Line Loss

WSDOT

Winter 2008

BZA

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OHM'S LAW

P = Watts (Power)

I = CURRENT (AMPERES)

R = RESISTANCE (OHMS)

E = ELECTROMOTIVE FORCE (VOLTS)

$P = EI$ WATTS = AMPERES X VOLTS

$I = \frac{E}{R}$ $\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$

$R = \frac{E}{I}$ $\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$

$E = IR$ VOLTS = AMPERES X OHMS

P = WATTS

$$\text{WATTS} = \frac{\text{VOLTS}^2}{\text{OHMS}}$$

$$\text{WATTS} = \text{AMPERES}^2 \times \text{OHMS}$$

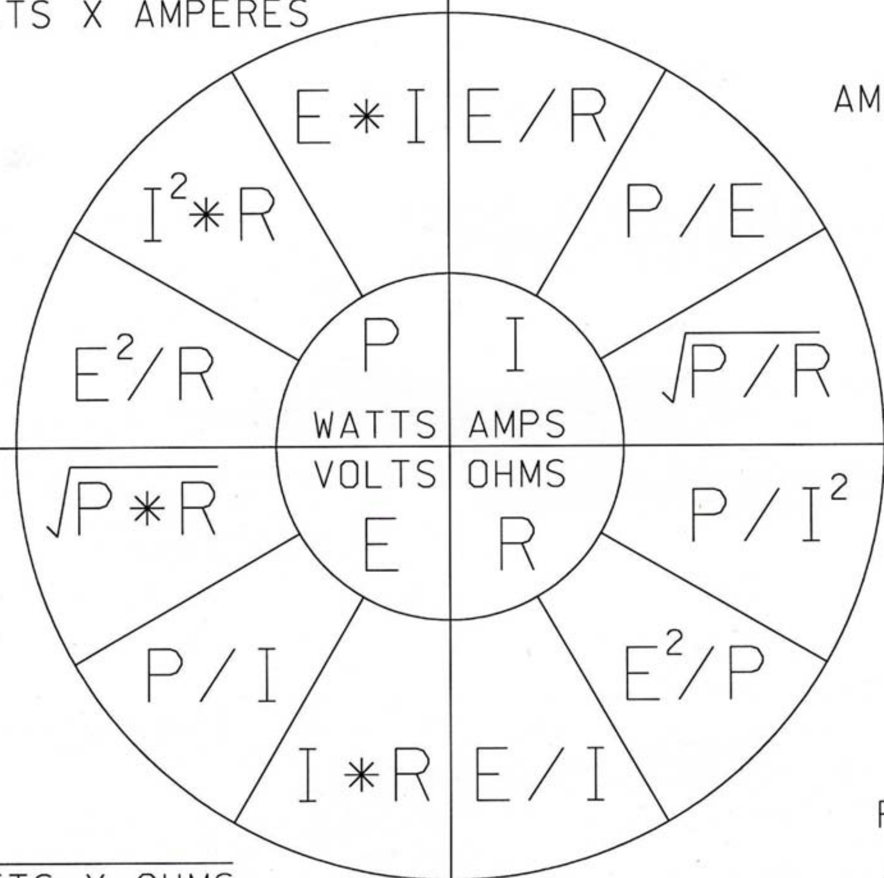
$$\text{WATTS} = \text{VOLTS} \times \text{AMPERES}$$

I = AMPERES

$$\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

$$\text{AMPERES} = \frac{\text{WATTS}}{\text{VOLTS}}$$

$$\text{AMPERES} = \sqrt{\frac{\text{WATTS}}{\text{OHMS}}}$$



E = VOLTS

$$\text{VOLTS} = \sqrt{\text{WATTS} \times \text{OHMS}}$$

$$\text{VOLTS} = \frac{\text{WATTS}}{\text{AMPERES}}$$

$$\text{VOLTS} = \text{AMPERES} \times \text{OHMS}$$

R=OHMS

$$\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

$$\text{OHMS} = \frac{\text{VOLTS}^2}{\text{WATTS}}$$

$$\text{OHMS} = \frac{\text{WATTS}}{\text{AMPERES}^2}$$

Clear Catinkus for PIER (Power)

(P) Power is the amount of current times the voltage level at a given point measured in wattage or watts.

(I) Current is what flows on a wire or conductor like water flowing down a stream. Current flows from points of high voltage to points of low voltage on the surface of a conductor. Current is measured in (A) amperes or amps.

(E) Voltage is the difference in electrical potential between two points in a circuit. It's the pressure or push behind current flow through a circuit, and is measured in (V) volts.

(R) Resistance determines how much current will flow through a component. Resistors are used to control voltage and current levels. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in ohms.

