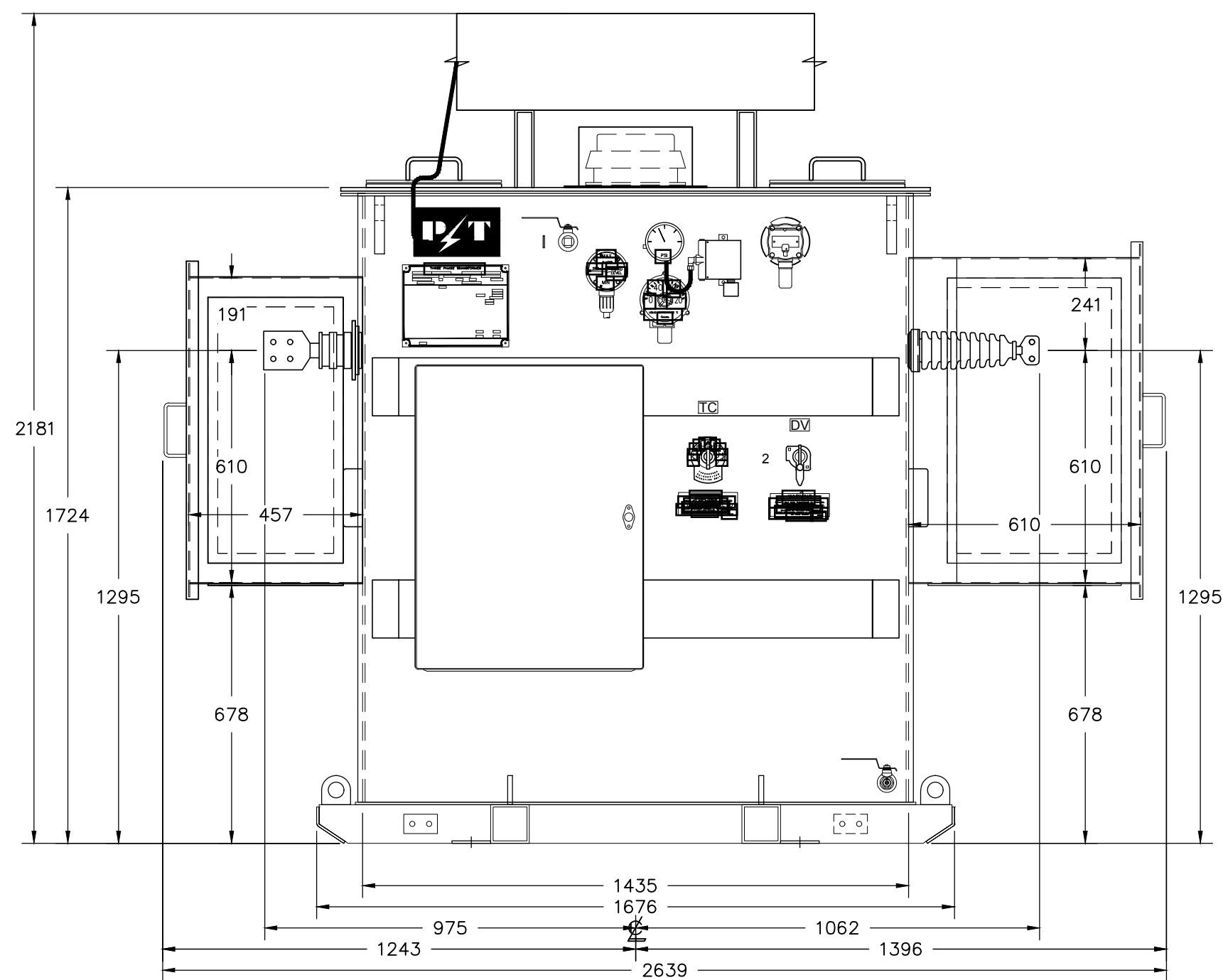
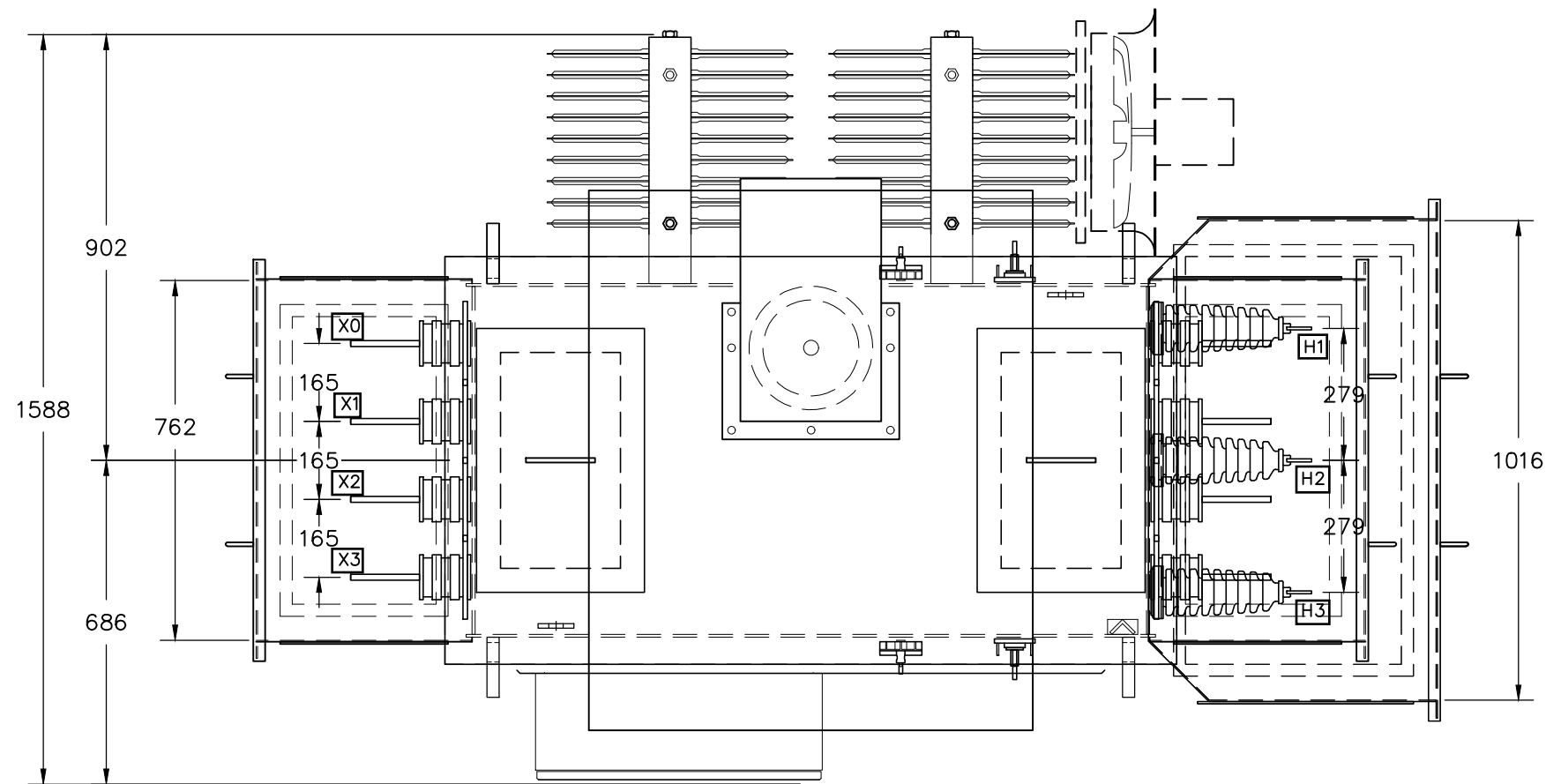
[ANSI 70 GREY] PAINT

**PRELIMINARY DRAWING :
NOT FOR CONSTRUCTION**

[WEIGHT & DIMENSIONS ARE APPROXIMATE ONLY.]
 [FINAL WEIGHT AND DIMENSIONS MAY VARY]
 [DEPENDING ON THE FINAL ELECTRICAL DESIGN.]

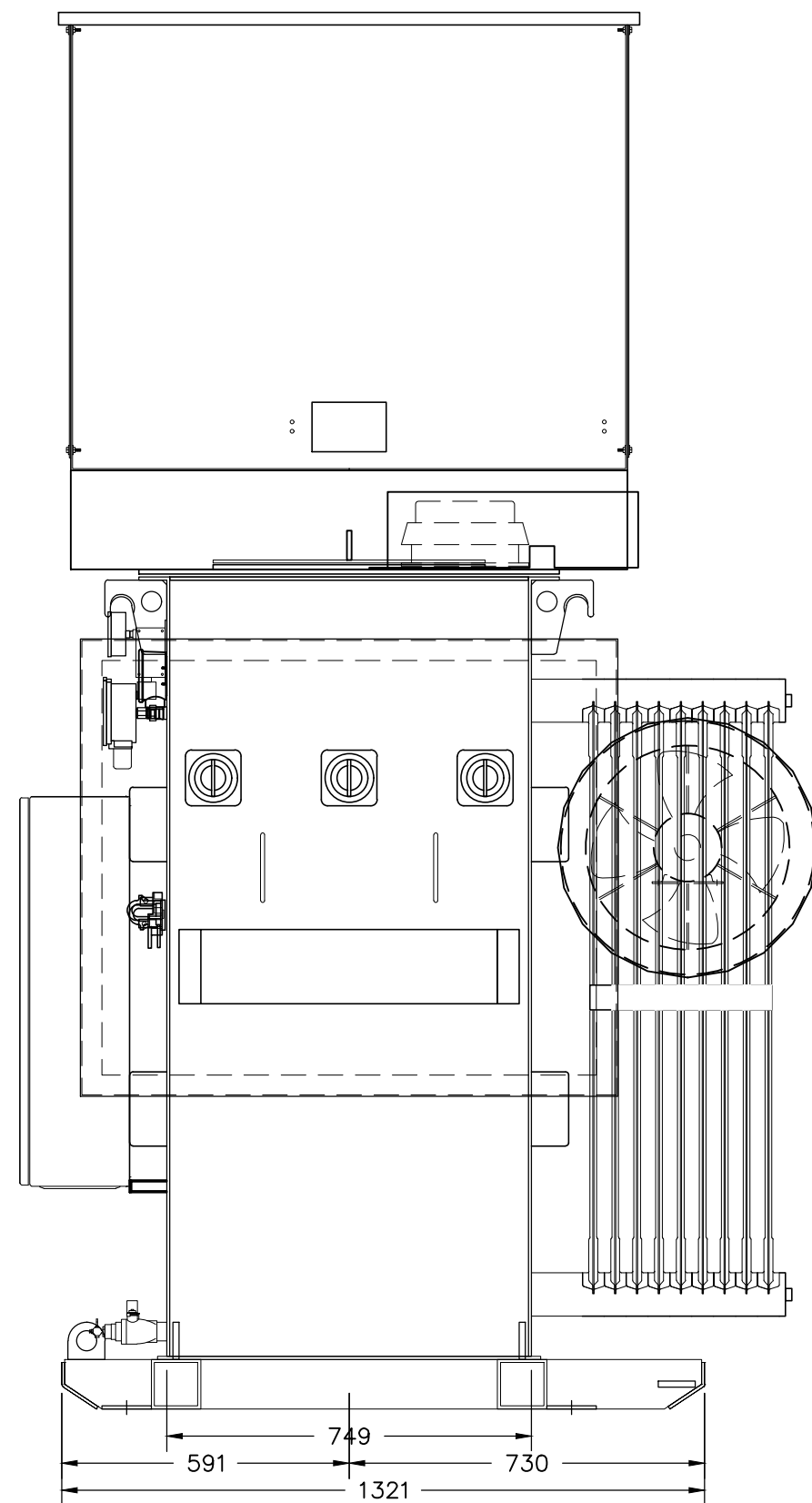


[5] [05-037-015]		[5] [05-037-015]	[5] [05-037-015]
[CUSTOMER]	[CUST. PRODUCT CODE]	[PURCH. ORDER NO.]	[ITEM]
NOTE: ADDITIONS TO THE ABOVE TABLE WILL NOT AFFECT THE REVISION NUMBER OF THIS DRAWING.			
[MAT.]		[TITLE]	
[DUP./REF.]		[DWG. NO.]	
[SCALE] 1 = 16		[REV.]	
[DRAWN] S.FLEURY [DATE] DEC-01-17		[OUTLINE DIMENSIONS]	
[CHECKED] [DATE]		[POWER TRANSFORMER C88-M90]	
[APP.] [DATE]		[05037015-5]	
[TOL.] ±12 MM		[TRANSFORMATEURS] LTÉE	
		[PIONEER TRANSFORMERS] LTD	



**PRELIMINARY DRAWING :
NOT FOR CONSTRUCTION**

WEIGHT & DIMENSIONS ARE APPROXIMATE ONLY.
FINAL WEIGHT AND DIMENSIONS MAY VARY
DEPENDING ON THE FINAL ELECTRICAL DESIGN.



0.75/0.84/PROV. 1.00/1.12	MVA	3	PHASE	60	CYCLES	ONAN/PROV. ONAF	TYPE
12470 DELTA X 24940 DELTA	H.V.	4160Y/2400	L.V.	4-2500% (2FCAN,2FCBN)	ON EACH VOLTAGE	TAPS	55/65°C
TEMP.RISE							
CALCULATED MASSES PER UNIT							
CORE & COILS		1370					kg.
TANK & FITTINGS		1425					kg.
1340 L NON-PCB, CLASS B, TYPE II, MINERAL OIL		1195					kg.
TOTAL		3990					kg.
ANSI 70 GREY PAINT							

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Quote No. 17L255Q – Rev 0

Attn: Malcolm Cameron

Subject: Supply of Labour & Materials for the Telkwa Coal Ltd. Project 600V Switchgear Line-up as requested, including the deliverables below – Design / Drawings / Commissioning
BUDGETARY ONLY. Please note that the pricing below is based on receiving a purchase order for the entire project.

600V Switchgear Building:

Building:

- 1) Supply of one (1) Switchgear Building – 20' high cube shipping container, c/w man doors (3), lighting, exhaust fan, heaters, lighting panel, interior & exterior lighting, receptacles, etc., including interior studding, insulation & wall covering. The finished interior will be panned in steel. The building will be mounted on 36" legs, & will come c/w stairs & platforms.
- 2) Installation of all equipment into the container.
- 3) ESA (Ontario – CSA equivalent) inspection of the completed container.
- 4) Shipping of the completed container assembly to site – Telkwa, B.C.

Electrical Materials:

- 1) Supply of one (1) 600V switchgear line-up – 600V 5000A 3 phase 3 wire solidly grounded 65kA RMS symmetrical bus bracing, 120VAC control power, NEMA 1 enclosure. There will be 3 sections split into three (3) shipping splits. The first section will be an entrance section c/w 4000A main breaker, one (1) 200A secondary breakers, one (1) PT metering section. The next pair of two sections will be breaker sections – four (4) 800A frame breakers, four (4) 2000A frame breaker. All breakers will be equipped with adjustable trip units. Harmonic filters to be supplied by others (not in this quote) & installed by Automation Now in the containers & wired by Automation Now to the switchgear breakers.

Testing & Commissioning:

- 1) Testing of the completed assembly prior to shipping to site, including pre-commissioning of the switchgear line-up & metering at our shop – Thunder Bay, Ontario.
- 2) On site start-up & commissioning – 2 men for 4 days on site (Telkwa, B.C.), time for on-site start-up & commissioning assistance. This will include travel time, equipment, etc.

Design & Drawings:

- 1) Supply of one (1) set of shop drawings for approval – digital only.
- 2) Supply of one (1) set of completed as-built drawings for the completed assembly – digital only.
- 3) Engineer stamp for the drawing / design package, including B.C. submittals as required.
- 4) Structural analysis & engineered stamped drawings for the container foundation system.

- 5) On site investigation – 1 man for 1 day on site time for on-site investigation. This will be by a B.C. engineering partner (MCA & Associates). This is the same firm that will stamp the drawing package & submit the design to B.C. electrical safety authority.

The containers will be shipped separately. The installation crew on site (by others) will have to install the foundation & legs, install the platform / stair assembly, bolt the containers together & roof system. The joint between the containers will have to be insulated & sealed on site (by others). All foundations are to be by others. All electrical installations & electrical connections (600V connections) are to be by others. Final start-up & commissioning will be by others, with out assistance. Access to the rear of the switchgear will be maintained via the bus separation.

The **BUDGETARY** price for all of the above materials & services is **\$285,500.00** + applicable taxes

Terms & Conditions

All materials will be warranted as per the standard manufactures warranty, with the warranty period beginning on the day the materials are shipped to the contractor or owner. The warranty period will not be extended, unless directed by the manufacturer. The following is Automation Now's standard warranty policy for services and supply:

Automation Now will require a purchase order from the client before proceeding to site or ordering any replacement materials for the warranty claim(s). In this case the defective product must be returned to either the Automation Now office or to a representative of Automation Now. If it is deemed that the product is defective and covered under the standard manufacturer's warranty, there will be no charge to the client. If, however, the product is deemed not to be covered under the standard manufactures warranty, the client will be required to pay for the replacement products supplied. All travel to and from the client's site for the warranty evaluation and/or work, the installation/removal of equipment and shipping are not covered by the warranty and will be charged to the client on a per trip basis. Quotation is valid for 30 days.

HST & all applicable taxes are extra. The above price does not include site installation or any other services or materials not outlined in the above description. Any services or materials required which are above and/or beyond the scope as described in the above documentation will require a purchase order and will be priced and charged on a per item basis as required. Issuance of a purchase order acknowledges acceptance of all terms & conditions described in this document. All payments are net 30 days after issuance of invoice.

WARRANTY FOR PRODUCTS

Standard Warranty

Automation Now Inc warrants to Buyer, subject to the limitations and conditions stated herein, that all new products manufactured or supplied by Automation Now Inc shall be free from defects in material and workmanship and shall deliver their rated output as indicated on the nameplates for a period of 21 months from the date of shipment to the Buyer.

This warranty does not cover failure or damage due to storage, installation, operation or maintenance not in conformance with Automation Now Inc's recommendations and industry standard practice or due to accident, misuse, abuse or negligence. Due to the special nature of electrical equipment larger than (1000kw, 400hp and above), this warranty shall not be applicable to these products unless start-up is accomplished by a Automation Now Inc.

This warranty also does not cover reimbursement for labor, gaining access, removal, installation, temporary power or any other expenses that may be incurred in connection with repair or replacement.

To Resolve Warranty Claims

Buyer must notify Automation Now Inc in writing of a defect or failure to deliver rated output within the applicable warranty period and give Automation Now Inc the opportunity to determine that the defect or failure exists. Buyer shall make defective product available for Automation Now Inc's inspection at Buyer's place of business or, at Automation Now Inc's option, return the product to Automation Now Inc's warehouse. Buyer is to return the defective item to Automation Now Inc within 45 days. If the defective item is not returned to Automation Now Inc within 45 days, Buyer will be invoiced for the price of the replacement item at current purchase price levels.

Returns must be coordinated through the original point of purchase. No products shall be returned to Automation Now Inc's plant except in accordance with Automation Now Inc's prior written instructions.

To remedy a product defect, Automation Now Inc may, at its option, elect to repair, rebuild or replace the defective product using new or reconditioned parts or product. In this case, the repaired, rebuilt or replaced product shall be warranted hereunder for the unexpired portion of the original warranty period or 90 days from shipment of replacement product, whichever is longer. It is the responsibility of the Buyer to insure minimum delays in the performance of the warranty service.

Delays in excess of 4 hours will be billed at the published rates.

Warranty Limitations

THE FOREGOING WARRANTY IS EXCLUSIVE EXCEPT FOR WARRANTIES OF TITLE AND AGAINST PATENT INFRINGEMENT. AUTOMATION NOW INC DISCLAIMS ALL OTHER WARRANTIES INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. CORRECTION OF NON-CONFORMITIES IN THE MANNER AND FOR THE PERIOD OF TIME PROVIDED ABOVE SHALL CONSTITUTE SOLE LIABILITY AND BUYER' S EXCLUSIVE REMEDY FOR FAILURE OF AUTOMATION NOW INC TO MEET ITS WARRANTY OBLIGATIONS, WHETHER CLAIMS OF THE BUYER ARE BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY), OR OTHERWISE. If a products manufacturers warranty is different and not part of a supplied system, the components manufacturer warranty will apply.

Limitation of Liability

THE REMEDIES OF THE BUYER SET FORTH HEREIN ARE EXCLUSIVE AND ARE ITS SOLE REMEDIES FOR ANY FAILURE OF AUTOMATION NOW INC TO COMPLY WITH ITS OBLIGATIONS HEREUNDER. IN NO EVENT SHALL AUTOMATION NOW INC BE LIABLE IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY) OR OTHERWISE FOR DAMAGE TO PROPERTY OR EQUIPMENT OTHER THAN PRODUCTS SOLD HEREUNDER, LOSS OF PROFITS OR REVENUE, LOSS OF USE OF PRODUCTS, COST OF CAPITAL, CLAIMS OF CUSTOMERS OF THE BUYER OR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES WHATSOEVER. THE TOTAL CUMULATIVE LIABILITY OF AUTOMATION NOW INC ARISING FROM OR RELATED TO THIS CONTRACT WHETHER THE CLAIMS ARE BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY) OR OTHERWISE, SHALL NOT EXCEED THE PRICE OF THE PRODUCT OR SERVICES ON WHICH SUCH LIABILITY IS BASED.

