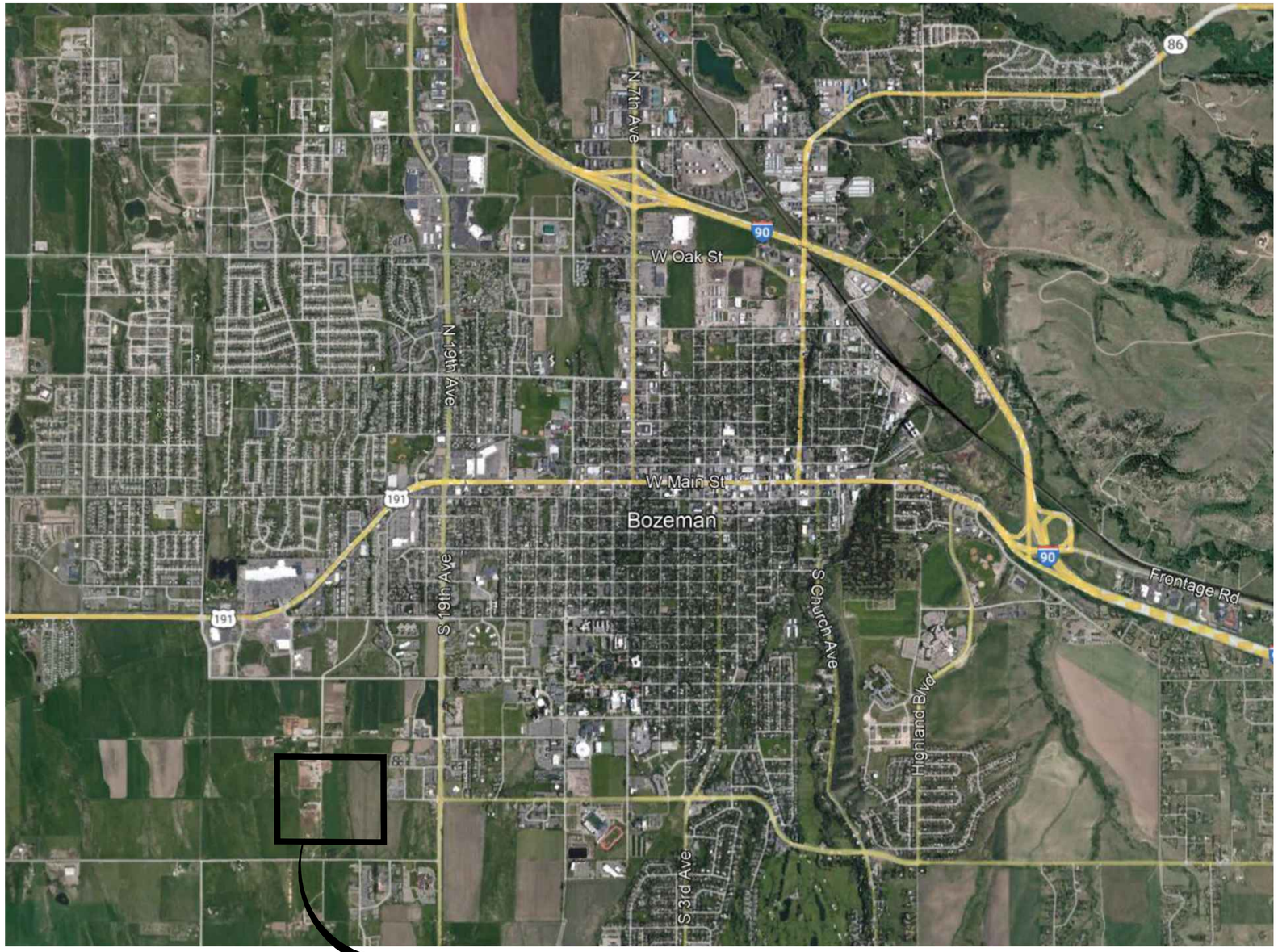
MONTANA STATE UNIVERSITY

BOZEMAN, MT

MAES - BART FARM
AURORA TEST RANGE ELECTRICAL

PPA 22-0544



SHEET INDEX

OWNER:
MONTANA STATE UNIVERSITY- BOZEMAN
BOZEMAN, MT 59717

CONSULTANT:
MORRISON-MAIERLE, INC.
2880 TECHNOLOGY BLVD. W.
BOZEMAN, MT 59718
(406) 587-0721

MONTANA STATE UNIVERSITY

MSU-CPDC
MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA
PHONE: 406.994.5413
FAX: 406.994.5665

CONSTRUCTION DOCUMENTS

MAES - BART FARM
AURORA TEST RANGE
ELECTRICAL

Morrison Maierle
engineers • surveyors • planners • scientists

DRAWN BY: MWB
REVIEWED BY: MJS

REV.	DESCRIPTION	DATE

MONTANA
MICHAEL JAMES STONE
PROFESSIONAL ENGINEER
8/15/22

22-0544

MMI# 0747.078

SHEET TITLE
COVER

SHEET
COVER

DATE
08-30-2022

LEGEND

X 20A 3P OR X 100AF 80AT 3P — LOW – VOLTAGE CIRCUIT BREAKER (CB). RATINGS AND NO. OF POLES AS SHOWN. WHEN SPECIFIC TYPE IS REQUIRED, X INDICATES TYPE.

TYPES:
- MCCB – MOLDED CASE
- ICCB – INSULATED CASE
- LVP – LOW – VOLTAGE POWER
- MCP – MOTOR CIRCUIT PROTECTOR (RATING PER CONNECTED LOAD)

CB — SEPARATELY MOUNTED CIRCUIT BREAKER; SEE ELECTRICAL ONE – LINE DIAGRAM OR SCHEDULE FOR DESCRIPTION

GFP — GROUND FAULT PROTECTION

52 — MEDIUM – VOLTAGE CIRCUIT BREAKER

FUSE, SIZE, AND NUMBER OF FUSES AS NOTED

FUSED CUTOUT, CURRENT RATING, FUSE SIZE, AND NUMBER OF POLES AS NOTED

FUSIBLE SWITCH, CURRENT RATING, FUSE SIZE, AND QUANTITY AS NOTED

NON–FUSED SWITCH, CURRENT RATING, AND NUMBER OF POLES AS NOTED

DISCONNECT OR DRAWOUT CONNECTION

A & A B — MAGNETIC MOTOR STARTER AND SEPARATELY MOUNTED COMBINATION MAGNETIC MOTOR STARTER

D & D B — MOTOR CONTROLLER AND SEPARATELY MOUNTED MOTOR CONTROLLER WITH SHORT CIRCUIT PROTECTION AND DISCONNECT

MOTOR STARTER AND CONTROLLER SUBSCRIPTS:

A – MAGNETIC STARTER NEMA SIZE

B – STARTER TYPE
- NONE – FULL VOLTAGE NON–REVERSING (FVNR)
- FVR – FULL VOLTAGE REVERSING
- 2S – TWO SPEED
- RVAT – REDUCED VOLTAGE AUTO TRANSFORMER

C – CONTROL DIAGRAM OR CONTROLS SCHEDULE NUMBER (IF REQUIRED)

D – CONTROLLER TYPE
- VFD – VARIABLE FREQUENCY DRIVE
- SS – SOLID STATE

SEPARATELY MOUNTED COMBINATION MOTOR STARTER OR CONTROLLER; SEE ELECTRICAL ONE – LINE DIAGRAM OR SCHEDULE FOR DESCRIPTION

THERMAL OVERLOAD ELEMENT

OL — THERMAL OVERLOAD RELAY CONTACT

DISCONNECT OR SAFETY SWITCH, 30A, 3P, NON–FUSED UNLESS OTHERWISE NOTED

7 1/2 OR HP — MOTOR WITH DESIGN HORSEPOWER (WHEN INDICATED)

G — GENERATOR

ATS — TRANSFER SWITCH, CURRENT RATING, AND NUMBER OF POLES AS NOTED
- ATS – AUTOMATIC
- MTS – MANUAL

TRANSFORMER (ONE–LINE)
- △ 3–PHASE, 3–WIRE DELTA CONNECTION
- Y 3–PHASE, 4–WIRE GROUNDED WYE CONNECTION

EXISTING TRANSFORMER (PLAN VIEW)

NEW TRANSFORMER (PLAN VIEW)

3–PHASE TRANSFORMER (PLAN VIEW)

DISTRIBUTION POLE: EXISTING / NEW

(POLE MATERIAL, HEIGHT, AND CLASS AS SPECIFIED IN STAKING SHEETS.)

SWITCHBOARD OR PANELBOARD; NAME, VOLTAGE, PHASE, NUMBER OF WIRES WHEN INDICATED

100 KVA — NON–MOTOR LOAD WITH DESIGN KVA, KW, OR AMP

CPT — CONTROL POWER TRANSFORMER (CPT)

VOLTAGE TRANSFORMER (VT OR PT)

CURRENT TRANSFORMER (CT)

WH — UTILITY WATT–HOUR METER PER UTILITY REQUIREMENTS

DMP — DIGITAL METERING PACKAGE

ETM — ELAPSED TIME METER

GROUND

LIGHTNING ARRESTER

SPD — LOW VOLTAGE SURGE PROTECTIVE DEVICE

ELECTRICAL CONNECTION

OR OR — NO ELECTRICAL CONNECTION

SV OR — SOLENOID VALVE

X Y — CONTROL/RELAY COIL; X INDICATES TYPE, Y INDICATES LOOP NO. WHEN USED

TYPES:
- CR – CONTROL RELAY
- DP – DEFINITE PURPOSE RELAY
- LC – LIGHTING CONTACTOR
- M – MOTOR STARTER
- PC – PHOTO CELL
- TC – TIME CLOCK
- TR – TIMING RELAY

NORMALLY OPEN CONTACT (N.O.)

NORMALLY CLOSED CONTACT (N.C.)

NORMALLY OPEN TIME DELAY RELAY CONTACT WITH TIME DELAY ON CLOSING AFTER COIL IS ENERGIZED

NORMALLY CLOSED TIME DELAY RELAY CONTACT WITH TIME DELAY ON OPENING AFTER COIL IS ENERGIZED

NORMALLY OPEN TIME DELAY RELAY CONTACT WITH TIME DELAY ON OPENING AFTER COIL IS DE–ENERGIZED

NORMALLY CLOSED TIME DELAY RELAY CONTACT WITH TIME DELAY ON CLOSING AFTER COIL IS DE–ENERGIZED

NORMALLY OPEN TEMPERATURE SWITCH; CLOSE ON RISING TEMPERATURE

NORMALLY CLOSED TEMPERATURE SWITCH; OPEN ON RISING TEMPERATURE

NORMALLY OPEN FLOW SWITCH; CLOSE ON INCREASING FLOW

NORMALLY CLOSED FLOW SWITCH; OPEN ON INCREASING FLOW

NORMALLY OPEN LEVEL SWITCH, CLOSE ON RISING LEVEL

NORMALLY CLOSED LEVEL SWITCH, OPEN ON RISING LEVEL

NORMALLY OPEN PRESSURE SWITCH, CLOSE ON INCREASING PRESSURE

NORMALLY CLOSED PRESSURE SWITCH, OPEN ON INCREASING PRESSURE

NORMALLY CLOSED PRESSURE SWITCH, OPEN ON INCREASING PRESSURE

NORMALLY OPEN LIMIT SWITCH, CLOSE ON REACHING LIMIT

NORMALLY CLOSED LIMIT SWITCH, OPEN ON REACHING LIMIT

FIELD WIRING EXTERNAL TO CONTROL PANEL

X — INTERLOCK; X INDICATES TYPE

TYPES:
- E – ELECTRICAL
- M – MECHANICAL
- K – KEY

HAND OFF AUTO XOO OOX — 3 POSITION SELECTOR SWITCH, MAINTAINED CONTACTS; UNLESS OTHERWISE NOTED, 2–POSITION SIMILAR

NORMALLY OPEN PUSHBUTTON, MOMENTARY CONTACT UNLESS OTHERWISE NOTED

NORMALLY CLOSED PUSHBUTTON, MOMENTARY CONTACT UNLESS OTHERWISE NOTED

X — INDICATING LIGHT, X INDICATES LENS COLOR

X — PUSH TO TEST INDICATING LIGHT, X INDICATES LENS COLOR

LENS COLORS:
- R – RED
- G – GREEN
- B – BLUE
- Y – YELLOW
- W – WHITE
- A – AMBER

T — TRANSFORMER

SS — SELECTOR SWITCH

PB — PUSHBUTTON

IC — INSTRUMENTATION/CONTROL DEVICE

CONTROL PANEL INTEGRAL OR PROVIDED WITH ASSOCIATED EQUIPMENT

CONTROL PANEL WITH DISCONNECT SWITCH INTEGRAL OR PROVIDED WITH ASSOCIATED EQUIPMENT

J — JUNCTION OR PULL BOX

PANELBOARD (250V TO 600V)

PANELBOARD (LESS THAN 250V)

ELECTRICAL EQUIPMENT ENCLOSURE: SWITCHBOARD, MOTOR CONTROL CENTER, CONTROL PANEL, OR OTHER EQUIPMENT AS INDICATED

D — MOTION DETECTOR, PROVIDE POWER PACK AS NEEDED

PC — PHOTOCELL

CEILING/PENDANT–MOUNTED LUMINAIRE – HID, COMPACT FLUORESCENT, OR INCANDESCENT

WALL–MOUNTED LUMINAIRE – HID, COMPACT FLUORESCENT, OR INCANDESCENT

CEILING/PENDANT–MOUNTED FLUORESCENT FIXTURE

WALL–MOUNTED FLUORESCENT FIXTURE

CEILING/PENDANT–MOUNTED FLUORESCENT FIXTURE NORMAL/EMERGENCY

WALL–MOUNTED FLUORESCENT FIXTURE NORMAL/EMERGENCY

EMERGENCY LIGHT FIXTURE, 2 ATTACHED HEADS AS SHOWN

EMERGENCY LIGHT, REMOTE MOUNTED HEAD

DOUBLE–FACED CEILING OR WALL–MOUNTED EXIT LIGHT; DIRECTIONAL ARROWS (IF REQUIRED) AS INDICATED ON PLANS

SINGLE–FACED CEILING OR WALL–MOUNTED EXIT LIGHT; DIRECTIONAL ARROWS (IF REQUIRED) AS INDICATED ON PLANS

AREA OR ROADWAY LIGHT – POLE–MOUNTED

LIGHTING FIXTURE SUBSCRIPTS:
- X – INDICATES FIXTURE TYPE PER LIGHTING FIXTURE SCHEDULE
- Y – INDICATES CIRCUIT NUMBER FROM PANELBOARD
- z – INDICATES CONTROLLING SWITCH (IF REQUIRED)

$m — MANUAL MOTOR STARTER

$ X Y — TOGGLE SWITCH

SUBSCRIPTS:
- X – INDICATES TYPE
- NONE – SINGLE POLE
- 3 – THREE–WAY
- 4 – FOUR–WAY
- HP – TOGGLE SWITCH, HORSEPOWER RATED
- K – KEY SWITCH
- TE – MANUAL MOTOR STARTER WITH THERMAL ELEMENT
- P – PILOT LIGHT
- L – LIGHTED HANDLE
- Y – SWITCH NAME/DESIGNATION

SPECIAL–PURPOSE RECEPTACLE AS DEFINED ON PLANS

PLUG–IN RECEPTACLE STRIP, QUANTITY AND SPACING OF RECEPTACLES AS NOTED OR SPECIFIED

TELECOMMUNICATIONS OUTLET JUNCTION BOX

QUAD–DUPLEX RECEPTACLE, TWO NEMA 5–20R UNDER COMMON COVER PLATE

DUPLEX RECEPTACLE, NEMA 5–20R

SIMPLEX RECEPTACLE, NEMA 5–20R

SUBSCRIPTS:
- X – INDICATES TYPE
- GFCI – GROUND FAULT CIRCUIT INTERRUPTER
- Y – INDICATES CIRCUIT NUMBER FROM PANELBOARD

CONDUIT TURNING UP

CONDUIT TURNING DOWN

HOME RUN TO PANEL, 2 #12, 1 #12G IN 3/4"C UNLESS OTHERWISE NOTED

HOME RUN WITH CONDUIT SEAL–OFF

CIRCUIT RUN BETWEEN DEVICES EXPOSED IN NON–ARCHITECTURALLY FINISHED AREAS; CONCEALED IN ARCHITECTURALLY FINISHED AREAS. CONDUIT AND CONDUCTOR SIZES SHALL BE THE SAME AS THE HOMERUN FOR THE CIRCUIT.