Example

- A circuit having a resistance of 5 ohms is under a pressure of 110 volts. How much current will flow?
- amperes = volts / resistance
- amperes = 110 volts / 5 ohms
- answer = <u>22 amperes</u>

Example

- If the resistance of a circuit is 10 ohms, what is the voltage necessary for a flow of 20 amperes?
- volts = amperes x ohms
- volts = 20 amperes x 10 ohms
- Answer = <u>200 volts</u>

Example

- On a 110 volt circuit what resistance is necessary to obtain a flow of 15 amperes?
- ohms = volts / amperes
- ohms = 110 volts / 15 amperes
- Answer = <u>7.33 ohms</u>

Example

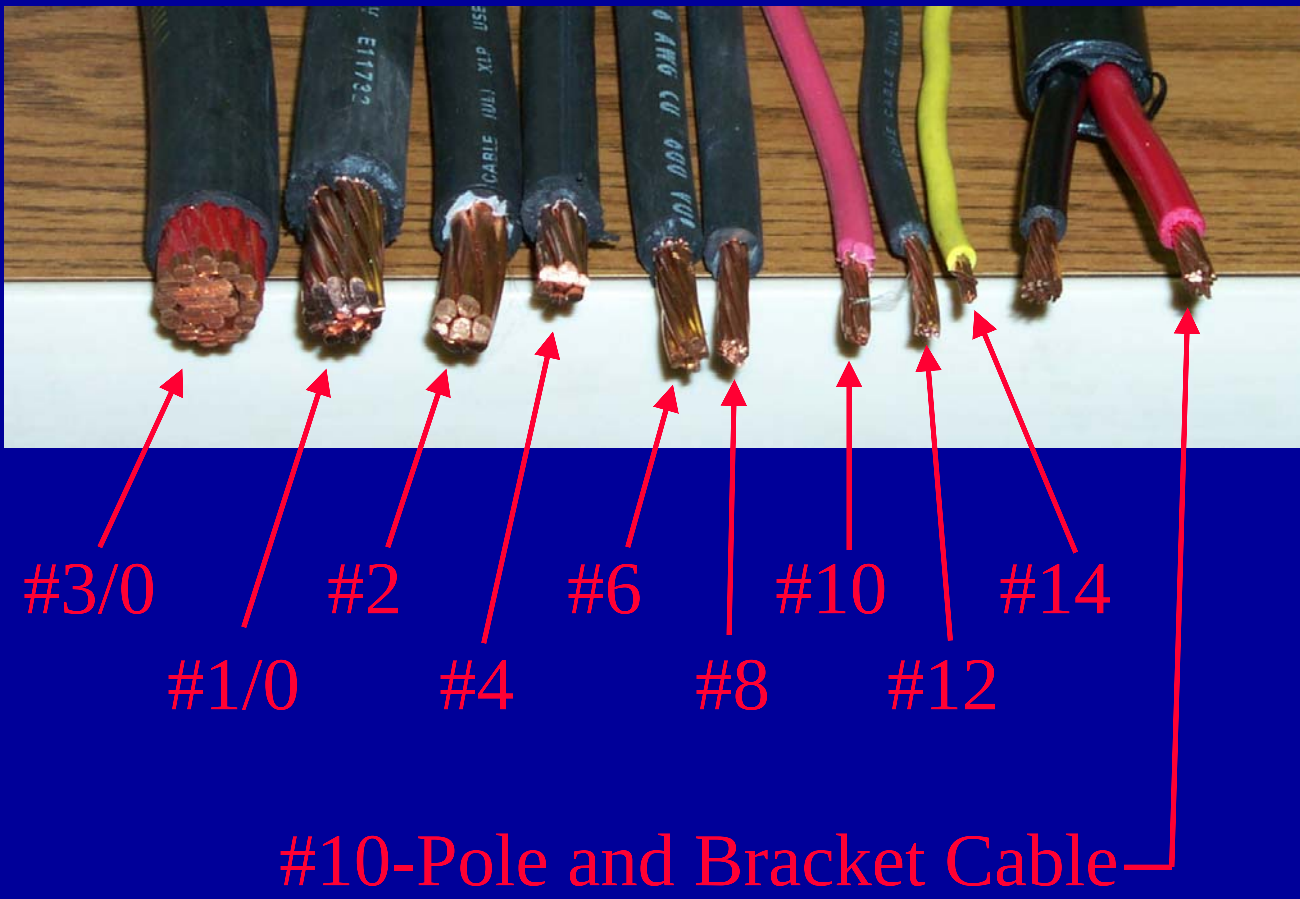
- A water heater is served by a 240 volt circuit. The heating element is 4500 watts. What is the load on this circuit?
- 4500 watt heating element / 240 volts = 18.75 amps
- On this circuit, what resistance is necessary within the heating element to obtain the flow of 18.75 amperes?
- ohms = volts / amperes
- ohms = 240 volts / 18.75 amperes
- Answer = <u>12.80 ohms</u>

Example

- A coffee pot is served by a 120 volt circuit. The heating element is 1500 watts. What is the load on this circuit?
- 1500 watt heating element / 120 volts = 12.50 amps
- On this circuit, what resistance is necessary within the heating element to obtain the flow of 12.50 amperes?
- ohms = volts / amperes
- ohms = 120 volts / 12.50 amperes
- Answer = <u>9.60 ohms</u>

Electrical Energy Unit Conversions

- 1 watt = 1 volt x 1 ampere x power factor* * *
- watts = volt amperes
- 1 ampere = 1 watt / 1 volt
- 1 volt = 1 watt / 1 ampere
- k = 1000 (accepted convention that “k” indicates 1000) NEC 110.6, Conductor sizes - comments
- ____ watts / 1000 = ____ kilo volt ampere (kVA)
- 1,528 watts / 1000 = 1.528 kVA
- ____ kVA x 1000 = ____ watts (or volt amperes)
- 3.224 kVA x 1000 = 3,224 watts (or volt amperes)
- * * * For WSDOT calculation purposes the power factor is assumed to be 1.