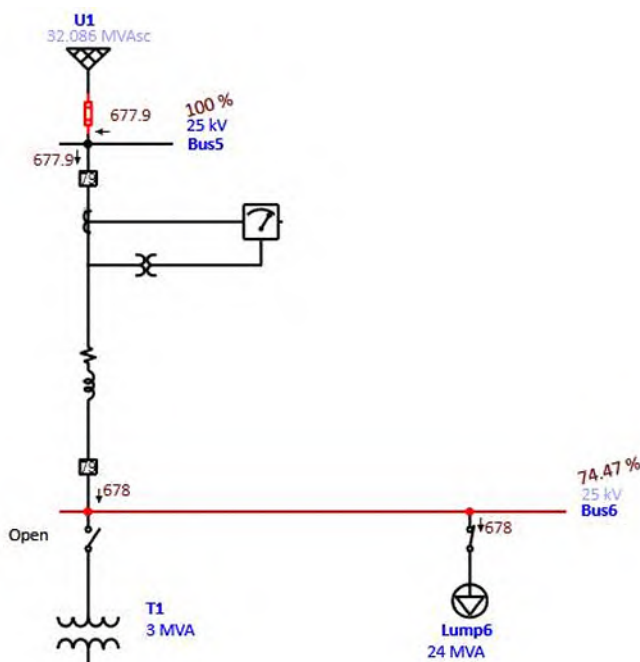
Regards,

Chris Chiasson
Project Manager

Transformer Energization (Rapid Voltage Changes)

Each time the transformer is energized, there will be an inrush current equal to approximately 10 times the full load current of the transformer. As the transformer is rated 3000 kVA, 25kV, the full load current is 69A. The inrush current will therefore be about 690A. The inrush current will last up to 100 milliseconds.

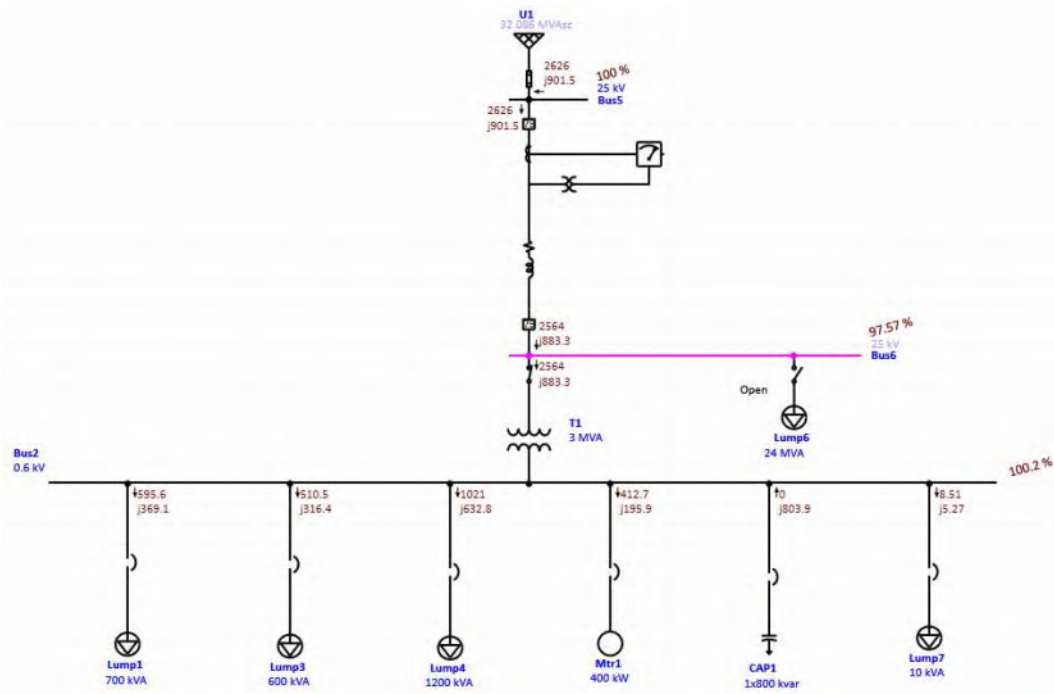
During this inrush, the voltage at the end of the line will drop to 74.5% as indicated below.



On the other hand, the voltage at the Point of Interconnection (Bus5) will remain at 25kV, so other customers on the line should not notice any flicker.

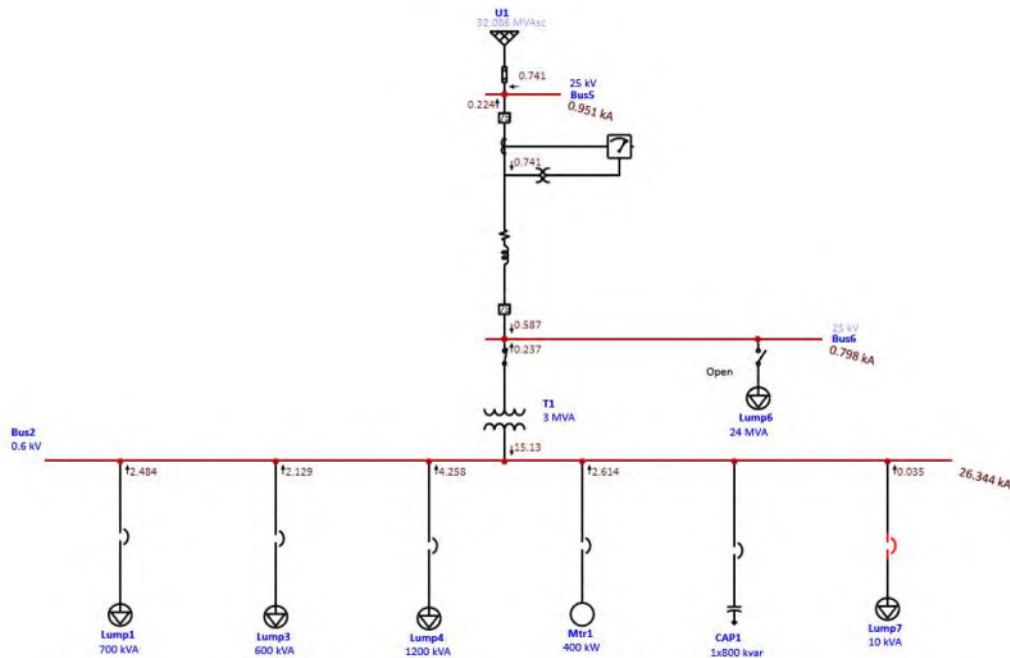
Load Flow

At full load, and with main transformer at the -5% tap, the following bus voltages will be observed. Note that the secondary main bus will be close to rated 600V.



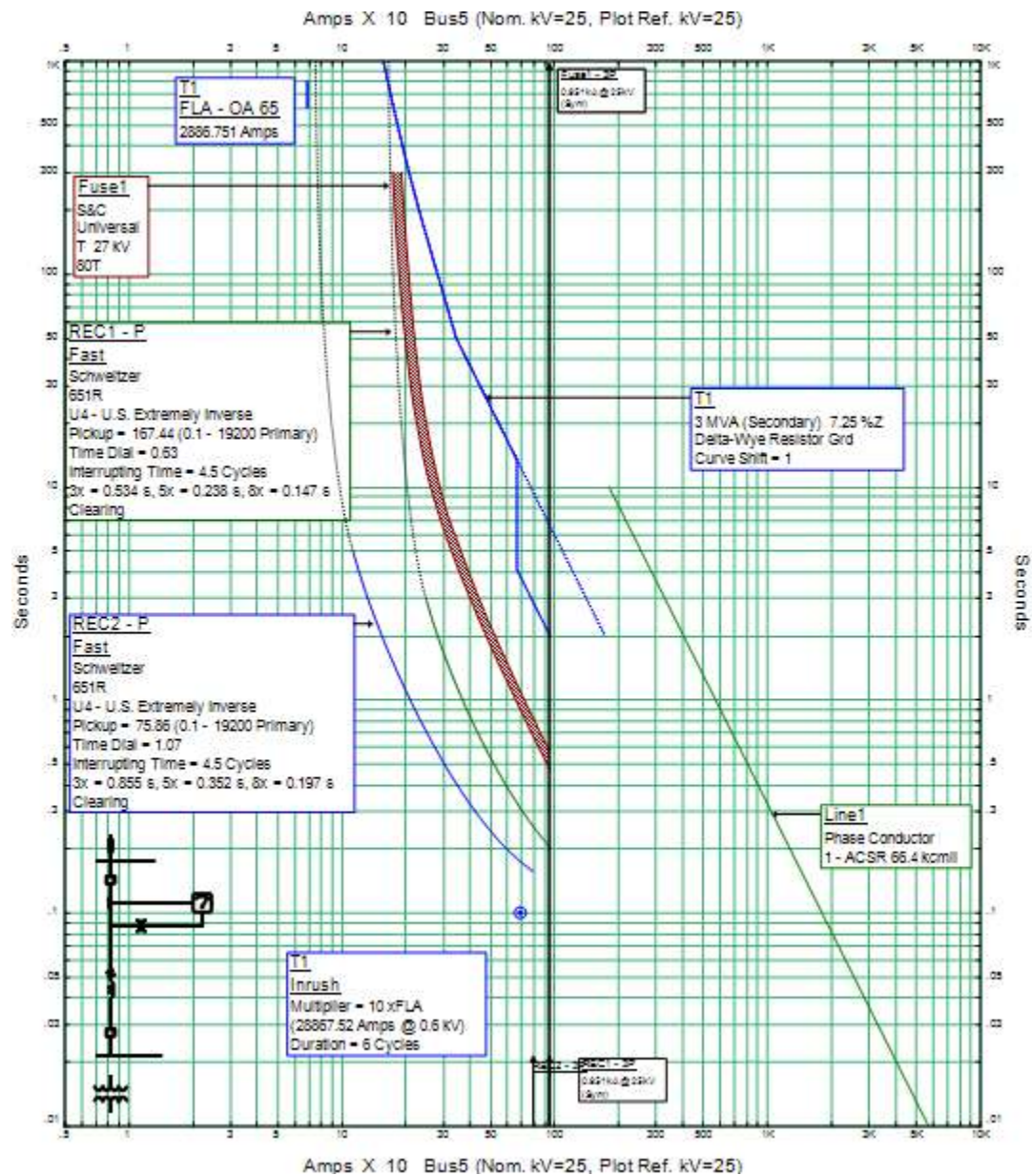
Fault Capacity

The fault capacity on the secondary main bus will be 26 kA sym. Downstream circuit breakers ratings will be minimum 42 kA.



Coordination

The upstream protection will be 80T fuses. The next downstream protection will be Recloser1. The next downstream protection will be Recloser2 at the plant. Recloser2 will also serve as the main transformer protection.

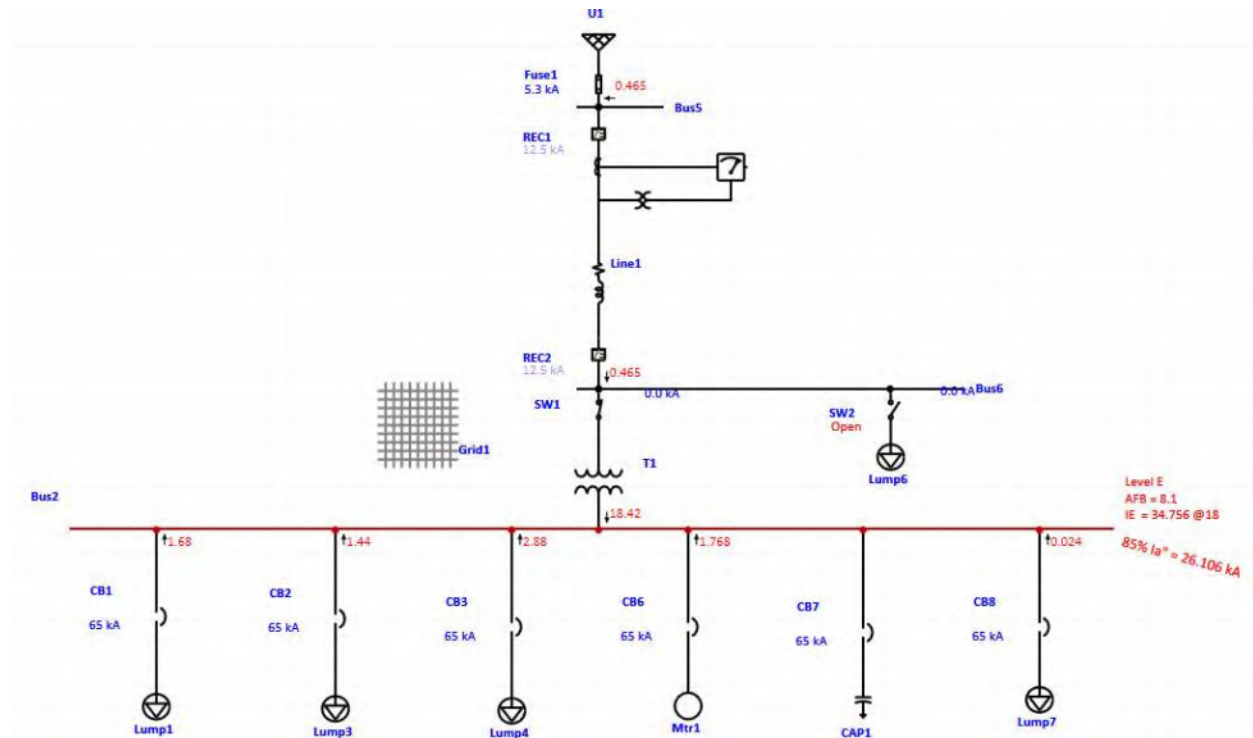


Harmonics

As there are no large VFDs in the system, harmonics will be negligible.

ArcFlash

As a cost savings measure, there will be no secondary breaker on the main transformer T1. Instead, the differential and overcurrent protection will trip the upstream device – REC1. In addition, the settings on REC1 will be decreased once inrush is finished. This will help to mitigate the ArcFlash results shown below.

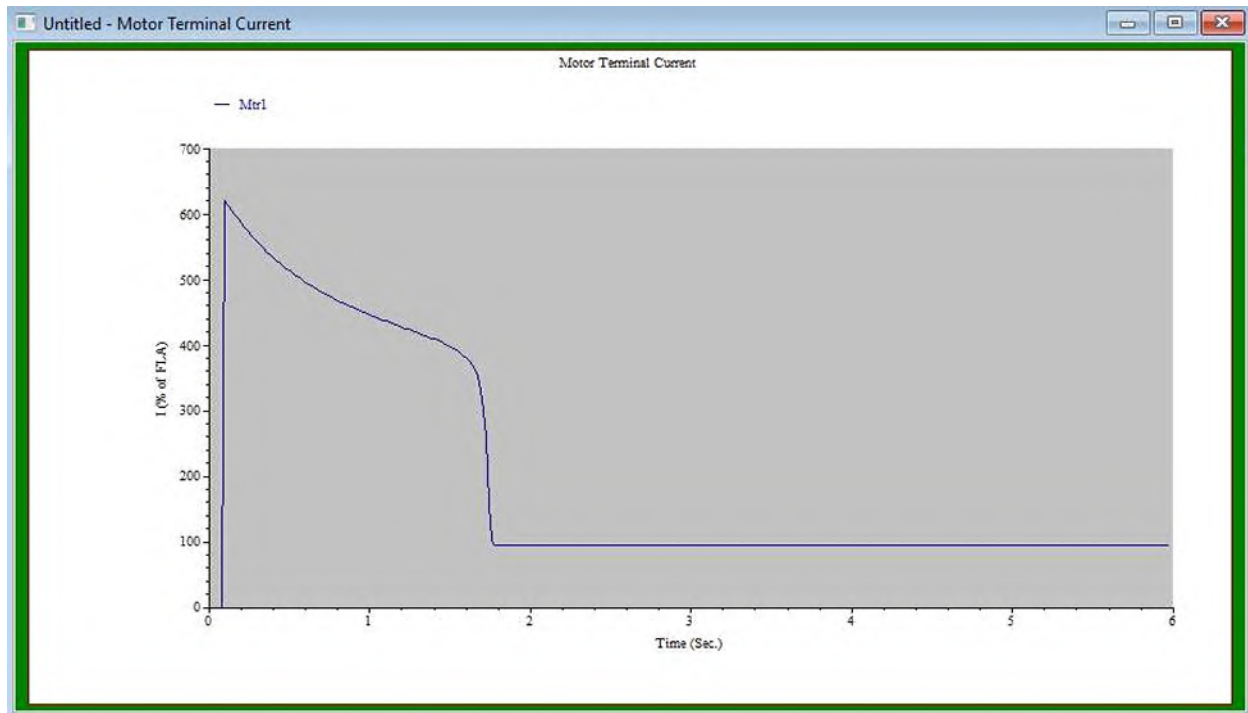


Motor Starting

Large motor starting has a similar effect as transformer energization, except that:

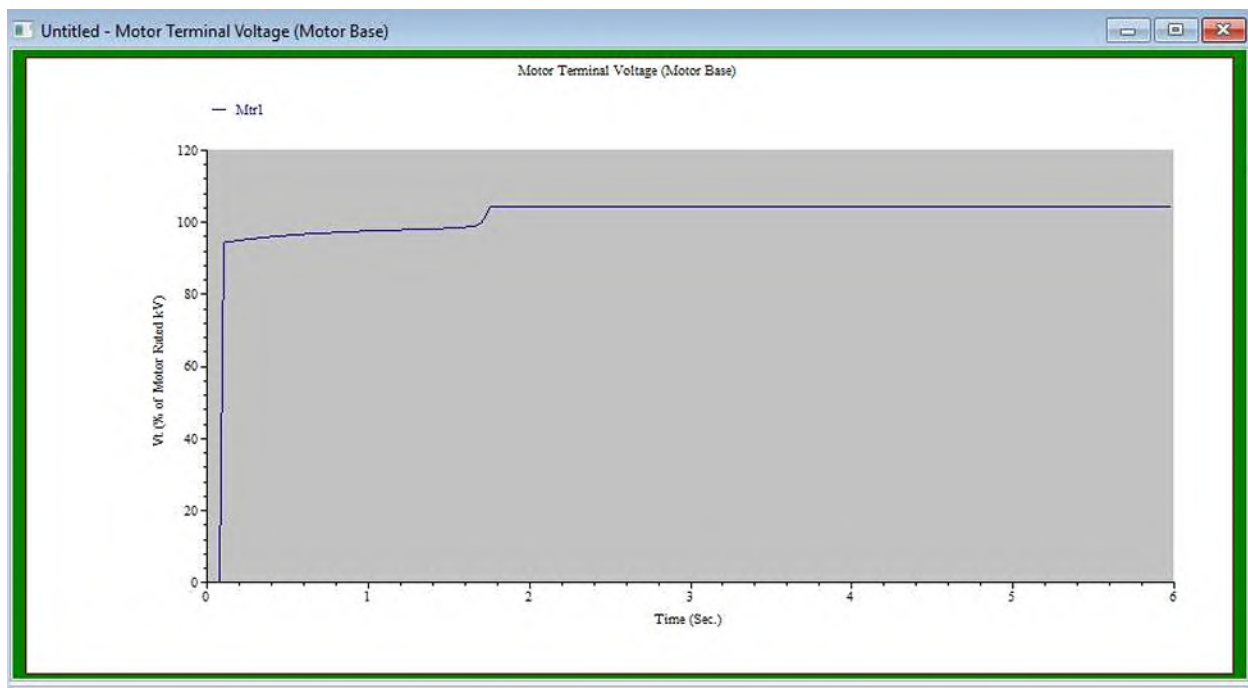
- Motor starting is more frequent
- The voltage dip is not as severe
- The voltage dip can last up to 4 or 5 seconds

The largest motor start is 400 kW. As this motor will start “Across the Line”, the expected inrush is 6 x full load current as indicated below:



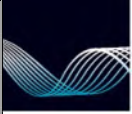
When the motor starts, the terminal voltage is pulled down to approximately 94%, and will stay there until the motor starts, in about 2 seconds.

As this is well above the IEEE minimum of 85%, there should be no effect of the rest of the system.



25kV Substation Grounding

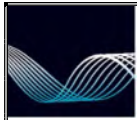
Refer to separate document.

 MCA Engineering Ltd.	ALLEGIANCE COAL GROUND GRID STUDY	Project No. : MCA-3177 Project Name : AC GRND GRID Revision No. : B Date : Nov 18, 2018
--	--	--

<i>PREPARED BY:</i>	M. Cameron		MCA Engineering Ltd.
<i>CHECKED BY:</i>			
<i>APPROVED BY:</i>			
<i>CLIENT:</i>			

STUDY REVISION SUMMARY

Revision No.	Date Revised	Engineering Specification	Signatures					
			Prepared By	Checked By	Approved By	Engineering Manager	Project Manager	Client
A	Sept 16, 2018	Issued for Review	MMC					
B	Nov 18, 2018	Revised	MMC					



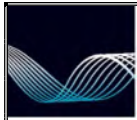
MCA Engineering Ltd.

**ALLEGIANCE COAL
GROUND GRID STUDY**

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

TABLE OF CONTENTS

1. Objective	3
2. Summary of Findings	3
3. Standards	3
4. Step and Touch Harzard	3
5. Study Cases	4
6. Study Set Up and Results.	6
7. Discussion and Recommendations.....	11



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

1. OBJECTIVE

The objective of this study is to ensure that the grounding system on the incoming service at the Allegiance Coal is safe, and results in tolerable Step and Touch Hazards in all but one unlikely case.

2. SUMMARY OF FINDINGS

This results of this study show that under the conditions identified herein, the grounding system installed at the Allegiance Coal satisfies applicable Step and Touch requirements. A sensitivity analysis also indicates that reasonable variations to the assumptions used to not materially alter the conclusions.

3. STANDARDS

Calculations contained in this report are in accordance with IEEE Standard 80-2000. The calculations have been generated using a Power Systems Analysis package: ETAP 18.0.0. (www.etap.com). ETAP products comply with U.S. Code of Federal Regulations as well as other Quality Assurance (QA) standards. ETAP is Verified and Validated (V&V) against field results, real system measurements, established programs, and hand calculations in order to ensure its technical accuracy. Each release of ETAP undergoes a complete V&V process using hundreds of test cases for each and every calculation module.

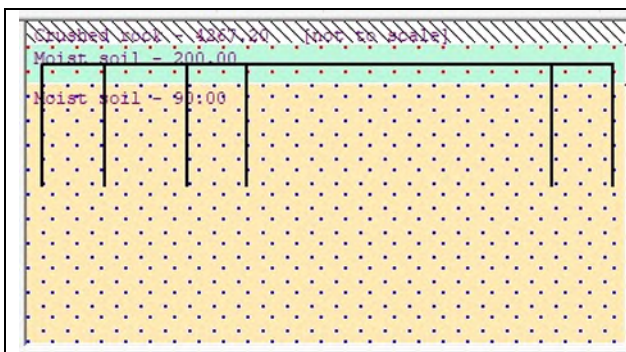
Standards are defined for body weights of 50 kg and 70 kg. This study uses 50 kg as it generally leads to more conservative (ie worst case) results.