CONDUIT RUN BETWEEN DEVICES CONCEALED IN NON–ARCHITECTURALLY FINISHED AREAS OR UNDER FLOOR SLAB. CONDUIT AND CONDUCTOR SIZES SHALL BE THE SAME AS THE HOMERUN FOR THE CIRCUIT.

CIRCUIT HASH MARKS (WHEN INDICATED); LONG, SHORT, SINGLE DOT, AND DOUBLE DOT REPRESENT PHASE, NEUTRAL, EQUIPMENT GROUND, AND ISOLATED EQUIPMENT GROUND, RESPECTIVELY. #12 IN 3/4" CONDUIT UNLESS OTHERWISE INDICATED.

CIRCUIT CONTINUATION

CONDUIT STUBBED OUT AND CAPPED

XXX — CONDUIT TAG OR CIRCUIT NUMBER – WIRE AND CONDUIT SIZE AS SPECIFIED IN CIRCUIT SCHEDULE ON THE SHEETS

GROUND CABLE

GROUND ROD

FAA — FIRE ALARM ANNUNCIATOR

FACP — FIRE ALARM CONTROL PANEL

F — FIRE ALARM MANUAL PULL STATION

CR — FIRE ALARM CONTROL RELAY

FS — FIRE ALARM CONTACT, FLOW SWITCH

TS — FIRE ALARM CONTACT, TAMPER SWITCH

PS — FIRE ALARM CONTACT, PRESSURE SWITCH

X AND X — SMOKE AND DUCT DETECTOR

SUBSCRIPT:
- I – IONIZATION TYPE
- P – PHOTOELECTRIC TYPE

X — HEAT DETECTOR

SUBSCRIPT:
- R/C – RATE COMPENSATION
- R/F – COMBINATION RATE OF RISE AND FIXED TEMP
- R – RATE OF RISE
- F – FIXED

X — ALARM BELL

X — ALARM HORN

X — ALARM FLASHING LIGHT

X — ALARM BELL AND FLASHING LIGHT COMBINATION UNIT

X — ALARM HORN AND FLASHING LIGHT COMBINATION UNIT

SUBSCRIPT:
- NONE – GENERAL ALARM DEVICE
- F – FIRE ALARM DEVICE

ABBREVIATIONS:

A or AMP	AMPERES
AC	ALTERNATING CURRENT
AFF	ABOVE FINISHED FLOOR
ATS	AUTOMATIC TRANSFER SWITCH
C	CONDUIT
CB	CIRCUIT BREAKER
CKT	CIRCUIT
CU	COPPER
EF	EXHAUST FAN
ELEC	ELECTRIC
EMT	ELECTRICAL METALLIC TUBING
EXP	EXPLOSION PROOF
GFI	GROUND FAULT INTERRUPTER
GND	GROUND
HOA	HAND–OFF–AUTOMATIC
HP	HORSEPOWER
HVAC	HEATING, VENTILATING & AIR CONDITIONING
HZ	HERTZ
J–BOX	JUNCTION BOX
kW	KILOWATTS
kVA	KILOVOLT AMPERES
LFMC	LIQUIDTIGHT FLEXIBLE METAL CONDUIT
MAN	MANUAL
MCC	MOTOR CONTROL CENTER
MECH	MECHANICAL
MFR	MANUFACTURER
N	NEUTRAL
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRICAL CODE
NO	NORMALLY OPEN
#	NUMBER
PB	PUSHBUTTON
PH	PHASE
PNL	PANEL
PVC	POLYVINYL CHLORIDE CONDUIT
PWR	POWER
RECPT	RECEPTACLE
RGS	RIGID GALVANIZED STEEL
RETIRE	REMOVE
SV	SOLENOID VALVE
SW	SWITCH
SWBD	SWITCHBOARD
SWGR	SWITCHGEAR
T	THERMOSTAT
TD	TIME DELAY
TEL	TELEPHONE
UG	UNDERGROUND
UH	UNIT HEATER
V	VOLT
VA	VOLT AMPERES
VFD	VARIABLE FREQUENCY DRIVE
W	WATTS
WP	WEATHERPROOF
XFMR	TRANSFORMER
Y	WYE CONNECTED
△	DELTA CONNECTED
Ø	PHASE

GENERAL NOTES:

1. THIS IS A STANDARD ELECTRICAL SYMBOLOGY SHEET. NOT ALL SYMBOLS MAY BE USED ON THIS PROJECT.
2. SCREENING OR SHADING OF WORK IS USED TO INDICATE EXISTING COMPONENTS OR TO DE–EMPHASIZE PROPOSED IMPROVEMENTS TO HIGHLIGHT SELECTED TRADE WORK. REFER TO CONTEXT OF EACH SHEET FOR USAGE.
3. REFERENCE OTHER LEGEND SHEETS FOR PROJECT–SPECIFIC EQUIPMENT SYMBOLS, EQUIPMENT ABBREVIATIONS, AND PIPING SYSTEM ABBREVIATIONS.

MONTANA STATE UNIVERSITY

MSU-CPDC
MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA
PHONE: 406.994.5413
FAX: 406.994.5665

CONSTRUCTION DOCUMENTS

MAES - BART FARM AURORA TEST RANGE ELECTRICAL

Morrison Maierle
engineers • surveyors • planners • scientists

DRAWN BY: MWB
REVIEWED BY: MJS

REV.	DESCRIPTION	DATE

MONTANA MICHAEL BRANDT 9812PE LICENSED PROFESSIONAL ENGINEER 8/15/22

22-0544

MMI# 0747.078

SHEET TITLE
LEGEND

SHEET
E-0

DATE
08-30-2022

COORDINATE TABLE

NORTHING	EASTING	DESCRIPTION
519026.55	1566467.80	P1
518879.36	1566464.77	P2
518698.79	1566460.66	P3
518517.43	1566456.96	P4
518506.25	1566527.96	S1

DESCRIPTION	ACTION	POLE HEIGHT - CLASS	BACK SPAN	CONDUCTOR LENGTH - SIZE TYPE	GUY	ANCHORING	GROUNDING	POLE TOP ASSEMBLY	SECONDARY	TRANSFORMER	COMMENT
POLE P1	EXISTING	40'-5	222		E1.1 E1.1	F2.8 F2.8	H1.1	C5.31 C5.31 A6.22G (LA)			EXISITING 40' CLASS 5 POLE WITH THREE-PHASE DEADEND POLE, THREE-PHASE TAP ACROSS ROAD, AND SINGLE-PHASE CONTINUING TO NEXT SPAN. TWO DOWN GUYS AND ANCHORS.
	RETIRE				E1.1	F2.8		A6.22G (LA)			RETIRE SINGLE-PHASE ASSEMBLY AND IN-LINE DOWN GUY. ABANDON ANCHOR.
	ADD							C6.21 (LA) A1.01			ADD POLE TOP INSULATOR AND IN-LINE INSULATORS TO EXISTING CROSSARM TO CONVERT TO THREE-PHASE DOUBLE DEAD-END ASSEMBLY.
POLE P2	EXISTING	40'-5	148	296 - #4 ACSR				A1.1			EXISTING 40'-5 POLE WITH SINGLE-PHASE IN-LINE ASSEMBLY.
	RETIRE	40'-5		296 - #4 ACSR				A1.1			RETIRE EXISTING POLE, SINGLE-PHASE ASSEMBLY, AND CONDUCTOR.
	ADD	40'-4		592 - #4 ACSR			H1.1	C1.12			ADD NEW 40' CLASS 4 POLE, THREE-PHASE IN-LINE POLE TOP ASSEMBLY, AND CONDUCTORS.
POLE P3	EXISTING	40'-5	180	360 - #4 ACSR	E1.1 E1.1	F2.8 F2.8	H1.1	A5.1 A5.1	UK1.1	G1.6	EXISTING SINGLE-PHASE DEAD-END POLE WITH 90° TAP ACROSS ROAD. SINGLE-PHASE TRANSFORMER WITH SECONDARY RISER ON STAND-OFF BRACKETS TO BUILDING.
	RETIRE	40'-5		360 - #4 ACSR	E1.1	F2.8		A5.1			RETIRE ENTIRE POLE. SAVE TRANSFORMER AND FUSE CUTOUT FOR RE-USE.
	ADD	40'-4		720 - #4 ACSR			H1.1	C1.12			INSTALL NEW 40' CLASS 4 POLE AND THREE-PHASE POLE TOP ASSEMBLY. RE-ATTACH 90° TAP ACROSS ROAD AND ASSOCIATED DOWN GUY USING NEW HARDWARE. HANG EXISTING TRASFORMER AND FUSE CUTOUT ON NEW POLE. RE-INSTALL RISER AND SERVICE TO BUILDING. SEE SINGLE PHASE TAP GUIDE C5.11G, SHEET E-6.
POLE P4	EXISTING										
	RETIRE										
	ADD	40'-4	182	728 - #4 ACSR	E1.1	F2.8 (30 ft)	H1.1	C5.31	K1.2	G3.3 (3x50kVA)	ADD NEW 40' CLASS 4 POLE WITH THREE-PHASE DEADEND ASSEMBLY, THREE PHASE TRANSFORMER BANK (3 x 50kVA) AND SERVICE DROP ASSEMBLY. ADD TYPE 10T OR 10K FUSE TO MATCH MSU SYSTEM PROTECTION SCHEME.
POLE S1	ADD	30'-5	50	72 - #350 MCM AL QUAD			H1.1		K1.2		ADD NEW 30' CLASS 5 SERVICE POLE AND 350MCM THHN OR THHW OVERHEAD QUADRUPLEX SERVICE CABLE, SLACK SPAN. INSTALL WEATERHEAD, CONDUIT, AND CONDUCTOR TO THE CT CABINET. TERMINATE CONDUCTOR IN CT CABINET.

GENERAL NOTES

1. LA - LESS CROSS ARM FOR EXISTING POLES WITH EXISTING CROSS ARMS.
2. ALL CROSS ARMS TO BE 10' LENGTH. ALL DEAD END CROSS ARMS TO BE FIBERGLASS.

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MSU-CPDC
MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA
PHONE: 406.994.5413
FAX: 406.994.5665

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engineers • surveyors • planners • scientists

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REVIEWED BY: MJS

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MONTANA
MICHAEL BRANDT
9812PE
LICENSED PROFESSIONAL ENGINEER
8/15/22

22-0544

MMI# 0747.078

SHEET TITLE
STAKING SHEET

SHEET
E-1

DATE
08-30-2022

GENERAL NOTES

1. SEE STAKING SHEET FOR DETAILED COMMENTS, SHEET E-1.
2. SEE SAG AND TENSION STRINGING CHART, SHEET E-3.
3. SEE POLE ASSEMBLY DETAILS, SHEETS E-4 AND E-5.

KEY NOTES

1. REMOVE EXISTING IN-LINE GUY.
2. INSTALL EXISTING DEAD-END ASSEMBLY AND ASSOCIATED DOWN GUY WITH NEW HARDWARE ON NEW 40' CLASS 4 POLE. RE-USE EXISTING TRANSFORMER AND FUSE CUTOUT. RE-INSTALL RISER AND SERVICE TO BUILDING.
3. INSTALL NEW GUY AND ANCHOR ASSEMBLY AT 30' FROM NEW POLE.
4. UNDERGROUND SERVICE CONDUCTOR, SEE DETAIL 1 SHEET E-5 AND ONE-LINE DIAGRAM & FEEDER SCHEDULE, DETAIL 1 SHEET E-6.
5. NEW 208/120V 3-PHASE SECONDARY OVERHEAD QUADRUPLEX SERVICE CABLE. SEE ONE-LINE AND FEEDER SCHEDULE, DETAIL 1 SHEET E-6.
6. INSTALL NEW 150kVA (3 x 50kVA) 12.47/7.2kV - 120/208V WYE, 3-PHASE TRANSFORMER BANK. INSTALL TYPE 10K OR 10T FUSE IN ACCORDANCE WITH MSU SYSTEM PROTECTION SCHEME.
7. SERVICE ENTRANCE EQUIPMENT, SEE DETAIL 1, SHEET E-5.
8. SEE SINGLE PHASE TAP GUIDE C.511G, SHEET E-6.