#3/0
#1/0
#2
#4
#6
#8
#10
#12
#14
#10-Pole and Bracket Cable

What is Line Loss?

- Line Loss is the voltage drop (Vd) between the electrical service and the load. Line loss usually controls wire size determination rather than the allowable ampacities listed in Chapter 3 of the National Electrical Code.

- Recommended allowable voltage drop is discussed in 2005 NEC article 210.19, FPN No.4

Why do we need to worry about Voltage Drop?

- If you have too much Voltage Drop on a circuit, the equipment you are trying to power may not work.

- Inefficiency equals using more power and receiving less output. (see reasonable operating efficiency commentary after NEC 2005 Article 215.2 in the handbook)

- You need to make sure you have enough capacity for future use. (Figure 3-4% for future Illumination loads and 1-2% for future ITS loads.)

Maximum Voltage Drop Requirements

- **High Pressure Sodium** - ultimate loads known Vd = 8%, unknown Vd = 5%.
- **Metal Halide** - ultimate loads known Vd = 8%, unknown Vd = 5%.
- **Mercury Vapor** - ultimate loads known Vd = 10%, unknown Vd = 5%.
- **Temporary Illumination System** (installed & removed within same contract) - Vd = 10%.
- **Traffic Signal** - Vd = 5%.
- **ITS System** - Vd = 3%

Wire size

- On <u>new ITS circuits</u> that are not powered by a transformer, pick your wire size so that you have 1.5-2% voltage drop.

- On <u>transformers</u> that have GFCI's included in the loading calculations, pick your wire so that you have 5% maximum voltage drop. If there are no GFCI's included (load for pump, fan motors, etc.) then use 3% voltage drop.

- Note: All transformers referred to in this class are for ITS or Traffic Signal loads. To size a transformer for a pump, motor or other specialty item, consult HQ Traffic Design.

- On <u>new illumination circuits</u> (ultimate load unknown) pick your wire size so that you have 4-5% voltage drop.

- On <u>new signal circuits</u> pick your wire size so that you have 3-4% voltage drop.

- On <u>existing ITS circuits</u> where you are <u>replacing the wire</u> the maximum voltage drop allowed is 3%.

- On <u>existing signal circuits</u> where you are <u>replacing the wire</u> the maximum voltage drop allowed is 5%.

- On <u>existing illumination</u> circuits (ultimate load known) where you are <u>replacing the wire</u> the maximum voltage drop allowed is 8%.

How do we calculate Voltage Drop?

In order to calculate line loss you need to know:

This formula: **Vd = 2ALR**

Where:

Vd= Voltage Drop.

2 = because the power goes out and back using two wires.

A = **load** being drawn. (Amperes)

L = **distance** the load is being carried. (Feet – one way length of the circuit)

R = **resistance** per foot of wire used. (Ohms) When looking up the "R" factor in the chart you need to know two things:

- The **wire size** carrying the load. (#2, #4, #6, #8, etc.)
- The **type of wire** being used. (**Copper** or Aluminum)

Determining the "R"

Use these columns depending on wire type

Size	X-Section	(copper only)	Copper	Aluminum
(AWG)	(Square Inches)	(Amps)	(ohms/foot)	(ohms/foot)
500 Kcmil	0.7901	380	0.000026	
350 Kcmil	0.5958	310	0.000038	
250 Kcmil	0.4596	255	0.000054	
4/0	0.3718	230	0.000063	
3/0	0.3117	200	0.000080	
2/0	0.2624	175	0.000101	
1/0	0.2223	150	0.000127	0.000201
1	0.1900	130	0.000160	
2	0.1333	115	0.000201	0.000319
4	0.0973	85	0.000321	0.000508
6	0.0726	65	0.000510	0.000808
8	0.0556	50	0.000809	
10	0.0330	30*	0.001290	
12	0.0260	20*	0.002051	
14	0.0210	15*	0.003261	
75 degree Celcius insulation	NEC, Chapter 9, Table 5-Type RHW* conductors-w/o outer covering	NEC, Table 310.16 *reduced per Article 240.4(D)	NEC Chapter 9, Table 8	NEC Chapter 9, Table 8

Calculating the distance (L) between loads

- Scale off the distance between each load or the distance between the load and the service.
- Add 5’ when entering the service cabinet or another cabinet to power.
- Add 10’ per in-grade junction box that the wire passes through. This takes into account the conduit sweeps and the 3’ of slack wire.
- Add 5’ to each side of wire run (instead of 10’) when there is a splice in the junction box.
- Add 5’ for the sweep into the luminaire and up to the handhole.
- Add 5’ for NEMA junction boxes.
- Add 2’ to each side of wire run (instead of 5’) when there is a splice in the NEMA junction box.
- Add 52’ (for 40’ pole with 16’ mast arm) or 62’ (for 50’ pole with 16’ mast arm) to the distance to accommodate for the last luminaire pole and mast arm on each run. Use a #10 wire (pole & bracket cable) for this distance.
- Add 2’ to enter terminal cabinet and terminate conductor on terminal block.
- **For aerial temporary illumination, add 10% of the total span length of aerial conductors**

Different Types of Loads (A)

- There are three different types of loads that we calculate.
  - 1.) Intelligent Transportation System (ITS), (previously SC&DI)
  - 2.) Traffic Signal System
  - 3.) Illumination System (including sign lights)
- There are different ways to calculate each of these loads

Amps - voltage relationship - Example

The basic way a load is calculated is by dividing the wattage (Volt Amperes) by the voltage serving the load.