4. STEP AND TOUCH HARZARD

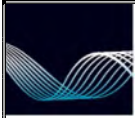
The main parameters of step and touch hazard are:

Soil Model

The Soil Model is assumed to be three layer. The top layer is normally crushed gravel, which provides a high resistance under a workers feet. The second layer is backfill, which is normally fine moist soil that provides an intermediate resistance. The third layer is native soil, whose resistance can vary widely, depending on composition and moisture. The resistivity of this layer is normally field measured with a drop of potential test. Generally, the higher the resistances, the higher the step and touch hazard.



	Resistivity ohm-m	Material	Depth m
Surface Material	4267.2	Crushed rock	0.15
Top Layer	200	Moist soil	1
Lower Layer	90	Moist soil	

 MCA Engineering Ltd.	ALLEGIANCE COAL GROUND GRID STUDY	Project No. : MCA-3177 Project Name : AC GRND GRID Revision No. : B Date : Nov 18, 2018
---	--	--

Ground Grid Layout

The ground grid is made up of horizontal conductors and vertical ground rods. The horizontal conductors are normally in the second soil layer. In general, the smaller the spacing and the greater the conductors, the lower the step potential hazard.

The vertical ground rods extend well into the low resistance third soil layer. In general, the more ground rods, the lower the touch potential hazard.

The ground grid layout is an iterative exercise of trying to minimize the grid cost, while achieving an acceptable step and touch hazard.

Magnitude of Line to Ground Current

The type of fault of interest is the line to ground fault, as it results in the greatest current that must find its way back to the source through the grid and the ground. In this study the high voltage connection on T1 (Main Transformer) is 25kV, so we are interested the LG fault near the primary of this transformer.

The magnitude of the LG fault will depend on the source impedance. This is a series combination of the utility impedance and the upstream transformer impedance. Normally the upstream transformer will be much larger than the utility impedance, and hence the most limiting factor to the LG magnitude.

Generally, the higher the fault current, the higher the step and touch hazard.

Duration of the Line to Ground Current

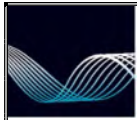
The duration of the fault will depend on the speed of the upstream protection. Generally, the faster the upstream protection, the lower the step and touch hazard.

Grid Current Factor

The ground current has two possible paths back to the source. The first path is through the grid and the earth. This component will result in the elevation of the ground grid potential. Generally, the higher this component, the higher the step and touch hazard.

The second path is through the ground wire, if one exists, between the fault and the source substation. Normally BC Hydro runs its 25 kV systems as 4 wire, with a multigrounded neutral. Normally the neutral is grounded at both the source and destination stations, so it is reasonable to expect that a large part of the fault current will follow this path, and not contribute to an increase in the ground grid potential.

The current division is described by the factor S_f . For the purposes of this study, a conservator factor of 100% is assumed in the present case (all ground current returning through the grid/earth), and 50% in the ultimate case.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

5. STUDY CASES

This study considers two cases. In Case 1 the existing 25kV fault capacity is used. In Case 2 the ultimate 25kV fault capacity is used.

Case 1 – 25kV Present (25P) – Grid around T1

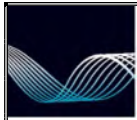
In this case, the site is connected to BCH 25kV line, as it currently is. The present system fault capacity is given by BC Hydro as 32 MVA.

It is further assumed that:

- there is one main transformer - T1.
- the transformer pad is concrete, with rebar connected to the ground grid thus forming a “Ufer” ground.
- The grid associated with T1 is comprised of #4/0 copper, with 10 foot ground rods.

Case 2 – 25kV Ultimate (25U) – Grid around T1

In this case, the site is connected to the BCH 25kV line, in its ultimate configuration. As BCH has not provided a fault capacity for this configuration, it is assumed that the 25kV is fed from a large transformer. Based on physical size, and ability to transport, a reasonable assumption would be a 20 MVA transformer. If we assume a 10% impedance, and an infinite primary bus, then the maximum fault current would be 200 MVA. All other assumptions are the same as Case 1.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

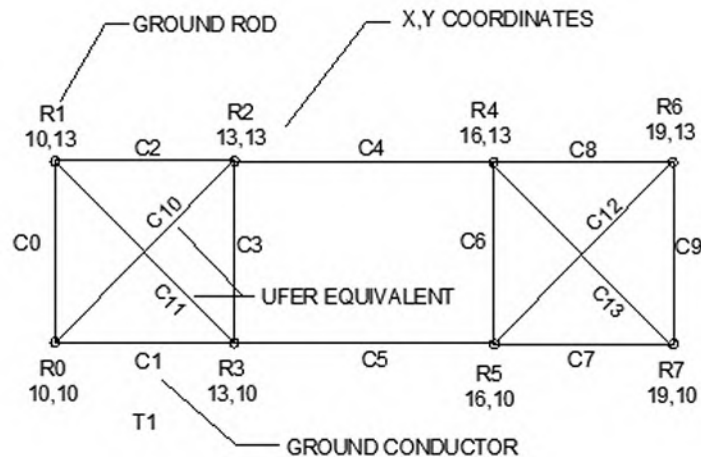
Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

6. STUDY SET UP AND RESULTS.

Case 1 – 25P - Setup and Results

The ground grid for T1 is shown below. Note that:

- The coordinates are in meters.
- The transformer pads are assumed to be 1.5m square.
- The ground rods (R0 to R7) are assumed to be 0.9m at 45 deg from each transformer pad corner.
- The angled conductors C16/C17 etc. are not physically present but are deemed to be equivalent to the ufer ground formed by the transformer pads



Rod Editor



Material Constants

Conductivity	Alpha Factor	K Factor	Fusing Temperature	Resistivity @ 20 C	Thermal Capacity
100.0	0.00393	234	1083	1.72	3.42

	Label	Length	X1	Y1	Z1	X2	Y2	Z2	Diameter	Type
1	R0	3.05	10	10	0.5	10	10	3.55	2	Copper, annealed soft-drawn
2	R1	3.05	10	13	0.5	10	13	3.55	2	Copper, annealed soft-drawn
3	R2	3.05	13	13	0.5	13	13	3.55	2	Copper, annealed soft-drawn
4	R3	3.05	13	10	0.5	13	10	3.55	2	Copper, annealed soft-drawn
5	R4	3.05	16	13	0.5	16	13	3.55	2	Copper, annealed soft-drawn
6	R5	3.05	16	10	0.5	16	10	3.55	2	Copper, annealed soft-drawn
7	R6	3.05	19	13	0.5	19	13	3.55	2	Copper, annealed soft-drawn
8	R7	3.05	19	10	0.5	19	10	3.55	2	Copper, annealed soft-drawn

Add

Insert

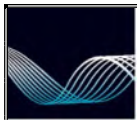
Delete

Copy

Help

OK

Cancel



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

Conductor Editor

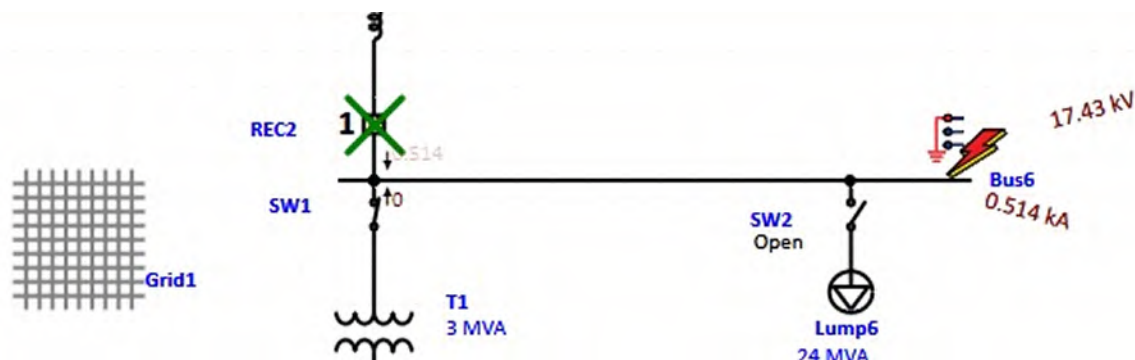
Material Constants

Conductivity	Alpha Factor	K Factor	Fusing Temperature	Resistivity @ 20 C	Thermal Capacity
100.0	0.00393	234	1083	1.72	3.42

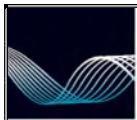
	Label	Length	X1	Y1	Z1	X2	Y2	Z2	Type	Size
1	C0	9	10	10	0.5	19	10	0.5	Copper, annealed soft-drawn	4/0
2	C1	9	10	13	0.5	19	13	0.5	Copper, annealed soft-drawn	4/0
3	C2	3	10	10	0.5	10	13	0.5	Copper, annealed soft-drawn	4/0
4	C3	3	13	10	0.5	13	13	0.5	Copper, annealed soft-drawn	4/0
5	C4	3	16	10	0.5	16	13	0.5	Copper, annealed soft-drawn	4/0
6	C5	3	19	10	0.5	19	13	0.5	Copper, annealed soft-drawn	4/0
7	C6	4.24	10	10	0.5	13	13	0.5	Copper, annealed soft-drawn	4/0
8	C7	4.24	16	10	0.5	19	13	0.5	Copper, annealed soft-drawn	4/0

Add Insert Delete Copy Help OK Cancel

The LG fault at the primary of the T1 is 0.514 kA as shown below:



The Sequence of Operation is shown below. For a LG fault on Bus 6, the first device to operate is REC2, and the second is REC1. REC2 operates in 174ms.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

Sequence-of-Operation Events - Output Report: Untitled



Line-to-Ground (Symmetrical) fault on bus: Bus6

Data Rev.: Base

Config: Normal

Date: 11-24-2018

Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
174	REC2	0.514	99.4	174	1st Operation - Lockout - Ground - Fast - TOC
195	REC1	0.514	120	195	1st Operation - Lockout - Ground - Fast - TOC
3379	Fuse1	0.422	2674	3379	

Hence the study case is as follows:

GRD Study Case Editor



Study Case

Study Case ID:

Options

Weight: ☒ 50 kg ☐ 70 kg

Ambient Temperature: °C

Method

☒ Finite Element

☐ IEEE 80 - 2000/2013

☐ IEEE 80 - 1986

☐ IEEE 665 - 1995

Update

☐ # of Conductors and Rods (Optimization)

Reports & Plots

☒ Auto Display Summary & Alert

☐ Report Details

Plot Step:

Boundary Extension:

Fault Durations

tf: Sec tc: Sec ts: Sec

Ground Short-Circuit Current

☒ User Specified Ifg: kA X/R:

☐ Short-Circuit Study

Grid Current Factors

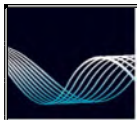
Sf: %

Cp: %

Remarks 2nd line

< GRD1 > Help OK Cancel

The corresponding fault results are shown below. The results are acceptable.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

GRD Analysis Alert View for GRD1

Summary and Alert

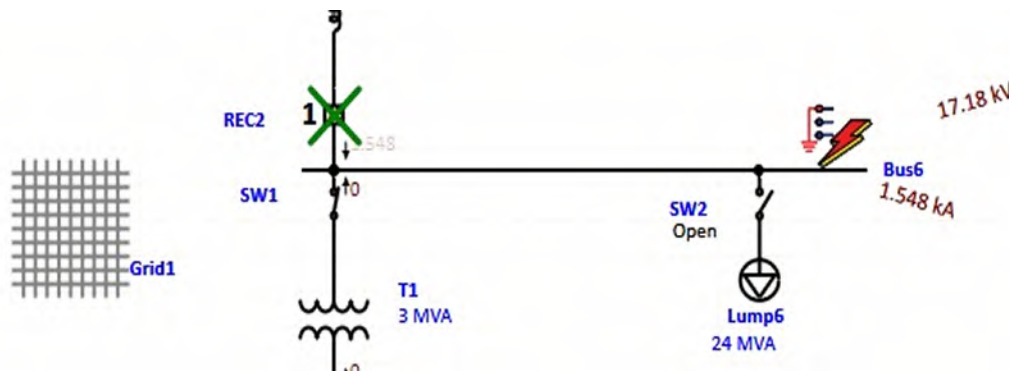
Result Summary

	Calculated Volts	Tolerable Volts	Location		
			X	Y	
Touch	933.9	1681.3	10	10	ft
Step	3407.1	5881	10.3	10.3	ft

GPR 7662.8 Volts Rg 14.403 Ohm

Case 2 – 25U - Setup and Results

Using the same grid setup, the LG fault for the 25U case at the primary of the T1 is 1.55 kA as shown below:

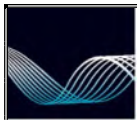


The Sequence of Operation is shown below. For a LG fault on Bus 6, the first device to operate is REC2, and the second is REC1. Device REC2 operates in 118 ms.

Sequence-of-Operation Events - Output Report: Untitled

Line-to-Ground (Symmetrical) fault on bus: Bus6					
Data Rev.: Base		Config: Normal		Date: 11-24-2018	
Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
118	REC2	1.448	42.6	118	1st Operation - Lockout - Phase - Fast - TOC
138	REC1	1.448	63.5	138	1st Operation - Lockout - Phase - Fast - TOC
255	Fuse1	1.448	202	255	

Hence the study case is shown as follows:



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

GRD Study Case Editor



Study Case |

Study Case ID:

Options: Weight ☒ 50 kg ☐ 70 kg
Ambient Temperature: °C

Method: ☒ Finite Element
☐ IEEE 80 - 2000/2013
☐ IEEE 80 - 1986
☐ IEEE 665 - 1995

Reports & Plots: ☒ Auto Display Summary & Alert
☐ Report Details
Plot Step:
Boundary Extension:

Update: ☐ # of Conductors and Rods (Optimization)

Fault Durations: tf Sec tc Sec ts Sec

Ground Short-Circuit Current: ☒ User Specified Ifg kA X/R
☐ Short-Circuit Study

Grid Current Factors: Sf %
Cp %

Remarks 2nd line:

< > Help OK Cancel

The corresponding fault results are shown below. The results are acceptable.

GRD Analysis Alert View for GRD1

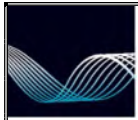


Summary and Alert |

Result Summary

	Calculated Volts	Tolerable Volts	Location	
			X	Y
Touch	1404.8	2001.1	10	10 ft
Step	5124.9	6999.8	10.3	10.3 ft

GPR Volts Rg Ohm



MCA Engineering Ltd.

**ALLEGIANCE COAL
GROUND GRID STUDY**

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

7. DISCUSSION AND RECOMMENDATIONS.

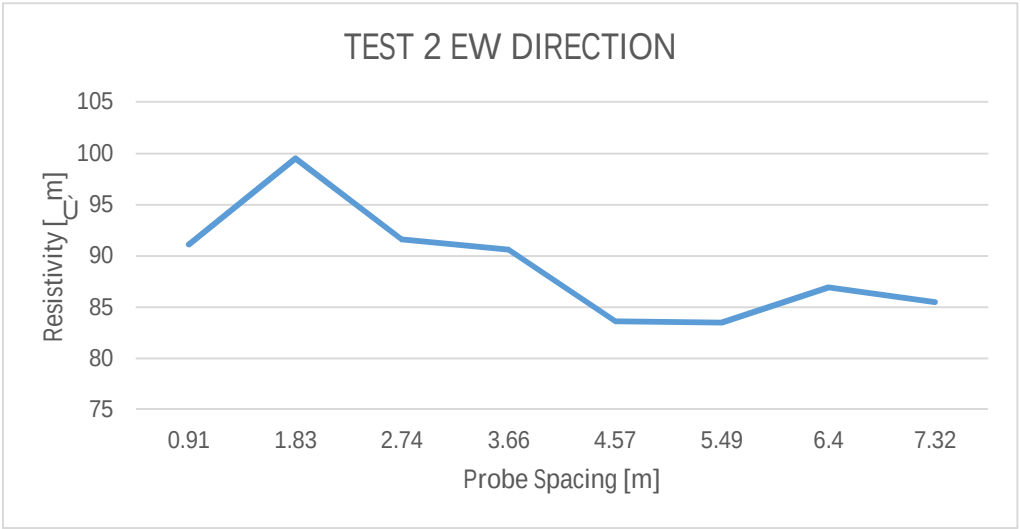
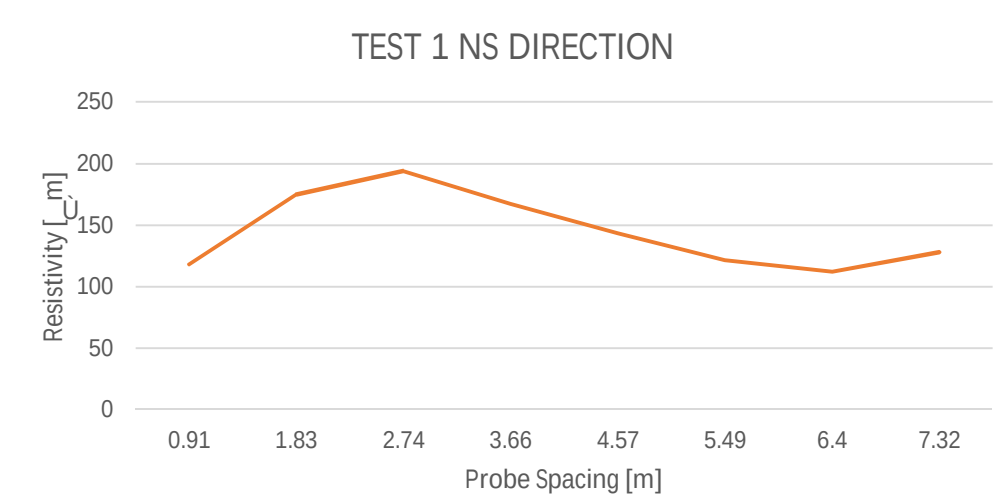
The ground grid described above will result in acceptable Step and Touch Potentials.

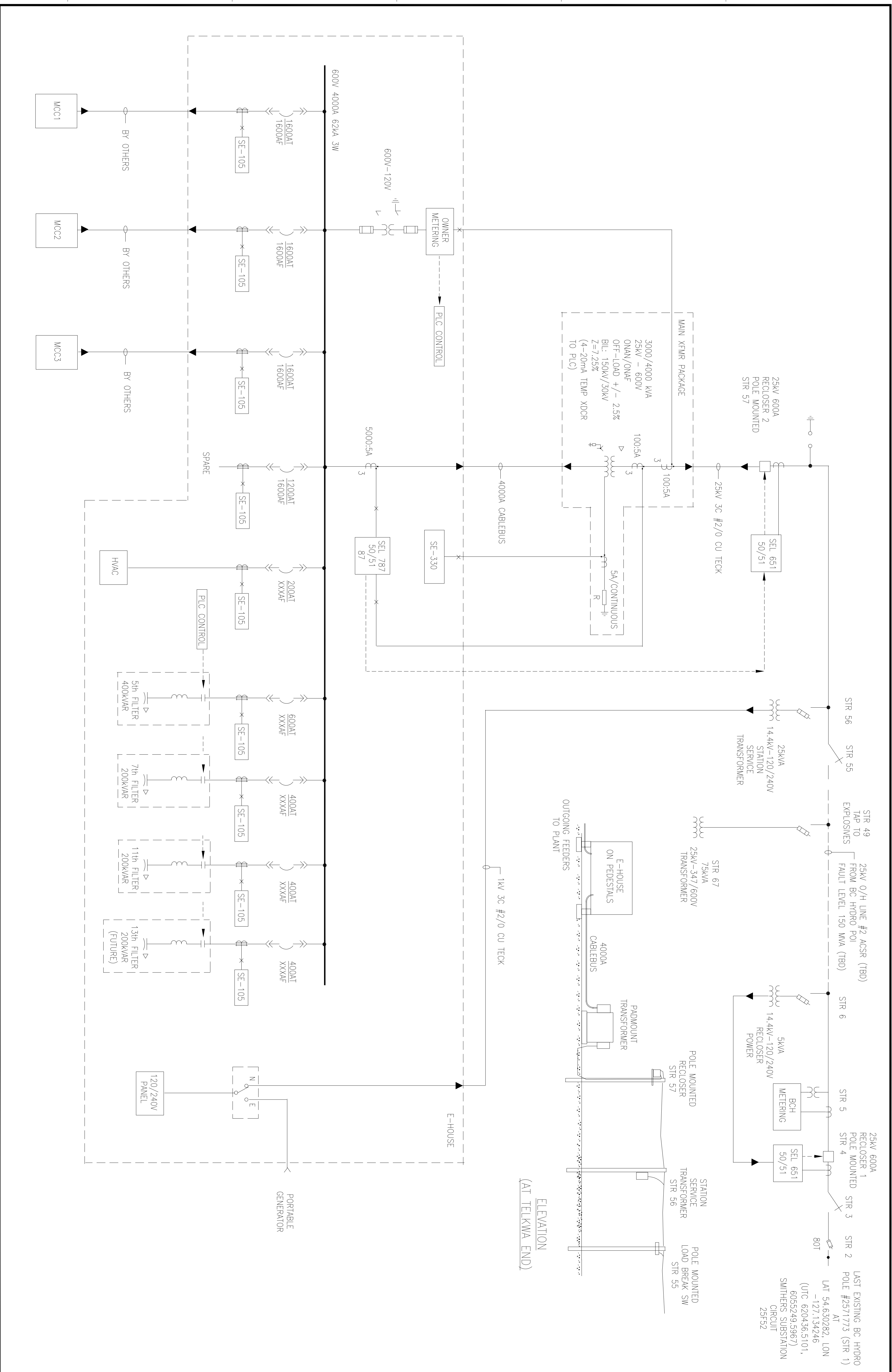
END OF REPORT

TEST 1 NS DIRECTION				
PROBE SPACING	PROBE SPACING	RESISTANCE	CALCULATED	
a [ft]	a [m]	R _E [Ω]	RESISTIVITY [Ωm]	
	3	0.91	20.58	118
	6	1.83	15.22	175
	9	2.74	11.27	194
	12	3.66	7.27	167
	15	4.57	4.99	143
	18	5.49	3.52	121
	21	6.4	2.79	112
	24	7.32	2.79	128

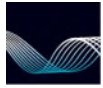
TEST 2 EW DIRECTION				
PROBE SPACING	PROBE SPACING	RESISTANCE	CALCULATED	
a [ft]	a [m]	R _E [Ω]	RESISTIVITY [Ωm]	
	3	0.91	15.94	91.1
	6	1.83	8.65	99.5
	9	2.74	5.32	91.6
	12	3.66	3.94	90.6
	15	4.57	2.91	83.6
	18	5.49	2.42	83.5
	21	6.4	2.16	86.9
	24	7.32	1.86	85.5

TEST INSTRUMENT	FLUKE 1625-2
TEST DATE	21-Jun-18
PROBE DEPTH	1 ft





THE INFORMATION CONTAINED ON THIS DRAWING HAS BEEN PREPARED SOLELY FOR THE OWNER FOR USE ON THIS PROJECT AND IS COPYRIGHTED. ANY UNAUTHORIZED USE OF THIS INFORMATION IS PROHIBITED. INFORMATION NOT WITHIN THE BOUNDARIES OF THIS PROJECT IS NOT THE PROPERTY OF THE ENGINEER. THE ENGINEER ASSUMES NO LIABILITY FOR THE ACCURACY OF THE INFORMATION ON THIS DRAWING IN WHOLE OR IN PART OTHER THAN FOR THE INTENDED PURPOSES IS AT THE SOLE RISK OF THE USER.										DWG. NO. REFERENCE DRAWINGS									
 MCA Engineering Ltd. 917 Columbia St., Lincoln BC V4K 1V0 250.559.8008																			
CLIENT										DISCIPLINE: PROCESS									
PROJ. MAN.										SCALE: NONE									
PROJ. ENG.										DATE									
PROCESS										DISCARD BY: MMC SEP '17									
ELECTR.										DEAN BY: MMC SEP '17									
INSTR.										5 AUG 18 -									
MECH.										CHECKED BY:									
STRUCT.										DATE									
SERVICES										BY									
ARCH.										APPROVED BY:									
LAYOUT																			
REV. ISSUE																			
No.																			
A										UPDATED FOR DESIGN BASIS									
B										REDUCED MAIN TRANSFORMER SIZE									
C										ISSUED FOR QUOTES									
DESCRIPTION																			
3177-E100.DWG										TELKWA COAL									
3177										ONE LINE DIAGRAM									
3177-E100										MAIN INCOMING AND									
C										E-HOUSE									



MCA Engineering Ltd.