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REV.	DESCRIPTION	DATE

MONTANA MICHAEL BRANDT 9812PE LICENSED PROFESSIONAL ENGINEER 8/15/22

22-0544

MMI# 0747.078

SHEET TITLE
SITE PLAN

SHEET
E-2

DATE
08-30-2022

PHASE AND NEUTRAL CONDUCTOR

LOADING ZONE	1 - HEAVY
CONDUCTOR	4 ACSR (7/1)
RULING SPAN	172.134285316809

Temperature oF	0	10	20	30	40	50	60	70	80	90
Initial Tension	667.508	630.448	583.298	541.263	504.252	461.637	424.8	382.317	342.198	303.423
Span Length										
140	0.25'	0.26'	0.28'	0.30'	0.33'	0.36'	0.39'	0.43'	0.48'	0.54'
150	0.28'	0.30'	0.32'	0.35'	0.37'	0.41'	0.44'	0.49'	0.55'	0.62'
160	0.32'	0.34'	0.37'	0.40'	0.43'	0.46'	0.50'	0.56'	0.63'	0.71'
170	0.36'	0.38'	0.41'	0.45'	0.48'	0.52'	0.57'	0.63'	0.71'	0.80'
172.134285316	**0.37'**	**0.39'**	**0.43'**	**0.46'**	**0.49'**	**0.54'**	**0.58'**	**0.65'**	**0.73'**	**0.82'**
180	0.41'	0.43'	0.47'	0.50'	0.54'	0.59'	0.64'	0.71'	0.79'	0.89'
190	0.45'	0.48'	0.52'	0.56'	0.60'	0.65'	0.71'	0.79'	0.88'	1.00'
200	0.50'	0.53'	0.57'	0.62'	0.66'	0.73'	0.79'	0.88'	0.98'	1.10'
210	0.55'	0.59'	0.63'	0.68'	0.73'	0.80'	0.87'	0.97'	1.08'	1.22'

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MONTANA
MICHAEL BRANDT
PROFESSIONAL ENGINEER

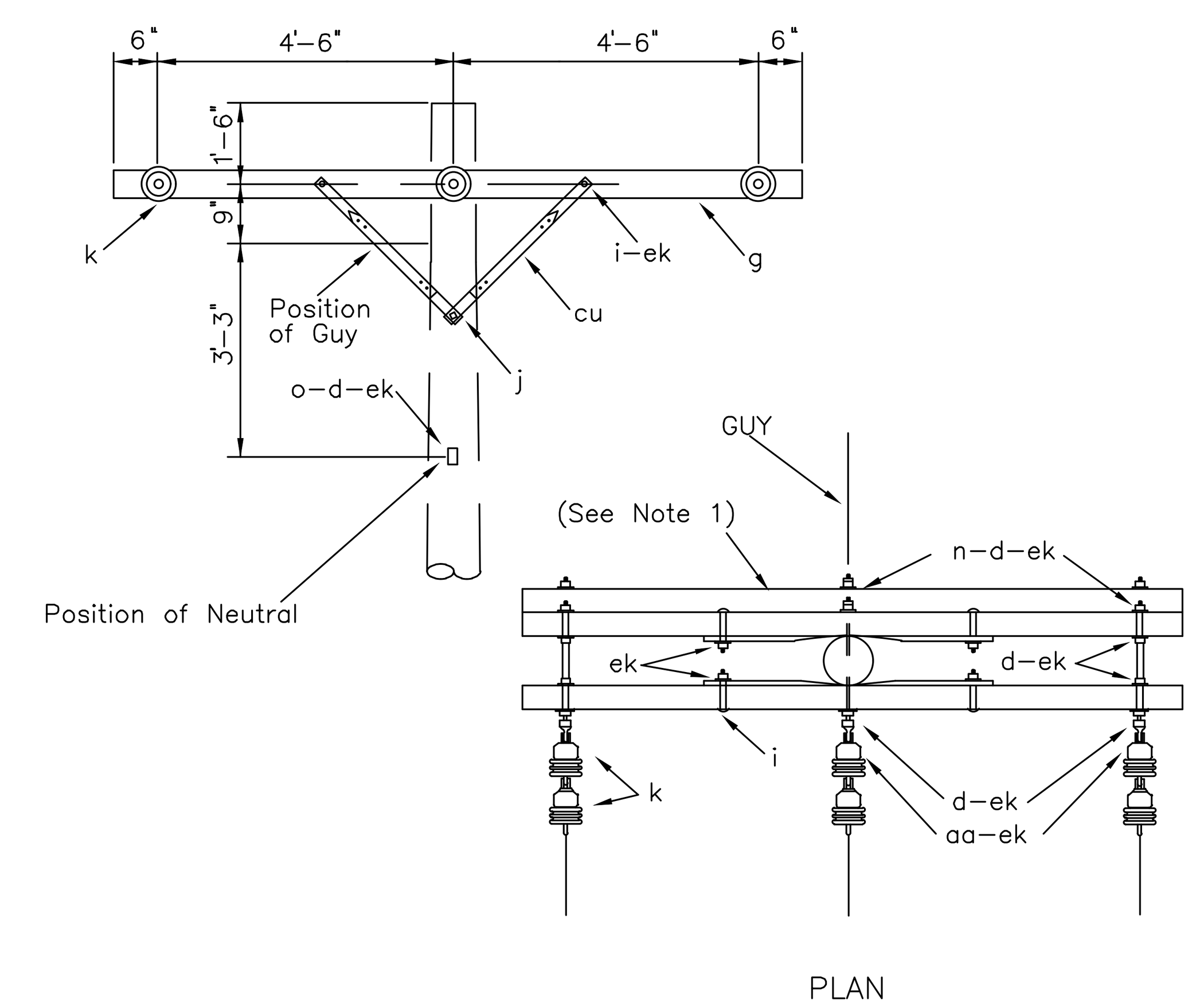
22-0544

MMI# 0747.078

SHEET TITLE
SAG & TENSION CHARTS

SHEET
E-3

DATE
08-30-2022



ITEM	QTY	MATERIAL
d	1	Washer, square, 3", curved
d	10	Washer, square, 2 1/4"
g	2	Crossarm, 3 5/8" x 4 5/8" x 10'-0"
i	4	Bolt, carriage, 3/8" x 4 1/2"
j	2	Screw, lag, 1/2" x 4"
k	6	Insulator, suspension, 4 1/4"
n	3	Bolt,double arming,5/8" x req'd length
o	1	Bolt, eye, 5/8" x req'd length
aa	3	Nut, eye, 5/8"
cu	4	Brace, 28"
ek	18	Locknuts

NOTES:

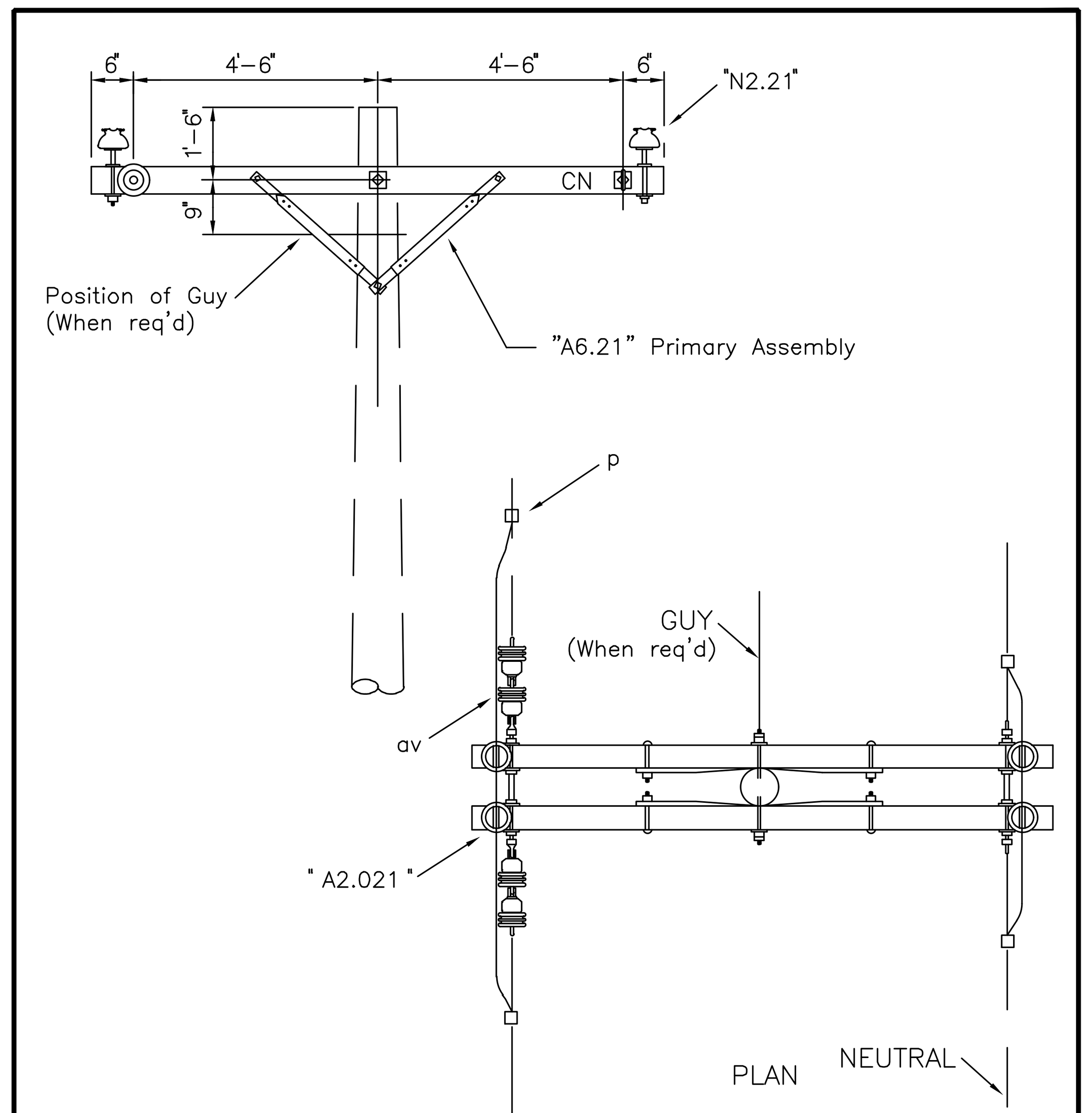
1. Designate as "C5.31" for assembly with three crossarms.
2. Double arming eye bolt, item "dy", may be used instead of double arming bolt, item "n", and eye nut, item "aa".
3. Other neutral assemblies may be used. See Section N. Adjust material as needed.

DESIGN PARAMETERS:

PERMITTED UNBALANCED CONDUCTOR TENSION:
See Table A (Exhibit 2)

SINGLE DEADEND ON CROSSARMS

APRIL 2005 | RUS | 3 – PHASE PRIMARY 12.47/7.2 kV | C5.21,C5.31 (C7),(C7-1)



ITEM	QTY	MATERIAL
	1	A6.21 Primary Assembly
	1	A2.021 Primary Assembly
	1	N2.21 Neutral Assembly
p		Connectors, as req'd
av		Jumpers, as req'd

NOTES:

LA: LESS CROSS ARMS

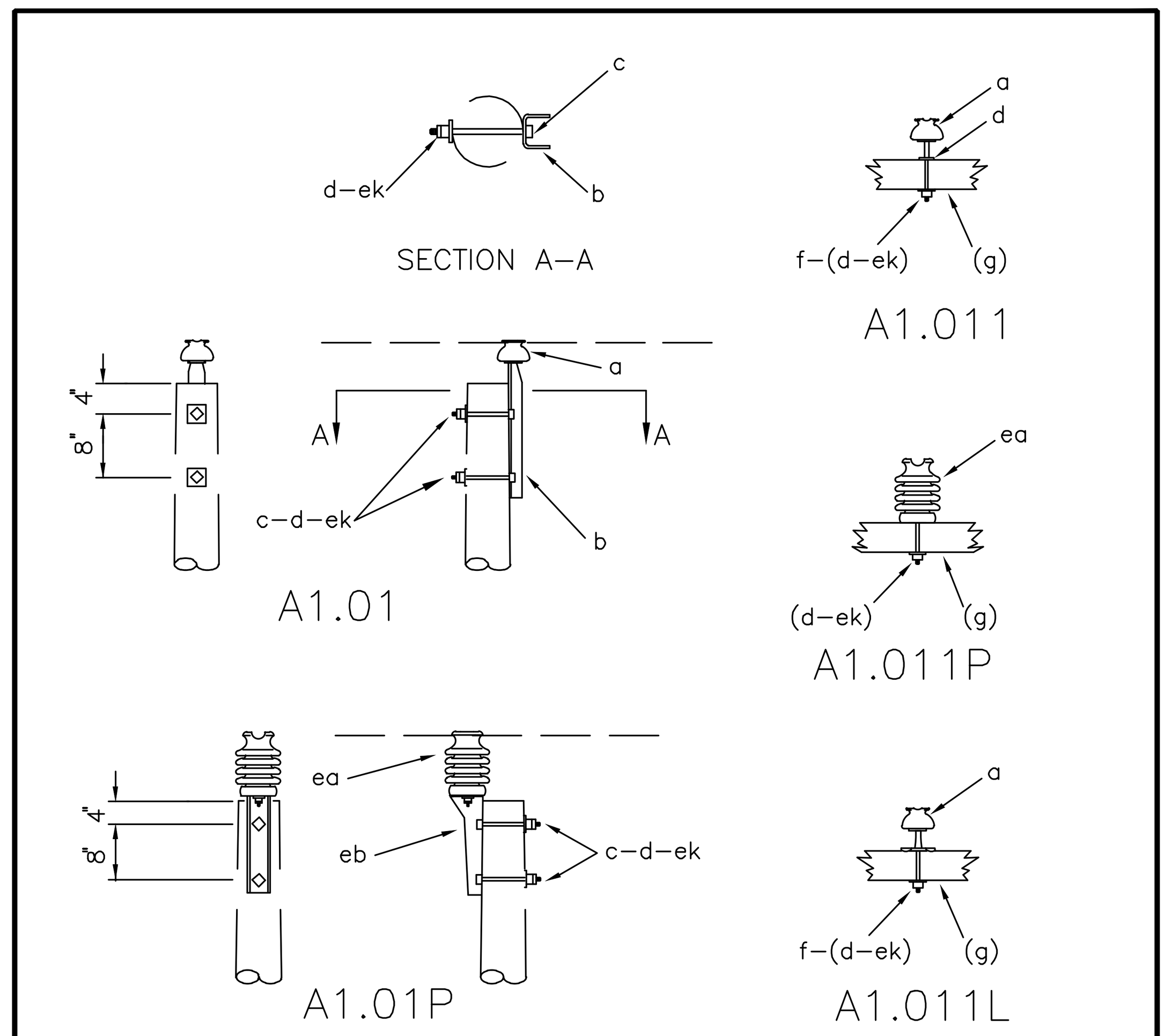
DESIGN PARAMETERS:

PERMITTED UNBALANCED CONDUCTOR TENSION:
See Table A (Exhibit 2)

MAXIMUM LINE ANGLE = 5° (See Dwg. A6-21)

DOUBLE DEADEND GUIDE (FEED THROUGH ON CROSSARMS)

APRIL 2005 | RUS | 1 – PHASE PRIMARY 12.47/7.2 kV | A6.22G



ITEM	MATERIAL	01 QTY	01P QTY	011 QTY	011P QTY	011L QTY
a	Insulator, pin type (12.47/7.2 kV)	1		1		1
b	Pin, pole top, 20"	1				
c	Bolt, machine, 5/8" x req'd length	2	2			
d	Washer, square, 2 1/4"	2	2	1		
f	Pin, crossarm steel, 5/8" x 10 3/4"			1		
f	Pin, crossarm steel, clamp type					1
ea	Insulator, post type (12.47/7.2 kV)		1		1	
eb	Bracket, pole top		1			
ek	Locknuts	2	2			

ASSEMBLY: A1.