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{120V}} = 21.0\text{Amps}$$

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{240V}} = 10.5\text{Amps}$$

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{480V}} = 5.25\text{Amps}$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{120V}} = 62.5\text{Amps}$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{240V}} = 31.25\text{Amps}$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{480V}} = 15.625\text{Amps}$$

ITS Loads

An ITS circuit is sized for the ultimate load that can be drawn at one time. This is usually controlled by the rated output of the transformer. If there is **no transformer,** use the figures below to calculate your loads. Most ITS cabinet are served with a 120 volt circuit – this is why you typically serve these cabinets with a transformer. Check your cabinet voltage requirement if you don't know.

Ramp Meter (RM) -720W+1800W(GFCI's)=2520W
Camera Cabinet (CC) -324W+1800W(GFCI's)=2124W
Data Station (ES) -252W+1800W(GFCI's)=2052W
Highway Advisory Radio Station (HAR)-200W+1800W(GFCI's)=2000W
RWIS – 120W+1800W(GFCI's)=1920W
Permanent Traffic Recorder & Weigh-In-Motion-240W + 1800W(GFCI's)= 2040W
Variable Message Sign (VMS)-Contact the ITS designer because each sign requires a different loading. If you are the ITS designer contact the manufacturers for like size and type VMS Sign data.

(Generally, if the load is below 1800 watts, there is not an included GFCI load.) **If the load is larger than 1800 watts, then a GFCI load is assumed to be included.**

Consult with ITS designers to let them know this is your intention and to make sure this will be adequate. If you are the ITS designer, please keep this in mind.)

ITS - Example

The basic way a load is calculated is by dividing the wattage (Volt Amperes) by the voltage serving the load.

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{120V}} = 21.0Amps$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{240V}} = 31.25Amps$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{480V}} = 15.625Amps$$

Signal Loads - LED

A Signal circuit is sized for the ultimate load that can be drawn at one time. This is usually the **sum** of the items below:

300W ------ **Controller**

1800W ----- **2-GFCI's** (receptacles - vent fan & cabinet light(s) are included within this load)

15W ------- multiply by the Total # of **Pedestrian Displays**

25W for 12" heads (signal displays) **or**

15W for 8" heads (flashing beacon displays)-multiply by the **Total # of Vehicle Display Lamps** illuminated at one time (1 Lamp per 3 section display, 2 Lamps per 4 or 5 section display)

USE THESE NUMBERS FOR SIZING CONDUCTORS.

Signal Loads – LED - Example

For a **“T” intersection** use 9-vehicle heads, and 6-pedestrian heads.

$$300W+1800W+(9*25W)+(6*15W)=2415W$$

$$\frac{2415W}{120V}=20.125Amps$$

For a **four legged intersection** use 12-vehicle heads, and 8-pedestrian heads.

$$300W+1800W+(12*25W)+(8*15W)=2520W$$

$$\frac{2520W}{120V}=21.00Amps$$

If there are supplemental heads used in your design these values may be larger. Use these values as a minimum.

Signal Loads - incandescent

A Signal circuit is sized for the ultimate load that can be drawn at one time. This is usually the **sum** of the items below:

300W ------ **Controller**

1800W ----- **2-GFCI's** (receptacles - vent fan & cabinet light(s) are included within this load)

116W ------- multiply by the Total # of **Pedestrian Displays**

165W for 12" heads (signal displays) **or**

69W for 8" heads (flashing beacon displays)-multiply by the **Total # of Vehicle Display Lamps** illuminated at one time (1 Lamp per 3 section display, 2 Lamps per 4 or 5 section display)

USE THE LED NUMBERS FOR SIZING CONDUCTORS.

Signal Loads - incandescent - Example

For a **<u>"T" intersection</u>** use 9-vehicle heads, and 6-pedestrian heads.

$$300W+1800W+(9*165W)+(6*116W)=4281W$$

$$\frac{4281W}{120V}=35.675Amps$$

For a **<u>four legged intersection</u>** use 12-vehicle heads, and 8-pedestrian heads.

$$300W+1800W+(12*165W)+(8*116W)=5008W$$

$$\frac{5008W}{120V}=41.73Amps$$

If there are supplemental heads used in your design these values may be larger. Use these values as a minimum.

Flashing Beacons

- 8” Lens – incandescent
- 1 lamp = 69 watts
- 2 lamps = 138 watts
- 4 lamps = 276 watts
- 8” Lens – LED
- 1 lamp = 15 watts
- 2 lamps = 30 watts
- 4 lamps = 60 watts

- 12” Lens – incandescent
- 1 lamp = 165 watts
- 2 lamps = 330 watts
- 4 lamps = 660 watts
- 12” Lens – LED
- 1 lamp = 25 watts
- 2 lamps = 50 watts
- 4 lamps = 100 watts

•The dimmable flashing unit draws 0.005 amps at 120 volts. For line loss calculation purposes, you can ignore the dimming flasher unit load.

•A large majority of existing flashers have 1 or 2 eight inch lens. The need would have to be great before you would use twelve inch lens.