917 Columbia St.
Lillooet BC Canada V0K 1V0
Phone: 250-256-8008
mcameron0980@gmail.com

October 18, 2020

Allegiance Coal Ltd.
Suite 1410 – 409 Granville St
Vancouver, BC
V6C 1T2

Attn: Dan Farmer – Chief Operating Officer

Re: Letter of Assurance - Electrical
Telkwa Coal

Please be advised that the electrical design of the Telkwa Coal Project has been completed in accordance with:

- Canadian Electrical Code and
- CSA M421-16 Use of Electricity in Mines

Sincerely,

Malcolm Cameron, P.Eng.
MCA Engineering Ltd.
250-256-8008



Telkwa 25 kV Line Design Criteria

Rev 1 – May 21, 2019



Voltage

The line voltage will be 25kV, 3 phase, with multigrounded neutral. The line will be an extension of circuit 25F52, fed from Smithers substation.

Wire Size

The wire size will be #2 ACSR. This is the existing wire size at the tap point. The ampacity of #2 ACSR is 184 amps Conductor temperature of 75°C, ambient temperature 25°C, emissivity 0.5, wind 2 ft./sec., in sun. This corresponds to a load of $1.73 \times 25 \times 184 = 8000$ kVA.

Plant Load

The Plant Load is expected to be 4000 kVA ultimate, therefore well within the line design capacity.

Standards

The electrical supply system into the mine will be designed according to the following standards:

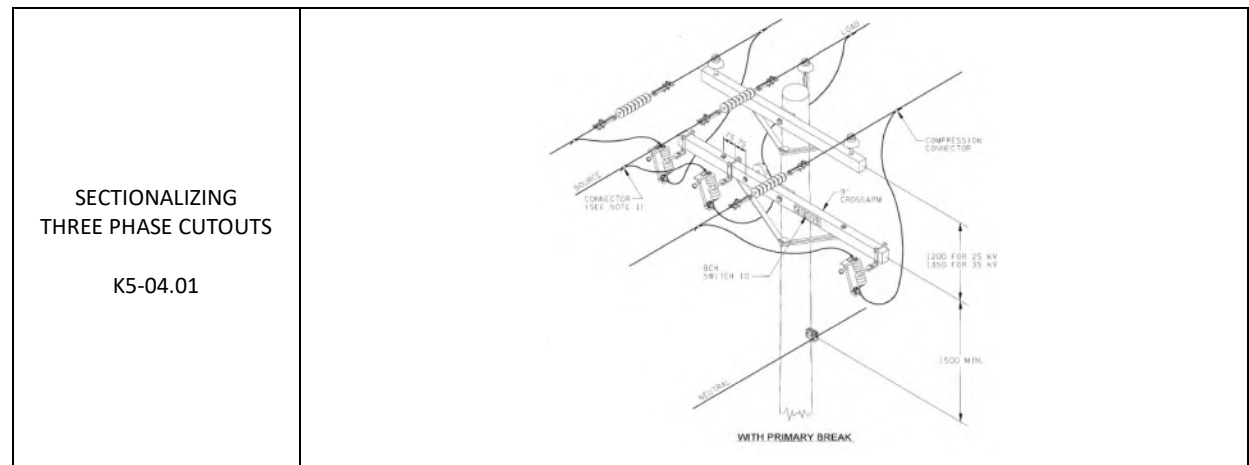
- CSA C22.1 - Canadian Electrical Code
- M421 – Standard for the Use of Electricity in Mines
- ES43 – BC Hydro Technical Standards and Guides
- C22.3 No.1-15 - Overhead Systems

Poles

Poles will be Western Red Cedar (WRC), minimum Class 3 for straight line, and Class 2 for angles, 50 foot, treated. Other, less expensive options include Douglas Fir and Pine, but WRC is recommended for its superior strength and life in heavy snow areas.

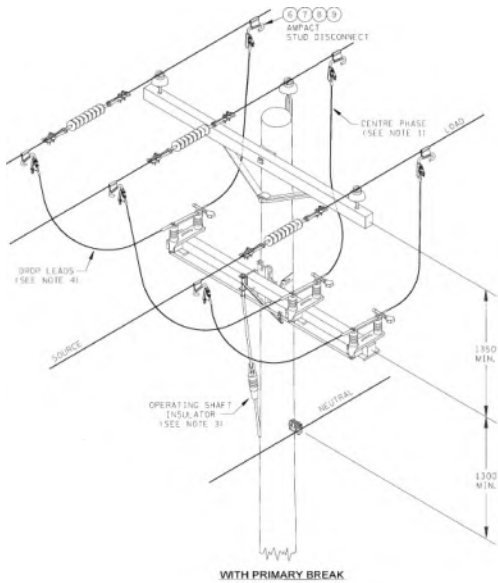
Structures

The following structures will be utilized:



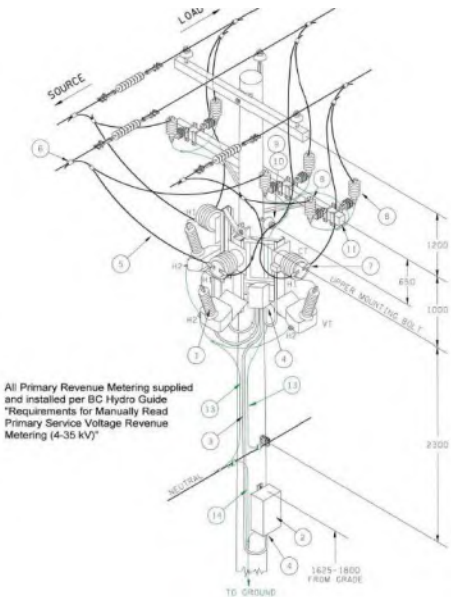
SECTIONALIZING
THREE PHASE WITH
GOLB SWITCH

K5-06.01



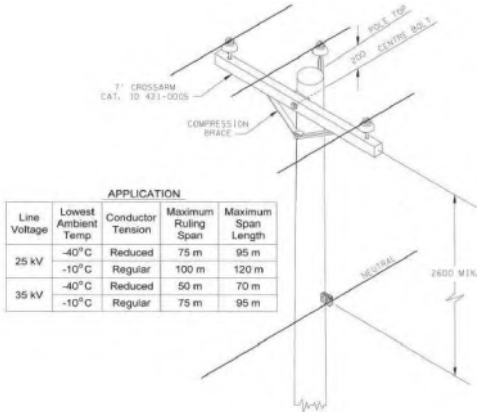
PRIMARY REVENUE
METERING THREE PHASE
FOUR WIRE

J7-01.01



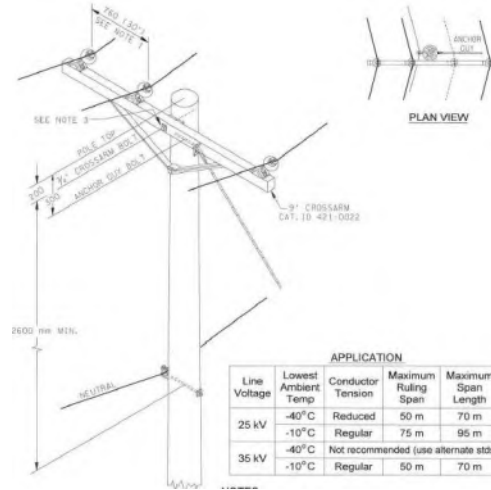
THREE PHASE TANGENT
SKYPIN

G4-02.01



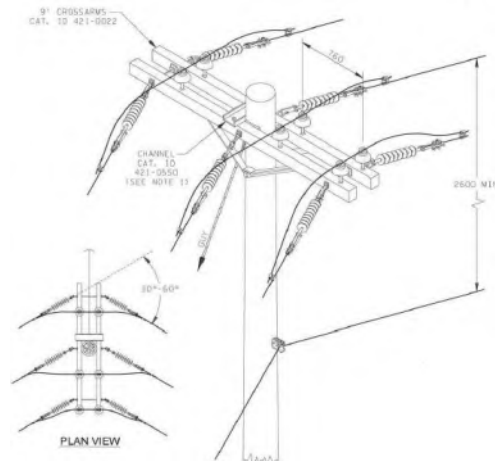
BASIC LINE STRUCTURES
THREE PHASE
ANGLE 5°-25°, FLAT

G4-10.02



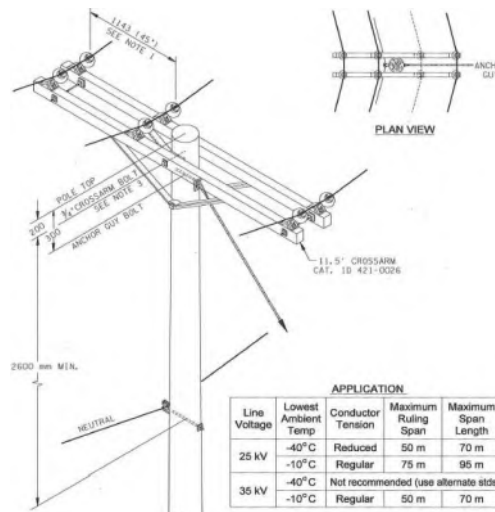
THREE PHASE HORIZONTAL
ANGLE 30°-60° CROSSARM

G4-09.01



BASIC LINE STRUCTURES
THREE PHASE
ANGLE 25°-45°, FLAT

G4-10.03



THREE PHASE CORNER 45°-90° G4-11.01	
SINGLE PHASE TRANSFORMER FRAMING STEP-DOWN TAP, POLE MOUNTED J2-09.01	
THREE PHASE DEAD END G4-05.01	

Metering

The line will be primary metered at the sending end. The billing Tariff will be BC Hydro 1611.

Pole Spacing

Poles will be conservatively spaced in order to reduce snow/wind loading, and associated tension, sag and sway. The average span will be 65 meters.

Surge Arresters

Surge Arresters will be installed at both ends of the line, and at the 1/3 and 2/3 intervals. A total of 4 sets of surge arresters will be installed.

Phase Spacing

Phase Spacing will be minimum 760mm, using 7 and 9 ft. crossarms, and 1143mm, using 11.5 ft. crossarms.

Grounding

The neutral of the 25kV system will be grounded at both ends in addition to at least 3 ground electrodes per kilometer. (Line length is 3.7 km, so 11 electrodes).

Source End Protection

The tap from BC Hydro would consist of a set of BC Hydro fused disconnects, followed by a customer owned gang operated disconnect and recloser. The recloser would provide automatic reclosing upon temporary shorts (ie tree branches, birds etc), but could be replaced by a set of fused disconnects, if the budget dictates.

Plant End Protection

The Plant End Protection would consist of a recloser (identical to Source End). The settings on the recloser would be programmed to protect the pad mounted step down transformer. As the recloser can be remotely operated, it would eliminate the need for an incoming breaker on the switchgear.

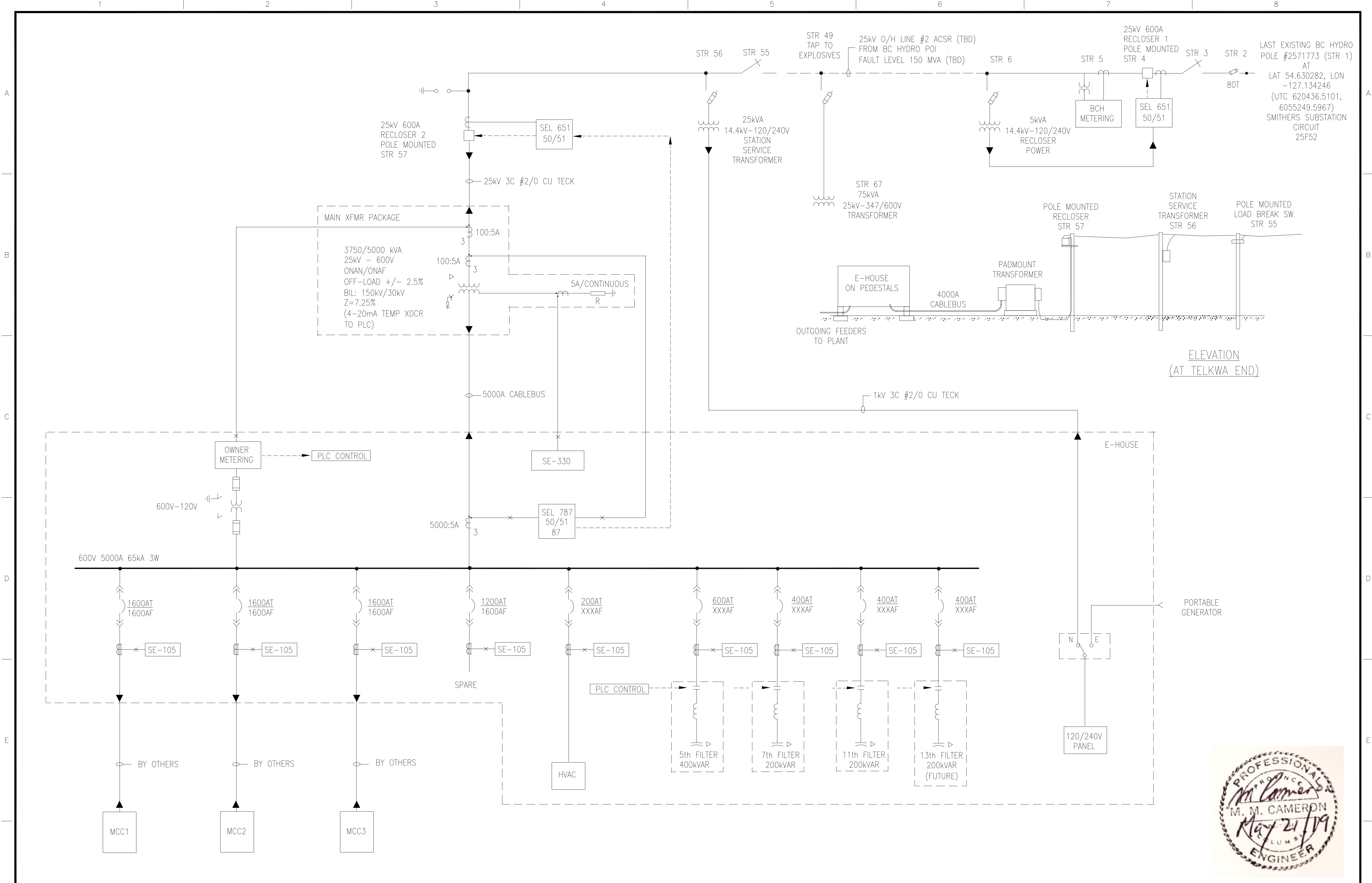
High Voltage Cable

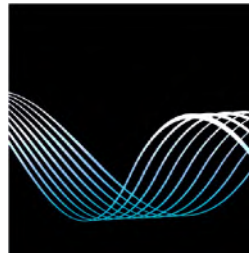
The overhead line would extend partly onto the plant site, and terminate at the recloser. From the recloser pole, there would be a high voltage cable extending down the pole, into a trench, then on to the main step down transformer, at the east end of the process building (a distance of approximately 150 meters). The high voltage cable would be direct buried, except for high traffic areas, where it would be encased in concrete, and PVC duct.

Main Transformer

The main transformer will be rated 3000/4000 kVA, 25kV-600V, ONAN/ONAF, with 4-2.5% taps (2@FCAN and 2@FCBN), with low flammability oil. The transformer will have sidewall mounted bushings for high and low voltage connections. The bushings will be enclosed in compartments with ample room for terminations, stress cones etc. High and low voltage cables will enter from below.

The transformer will be mounted on a foundation with spill containment.