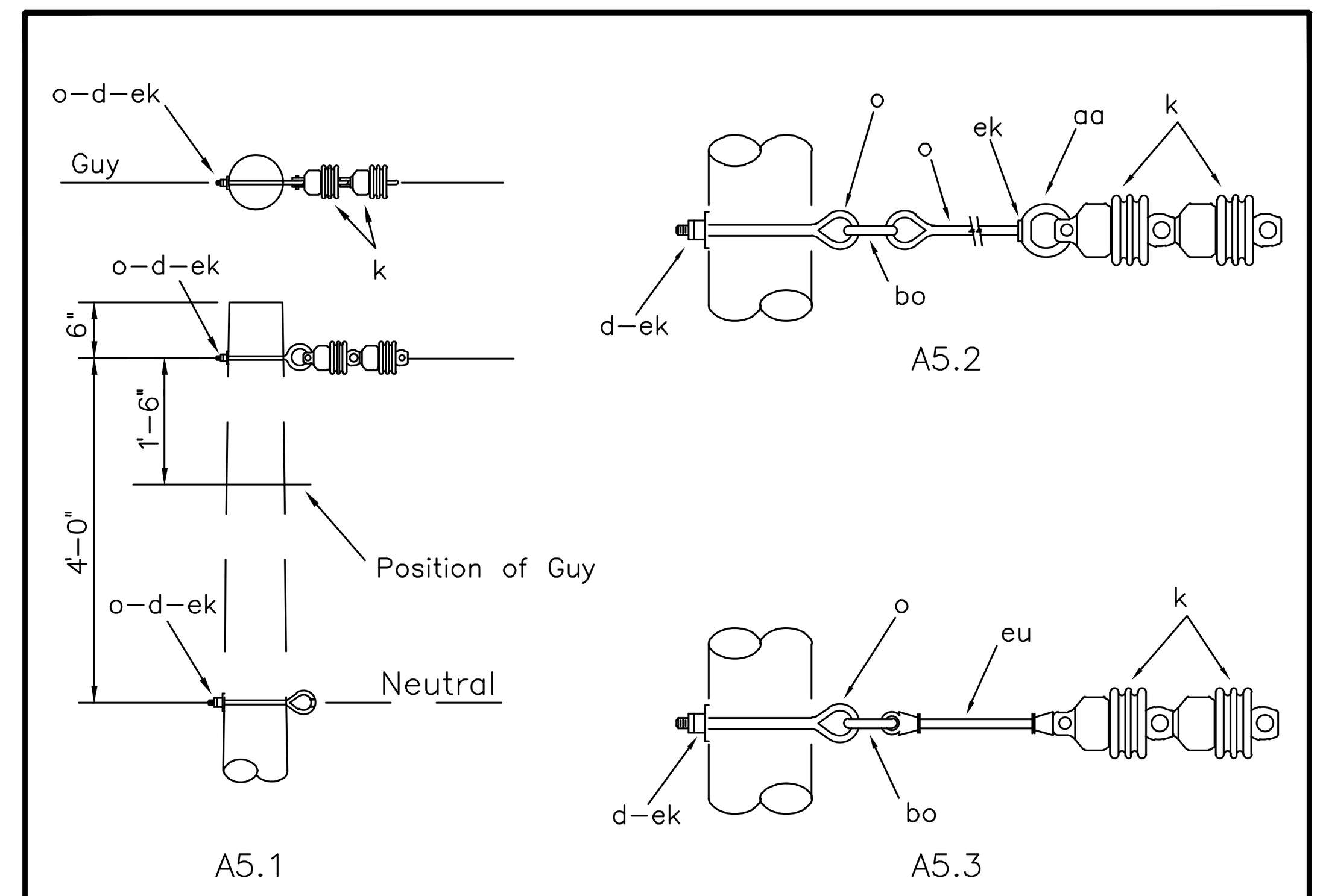
ASSEMBLY NUMBERS	
NEW	(OLD)
A1.01	(M5-2)
A1.01P	(M5-18)
A1.011	(M5-5)
A1.011P	(M5-7)
A1.011L	

DESIGN PARAMETERS:

A1.01: See TABLE I
A1.01P: See TABLE II
A1.011: See TABLE II
A1.011P: See TABLE II
A1.011L: See TABLE III

SINGLE SUPPORT-PRIMARY

APRIL 2005 | RUS | 1 – PHASE PRIMARY 12.47/7.2 kV | A1.01,A1.01P A1.011,A1.011P A1.011L



NOTE: When connecting to existing bolt end, use eyenut "aa" and locknut "ek" instead of eyebolt subassembly "o-d-ek".

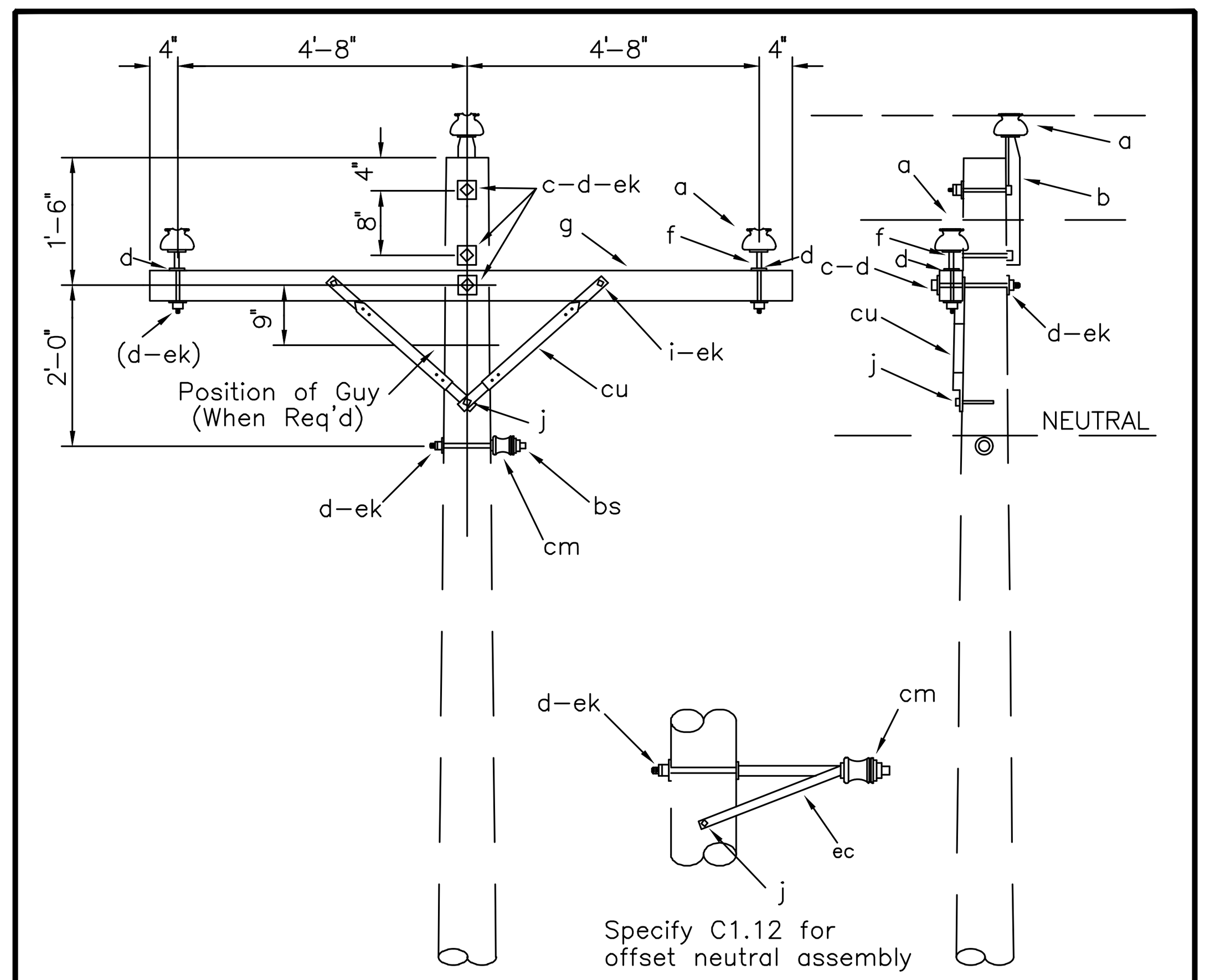
ASSEMBLY: A5

ITEM	MATERIAL	.1 QTY	.2 QTY	.3 QTY
d	Washer, square, 3", curved	2	2	2
k	Insulator, suspension, 4 1/4"	2	2	2
o	Bolt, eye, 5/8"x req'd length	2	3	2
p	Connectors, as req'd			
aa	Nut, eye		1	
av	Jumper's, as req'd			
bo	Shackle, anchor		1	1
ek	Locknuts	2	3	2
eu	Link, extension, insulated			1
(du)	(Link, extension) – (optional)			(1)

DESIGN PARAMETERS:
PERMITTED LONGITUDINAL LOAD = 5000 lbs./Conductor

SINGLE DEADENDS

APRIL 2005 | RUS | 1 – PHASE PRIMARY 12.47/7.2 kV | A5.1,A5.2,A5.3 (A5),(A5-2)



ASSEMBLY: C1.

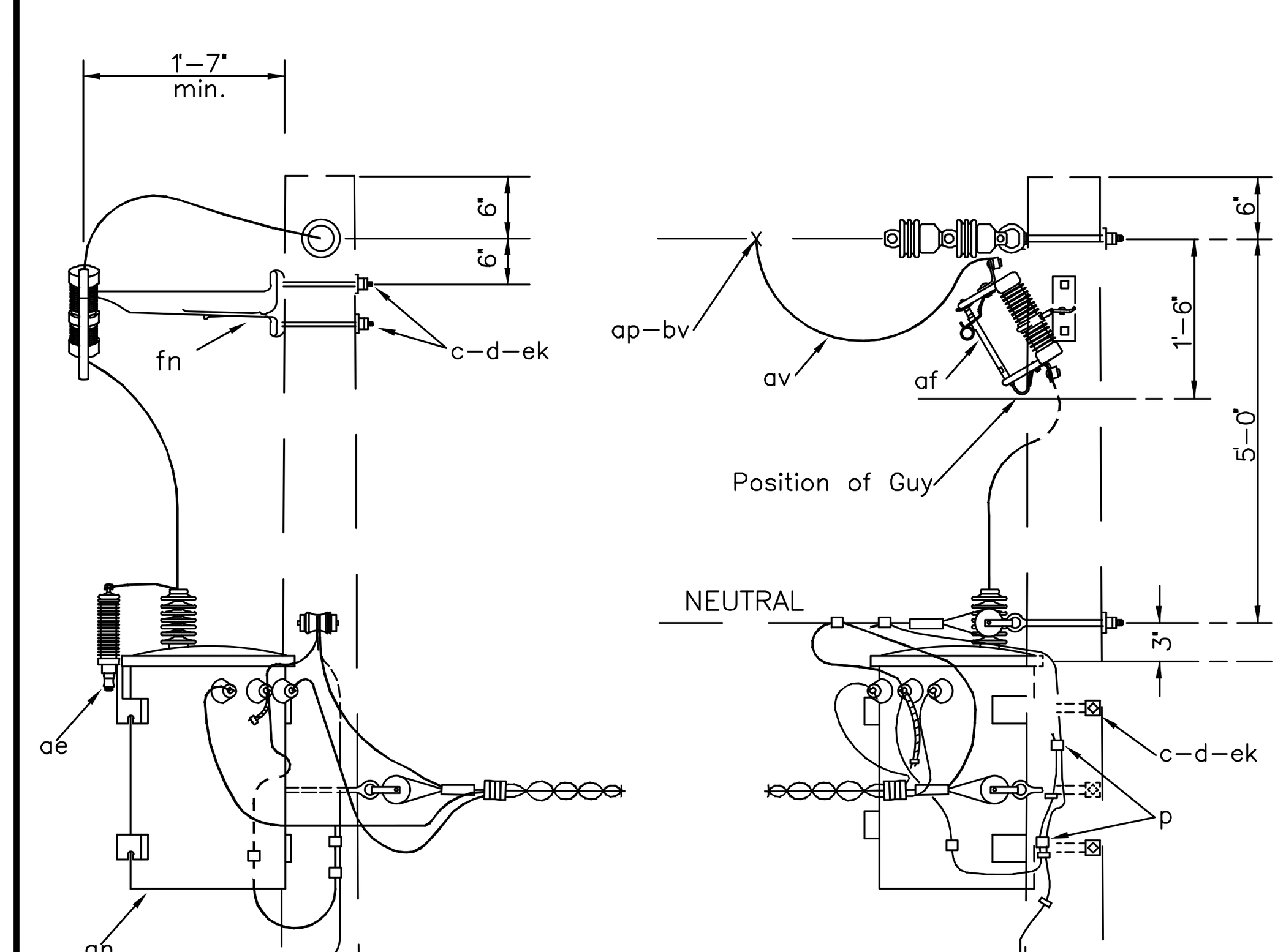
ITEM	MATERIAL	11 QTY	12 QTY
a	Insulator, pin type, (12.47/7.2 kV)	3	3
b	Pin, pole top, 20"	1	1
c	Bolt, machine, 5/8 x req'd length	3	3
d	Washer, square, 2 1/4"	7	7
f	Pin, crossarm, steel, 5/8" x 10 3/4"	2	2
g	Crossarm, 3 5/8" x 4 5/8" x 10'-0"	1	1
i	Bolt, carriage, 3/8" x 4"	2	2
j	Screw, lag, 1/2" x 4"	1	3
bs	Bolt, single, upset	1	
cm	Insulator, spool, 3"	1	1
cu	Brace, 28"	2	2
ec	Bracket, offset neutral		1
ek	Locknuts	6	6

DESIGN PARAMETERS:

MAXIMUM LINE ANGLES:
5° – Small Conductors
2° – Larger than #1/0

SINGLE SUPPORT ON CROSSARM (TANGENT)

APRIL 2005 | RUS | 3 – PHASE PRIMARY 12.47/7.2 kV | C1.11 (C1) C1.12 (C1A)



NOTE: Rotate cutout so that the blade faces climbing face of pole.