Illumination Loads

Each luminaire has a different lamp load factor depending on what **wattage** lamp and what **voltage** you are using. You have to check the manufacturers catalog cuts to see what voltage the particular luminaire draws during it's "start-up" period. This is roughly the same as **multiplying the wattage by 1.2 then dividing by the serving voltage**, but the catalog values are more accurate. These are the numbers from the GE catalog.

Bulb Wattage	HPS AMPS Load@ 240V	HPS AMPS Load@ 480V	MH AMPS Load@ 240V	MH AMPS Load@ 480V
100	0.6	0.3		
150	0.9	0.5		
175*	0.9	0.5		
200	1.1	0.6	1.1	
250	1.4	0.7	1.3	0.6
310	1.7	0.9	1.7	
400	2.1	1.1	2.0	1.0
1000	4.8	2.5		

* Mercury Vapor

Illumination Load Examples

175W MV = ~ 240w / 480v = 0.5 Amps

250w HPS = ~ 336w / 480v = 0.7Amps

310w HPS = ~ 432w / 480v = 0.9Amps

400w HPS = ~ 528w / 480v = 1.1Amps

Things to consider when laying out your circuits

Try to balance the loads on your circuits.

Run an individual branch circuit to each cabinet.

No illumination circuit breaker can be larger than 50 amps. **(NEC 2005 210.23 D)**

Distance vs load… running large wire a long distance…it may be better to install a new service.

Example: 1000' of #2 wire inside 2" conduit = $26,860.

New Type B, 25 feet of conduit & #8 conductors +$6,000 (plus utility hookup fee).

Stagger lights on different circuits on a roadway:

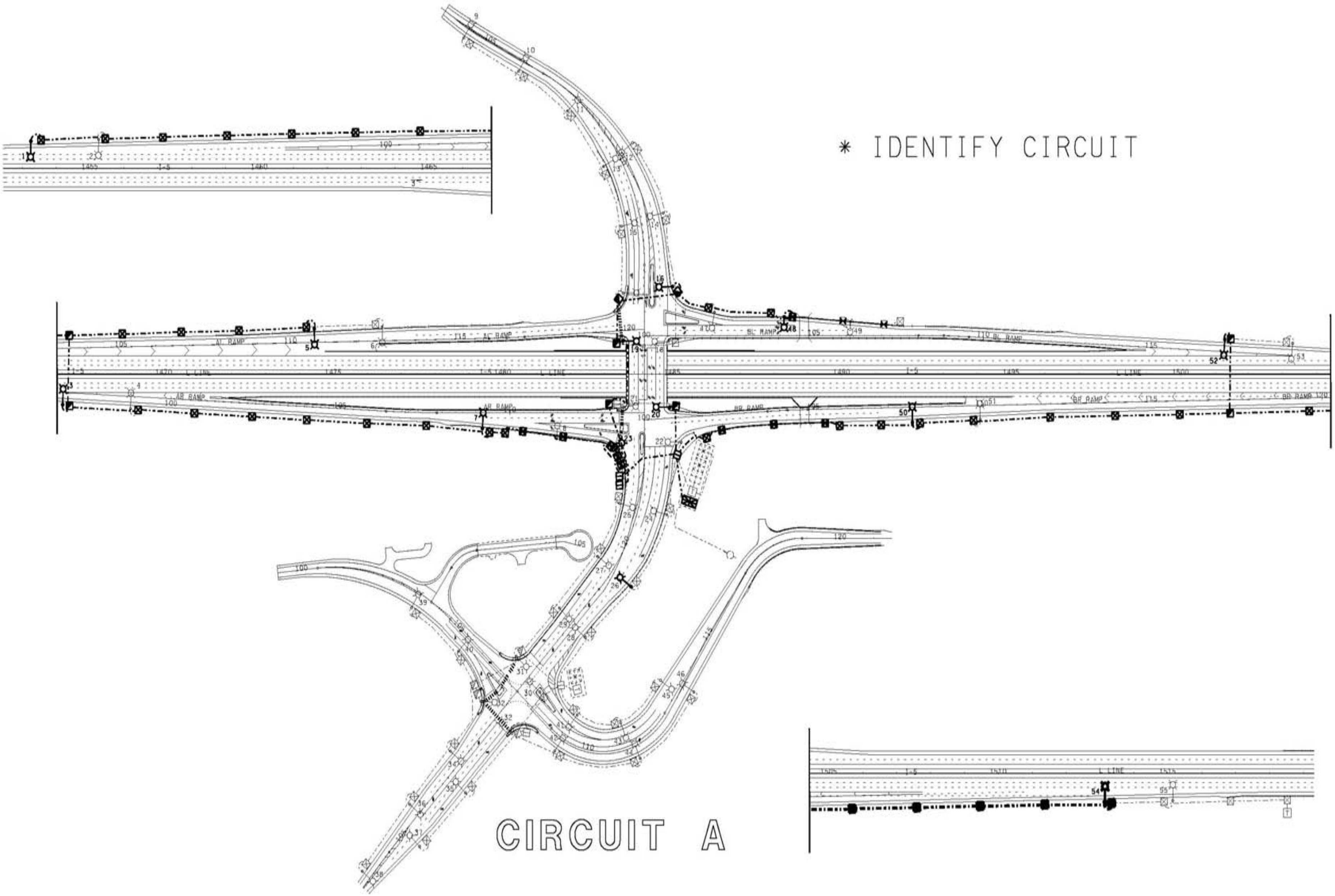
Order of preference:

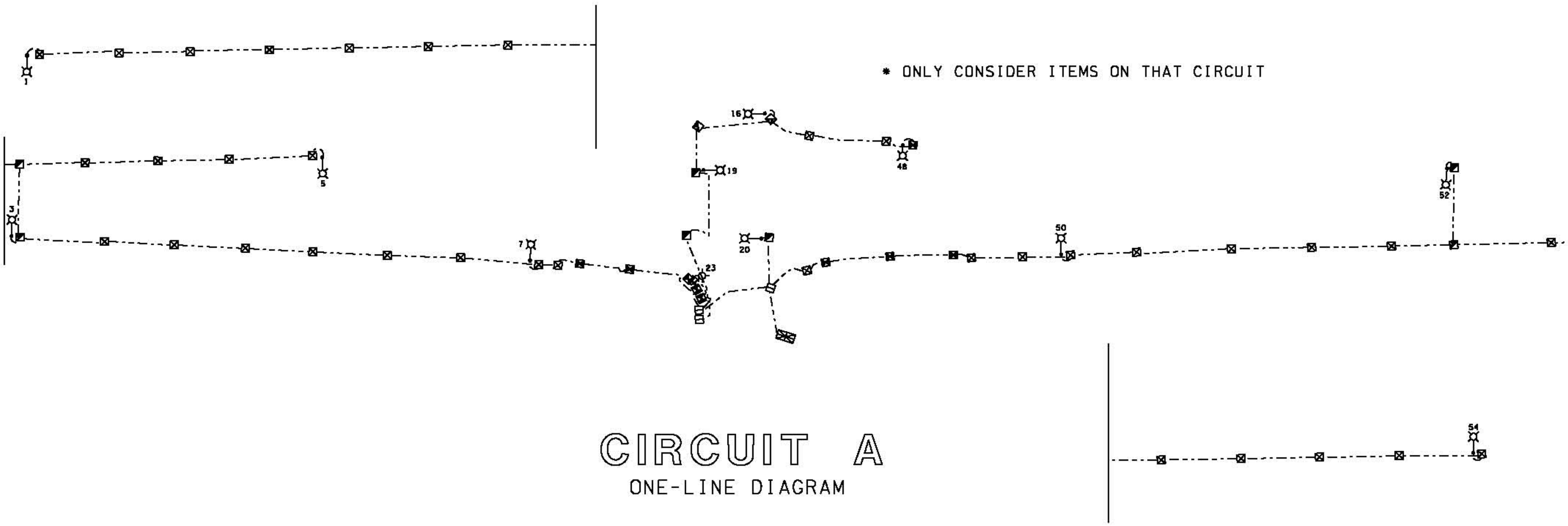
Every other light on a roadway is on a different circuit.

Each side of roadway is on a different circuit.

Each leg of an intersection is on a different circuit.

Everything is on one circuit.

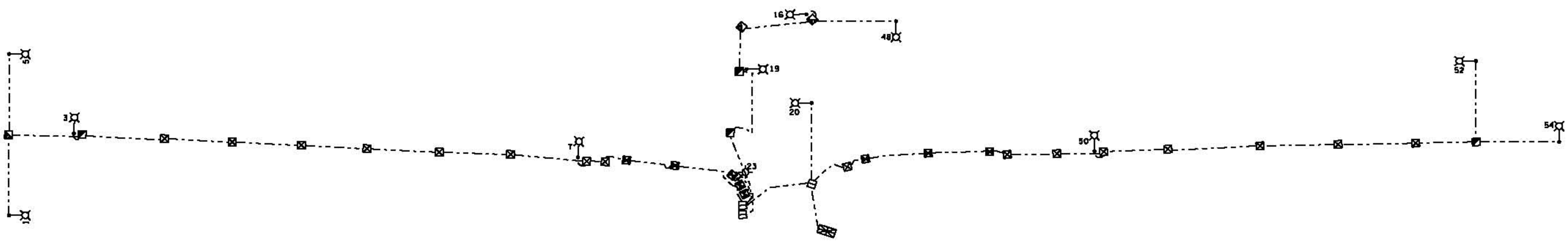

* IDENTIFY CIRCUIT
CIRCUIT A



CIRCUIT A

ONE-LINE DIAGRAM

* BREAK EVERYTHING DOWN TO "POINT LOADS"