F	THE INFORMATION CONTAINED ON THIS DRAWING HAS BEEN PREPARED SOLELY FOR THE OWNER FOR USE ON THIS PROJECT AND IS COPYRIGHTED. ANY UNAUTHORIZED USE OF THIS INFORMATION IS A BREACH OF COPYRIGHT AND WILL BE PURSUED AS SUCH. USE OF THE INFORMATION ON THIS DRAWING IN WHOLE OR IN PART OTHER THAN FOR THE INTENDED PURPOSE IS AT THE SOLE RISK OF THE USER.			 MCA Engineering Ltd. 917 Columbia St., Lillooet BC V0K1V0 250-256-8008																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
---	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Structure No.	Structure Type	BCH Drawing	X	Y	Horiz Dist	Cummulative	Z	Line Angle Deg	No. of Poles	Pole Species	Pole Class	Pole Length (ft)	Guy		Remarks
0			620450.0051	6055326.1515	50.00					tbd					
1			620437.4500	6055250.0800	77.10	50.00	688.00		1	WRC	2	50			
2		K5-04.01	620431.9539	6055224.5113	26.15	76.15	690.00		1	WRC	3	50			Fused Cutouts
3		K5-06.01	620427.3496	6055197.5759	27.33	103.48	684.00		1	WRC	3	50			Gang Switch
4		K3-06.01	620422.4300	6055170.0966	27.92	131.40	682.00		1	WRC	3	50			Recloser
5		J7-01.01	620417.6307	6055142.8389	27.68	159.07	678.00		1	WRC	3	50			Hydro Metering
6		G4-02.01	620411.4758	6055107.1371	36.23	195.30	675.00		1	WRC	3	50			
7		G4-10.02	620406.4063	6055079.1595	28.43	223.73	674.00	10.7	1	WRC	2	50	1		
8		G4-02.01	620407.1082	6055023.3125	55.85	279.59	673.00		1	WRC	3	50			
9		G4-02.01	620407.4827	6054964.4160	58.90	338.48	672.00		1	WRC	3	50			
10		G4-02.01	620408.2247	6054913.2933	51.13	389.61	671.00		1	WRC	3	50			
11		G4-02.01	620408.9173	6054858.2994	55.00	444.61	671.00		1	WRC	3	50			
12		G4-02.01	620409.5618	6054801.1389	57.16	501.77	671.00		1	WRC	3	50			
13		G4-02.01	620410.3345	6054740.6091	60.53	562.31	672.00		1	WRC	3	50			
14		G4-02.01	620411.0058	6054680.4531	60.16	622.47	672.00		1	WRC	3	50			
15		G4-02.01	620411.6020	6054625.7224	54.73	677.20	672.00		1	WRC	3	50			
16		G4-02.01	620412.3297	6054566.3864	59.34	736.54	673.00		1	WRC	3	50			
17		G4-10.02	620412.9107	6054511.5362	54.85	791.40	675.00	11.0	1	WRC	2	50	1		
18		G4-02.01	620403.5024	6054459.8464	52.54	843.93	677.00		1	WRC	3	50			
19		G4-02.01	620392.8704	6054401.2432	59.56	903.49	679.00		1	WRC	3	50			
20		G4-02.01	620381.6864	6054339.9396	62.32	965.81	680.00		1	WRC	3	50			
21		G4-09.01	620371.2614	6054282.2026	58.67	1024.48	682.00		1	WRC	3	50			
22		G4-10.03	620358.9169	6054215.2600	68.07	1092.55	684.00	35.3	1	WRC	2	50	2		
23		G4-02.01	620390.0479	6054148.3932	73.76	1166.31	686.00		1	WRC	3	50			
24		G4-02.01	620426.1025	6054070.7473	85.61	1251.92	688.00		1	WRC	3	50			
25		G4-02.01	620461.5242	6053995.4388	83.22	1335.14	690.00		1	WRC	3	50			
26		G4-02.01	620497.3392	6053918.1397	85.19	1420.33	692.00		1	WRC	3	50			
27		G4-11.01	620537.0748	6053833.1440	93.83	1514.16	692.00	95.4	1	WRC	2	50	2		
28		G4-10.02	620463.4756	6053806.9170	78.13	1592.29	692.00	12.2	1	WRC	2	50	1		
29		G4-11.01	620412.8203	6053800.4791	51.06	1643.36	693.00	54.8	1	WRC	2	50	2		
30		G4-02.01	620357.3316	6053860.4092	81.67	1725.03	693.00		1	WRC	3	50			
31		G4-02.01	620300.2368	6053922.0302	84.01	1809.03	694.00		1	WRC	3	50			
32		G4-02.01	620240.9183	6053986.1767	87.37	1896.40	695.00		1	WRC	3	50			
33		G4-02.01	620182.2251	6054049.4532	86.31	1982.71	697.00		1	WRC	3	50			
34		G4-10.03	620128.2517	6054108.0662	79.68	2062.39	699.00	23.0	1	WRC	2	50	2		
35		G4-02.01	620049.5192	6054143.5908	86.38	2148.77	705.00		1	WRC	3	50			
36		G4-02.01	619964.9120	6054181.5448	92.73	2241.50	725.00		1	WRC	3	50			
37		G4-02.01	619887.2284	6054216.5012	85.19	2326.68	735.00		1	WRC	3	50			
38		G4-02.01	619810.3717	6054251.0649	84.27	2410.95	750.00		1	WRC	3	50			
39		G4-11.01	619728.2304	6054288.0183	90.07	2501.02	765.00	48.8	1	WRC	2	50	2		
40		G4-02.01	619670.6070	6054261.8674	63.28	2564.30	766.00		1	WRC	3	50			
41		G4-10.03	619607.9056	6054232.9256	69.06	2633.36	768.00	32.4	1	WRC	2	50	2		
42		G4-02.01	619563.8598	6054165.1699	80.81	2714.18	770.00		1	WRC	3	50			
43		G4-02.01	619526.0438	6054106.8329	69.52	2783.70	772.00		1	WRC	3	50			
44		G4-11.01	619489.8030	6054051.1877	66.41	2850.10	775.00	46.7	1	WRC	2	50	2		
45		G4-02.01	619421.0847	6054038.7446	69.84	2919.94	789.50		1	WRC	3	50			
46		G4-02.01	619347.2133	6054025.4907	75.05	2994.99	788.00		1	WRC	3	50			
47		G4-10.03	619269.4792	6054011.5077	78.98	3073.97	787.00	27.7	1	WRC	2	50	2		
48		G4-02.01	619211.3709	6053966.1852	73.69	3147.67	787.00		1	WRC	3	50			
49		G4-02.01	619150.8662	6053919.0435	76.70	3224.37	787.00		1	WRC	3	50	2		
50		G4-11.01	619088.7174	6053870.4997	78.86	3303.23	787.00	53.00	1	WRC	2	50	2		
51		G4-02.01	619090.2276	6053774.6951	95.82	3399.04	792.00		1	WRC	3	50			
52		G4-11.01	619091.9270	6053682.8981	91.81	3490.86	798.00	46.00	1	WRC	2	50	2		
53		G4-02.01	619057.6280	6053643.3977	52.31	3543.17	801.00		1	WRC	3	50			
54		G4-11.01	619006.9744	6053597.6016	68.29	3611.46	801.00	95.30	1	WRC	2	50	2		
55		K5-06.01	619018.9834	6053587.4893	15.70	3627.16	802.00		1	WRC	3	50			Gang Switch
56		J2-09-01A	619032.1219	6053576.7107	16.99	3644.15	803.00		1	WRC	3	50			Transformer
57		K3-06.01-04 & G4-05.01	619045.3637	6053565.5038	17.35	3661.50	790.00		1	WRC	3	50	1		Recloser/Drop (use G4-05.01 structure with Recloser as shown on K3-06.01-04)
58		G4-02.01	619112.5082	6053946.9352	47.43	3708.92	800.00		1	WRC	3	50			
59		G4-02.01	619042.5511	6053997.8195	86.51	3795.43	800.00		1	WRC	3	50			
60		G4-02.01	618972.4949	6054049.2583	86.91	3882.34	800.00		1	WRC	3	50			
61		G4-02.01	618904.9382	6054098.0196	83.32	3965.66	800.00		1	WRC	3	50			
62		G4-02.01	618834.9811	6054148.9039	86.51	4052.16	800.00		1	WRC	3	50			
63		G4-02.01	618764.9248	6054200.3427	86.91	4139.08	800.00		1	WRC	3	50			
64		G4-02.01	618687.1214	6054256.6515	96.04	4235.12	800.00		1	WRC	3	50			
65		G4-10.03	618613.3009	6054310.5878	91.43	4326.54	800.00	27.00	1	WRC	2	50	2		
66		G4-02.01	618592.2706	6054390.1775	82.32	4408.87	800.00		1	WRC	3	50			
67		G4-02.01	618573.5528	6054462.9120	75.10	4483.97	800.00		1	WRC	3	50	1		



Straight with Pole Top Pin	G4-02.01	NA	Machine Bolt (5/8" x length)	100-20XX	1
Straight with Pole Top Pin	G4-02.01	NA	Square Washer (50mm x 50mm)	420-1521	1
Straight with Pole Top Pin	G4-02.01	NA	Lock Washer (5/8')	102-4158	1
Straight with Pole Top Pin	G4-02.01	NA	Secondary Clevis	413-0051	1
Straight with Pole Top Pin	G4-02.01	NA	Neutral Spool Insulator (White)	410-0050	1
Straight with Pole Top Pin	G4-02.01	PPA	Pole Top Straight Pin	421-0410	1
Straight with Pole Top Pin	G4-02.01	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	2
Straight with Pole Top Pin	G4-02.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Straight with Pole Top Pin	G4-02.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Straight with Pole Top Pin	G4-02.01	PPA	Pin Insulator	410-0650	1
Straight with Pole Top Pin	G4-02.01	PPA	Crossarm Straight Pin	421-0307	2
Straight with Pole Top Pin	G4-02.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Straight with Pole Top Pin	G4-02.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Straight with Pole Top Pin	G4-02.01	PPA	Pin Insulator	410-0650	2
Straight with Pole Top Pin	G4-02.01	CA	7' Crossarm	421-0005	1
Straight with Pole Top Pin	G4-02.01	CA	Helical Spring Washer (1/2")	102-4156	2
Straight with Pole Top Pin	G4-02.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	2
Straight with Pole Top Pin	G4-02.01	CA	Helical Spring Washer (1/2")	102-4156	2
Straight with Pole Top Pin	G4-02.01	CA	Crossarm Gain	421-0207	1
Light Angle (5-25 deg)	G4-10.02	NA	Machine Bolt (5/8" x length)	100-20XX	1
Light Angle (5-25 deg)	G4-10.02	NA	Square Washer (50mm x 50mm)	420-1521	1
Light Angle (5-25 deg)	G4-10.02	NA	Lock Washer (5/8')	102-4158	1
Light Angle (5-25 deg)	G4-10.02	NA	Secondary Clevis	413-0051	1
Light Angle (5-25 deg)	G4-10.02	NA	Neutral Spool Insulator (White)	410-0050	1
Light Angle (5-25 deg)	G4-10.02	CA	Machine Bolt (5/8" x length)	100-20XX	1
Light Angle (5-25 deg)	G4-10.02	CA	Square Washer (50mm x 50mm)	420-1521	1
Light Angle (5-25 deg)	G4-10.02	CA	Helical Spring Washer (5/8")	102-4158	1
Light Angle (5-25 deg)	G4-10.02	CA	Machine Bolt (3/4" x length) c/w Nut	100-21XX	1
Light Angle (5-25 deg)	G4-10.02	CA	Square Washer (75mm x 75mm)	420-1521	2
Light Angle (5-25 deg)	G4-10.02	CA	Helical Spring Washer (3/4")	102-4160	1
Light Angle (5-25 deg)	G4-10.02	CA	Carriage Bolt (1/2"x150mm)	100-0547	2
Light Angle (5-25 deg)	G4-10.02	CA	Helical Spring Washer (1/2")	102-4156	2
Light Angle (5-25 deg)	G4-10.02	CA	9' Crossarm	421-0022	1
Light Angle (5-25 deg)	G4-10.02	CA	Compression Brace (1525mm)	421-0121	1
Light Angle (5-25 deg)	G4-10.02	CA	Crossarm Gain	421-0207	1
Light Angle (5-25 deg)	G4-10.02	PPA	Crossarm Angle Pin	421-0351	3
Light Angle (5-25 deg)	G4-10.02	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	3
Light Angle (5-25 deg)	G4-10.02	PPA	Square Washer (50mm x 50mm)	420-1521	3
Light Angle (5-25 deg)	G4-10.02	PPA	Helical Spring Washer (5/8")	102-4158	3
Light Angle (5-25 deg)	G4-10.02	PPA	Pin Insulator	410-0650	3
Light Angle (5-25 deg)	G4-10.02	GA	Guy Attachment	420-0766	1
Light Angle (5-25 deg)	G4-10.02	GA	Preformed Guy Grip Size 10 Guy	420-0975	6
Light Angle (5-25 deg)	G4-10.02	GA	Guy Strand Size 10	382-4235	lot
Light Angle (5-25 deg)	G4-10.02	GA	Strain Insulator	410-1208	2
Light Angle (5-25 deg)	G4-10.02	GA	Guy Guard	420-0910	1
Medium Angle (25-45 deg)	G4-10.03	NA	Machine Bolt (5/8" x length)	100-20XX	1
Medium Angle (25-45 deg)	G4-10.03	NA	Square Washer (50mm x 50mm)	420-1521	1
Medium Angle (25-45 deg)	G4-10.03	NA	Lock Washer (5/8')	102-4158	1
Medium Angle (25-45 deg)	G4-10.03	NA	Secondary Clevis	413-0051	1
Medium Angle (25-45 deg)	G4-10.03	NA	Neutral Spool Insulator (White)	410-0050	1
Medium Angle (25-45 deg)	G4-10.03	CA	Machine Bolt (5/8" x length)	100-20XX	1
Medium Angle (25-45 deg)	G4-10.03	CA	Square Washer (50mm x 50mm)	420-1521	8
Medium Angle (25-45 deg)	G4-10.03	CA	Helical Spring Washer (5/8")	102-4158	5
Medium Angle (25-45 deg)	G4-10.03	CA	Machine Bolt (3/4" x length) c/w Nut	100-21XX	1
Medium Angle (25-45 deg)	G4-10.03	CA	Square Washer (75mm x 75mm)	420-1521	2
Medium Angle (25-45 deg)	G4-10.03	CA	Helical Spring Washer (3/4")	102-4160	1
Medium Angle (25-45 deg)	G4-10.03	CA	Carriage Bolt (1/2"x150mm)	100-0547	4
Medium Angle (25-45 deg)	G4-10.03	CA	Helical Spring Washer (1/2")	102-4156	4
Medium Angle (25-45 deg)	G4-10.03	CA	Compression Brace (1525mm)	421-0121	2
Medium Angle (25-45 deg)	G4-10.03	CA	Crossarm Gain	421-0207	2
Medium Angle (25-45 deg)	G4-10.03	CA	Double Arming Bolt (5/8" x length)	420-XXXX	2
Medium Angle (25-45 deg)	G4-10.03	CA	9' Crossarm	421-0022	2
Medium Angle (25-45 deg)	G4-10.03	PPA	Crossarm Angle Pin	421-0351	6
Medium Angle (25-45 deg)	G4-10.03	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	6
Medium Angle (25-45 deg)	G4-10.03	PPA	Square Washer (50mm x 50mm)	420-1521	6
Medium Angle (25-45 deg)	G4-10.03	PPA	Helical Spring Washer (5/8")	102-4158	6

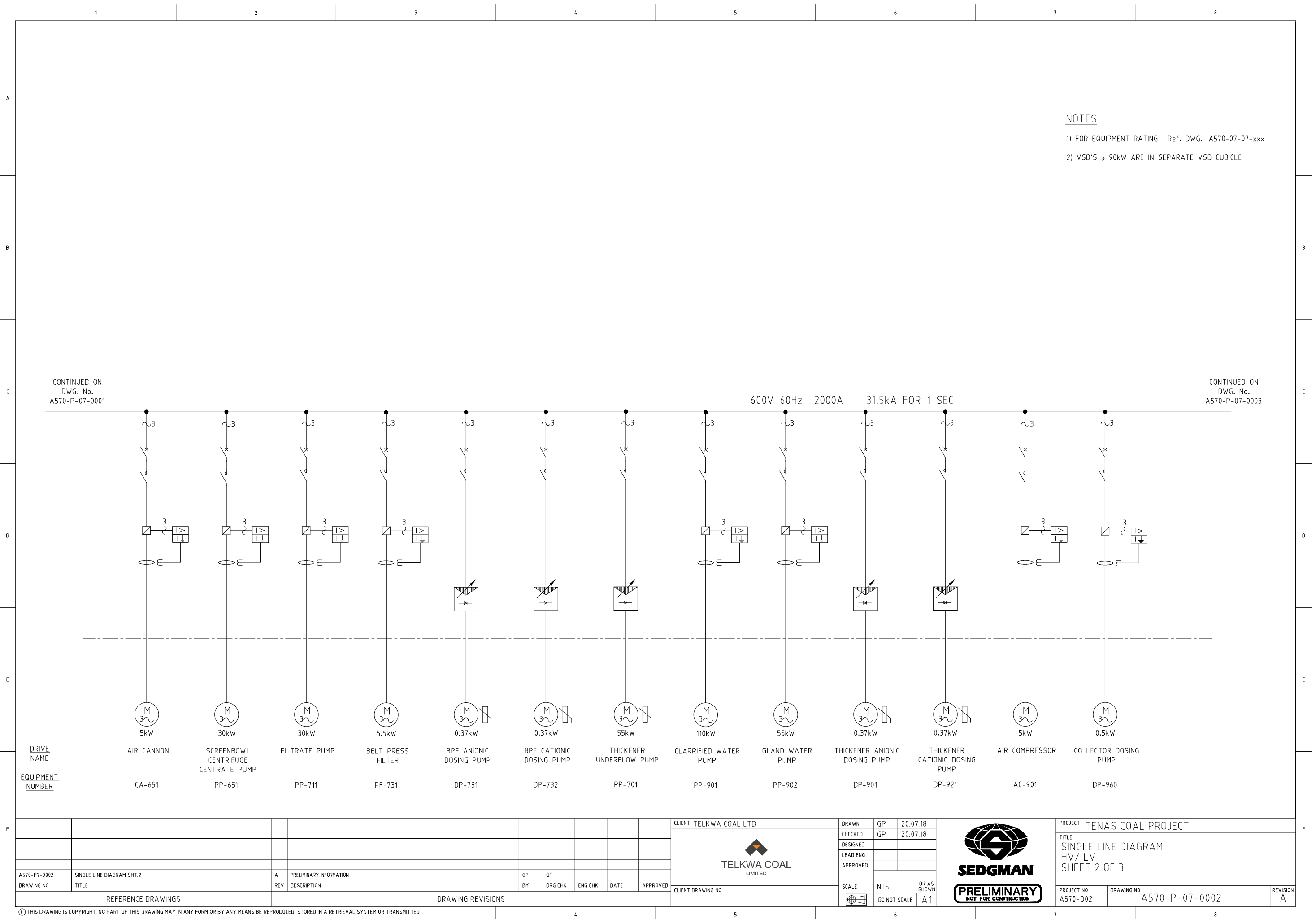


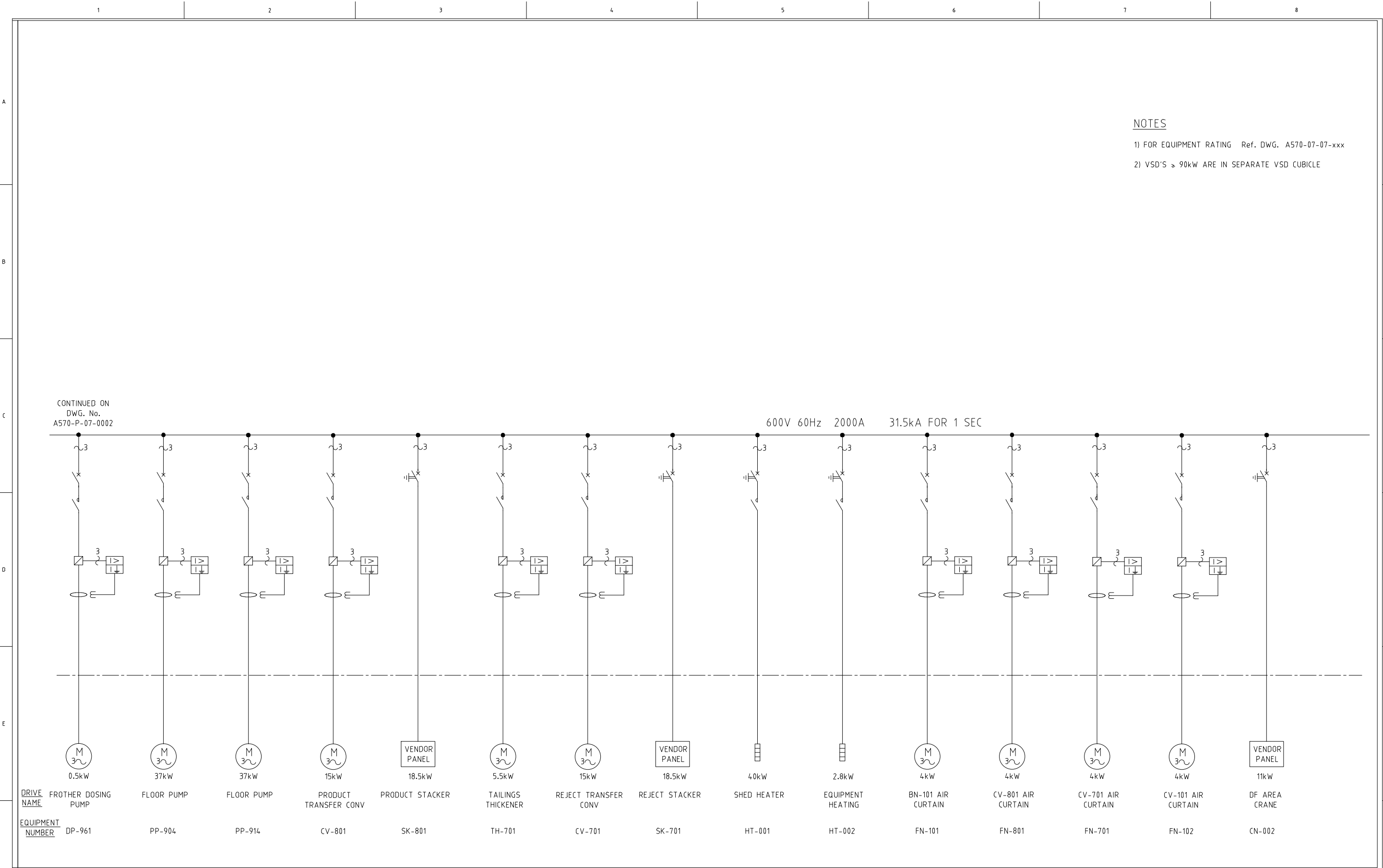
Medium Angle (25-45 deg)	G4-10.03	PPA	Pin Insulator	410-0650	6
Medium Angle (25-45 deg)	G4-10.03	GA	Guy Attachment	420-0766	1
Medium Angle (25-45 deg)	G4-10.03	GA	Preformed Guy Grip Size 10 Guy	420-0975	6
Medium Angle (25-45 deg)	G4-10.03	GA	Guy Strand Size 10	382-4235	lot
Medium Angle (25-45 deg)	G4-10.03	GA	Strain Insulator	410-1208	2
Medium Angle (25-45 deg)	G4-10.03	GA	Guy Guard	420-0910	1
Corner (45-90 deg) DDE	G4.11.01	NA	Machine Bolt (5/8" x length)	100-XXXX	2
Corner (45-90 deg) DDE	G4.11.01	NA	Square Washer (50mm x 50mm)	420-1521	2
Corner (45-90 deg) DDE	G4.11.01	NA	Lock Washer (5/8')	102-4158	2
Corner (45-90 deg) DDE	G4.11.01	NA	Secondary Clevis	413-0051	2
Corner (45-90 deg) DDE	G4.11.01	NA	Neutral Spool Insulator (White)	410-0050	2
Corner (45-90 deg) DDE	G4.11.01	NA	Grip for Bare Neutral	413-054X	2
Corner (45-90 deg) DDE	G4.11.01	NA	Compression Connector	388-XXXX	1
Corner (45-90 deg) DDE	G4.11.01	CA	Machine Bolt (5/8" x length)	100-20XX	2
Corner (45-90 deg) DDE	G4.11.01	CA	Square Washer (50mm x 50mm)	420-1521	10
Corner (45-90 deg) DDE	G4.11.01	CA	Helical Spring Washer (5/8")	102-4158	6
Corner (45-90 deg) DDE	G4.11.01	CA	Machine Bolt (3/4" x length) c/w Nut	100-21XX	1
Corner (45-90 deg) DDE	G4.11.01	CA	Square Washer (75mm x 75mm)	420-1521	2
Corner (45-90 deg) DDE	G4.11.01	CA	Helical Spring Washer (3/4")	102-4160	1
Corner (45-90 deg) DDE	G4.11.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	4
Corner (45-90 deg) DDE	G4.11.01	CA	Helical Spring Washer (1/2")	102-4156	4
Corner (45-90 deg) DDE	G4.11.01	CA	Compression Brace (1525mm)	421-0121	2
Corner (45-90 deg) DDE	G4.11.01	CA	Crossarm Gain	421-0207	2
Corner (45-90 deg) DDE	G4.11.01	CA	Double Arming Bolt (5/8" x length)	420-XXXX	2
Corner (45-90 deg) DDE	G4.11.01	CA	9' Crossarm	421-0022	4
Corner (45-90 deg) DDE	G4.11.01	GA	Guy Attachment	420-0766	1
Corner (45-90 deg) DDE	G4.11.01	GA	Preformed Guy Grip Size 10 Guy	420-0975	6
Corner (45-90 deg) DDE	G4.11.01	GA	Guy Strand Size 10	382-4235	lot
Corner (45-90 deg) DDE	G4.11.01	GA	Strain Insulator	410-1208	2
Corner (45-90 deg) DDE	G4.11.01	GA	Guy Guard	420-0910	1
Corner (45-90 deg) DDE	G4.11.01	NDE	Machine Bolt (5/8" x length)	100-XXXX	3
Corner (45-90 deg) DDE	G4.11.01	NDE	Square Washer (50mm x 50mm)	420-1521	6
Corner (45-90 deg) DDE	G4.11.01	NDE	Lock Washer (5/8')	102-4158	6
Corner (45-90 deg) DDE	G4.11.01	NDE	Secondary Clevis	413-0051	6
Corner (45-90 deg) DDE	G4.11.01	NDE	Neutral Spool Insulator (White)	410-0500	2
Corner (45-90 deg) DDE	G4.11.01	NDE	Grip for Bare Neutral	413-054X	2
Corner (45-90 deg) DDE	G4.11.01	PDE	Suspension Insulator Polymeric	410-1027	6
Corner (45-90 deg) DDE	G4.11.01	PDE	Dead End Clamp #2 to 1/0 ACSR	413-0579	6
Corner (45-90 deg) DDE	G4.11.01	PDE	Nut (5/8")	102-0126	6
Corner (45-90 deg) DDE	G4.11.01	PDE	Extension Strap (125mm)	420-1009	2
Corner (45-90 deg) DDE	G4.11.01	PDE	Eyenuit (5/8")	420-1400	6
Heavy Angle (30-60 deg) DDE	G4-09.01	NA	Machine Bolt (5/8" x length)	100-20XX	1
Heavy Angle (30-60 deg) DDE	G4-09.01	NA	Square Washer (50mm x 50mm)	420-1521	1
Heavy Angle (30-60 deg) DDE	G4-09.01	NA	Lock Washer (5/8')	102-4158	1
Heavy Angle (30-60 deg) DDE	G4-09.01	NA	Secondary Clevis	413-0051	1
Heavy Angle (30-60 deg) DDE	G4-09.01	NA	Neutral Spool Insulator (White)	410-0050	1
Heavy Angle (30-60 deg) DDE	G4-09.01	PDE	Suspension Insulator Polymeric	410-1027	6
Heavy Angle (30-60 deg) DDE	G4-09.01	PDE	Dead End Clamp #2 to 1/0 ACSR	413-0579	6
Heavy Angle (30-60 deg) DDE	G4-09.01	PDE	Nut (5/8")	102-0126	6
Heavy Angle (30-60 deg) DDE	G4-09.01	PDE	Extension Strap (125mm)	420-1009	2
Heavy Angle (30-60 deg) DDE	G4-09.01	PDE	Eyenuit (5/8")	420-1400	6
Heavy Angle (30-60 deg) DDE	G4-09.01	PPA	Pin Insulator	410-0650	6
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Machine Bolt (5/8" x length)	100-20XX	1
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Square Washer (50mm x 50mm)	420-1521	8
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Helical Spring Washer (5/8")	102-4158	5
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Machine Bolt (3/4" x length) c/w Nut	100-21XX	1
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Square Washer (75mm x 75mm)	420-1521	2
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Helical Spring Washer (3/4")	102-4160	1
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	4
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Helical Spring Washer (1/2")	102-4156	4
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Compression Brace (1525mm)	421-0121	2
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Crossarm Gain	421-0207	2
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Double Arming Bolt (5/8" x length)	420-XXXX	2
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	9' Crossarm	421-0022	2
Heavy Angle (30-60 deg) DDE	G4-09.01	CA	Channel	421-0550	1
Transformer Pole (Straight)	J2-09.01	GE	Ground Rod	420-1093	1