ITEM	QTY	MATERIAL
c	4	Bolt, machine, 5/8" x req'd length
d	4	Washer, square, 2 1/4"
p		Connectors, as req'd
ae	1	Arrester, surge (9 kV)
af	1	Cutout, dist. open (15 kV)
an	1	Transformer, 12.47 kV, conventional

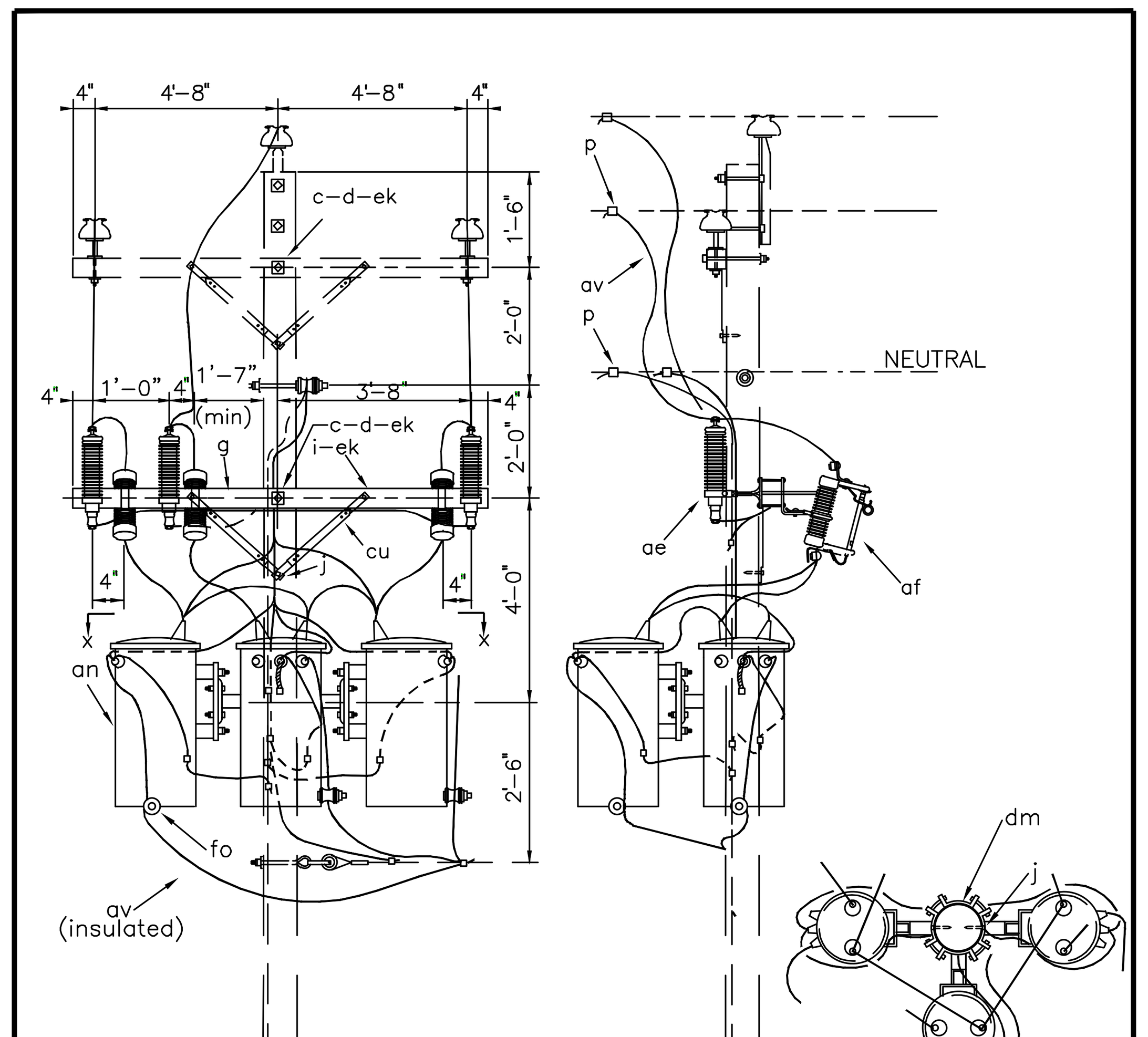
ITEM	QTY	MATERIAL
ap	1	Clamp, hot line
av		Jumpers, stranded, as req'd
bv	1	Rod, armor as req'd
ek	4	Locknuts
fn	1	Bracket, extension

DESIGN PARAMETERS:

See Guide Drawing "G1.1G"

SINGLE-PHASE, CONVENTIONAL TRANSFORMER (DEADEND POLE)

APRIL 2005 | RUS | 12.47/7.2 kV | G1.6



NOTES:
1. See Drawing "Q3.3" for additional connection and metering details.

ITEM	QTY	MATERIAL
d	2	Washer, square, 2 1/4"
g	1	Crossarm, 3 5/8" x 4 5/8" x 10'-0"
i	2	Bolt, carriage, 3/8" x 4 1/2"
j		Screw, lag, 1/2" x 4", as req'd
n	1	Bolt, dble arm, 5/8" x req'd length
p		Connectors, as req'd
p		Connectors, compression, as req'd
ae	3	Arrester, surge, (9 kV)

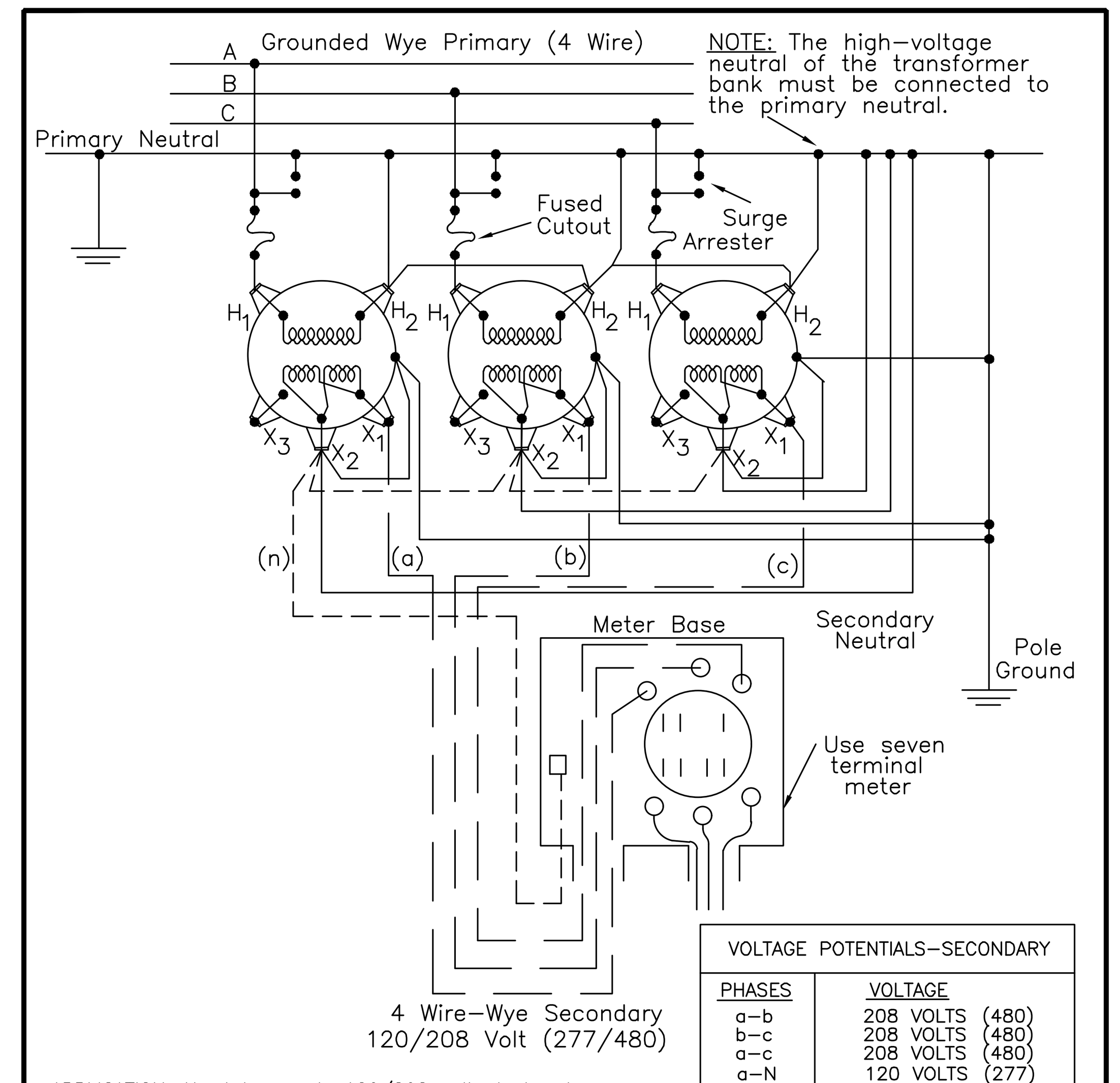
ITEM	QTY	MATERIAL
af	3	Cutout, dist. open (15 kV)
an	3	Transformer, 12.47 kV, conventional
av		Jumpers, bare, stranded
av		Jumpers, service, as req'd
cu	2	Brace, 28"
dm	1	Bracket, transformer, cluster with adapter plates as req'd
ek	5	Locknuts
fo	3	Bracket, transformer, insulated

DESIGN PARAMETERS:

See Guide Drawing "G3.3G"

THREE-PHASE TRANSFORMER BANK
GROUNDED-WYE PRIMARY
GROUNDED WYE, 4 WIRE SECONDARY

APRIL 2005 | RUS | 3 – PHASE PRIMARY 12.47/7.2 kV | G3.3 (G312-)



NOTE: The high-voltage neutral of the transformer bank must be connected to the primary neutral.

VOLTAGE POTENTIALS-SECONDARY	
PHASES	VOLTAGE
a-b	208 VOLTS (480)
b-c	208 VOLTS (480)
a-c	208 VOLTS (480)
a-N	120 VOLTS (277)
b-N	120 VOLTS (277)
c-N	120 VOLTS (277)

0° ANGULAR DISPLACEMENT

(Additive Polarity– See TRANSFORMER SPECIFICATIONS)

APPLICATION: Used to supply 120/208 volt single-phase and 208 volt, three-phase power loads.

See drawing "G3.3" or "VG3.3" for construction details. Reconnect secondary windings of transformers as shown. Matched (impedance and kVA) transformers are usually used.

BANK RATING: Each unit will supply 1/3 of the three-phase load and all of the single-phase load connected to it.

CAUTION: The primary and secondary neutrals must be firmly tied together and grounded or else excessive secondary voltages may develop.

TRANSFORMER/METER CONNECTION GUIDE
GROUNDED WYE – GROUNDED WYE
FOR 120/208 VOLT POWER LOADS

APRIL 2005 | RUS | 3 – PHASE PRIMARY | G3.3G

GENERAL NOTES

1. SEE STAKING SHEET E-1 FOR LOCATION OF EACH DETAIL USED.

CONSTRUCTION DOCUMENTS

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MSU-CPDC
MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA
PHONE: 406.994.5413
FAX: 406.994.5665