CIRCUIT A

ONE-LINE DIAGRAM

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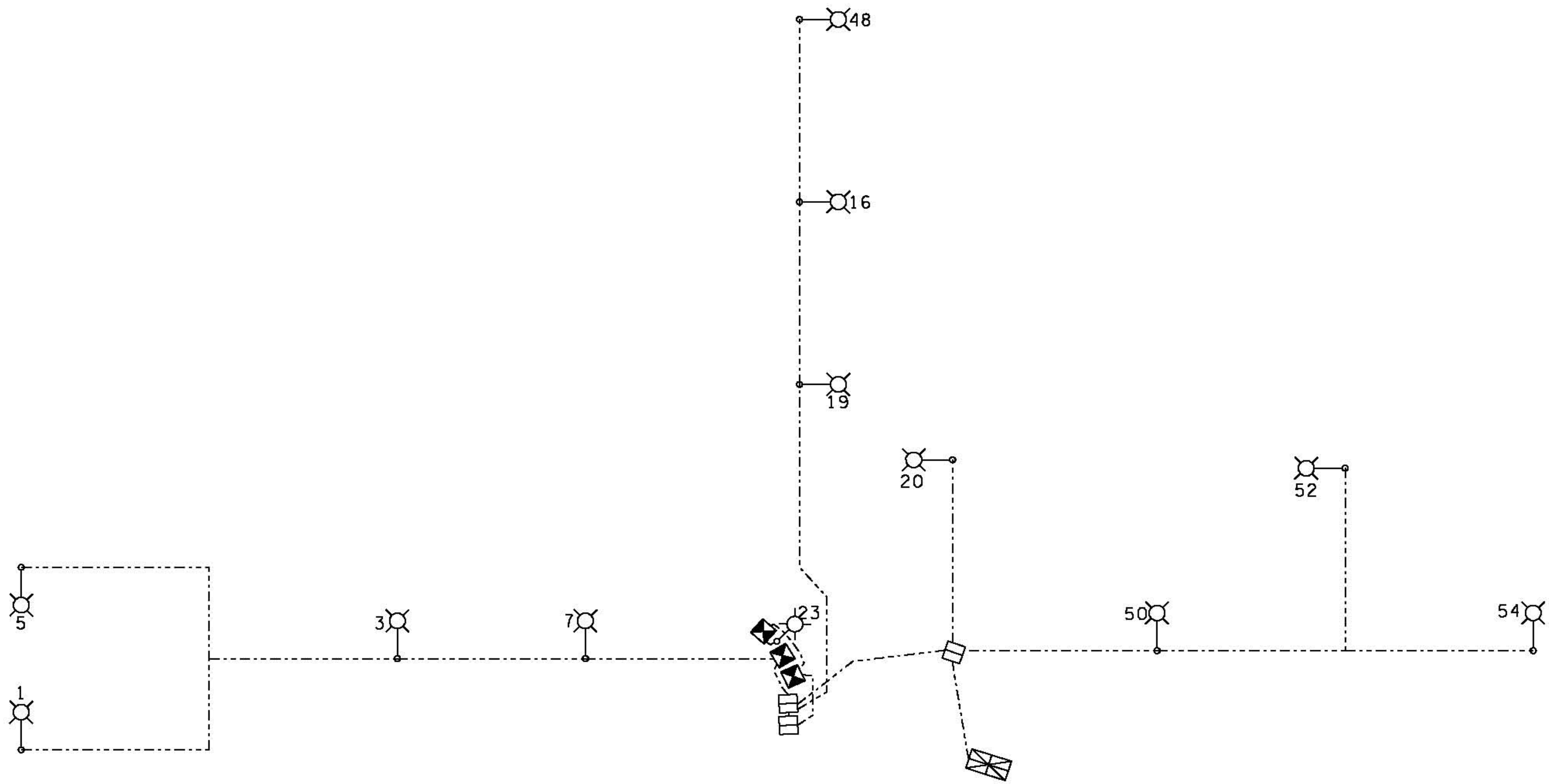
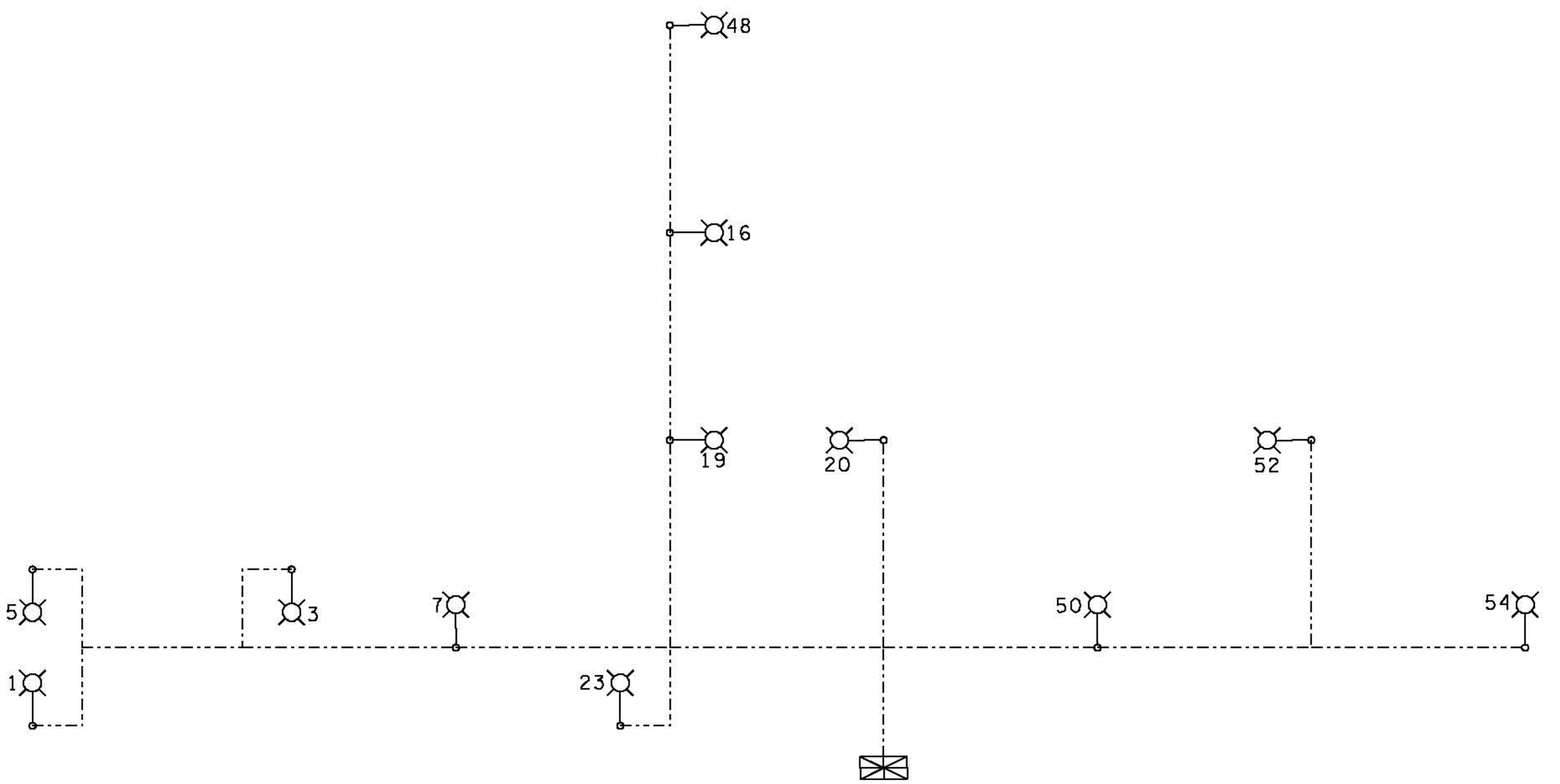