Transformer Pole (Straight)	J2-09.01	GE	Ground Rod Connector	420-1158	1
Transformer Pole (Straight)	J2-09.01	GE	Theft Deterrent Galvanized Grounding Wire	96006427	lot
Transformer Pole (Straight)	J2-09.01	GE	Staple, Ground Conductor	103-0224	lot
Transformer Pole (Straight)	J2-09.01	GE	Staple, Conductor Moulding	103-0228	lot
Transformer Pole (Straight)	J2-09.01	GE	Moulding Ground Conductor	388-5221	lot
Transformer Pole (Straight)	J2-09.01	GE	Ground Plate	420-1080	1
Transformer Pole (Straight)	J2-09.01	GE	Split Stud Connector	388-2103	1
Transformer Pole (Straight)	J2-09.01	GE	3/8" Nut Hex Galvanized	102-0122	1
Transformer Pole (Straight)	J2-09.01	GE	3/8" Washer, Spring, Galvanized	102-4154	1
Transformer Pole (Straight)	J2-09.01	GE	1/4" X 50mm Lag Screw Galvanized	101-0246	1
Transformer Pole (Straight)	J2-09.01	GE	#4 AWG Cu Conductor PE Covered	380-5051	lot
Transformer Pole (Straight)	J2-09.01	GE	Miniwedge, Erico - #2 ACSR	96006695	1
Transformer Pole (Straight)	J2-09.01	NA	Machine Bolt (5/8" x length)	100-20XX	1
Transformer Pole (Straight)	J2-09.01	NA	Square Washer (50mm x 50mm)	420-1521	1
Transformer Pole (Straight)	J2-09.01	NA	Lock Washer (5/8')	102-4158	1
Transformer Pole (Straight)	J2-09.01	NA	Secondary Clevis	413-0051	1
Transformer Pole (Straight)	J2-09.01	NA	Neutral Spool Insulator (White)	410-0050	1
Transformer Pole (Straight)	J2-09.01	PPA	Pole Top Straight Pin	421-0410	1
Transformer Pole (Straight)	J2-09.01	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	2
Transformer Pole (Straight)	J2-09.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Transformer Pole (Straight)	J2-09.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Transformer Pole (Straight)	J2-09.01	PPA	Pin Insulator	410-0650	1
Transformer Pole (Straight)	J2-09.01	PPA	Crossarm Straight Pin	421-0307	2
Transformer Pole (Straight)	J2-09.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Transformer Pole (Straight)	J2-09.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Transformer Pole (Straight)	J2-09.01	PPA	Pin Insulator	410-0650	2
Transformer Pole (Straight)	J2-09.01	CA	7' Crossarm	421-0005	1
Transformer Pole (Straight)	J2-09.01	CA	Helical Spring Washer (1/2")	102-4156	2
Transformer Pole (Straight)	J2-09.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	2
Transformer Pole (Straight)	J2-09.01	CA	Helical Spring Washer (1/2")	102-4156	2
Transformer Pole (Straight)	J2-09.01	CA	Crossarm Gain	421-0207	1
		TG			
Primary Metering Pole (Straight)	J7-01.01	MK	Metering Kit 25kV, 200A	362-6032	1
Primary Metering Pole (Straight)	J7-01.01	MK	Meter Cabinet	372-9204	1
Primary Metering Pole (Straight)	J7-01.01	MK	Teck Cable 11 conductor	380-4545	10m
Primary Metering Pole (Straight)	J7-01.01	MK	Cable Fitting	390-1125	2
Primary Metering Pole (Straight)	J7-01.01	MK	Polyethylene Covered Conductor #2 Cu	380-0256	lot
Primary Metering Pole (Straight)	J7-01.01	MK	Ampact Connectors	380-0531	9
Primary Metering Pole (Straight)	J7-01.01	MK	Compression Spade Connectors	388-1030	6
Primary Metering Pole (Straight)	J7-01.01	MK	Surge Arrestors	351-0016	6
Primary Metering Pole (Straight)	J7-01.01	MK	Pin Insulator	410-0649	1
Primary Metering Pole (Straight)	J7-01.01	MK	Drop Lead Insulator Pin	421-0311	1
Primary Metering Pole (Straight)	J7-01.01	MK	9' Crossarm	421-0022	1
Primary Metering Pole (Straight)	J7-01.01	MK	Insulator, Horizontal Line Post 25kV	410-0681	1
Primary Metering Pole (Straight)	J7-01.01	MK	#4 AWG PE Covered Cu Conductor	380-5051	lot
Primary Metering Pole (Straight)	J7-01.01	MK	Theft Deterrent Grounding Wire	96006427	lot
Primary Metering Pole (Straight)	J7-01.01	NA	Machine Bolt (5/8" x length)	100-20XX	1
Primary Metering Pole (Straight)	J7-01.01	NA	Square Washer (50mm x 50mm)	420-1521	1
Primary Metering Pole (Straight)	J7-01.01	NA	Lock Washer (5/8')	102-4158	1
Primary Metering Pole (Straight)	J7-01.01	NA	Secondary Clevis	413-0051	1
Primary Metering Pole (Straight)	J7-01.01	NA	Neutral Spool Insulator (White)	410-0050	1
Primary Metering Pole (Straight)	J7-01.01	PPA	Pole Top Straight Pin	421-0410	1
Primary Metering Pole (Straight)	J7-01.01	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	2
Primary Metering Pole (Straight)	J7-01.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Primary Metering Pole (Straight)	J7-01.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Primary Metering Pole (Straight)	J7-01.01	PPA	Pin Insulator	410-0650	1
Primary Metering Pole (Straight)	J7-01.01	PPA	Crossarm Straight Pin	421-0307	2
Primary Metering Pole (Straight)	J7-01.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Primary Metering Pole (Straight)	J7-01.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Primary Metering Pole (Straight)	J7-01.01	PPA	Pin Insulator	410-0650	2
Primary Metering Pole (Straight)	J7-01.01	CA	7' Crossarm	421-0005	1
Primary Metering Pole (Straight)	J7-01.01	CA	Helical Spring Washer (1/2")	102-4156	2
Primary Metering Pole (Straight)	J7-01.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	2
Primary Metering Pole (Straight)	J7-01.01	CA	Helical Spring Washer (1/2")	102-4156	2
Primary Metering Pole (Straight)	J7-01.01	CA	Crossarm Gain	421-0207	1
Primary Metering Pole (Straight)	J7-01.01	SIL	DS-35 Polymeric Suspension Insulator	410-1027	3
Primary Metering Pole (Straight)	J7-01.01	SIL	DDE Clamp #2 /AWG	413-0579	6
Primary Metering Pole (Straight)	J7-01.01	SIL	Extension Line	420-1009	1

Recloser Pole (Straight)	K3-06.01	RE	Recloser Control	96004906	1
Recloser Pole (Straight)	K3-06.01	RE	Recloser Head	96004903	1
Recloser Pole (Straight)	K3-06.01	RE	Wildlife Guard - vertical bushing	96006524	3
Recloser Pole (Straight)	K3-06.01	RE	Wildlife Guard - horizontal bushing	96006524	3
Recloser Pole (Straight)	K3-06.01	RE	25 kV, 600A GOLB Switch - w/pipe handle	350-8078	1
Recloser Pole (Straight)	K3-06.01	RE	Crossarm Cutout Mounting Bracket	350-5396	3
Recloser Pole (Straight)	K3-06.01	RE	14.4/25 kV Cutout, Polymer body	96005747	3
Recloser Pole (Straight)	K3-06.01	RE	Blade, Disconnect, Solid, 300A	350-5271	3
Recloser Pole (Straight)	K3-06.01	RE	Crossarm Insulator Pin	421-0307	1
Recloser Pole (Straight)	K3-06.01	RE	Pin Insulator, 14.4/25 kV	410-0649	1
Recloser Pole (Straight)	K3-06.01	RE	Wire 2/0 AWG, soft, 19 Str, PE cover	380-0259	lot
Recloser Pole (Straight)	K3-06.01	RE	Wire #4 AWG, 1C, copper, Str PE cover	380-5051	lot
Recloser Pole (Straight)	K3-06.01	RE	Machine Bolt (3/4" x Length)	100-XXXX	4
Recloser Pole (Straight)	K3-06.01	RE	Square Washer (75mm x 75mm)	420-1525	4
Recloser Pole (Straight)	K3-06.01	RE	Helical Spring Washer (3/4")	102-4160	4
Recloser Pole (Straight)	K3-06.01	RE	Plate, Pocket Panel, Horizontal, 2 spaces, 110 mm	96006326	2
Recloser Pole (Straight)	K3-06.01	RE	Plate, Pocket Panel, Vertical, 6 spaces, 65 mm lon	96005904	1
Recloser Pole (Straight)	K3-06.01	RE	Connector, 2 Bolt, 4/0 Run, #6 - 4/0 Tap, w/Separ	388-0353	6
Recloser Pole (Straight)	K3-06.01	RE	Crossarm 9'	421-0022	1
Recloser Pole (Straight)	K3-06.01	RE	Ampact Stud Disconnect	F5-11.02	12
Recloser Pole (Straight)	K3-06.01	RE	Power Supply	K9-01	1
Switch Pole (Straight)	K5-06.01	NA	Machine Bolt (5/8" x length)	100-20XX	1
Switch Pole (Straight)	K5-06.01	NA	Square Washer (50mm x 50mm)	420-1521	1
Switch Pole (Straight)	K5-06.01	NA	Lock Washer (5/8')	102-4158	1
Switch Pole (Straight)	K5-06.01	NA	Secondary Clevis	413-0051	1
Switch Pole (Straight)	K5-06.01	NA	Neutral Spool Insulator (White)	410-0050	1
Switch Pole (Straight)	K5-06.01	PPA	Pole Top Straight Pin	421-0410	1
Switch Pole (Straight)	K5-06.01	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	2
Switch Pole (Straight)	K5-06.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Switch Pole (Straight)	K5-06.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Switch Pole (Straight)	K5-06.01	PPA	Pin Insulator	410-0650	1
Switch Pole (Straight)	K5-06.01	PPA	Crossarm Straight Pin	421-0307	2
Switch Pole (Straight)	K5-06.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Switch Pole (Straight)	K5-06.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Switch Pole (Straight)	K5-06.01	PPA	Pin Insulator	410-0650	2
Switch Pole (Straight)	K5-06.01	CA	7' Crossarm	421-0005	1
Switch Pole (Straight)	K5-06.01	CA	Helical Spring Washer (1/2")	102-4156	2
Switch Pole (Straight)	K5-06.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	2
Switch Pole (Straight)	K5-06.01	CA	Helical Spring Washer (1/2")	102-4156	2
Switch Pole (Straight)	K5-06.01	CA	Crossarm Gain	421-0207	1
Switch Pole (Straight)	K5-06.01	SW	25 kV, 600A GOLB Switch - w/pipe handle	350-8078	1
Switch Pole (Straight)	K5-06.01	PPA	Pole Top Straight Pin	421-0410	1
Switch Pole (Straight)	K5-06.01	PPA	Machine Bolt (5/8" x length) c/w Nut	100-20XX	2
Switch Pole (Straight)	K5-06.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Switch Pole (Straight)	K5-06.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Switch Pole (Straight)	K5-06.01	PPA	Pin Insulator	410-0650	1
Switch Pole (Straight)	K5-06.01	PPA	Crossarm Straight Pin	421-0307	2
Switch Pole (Straight)	K5-06.01	PPA	Square Washer (50mm x 50mm)	420-1521	2
Switch Pole (Straight)	K5-06.01	PPA	Helical Spring Washer (5/8")	102-4158	2
Switch Pole (Straight)	K5-06.01	PPA	Pin Insulator	410-0650	2
Switch Pole (Straight)	K5-06.01	CA	7' Crossarm	421-0005	1
Switch Pole (Straight)	K5-06.01	CA	Helical Spring Washer (1/2")	102-4156	2
Switch Pole (Straight)	K5-06.01	CA	Carriage Bolt (1/2"x150mm)	100-0547	2
Switch Pole (Straight)	K5-06.01	CA	Helical Spring Washer (1/2")	102-4156	2
Switch Pole (Straight)	K5-06.01	CA	Crossarm Gain	421-0207	1
Switch Pole (Straight)	K5-06.01	SIL	DS-35 Polymeric Suspension Insulator	410-1027	3
Switch Pole (Straight)	K5-06.01	SIL	DDE Clamp #2 /AWG	413-0579	6
Switch Pole (Straight)	K5-06.01	SIL	Extension Line	420-1009	1
Sectionalizing 3PH with Cutouts	K5-04.01		DS-35 Polymeric Suspension Insulator	410-1027	3
Sectionalizing 3PH with Cutouts	K5-04.01		Dead End Clamp #2 AWG Al to 2/0 ACSR	413-0579	6
Sectionalizing 3PH with Cutouts	K5-04.01		Extension Link	420-1009	3
Sectionalizing 3PH with Cutouts	K5-04.01		Bracket	350-5295	3
Sectionalizing 3PH with Cutouts	K5-04.01		14.4/25 kV Cutout, Polymer Body	96005747	3

Sectionalizing 3PH with Cutouts	K5-04.01	Machine Bolt (5/8" x length)	100-20XX	2
Sectionalizing 3PH with Cutouts	K5-04.01	Square Washer (50mm x 50mm)	420-1521	2
Sectionalizing 3PH with Cutouts	K5-04.01	Helical Spring Washer (5/8")	102-4158	2
Sectionalizing 3PH with Cutouts	K5-04.01	7' Crossarm	421-0005	1
Sectionalizing 3PH with Cutouts	K5-04.01	Compression Brace	421-0120	