MAES - BART FARM
AURORA LINE EXTENSION

Morrison Maierle
engineers • surveyors • planners • scientists

DRAWN BY: MWB
REVIEWED BY: -

REV.	DESCRIPTION	DATE

MONTANA
MICHAEL BRANDT
9812PE
LICENSED PROFESSIONAL ENGINEER
8/15/22

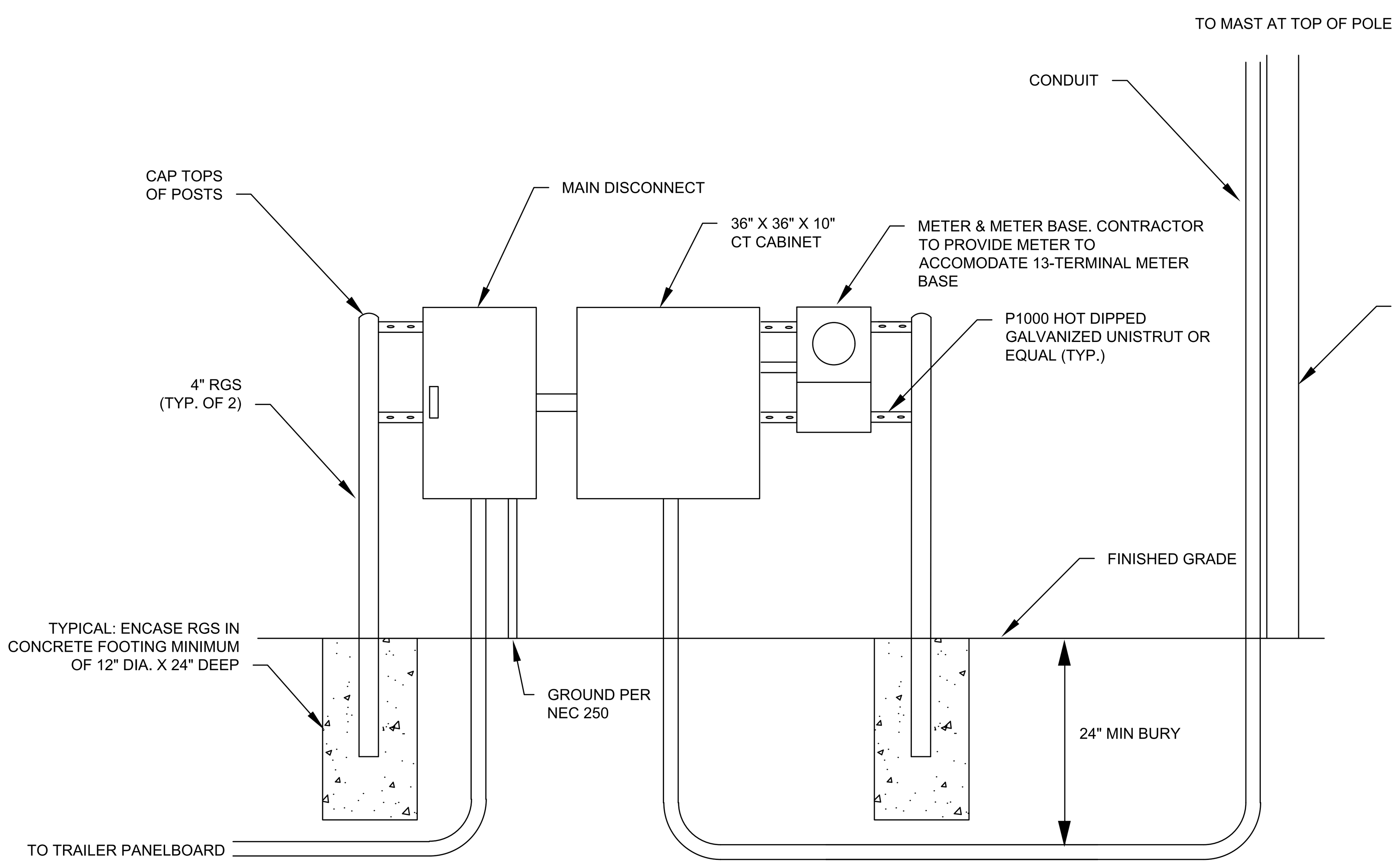
22-0544

MMI# 0747.078

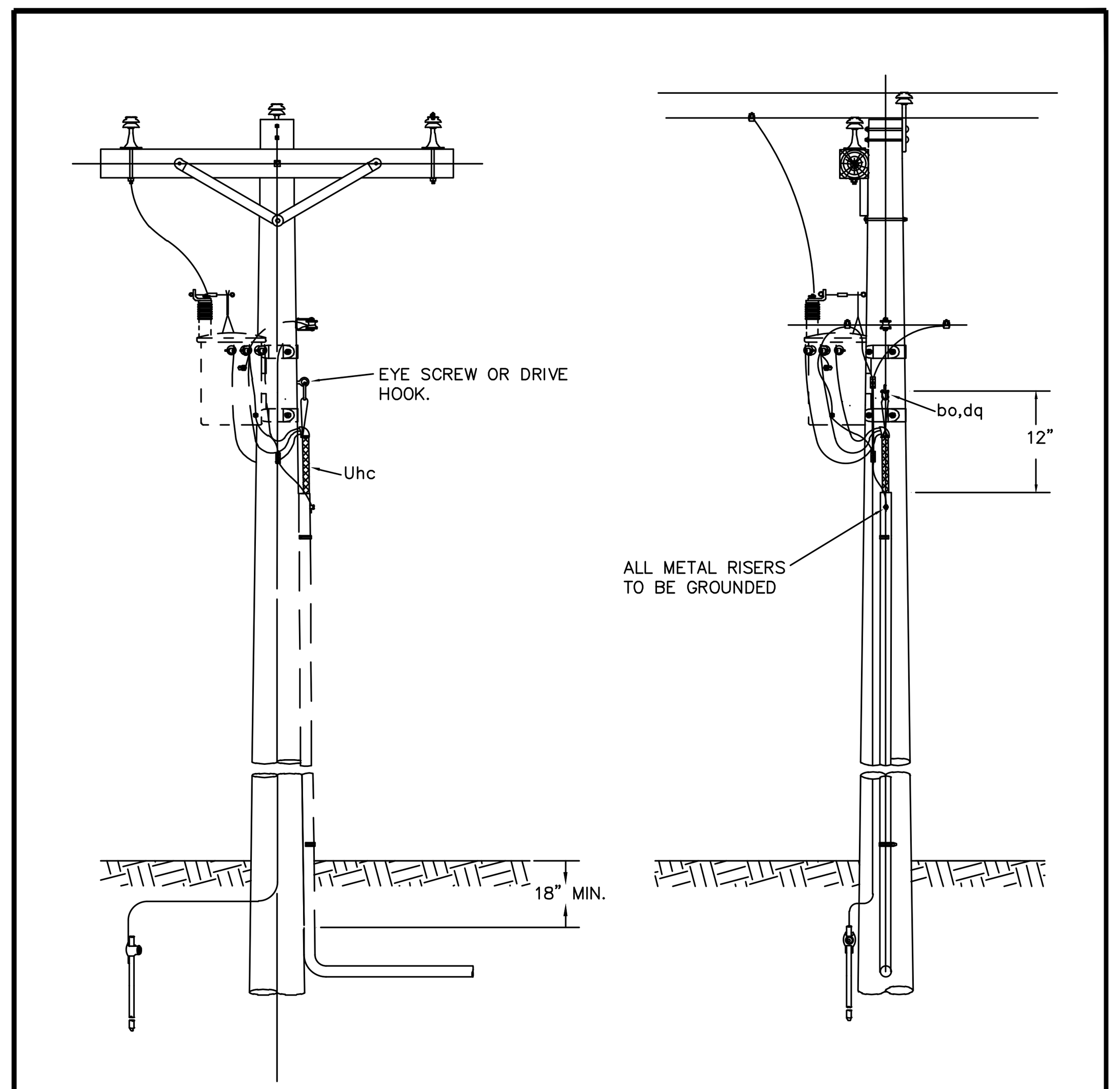
SHEET TITLE
DETAILS

SHEET
E-4

DATE
08-30-2022



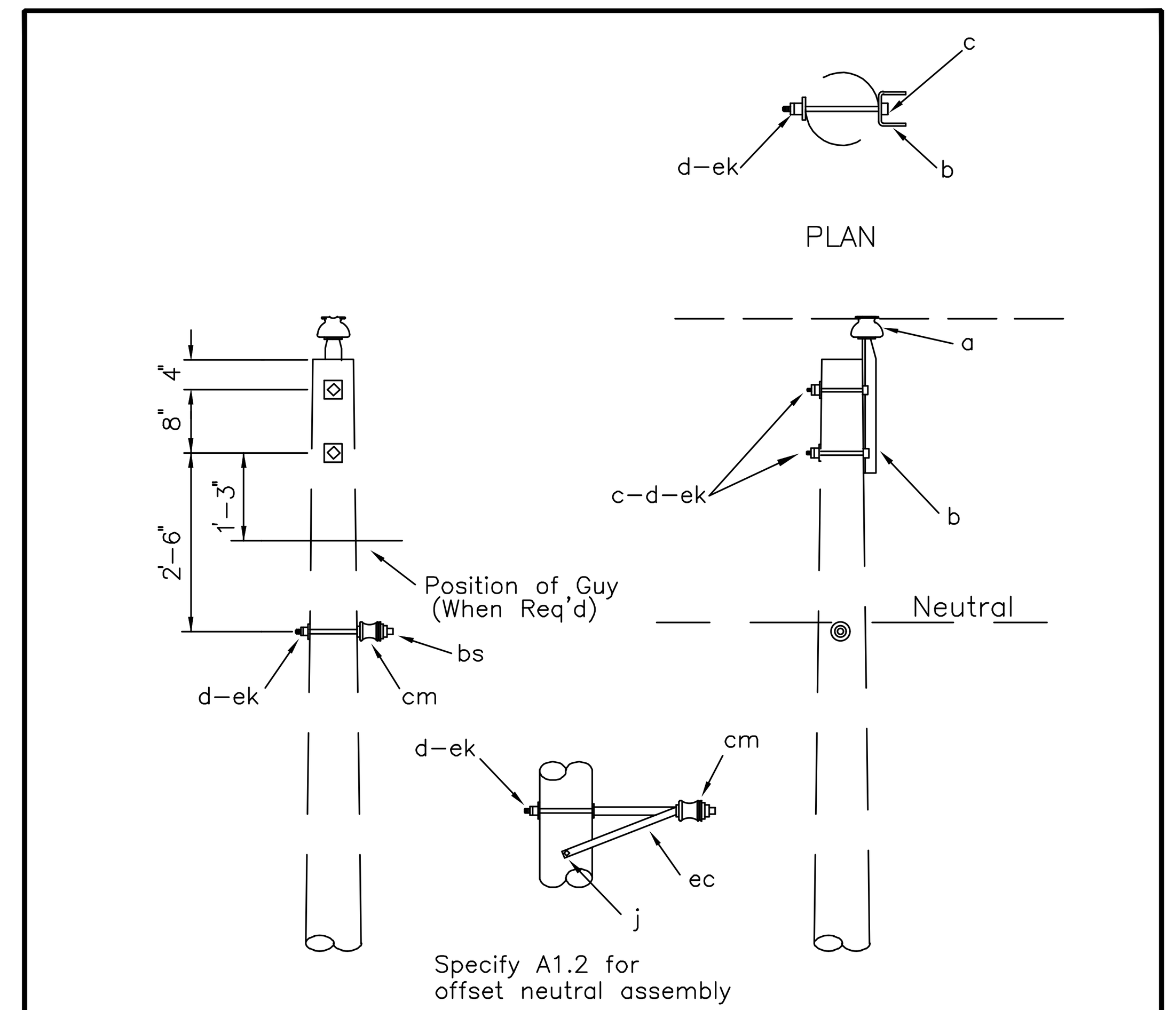
1 E-2 MAIN DISCONNECT/METER/ CT CABINET DETAIL
SCALE: NO SCALE



ITEM	QTY.	MATERIAL
bo	1	Shackle, anchor
dq	1	Eye Screw, Elliptical or Drive Hook
Uhc	1	Cable Support

NOTES:
1. ALLOW MINIMUM CABLE SLACK OF 24" AT BOTTOM OF RISER.
2. ADD UP7 UNIT TO COMPLETE CABLE PROTECTION FOR THIS UNIT.

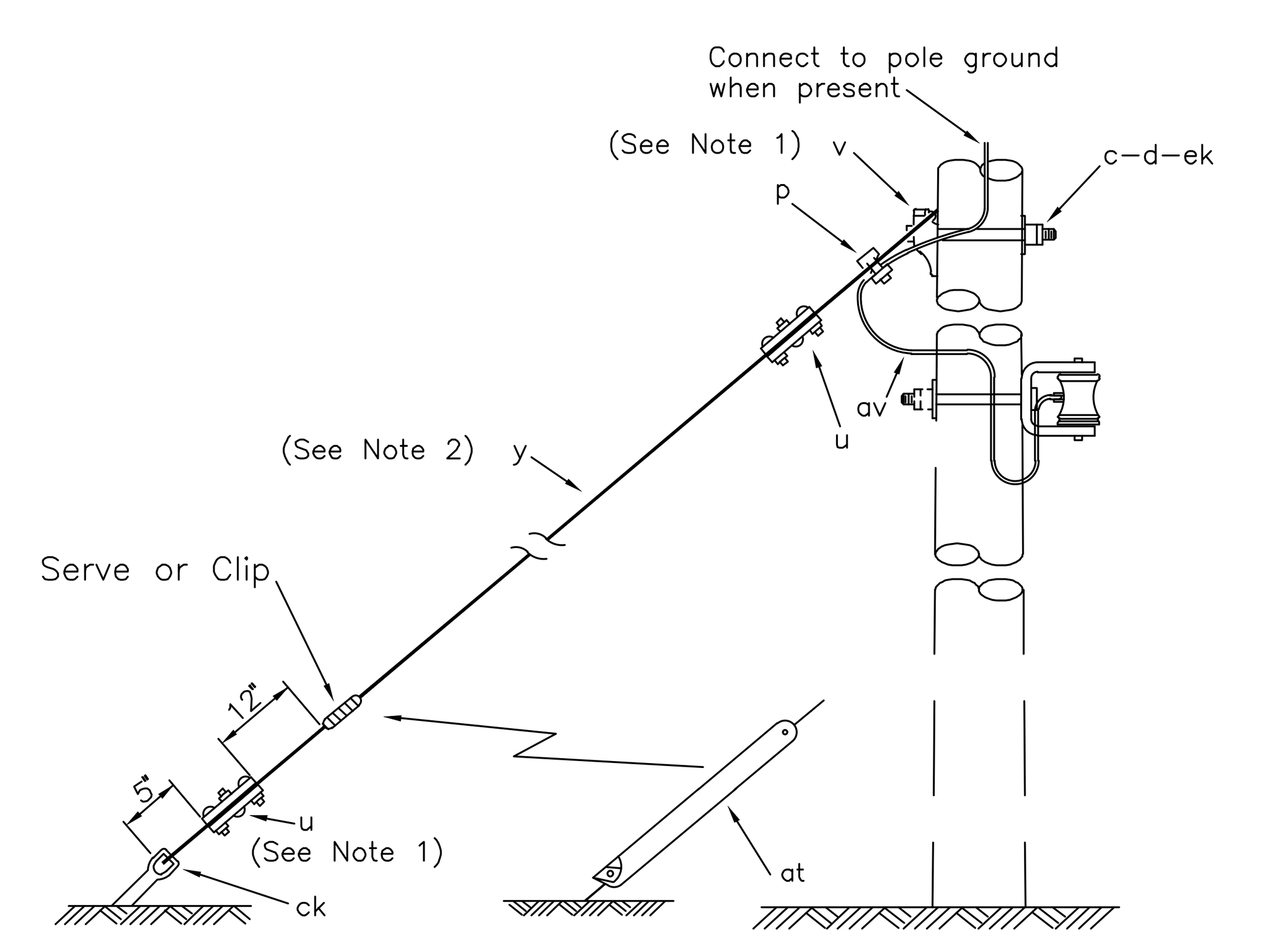
SECONDARY CABLE RISER POLE WITHOUT METER BASE
AUG 2016
RUS
UK1.1



	ASSEMBLY:	A1.1	A1.2
ITEM	MATERIAL	QTY	QTY
a	Insulator, pin type (12.47/7.2 kV)	1	1
b	Pin, pole top, 20"	1	1
c	Bolt, machine, 5/8" x req'd length	2	2
d	Washer, square 2 1/4"	3	3
j	Screw, lag, 1/2" x 4"		2
bs	Bolt, single, upset	1	
cm	Insulator, spool, 3"	1	1
ec	Bracket, offset neutral		1
ek	Locknuts	3	3

DESIGN PARAMETERS:
MAXIMUM LINE ANGLES:
5° – Small Conductors
2° – Larger than #1/0

SINGLE SUPPORT (TANGENT)
APRIL 2005
RUS
1 – PHASE PRIMARY 12.47/7.2 kV
A1.1 (A1)
A1.2 (A1A)