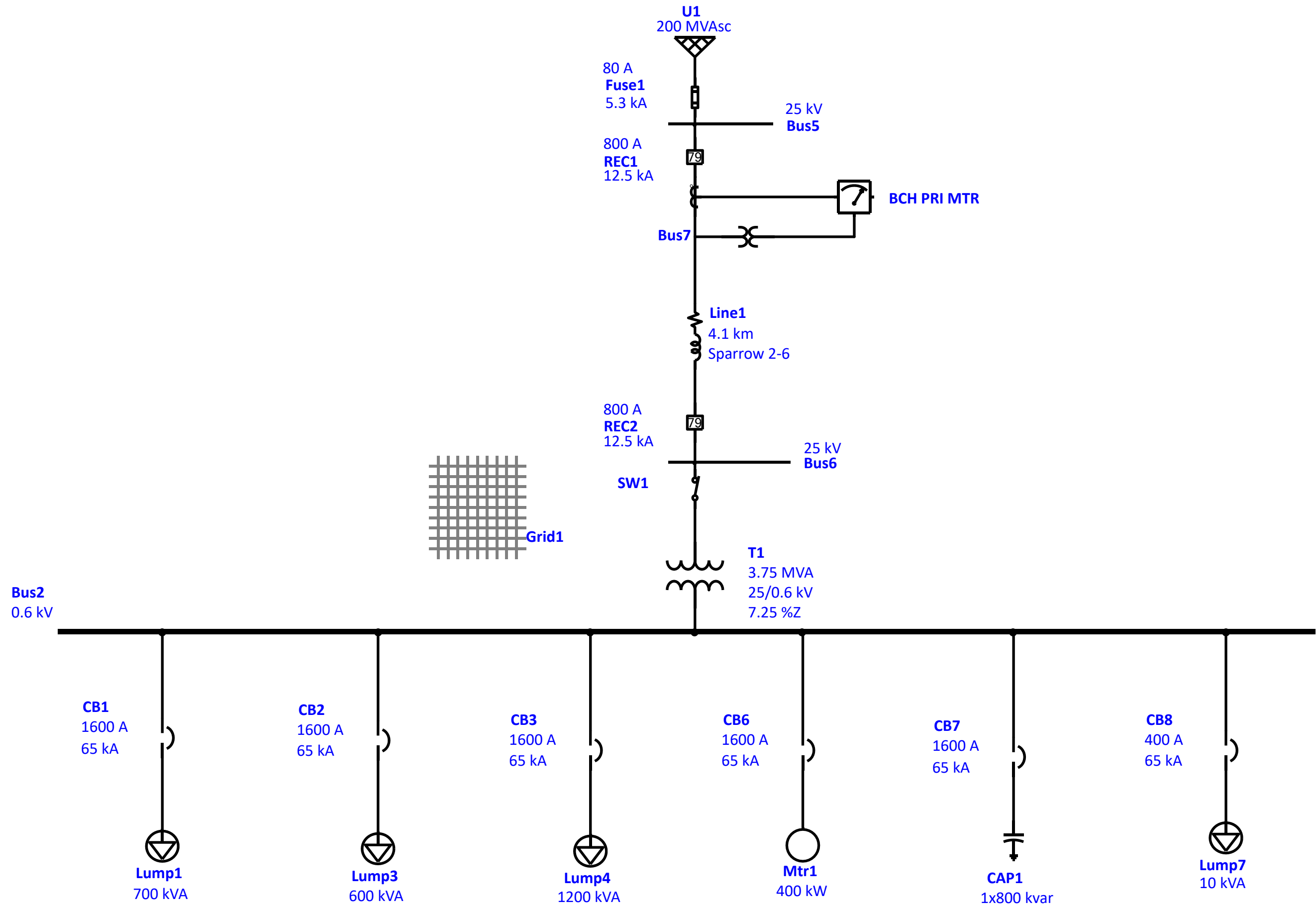


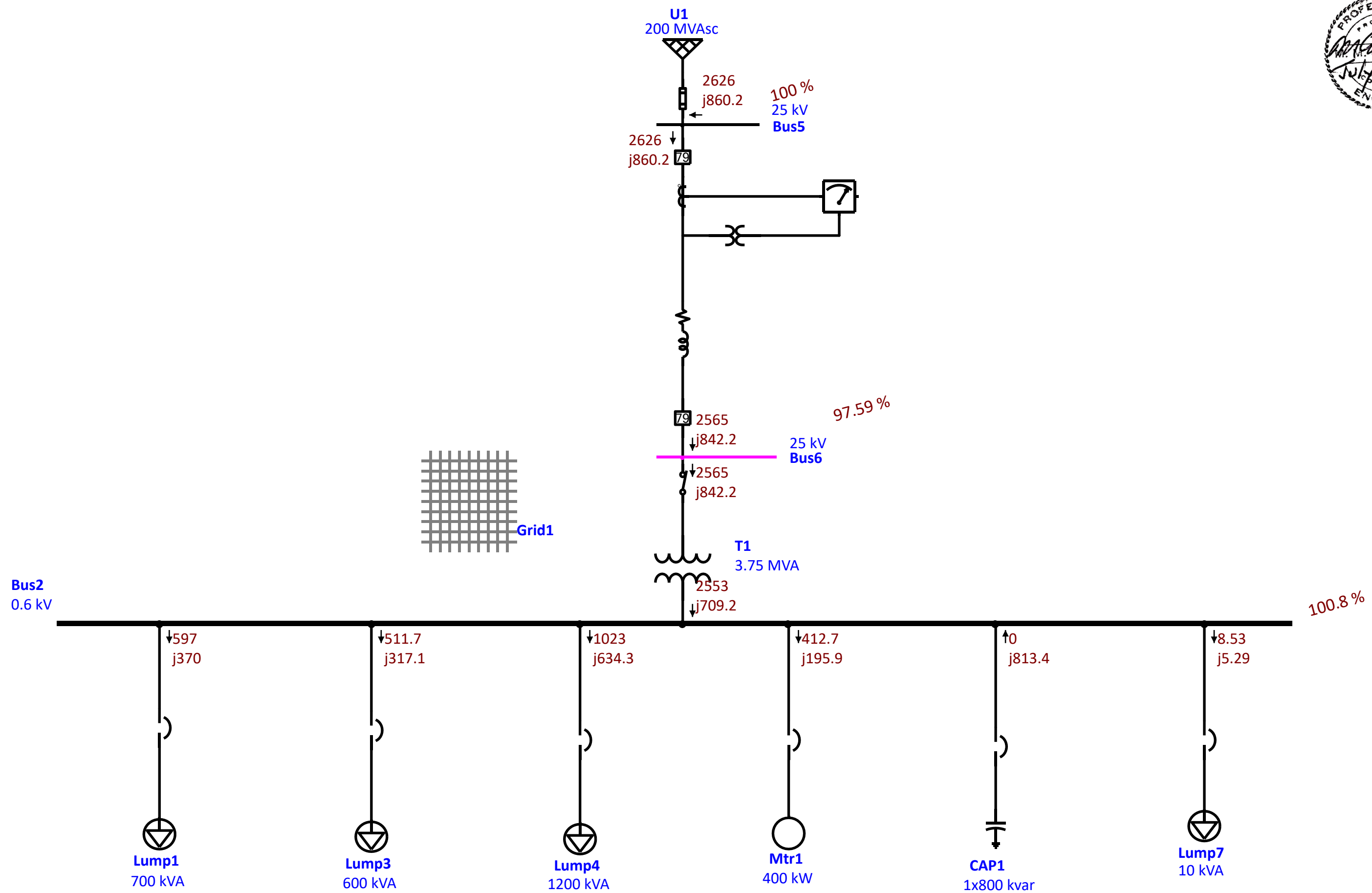


NOTES

- 1) FOR EQUIPMENT RATING Ref. DWG. A570-07-07-xxx
- 2) VSD'S > 90kW ARE IN SEPARATE VSD CUBICLE

F																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

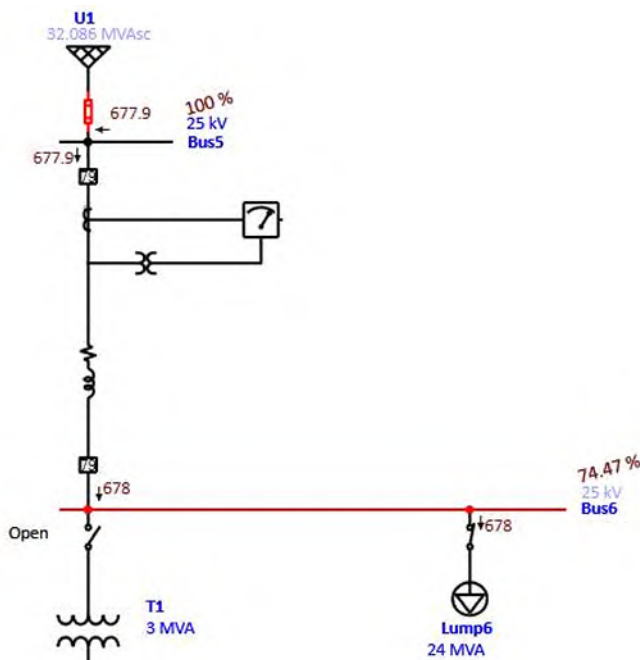




Transformer Energization (Rapid Voltage Changes)

Each time the transformer is energized, there will be an inrush current equal to approximately 10 times the full load current of the transformer. As the transformer is rated 3000 kVA, 25kV, the full load current is 69A. The inrush current will therefore be about 690A. The inrush current will last up to 100 milliseconds.

During this inrush, the voltage at the end of the line will drop to 74.5% as indicated below.

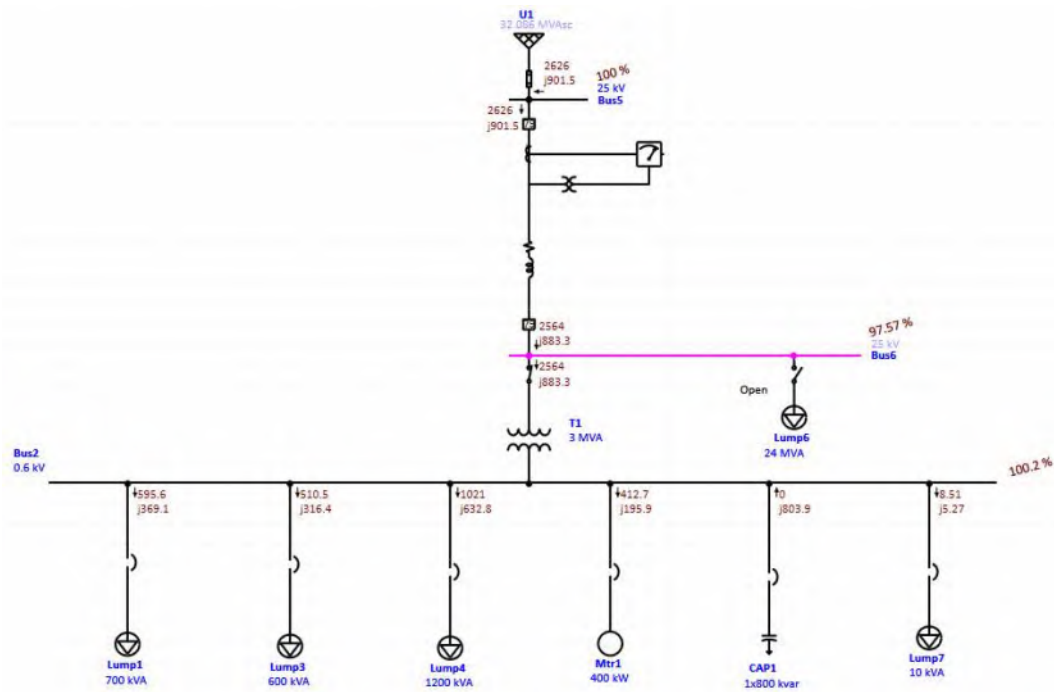


On the other hand, the voltage at the Point of Interconnection (Bus5) will remain at 25kV, so other customers on the line should not notice any flicker.



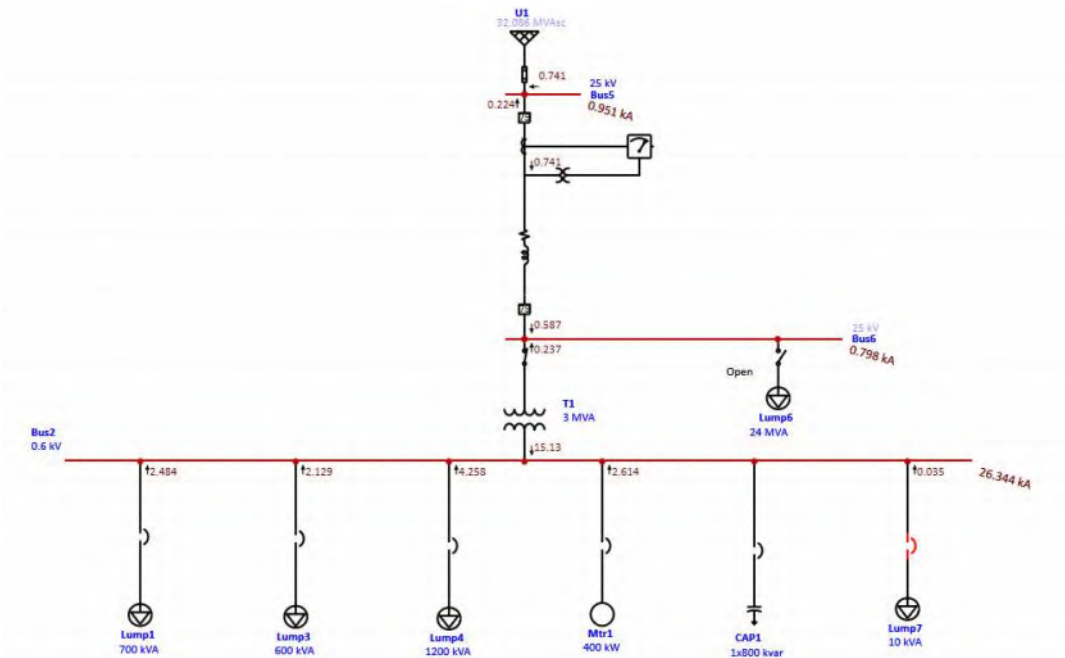
Load Flow

At full load, and with main transformer at the -5% tap, the following bus voltages will be observed. Note that the secondary main bus will be close to rated 600V.



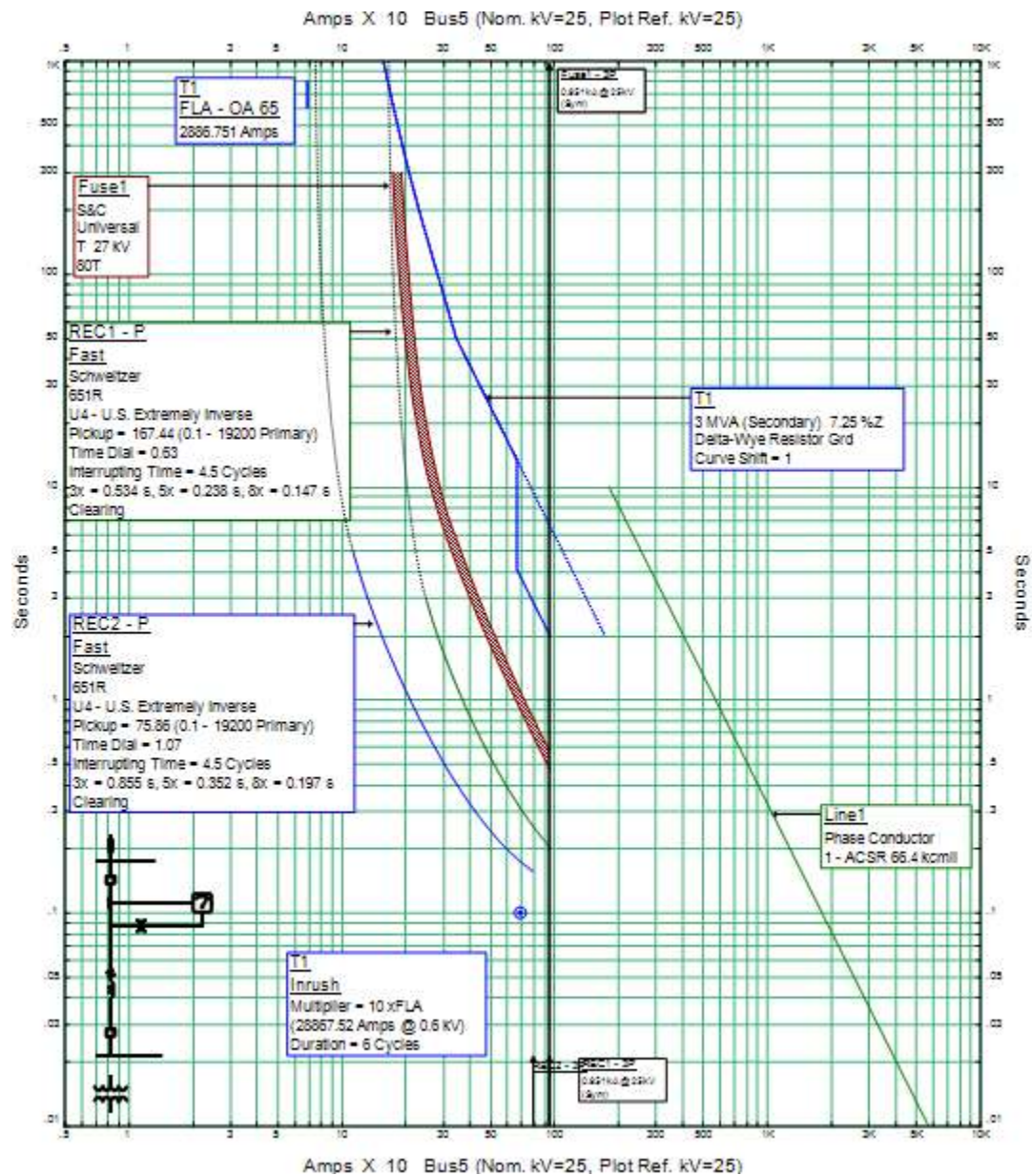
Fault Capacity

The fault capacity on the secondary main bus will be 26 kA sym. Downstream circuit breakers ratings will be minimum 42 kA.



Coordination

The upstream protection will be 80T fuses. The next downstream protection will be Recloser1. The next downstream protection will be Recloser2 at the plant. Recloser2 will also serve as the main transformer protection.

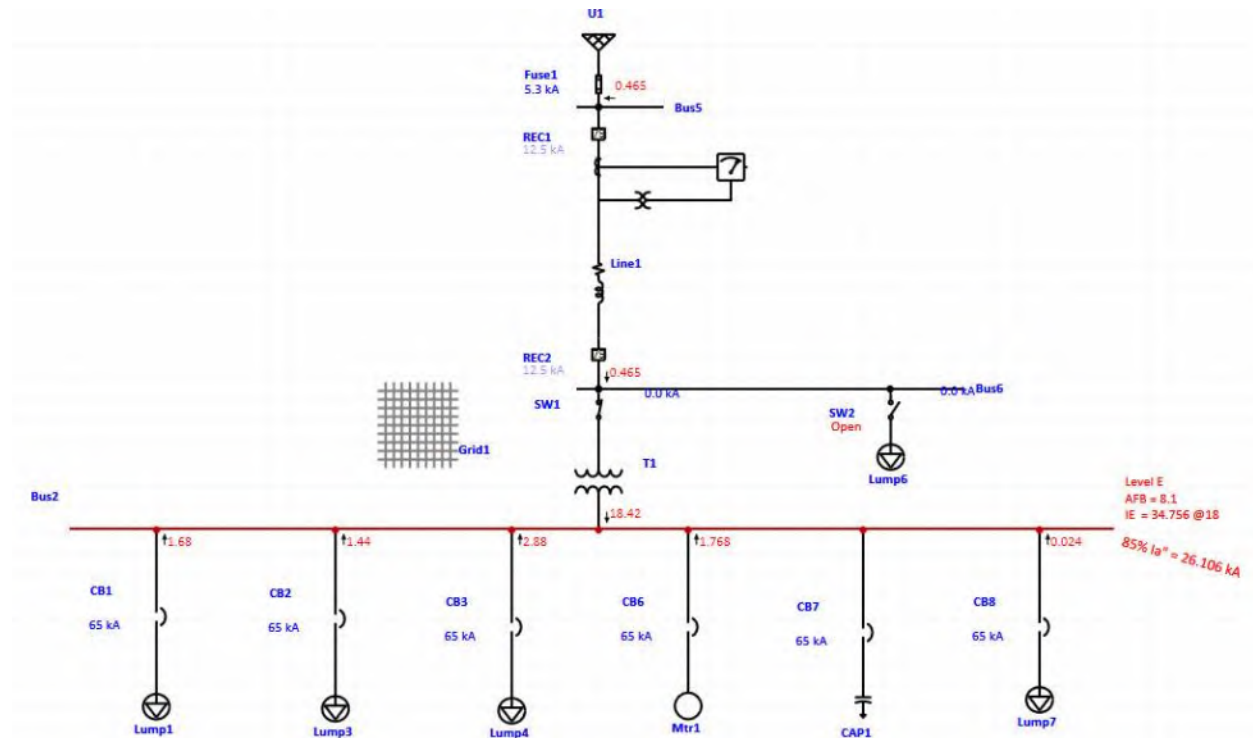


Harmonics

As there are no large VFDs in the system, harmonics will be negligible.

ArcFlash

As a cost savings measure, there will be no secondary breaker on the main transformer T1. Instead, the differential and overcurrent protection will trip the upstream device – REC1. In addition, the settings on REC1 will be decreased once inrush is finished. This will help to mitigate the ArcFlash results shown below.

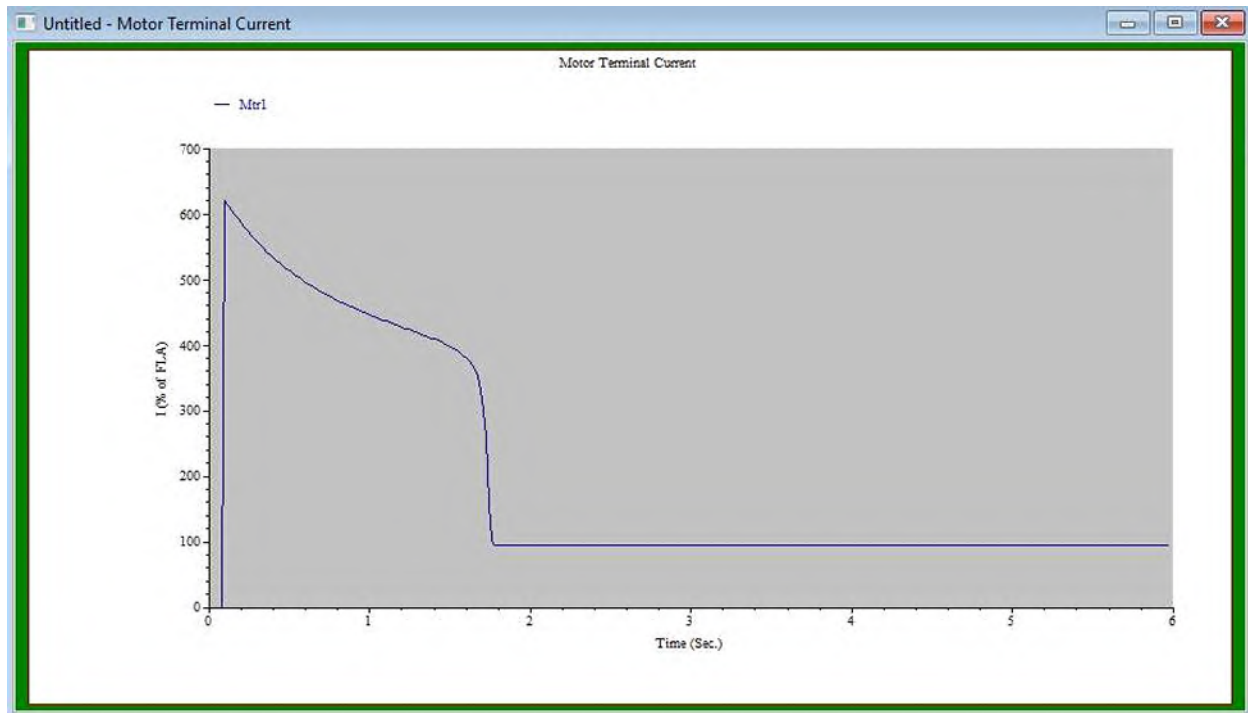


Motor Starting

Large motor starting has a similar effect as transformer energization, except that:

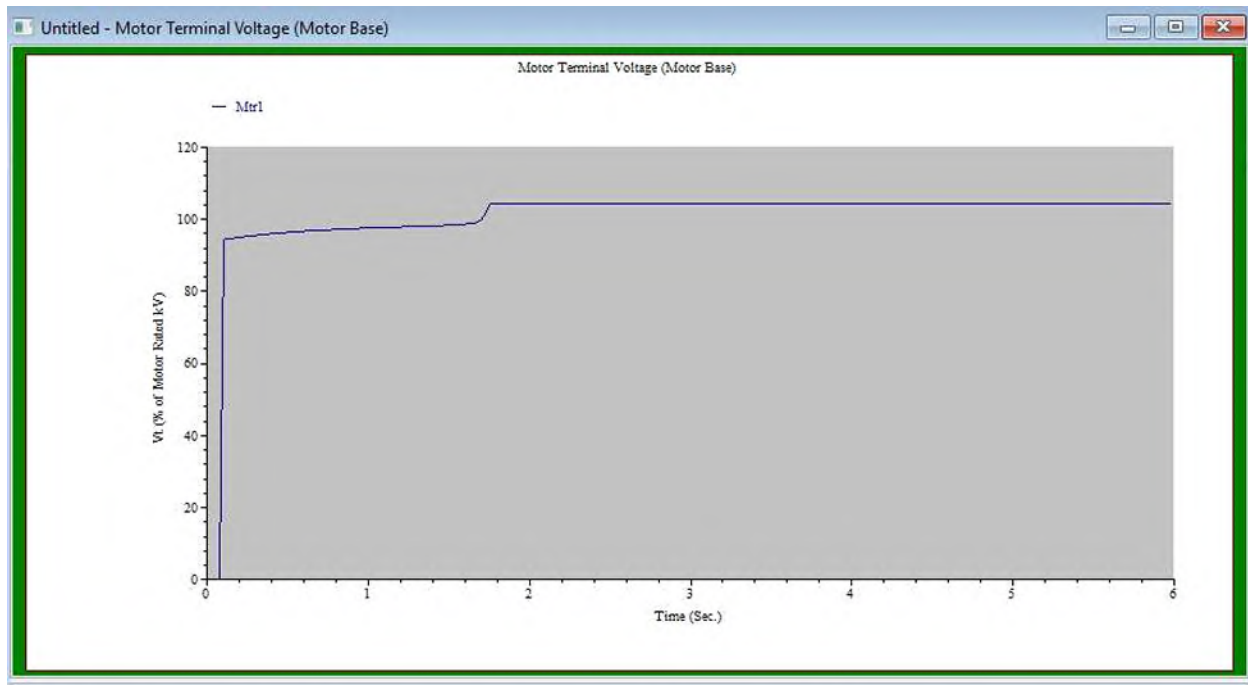
- Motor starting is more frequent
- The voltage dip is not as severe
- The voltage dip can last up to 4 or 5 seconds

The largest motor start is 400 kW. As this motor will start “Across the Line”, the expected inrush is 6 x full load current as indicated below:



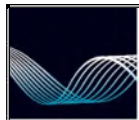
When the motor starts, the terminal voltage is pulled down to approximately 94%, and will stay there until the motor starts, in about 2 seconds.

As this is well above the IEEE minimum of 85%, there should be no effect of the rest of the system.



25kV Substation Grounding

Refer to separate document.



MCA Engineering Ltd.

**ALLEGIANCE COAL
GROUND GRID STUDY**

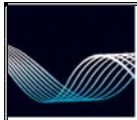
Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

<i>PREPARED BY:</i>	M. Cameron		MCA Engineering Ltd.
<i>CHECKED BY:</i>			
<i>APPROVED BY:</i>			
<i>CLIENT:</i>			



STUDY REVISION SUMMARY

Revision No.	Date Revised	Engineering Specification	Signatures					
			Prepared By	Checked By	Approved By	Engineering Manager	Project Manager	Client
A	Sept 16, 2018	Issued for Review	MMC					
B	Nov 18, 2018	Revised	MMC					



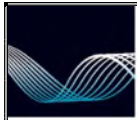
MCA Engineering Ltd.

**ALLEGIANCE COAL
GROUND GRID STUDY**

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

TABLE OF CONTENTS

1. Objective	3
2. Summary of Findings	3
3. Standards	3
4. Step and Touch Harzard	3
5. Study Cases	4
6. Study Set Up and Results.	6
7. Discussion and Recommendations.....	11



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

1. OBJECTIVE

The objective of this study is to ensure that the grounding system on the incoming service at the Allegiance Coal is safe, and results in tolerable Step and Touch Hazards in all but one unlikely case.

2. SUMMARY OF FINDINGS

This results of this study show that under the conditions identified herein, the grounding system installed at the Allegiance Coal satisfies applicable Step and Touch requirements. A sensitivity analysis also indicates that reasonable variations to the assumptions used to not materially alter the conclusions.

3. STANDARDS

Calculations contained in this report are in accordance with IEEE Standard 80-2000. The calculations have been generated using a Power Systems Analysis package: ETAP 18.0.0. (www.etap.com). ETAP products comply with U.S. Code of Federal Regulations as well as other Quality Assurance (QA) standards. ETAP is Verified and Validated (V&V) against field results, real system measurements, established programs, and hand calculations in order to ensure its technical accuracy. Each release of ETAP undergoes a complete V&V process using hundreds of test cases for each and every calculation module.

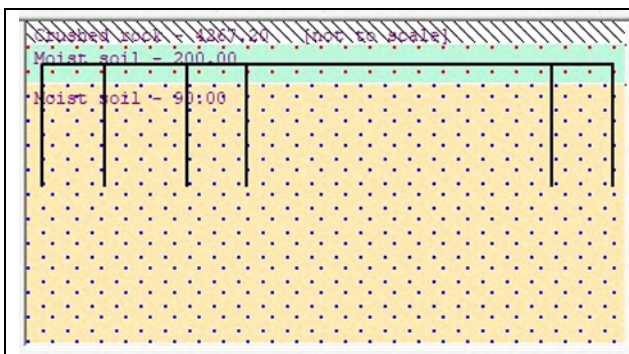
Standards are defined for body weights of 50 kg and 70 kg. This study uses 50 kg as it generally leads to more conservative (ie worst case) results.

4. STEP AND TOUCH HARZARD

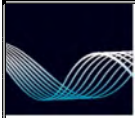
The main parameters of step and touch hazard are:

Soil Model

The Soil Model is assumed to be three layer. The top layer is normally crushed gravel, which provides a high resistance under a workers feet. The second layer is backfill, which is normally fine moist soil that provides an intermediate resistance. The third layer is native soil, whose resistance can vary widely, depending on composition and moisture. The resistivity of this layer is normally field measured with a drop of potential test. Generally, the higher the resistances, the higher the step and touch hazard.



	Resistivity ohm-m	Material	Depth m
Surface Material	4267.2	Crushed rock	0.15
Top Layer	200	Moist soil	1
Lower Layer	90	Moist soil	

 MCA Engineering Ltd.	ALLEGIANCE COAL GROUND GRID STUDY	Project No. : MCA-3177 Project Name : AC GRND GRID Revision No. : B Date : Nov 18, 2018
---	--	--

Ground Grid Layout

The ground grid is made up of horizontal conductors and vertical ground rods. The horizontal conductors are normally in the second soil layer. In general, the smaller the spacing and the greater the conductors, the lower the step potential hazard.

The vertical ground rods extend well into the low resistance third soil layer. In general, the more ground rods, the lower the touch potential hazard.

The ground grid layout is an iterative exercise of trying to minimize the grid cost, while achieving an acceptable step and touch hazard.

Magnitude of Line to Ground Current

The type of fault of interest is the line to ground fault, as it results in the greatest current that must find its way back to the source through the grid and the ground. In this study the high voltage connection on T1 (Main Transformer) is 25kV, so we are interested the LG fault near the primary of this transformer.

The magnitude of the LG fault will depend on the source impedance. This is a series combination of the utility impedance and the upstream transformer impedance. Normally the upstream transformer will be much larger than the utility impedance, and hence the most limiting factor to the LG magnitude.

Generally, the higher the fault current, the higher the step and touch hazard.

Duration of the Line to Ground Current

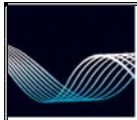
The duration of the fault will depend on the speed of the upstream protection. Generally, the faster the upstream protection, the lower the step and touch hazard.

Grid Current Factor

The ground current has two possible paths back to the source. The first path is through the grid and the earth. This component will result in the elevation of the ground grid potential. Generally, the higher this component, the higher the step and touch hazard.

The second path is through the ground wire, if one exists, between the fault and the source substation. Normally BC Hydro runs its 25 kV systems as 4 wire, with a multigrounded neutral. Normally the neutral is grounded at both the source and destination stations, so it is reasonable to expect that a large part of the fault current will follow this path, and not contribute to an increase in the ground grid potential.

The current division is described by the factor S_f . For the purposes of this study, a conservator factor of 100% is assumed in the present case (all ground current returning through the grid/earth), and 50% in the ultimate case.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

5. STUDY CASES

This study considers two cases. In Case 1 the existing 25kV fault capacity is used. In Case 2 the ultimate 25kV fault capacity is used.

Case 1 – 25kV Present (25P) – Grid around T1

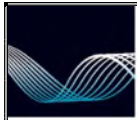
In this case, the site is connected to BCH 25kV line, as it currently is. The present system fault capacity is given by BC Hydro as 32 MVA.

It is further assumed that:

- there is one main transformer - T1.
- the transformer pad is concrete, with rebar connected to the ground grid thus forming a “Ufer” ground.
- The grid associated with T1 is comprised of #4/0 copper, with 10 foot ground rods.

Case 2 – 25kV Ultimate (25U) – Grid around T1

In this case, the site is connected to the BCH 25kV line, in its ultimate configuration. As BCH has not provided a fault capacity for this configuration, it is assumed that the 25kV is fed from a large transformer. Based on physical size, and ability to transport, a reasonable assumption would be a 20 MVA transformer. If we assume a 10% impedance, and an infinite primary bus, then the maximum fault current would be 200 MVA. All other assumptions are the same as Case 1.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

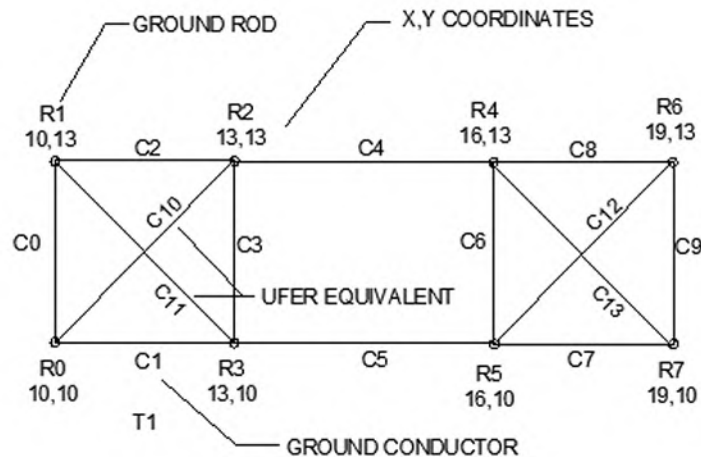
Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

6. STUDY SET UP AND RESULTS.

Case 1 – 25P - Setup and Results

The ground grid for T1 is shown below. Note that:

- The coordinates are in meters.
- The transformer pads are assumed to be 1.5m square.
- The ground rods (R0 to R7) are assumed to be 0.9m at 45 deg from each transformer pad corner.
- The angled conductors C16/C17 etc. are not physically present but are deemed to be equivalent to the ufer ground formed by the transformer pads



Rod Editor

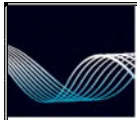


Material Constants										
Conductivity	Alpha Factor	K Factor	Fusing Temperature	Resistivity @ 20 C	Thermal Capacity					
100.0	0.00393	234	1083	1.72	3.42					

	Label	Length	X1	Y1	Z1	X2	Y2	Z2	Diameter	Type
1	R0	3.05	10	10	0.5	10	10	3.55	2	Copper, annealed soft-drawn
2	R1	3.05	10	13	0.5	10	13	3.55	2	Copper, annealed soft-drawn
3	R2	3.05	13	13	0.5	13	13	3.55	2	Copper, annealed soft-drawn
4	R3	3.05	13	10	0.5	13	10	3.55	2	Copper, annealed soft-drawn
5	R4	3.05	16	13	0.5	16	13	3.55	2	Copper, annealed soft-drawn
6	R5	3.05	16	10	0.5	16	10	3.55	2	Copper, annealed soft-drawn
7	R6	3.05	19	13	0.5	19	13	3.55	2	Copper, annealed soft-drawn
8	R7	3.05	19	10	0.5	19	10	3.55	2	Copper, annealed soft-drawn

◀ ▶

Add Insert Delete Copy Help OK Cancel



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

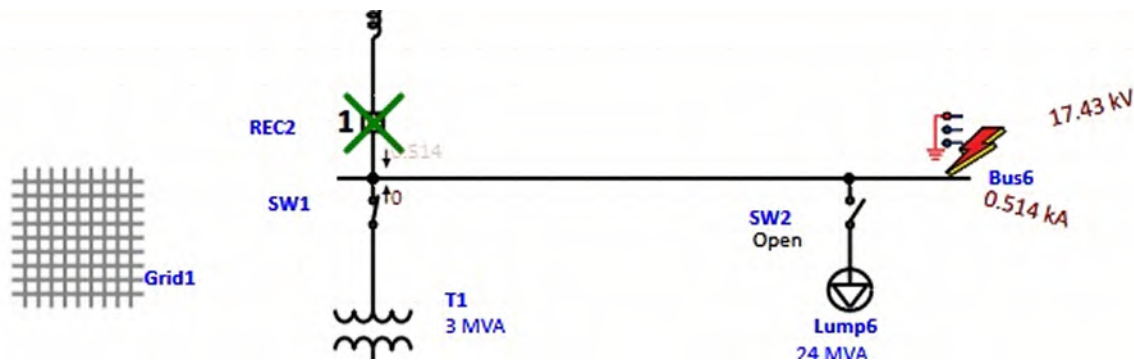
Conductor Editor

Material Constants						
Conductivity	Alpha Factor	K Factor	Fusing Temperature	Resistivity @ 20 C	Thermal Capacity	
100.0	0.00393	234	1083	1.72	3.42	

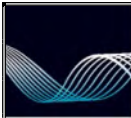
	Label	Length	X1	Y1	Z1	X2	Y2	Z2	Type	Size
1	C0	9	10	10	0.5	19	10	0.5	Copper, annealed soft-drawn	4/0
2	C1	9	10	13	0.5	19	13	0.5	Copper, annealed soft-drawn	4/0
3	C2	3	10	10	0.5	10	13	0.5	Copper, annealed soft-drawn	4/0
4	C3	3	13	10	0.5	13	13	0.5	Copper, annealed soft-drawn	4/0
5	C4	3	16	10	0.5	16	13	0.5	Copper, annealed soft-drawn	4/0
6	C5	3	19	10	0.5	19	13	0.5	Copper, annealed soft-drawn	4/0
7	C6	4.24	10	10	0.5	13	13	0.5	Copper, annealed soft-drawn	4/0
8	C7	4.24	16	10	0.5	19	13	0.5	Copper, annealed soft-drawn	4/0

Add Insert Delete Copy Help OK Cancel

The LG fault at the primary of the T1 is 0.514 kA as shown below:



The Sequence of Operation is shown below. For a LG fault on Bus 6, the first device to operate is REC2, and the second is REC1. REC2 operates in 174ms.

 MCA Engineering Ltd.	ALLEGIANCE COAL GROUND GRID STUDY	Project No. : MCA-3177 Project Name : AC GRND GRID Revision No. : B Date : Nov 18, 2018
---	--	--

Sequence-of-Operation Events - Output Report: Untitled

Line-to-Ground (Symmetrical) fault on bus: Bus6

Data Rev.: Base Config: Normal Date: 11-24-2018

Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
174	REC2	0.514	99.4	174	1st Operation - Lockout - Ground - Fast - TOC
195	REC1	0.514	120	195	1st Operation - Lockout - Ground - Fast - TOC
3379	Fuse1	0.422	2674	3379	

Hence the study case is as follows:

GRD Study Case Editor

Study Case

Study Case ID:

Options

Weight: ☒ 50 kg ☐ 70 kg

Ambient Temperature: °C

Method

☒ Finite Element

☐ IEEE 80 - 2000/2013

☐ IEEE 80 - 1986

☐ IEEE 665 - 1995

Reports & Plots

☒ Auto Display Summary & Alert

☐ Report Details

Plot Step:

Boundary Extension:

Update

☐ # of Conductors and Rods (Optimization)

Fault Durations

tf: Sec tc: Sec ts: Sec

Ground Short-Circuit Current

☒ User Specified Ifg: kA X/R:

☐ Short-Circuit Study

Grid Current Factors

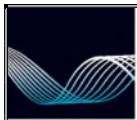
Sf: %

Cp: %

Remarks 2nd line:

< > Help OK Cancel

The corresponding fault results are shown below. The results are acceptable.



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

GRD Analysis Alert View for GRD1

Summary and Alert

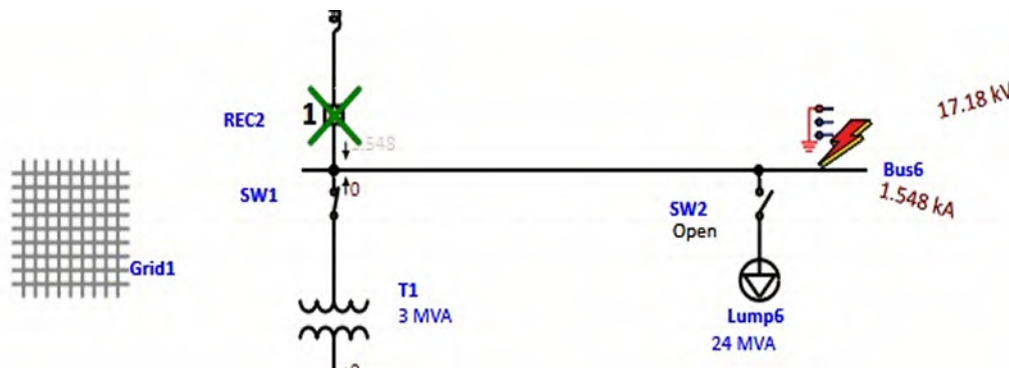
Result Summary

	Calculated Volts	Tolerable Volts	Location		
			X	Y	
Touch	933.9	1681.3	10	10	ft
Step	3407.1	5881	10.3	10.3	ft

GPR 7662.8 Volts Rg 14.403 Ohm

Case 2 – 25U - Setup and Results

Using the same grid setup, the LG fault for the 25U case at the primary of the T1 is 1.55 kA as shown below:



The Sequence of Operation is shown below. For a LG fault on Bus 6, the first device to operate is REC2, and the second is REC1. Device REC2 operates in 118 ms.

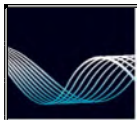
Sequence-of-Operation Events - Output Report: Untitled

Line-to-Ground (Symmetrical) fault on bus: Bus6

Data Rev.: Base Config: Normal Date: 11-24-2018

Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
118	REC2	1.448	42.6	118	1st Operation - Lockout - Phase - Fast - TOC
138	REC1	1.448	63.5	138	1st Operation - Lockout - Phase - Fast - TOC
255	Fuse1	1.448	202	255	

Hence the study case is shown as follows:



MCA Engineering Ltd.

ALLEGIANCE COAL GROUND GRID STUDY

Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

GRD Study Case Editor



Study Case |

Study Case ID:

Options: Weight ☒ 50 kg ☐ 70 kg
Ambient Temperature: °C

Method: ☒ Finite Element
☐ IEEE 80 - 2000/2013
☐ IEEE 80 - 1986
☐ IEEE 665 - 1995

Reports & Plots: ☒ Auto Display Summary & Alert
☐ Report Details
Plot Step:
Boundary Extension:

Update: ☐ # of Conductors and Rods (Optimization)

Fault Durations: tf Sec tc Sec ts Sec

Ground Short-Circuit Current: ☒ User Specified Ifg kA X/R
☐ Short-Circuit Study

Grid Current Factors: Sf %
Cp %

Remarks 2nd line:

< GRD1 > Help OK Cancel

The corresponding fault results are shown below. The results are acceptable.

GRD Analysis Alert View for GRD1

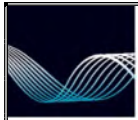


Summary and Alert |

Result Summary

	Calculated Volts	Tolerable Volts	Location	
			X	Y
Touch	1404.8	2001.1	10	10 ft
Step	5124.9	6999.8	10.3	10.3 ft

GPR Volts Rg Ohm



MCA Engineering Ltd.

**ALLEGIANCE COAL
GROUND GRID STUDY**

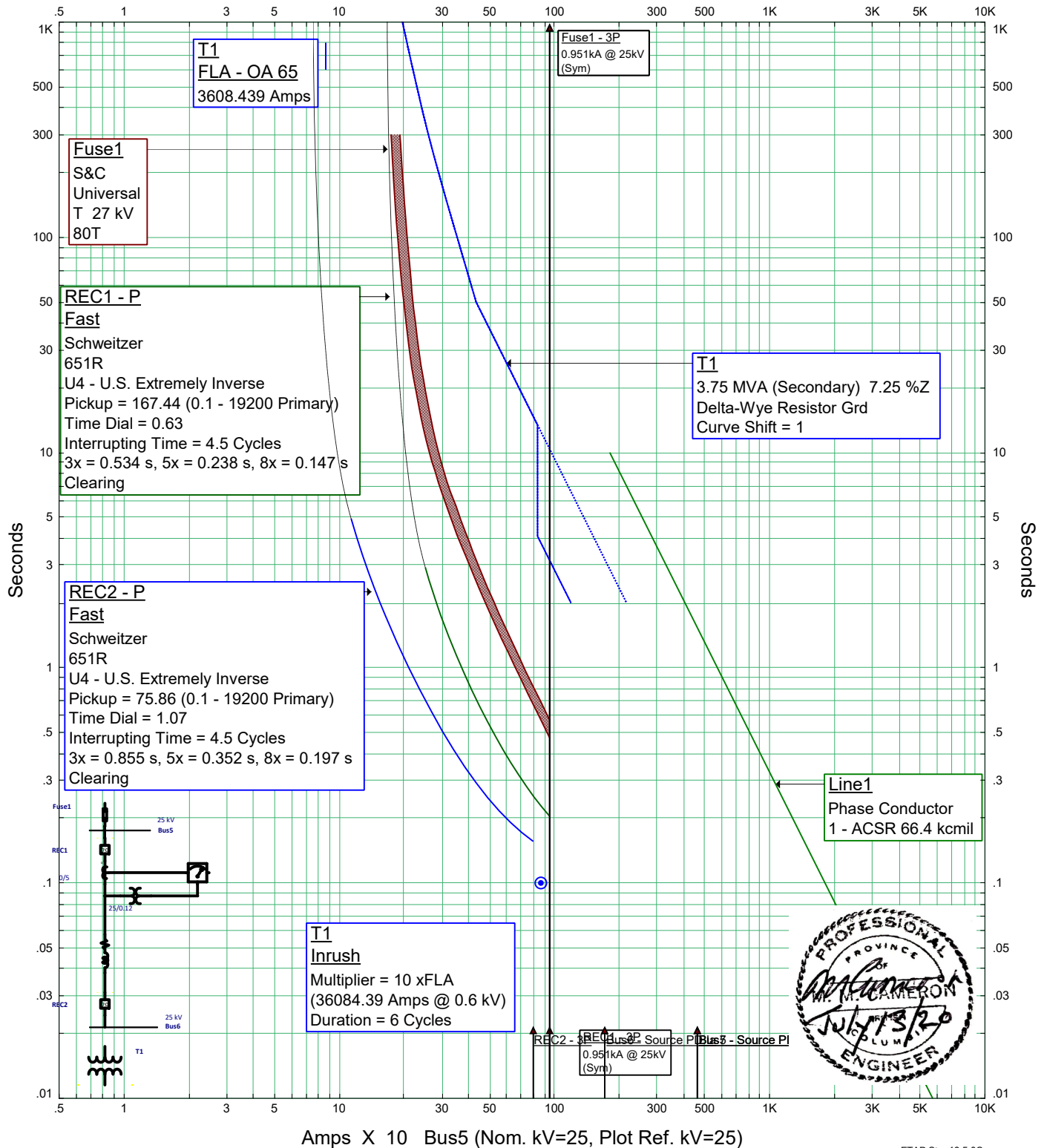
Project No. : MCA-3177
Project Name : AC GRND GRID
Revision No. : B
Date : Nov 18, 2018

7. DISCUSSION AND RECOMMENDATIONS.

The ground grid described above will result in acceptable Step and Touch Potentials.

END OF REPORT

Amps X 10 Bus5 (Nom. kV=25, Plot Ref. kV=25)



Amps X 10 Bus5 (Nom. kV=25, Plot Ref. kV=25)

ETAP Star 19.5.0C

Star1	
Project: Location: Contract: Engineer: Filename: L:\MCA Engineering Files\Project Files\3177 Bulkley - Allegiance Coal\Allegiance ETAP	Date: 07-28-2017 SN: MCA-ENGLTD Rev: Base Fault: Phase