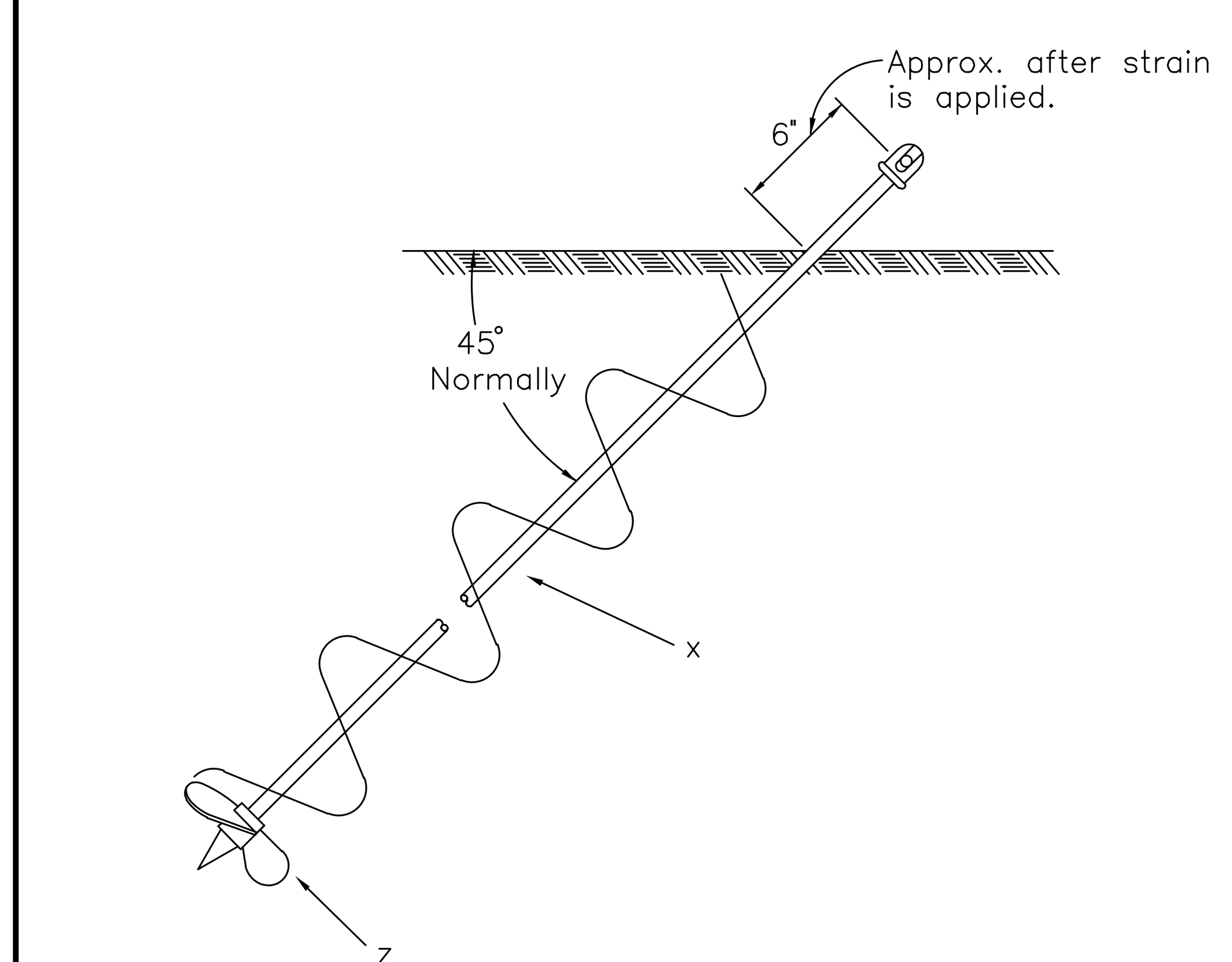


NOTES:
1. Other accepted and equivalent guy deadend (item "u") and attachment (item "v") material may be substituted for the ones shown.
2. Some types of guy attachments use 2 bolts and washer or lag screw (item "j"), change materials accordingly.
3. Specify guy wire size, type and required length.

ITEM	QTY	MATERIAL
c	1	Bolt, machine, 5/8" x req'd length
d	1	Washer, 3" square, curved
p		Connectors, guy bond and as req'd
u	2	Deadend for guy strand (See Note 1)
v	1	Guy attachment (See Note 1)
y		Guy wire, as req'd (See Note 3)
at	1	Guy marker
av		Jumpers, as req'd
ck	1	Clamp, anchor bonding
ek	1	Locknuts

DESIGN PARAMETERS:
PERMITTED LOAD IS LESSER OF: 6,600 lbs (in any direction) or 90% of RATED BREAKING STRENGTH OF GUY WIRE

SINGLE DOWN GUY (THROUGH BOLT TYPE)
APRIL 2005
RUS
E1.1 (E1–2)



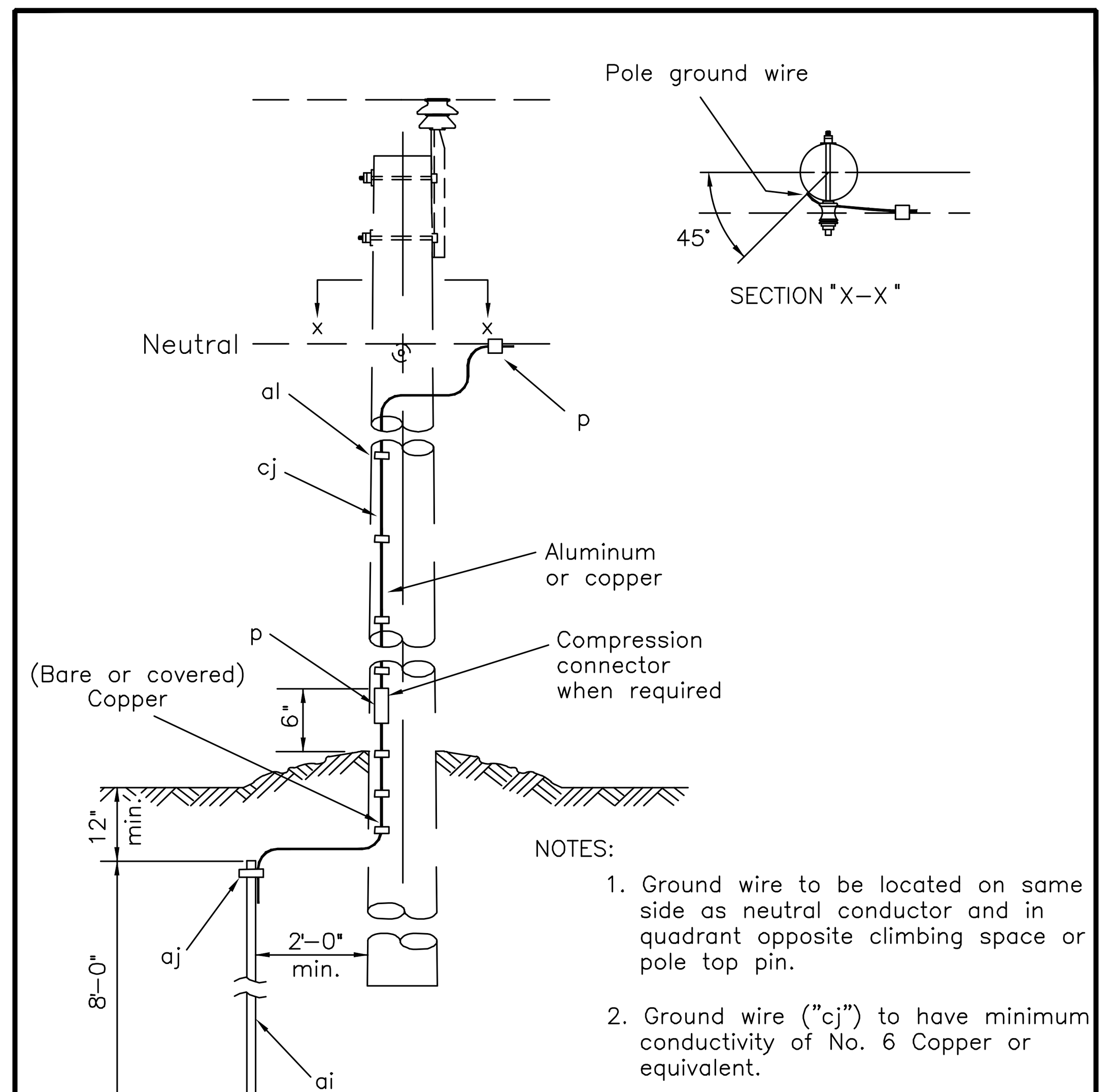
NOTE: Designated maximum holding power rating assumes proper installation in class 5 soil.

	ASSEMBLY: F2	.6	.8	.10	.12
	Minimum Area (sq. in.)	90	100	120	135
ITEM	MATERIAL	QTY	QTY	QTY	QTY
x	Rod, anchor, thimble eye, 5/8" x 7'0"	1	1		
x	Rod, anchor, twin eye, 3/4 X 8'0			1	1
z	Anchor, screw type, power installed	1	1	1	1

ASSEMBLY NUMBERS	
NEW	(OLD)
F2.6	(F1–1S)
F2.8	(F1–2S)
F2.10	(F1–3S)
F2.12	(F1–4S)

DESIGN PARAMETERS:
DESIGNATED MAXIMUM HOLDING POWER (lbs.)
F2.6: 6,000
F2.8: 8,000
F2.10: 10,000
F2.12: 12,000

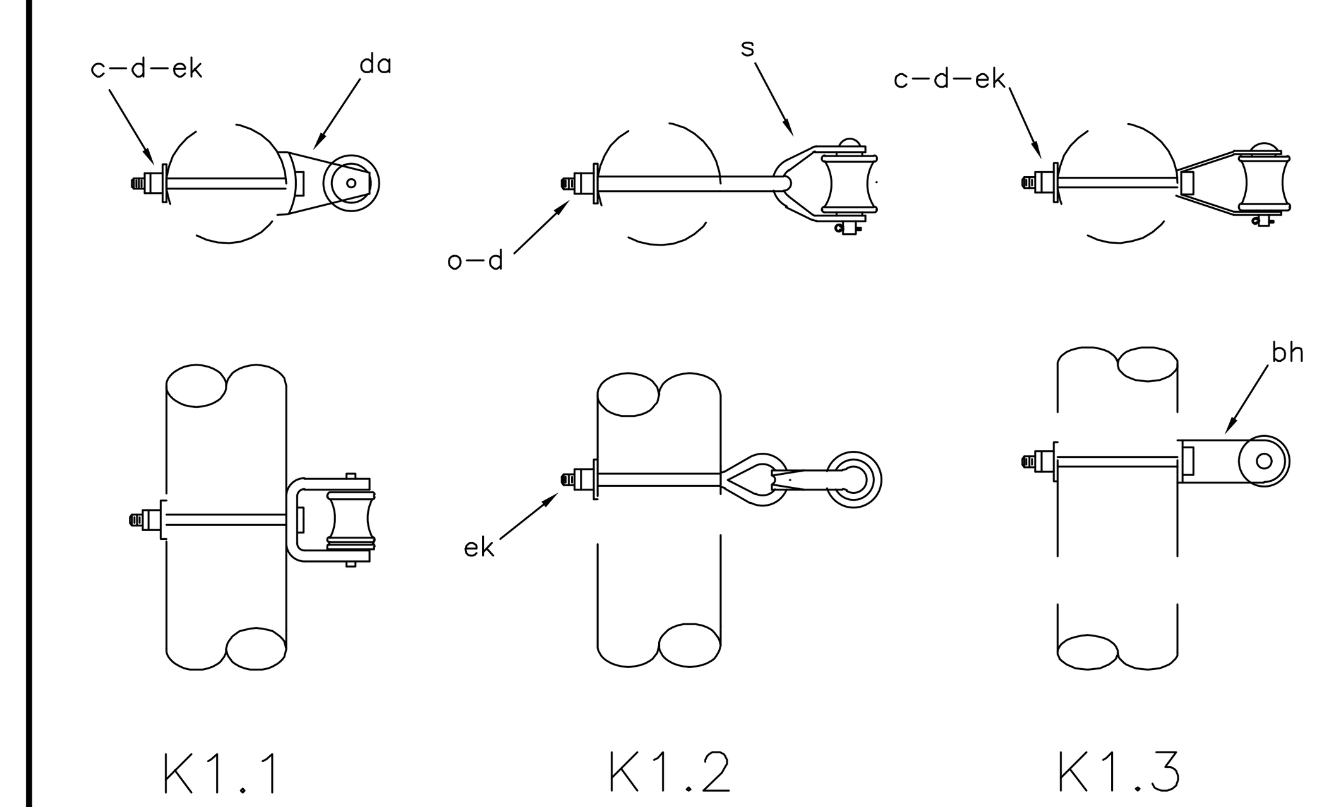
SCREW ANCHORS, (POWER INSTALLED)
APRIL 2005
RUS
F2.6, F2.8, F2.10, F2.12



NOTES:
1. Ground wire to be located on same side as neutral conductor and in quadrant opposite climbing space or pole top pin.
2. Ground wire ("cj") to have minimum conductivity of No. 6 Copper or equivalent.
3. Use copper plated ground rod and copper ground wire and staples, or use galvanized steel ground rod, staples and soft annealed iron, 3–strand, 5/16" ground wire with class C galvanizing.

ITEM	QTY	MATERIAL
p		Connector, compression, as req'd
ai	1	Rod, ground, 5/8" min. diameter
aj	1	Clamp, ground rod
al		Staple, ground wire, as reg'd
cj		Wire, pole ground, as req'd

GROUNDING ASSEMBLY – GROUND ROD TYPE
APRIL 2005
RUS
H1.1 (M2–11)



	ASSEMBLY: K1	.1	.2	.3
ITEM	MATERIAL	QTY	QTY	QTY
c	Bolt, machine, 5/8" X req'd length	1		1
d	Washer, 2 1/4" square	1	1	1
o	Bolt, eye, 5/8" X req'd length		1	
s	Clevis, secondary, swinging, insulated		1	
bh	Clevis, service, deadend, insulated			1
ek	Locknuts	1	1	1
da	Bracket, insulated	1		

ASSEMBLY NUMBERS	
NEW	(OLD)
K1.1	(K14C)
K1.2	(K11C)
K1.3	(K14)
	(K14L)

DESIGN PARAMETERS:
PERMITTED LONGITUDINAL LOADING:
1,500 lbs. (ANSI Class 53–2 Insulator)
2,250 lbs. (ANSI Class 53–4 Insulator)

SERVICE ASSEMBLIES (POLE MOUNTED)
APRIL 2005
RUS
K1.1,K1.2,K1.3

GENERAL NOTES
1. SEE STAKING SHEET E-1 FOR LOCATION OF EACH DETAIL USED.

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MSU-CPDC
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BOZEMAN, MONTANA
PHONE: 406.994.5413
FAX: 406.994.5665

CONSTRUCTION DOCUMENTS

MAES - BART FARM AURORA TEST RANGE ELECTRICAL

Morrison Maierle
engineers • surveyors • planners • scientists

DRAWN BY: MWB
REVIEWED BY: -

REV.	DESCRIPTION	DATE

MONTANA MICHAEL W. BRANDT 9812PE LICENSED PROFESSIONAL ENGINEER 8/15/22

22-0544
MMI# 0747.078
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DETAILS
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DATE
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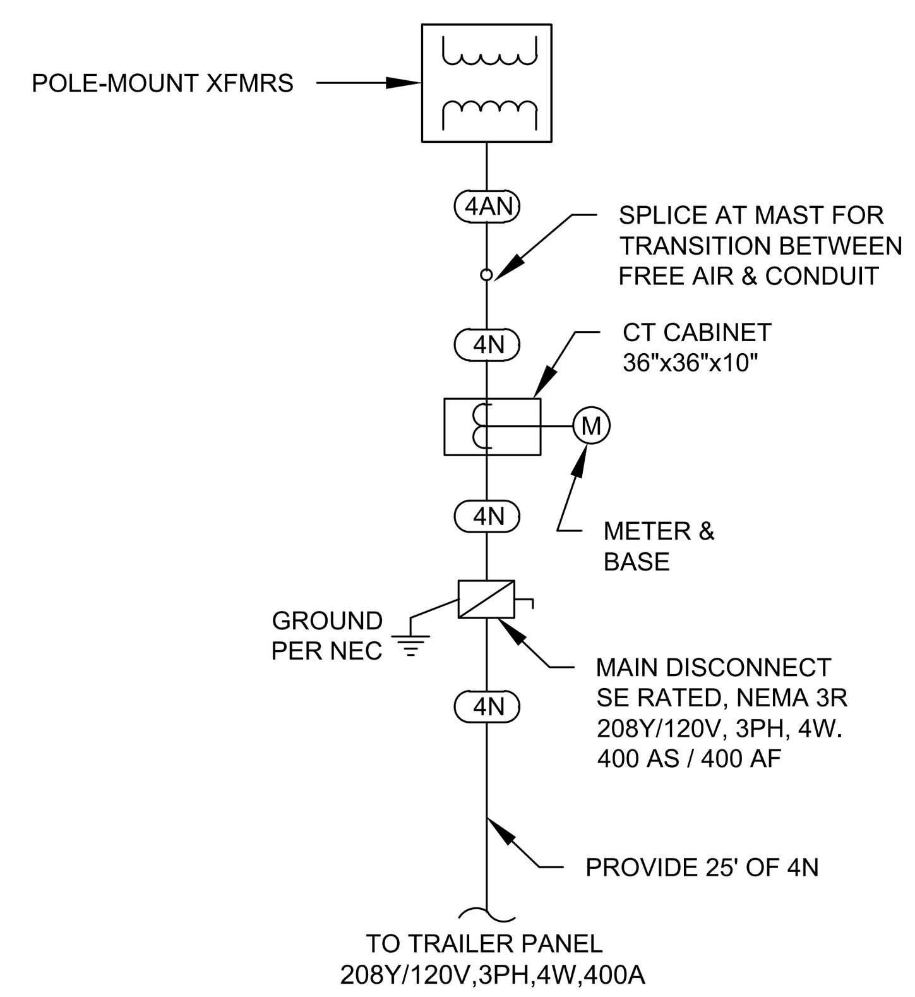


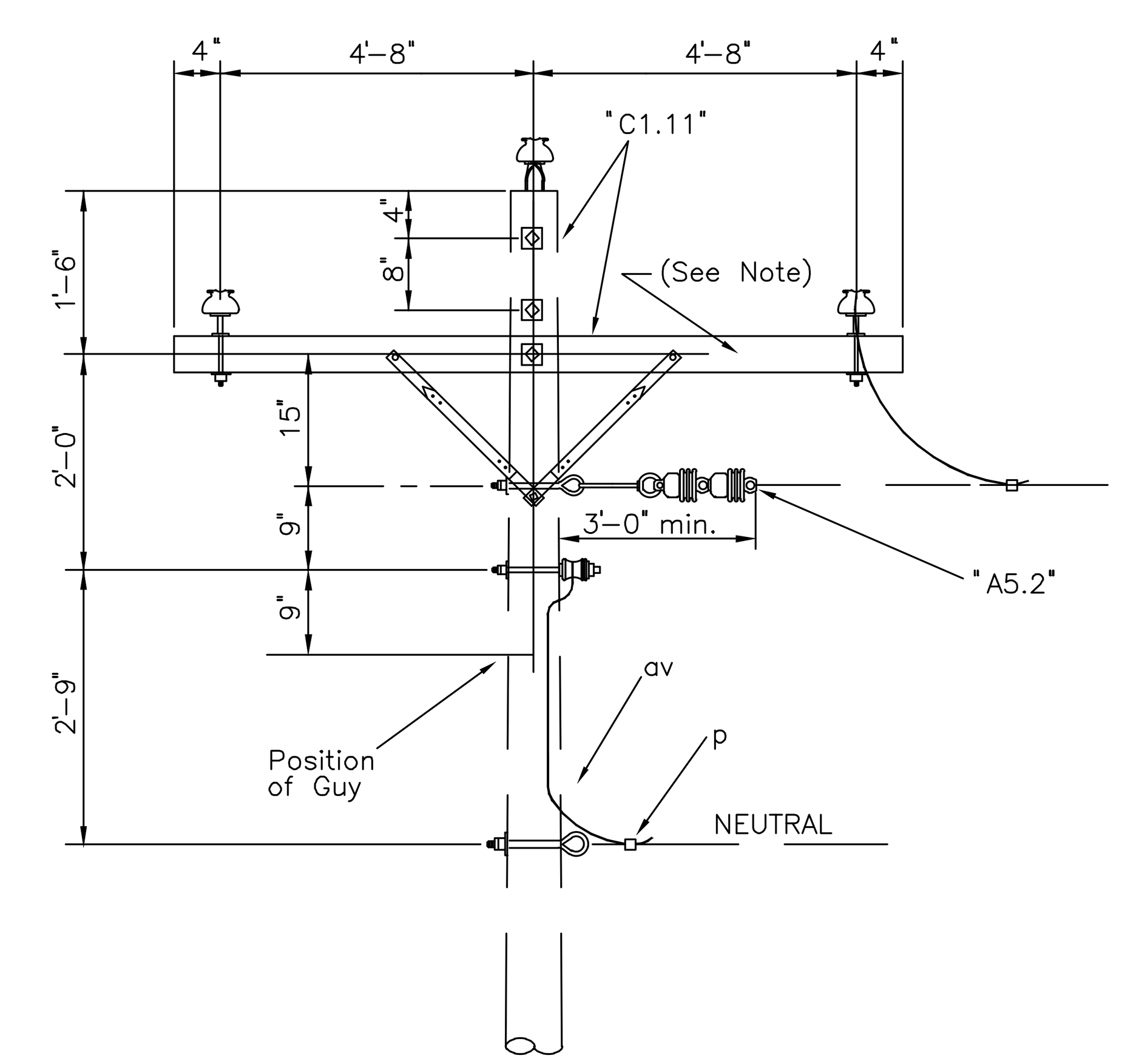
1 E-2 SECONDARY ONE LINE DIAGRAM
SCALE: NO SCALE

FEEDER SCHEDULE - IN CONDUIT

FEEDER NUMBER	AMPS	WIRE QTY PER CONDUIT	SETS IN PARALLEL	CONDUIT	75 DEG COPPER PHASE QTY AND AWG	75 DEG COPPER NEUTRAL AWG	GROUND AWG
4N	400	4W	1	4"	3#500	1#500	1#3

FEEDER SCHEDULE - FREE AIR

FEEDER NUMBER	AMPS	WIRE QTY	SETS IN PARALLEL	CONDUIT	75 DEG ALUMINUM PHASE QTY AND AWG	75 DEG ALUMINUM NEUTRAL AWG	GROUND AWG
4AN	400	4W	1	N/A	3#350	1#350	1#3

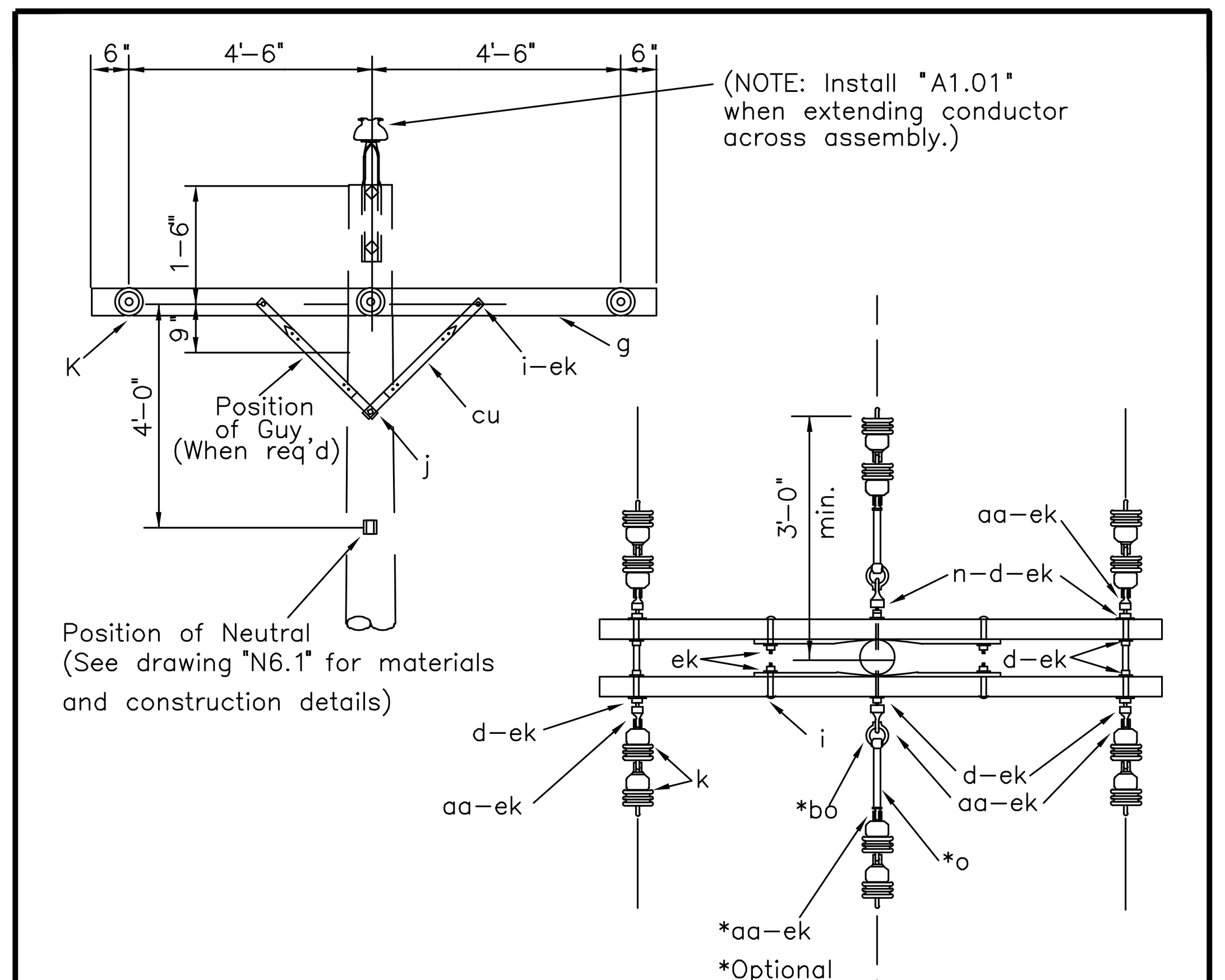


NOTE:
When tapping center phase, install post type insulator, "A1.011P", horizontally on crossarm, 19 inches (minimum) from surface of pole and fasten jumper to insulator.

ITEM	QTY	MATERIAL
	1	"C1.11" Primary Assembly
	1	"A5.2" Primary Assembly
p		Connectors, as req'd
av		Jumpers, as req'd

DESIGN PARAMETERS:
PERMITTED LONGITUDINAL LOAD = 5,000 lbs./Conductor

SINGLE PHASE TAP GUIDE
APRIL 2005 | RUS | 3 – PHASE PRIMARY 12.47/7.2 kV | C5.11G



ITEM	QTY	MATERIAL
d	2	Washer, square, 3", curved
d	10	Washer, square, 2 1/4"
g	2	Crossarm, 3 5/8" x 4 5/8" x 10'–0"
i	4	Bolt, carriage, 3/8" x 4 1/2"
j	2	Screw, lag, 1/2" x 4"
k	12	Insulator, suspension, 4 1/4"
n	4	Bolt,double arming,5/8" x req'd length
o	2	Bolt, eye, 5/8" x req'd length
p		Connectors, as req'd
aa	8	Nut, eye, 5/8"
av		Jumpers, as req'd
bo	2	Shackle, anchor
cu	4	Brace, 28"
ek	26	Locknuts

NOTES:
1. Double arming bolt, item "n," and eye nut, item "aa," may be re–placed with double arming eye bolt, item "dy."
2. Maximum line angle may be increased to 15° by installing anchor shackles, item "bo," to (horizontal) eye nuts and installing side guys as req'd.
3. Designate as C6.31 for assembly with three crossarms.

DESIGN PARAMETERS:
PERMITTED UNBALANCED CONDUCTOR TENSION:
See Table A (Exhibit 2)
MAXIMUM LINE ANGLE = 5°
(See Note 2)

DOUBLE DEADEND ON CROSSARMS
APRIL 2005 | RUS | 3 – PHASE PRIMARY 12.47/7.2 kV | C6.21 (C8) C6.31

CONSTRUCTION DOCUMENTS

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MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA
PHONE: 406.994.5413
FAX: 406.994.5665

MAES - BART FARM AURORA TEST RANGE ELECTRICAL

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