CIRCUIT A

ONE-LINE DIAGRAM

* BREAK EVERYTHING DOWN
TO "POINT LOADS"



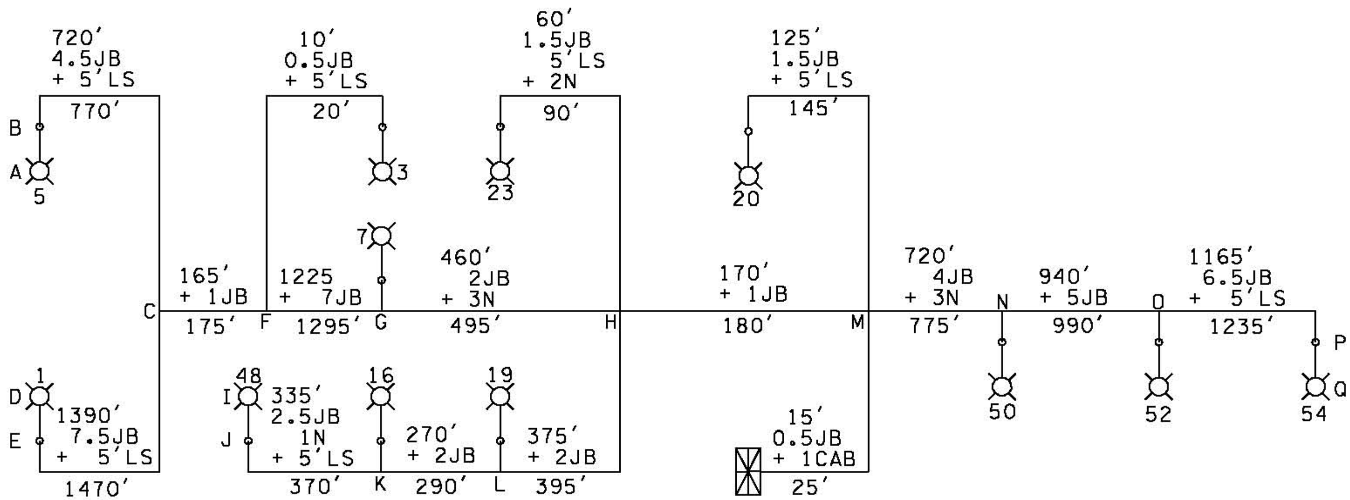
CIRCUIT A

ONE-LINE DIAGRAM

* LAY IN YOUR DISTANCES, THIS INCLUDES ALL ADDITIONS FOR JUNCTION BOXES, CABINETS, ETC.

NOTES:

1) ALL IN GRADE LUMINAIRES ARE 40' MOUNTING HEIGHT, 16' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (52' TOTAL WIRE LENGTH).
2) ALL STRUCTURE MOUNTED LUMINAIRES ARE 40' MOUNTING HEIGHT, 10' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (46' TOTAL WIRE LENGTH).
3) ADD 10' TO WIRE LENGTH FOR ALL IN GRADE JUNCTION BOXES.
4) ADD 5' TO WIRE LENGTH FOR ALL NEMA JUNCTION BOXES.
5) ADD 5' TO WIRE LENGTH FOR ALL CABINET TERMINATIONS.
6) ADD 5' FOR THE CONDUIT SWEEP INTO LUMINAIRE.



CIRCUIT A

ONE-LINE DIAGRAM

* IDENTIFY YOUR LARGEST LEG
TO DETERMINE WIRE SIZE

NOTES:

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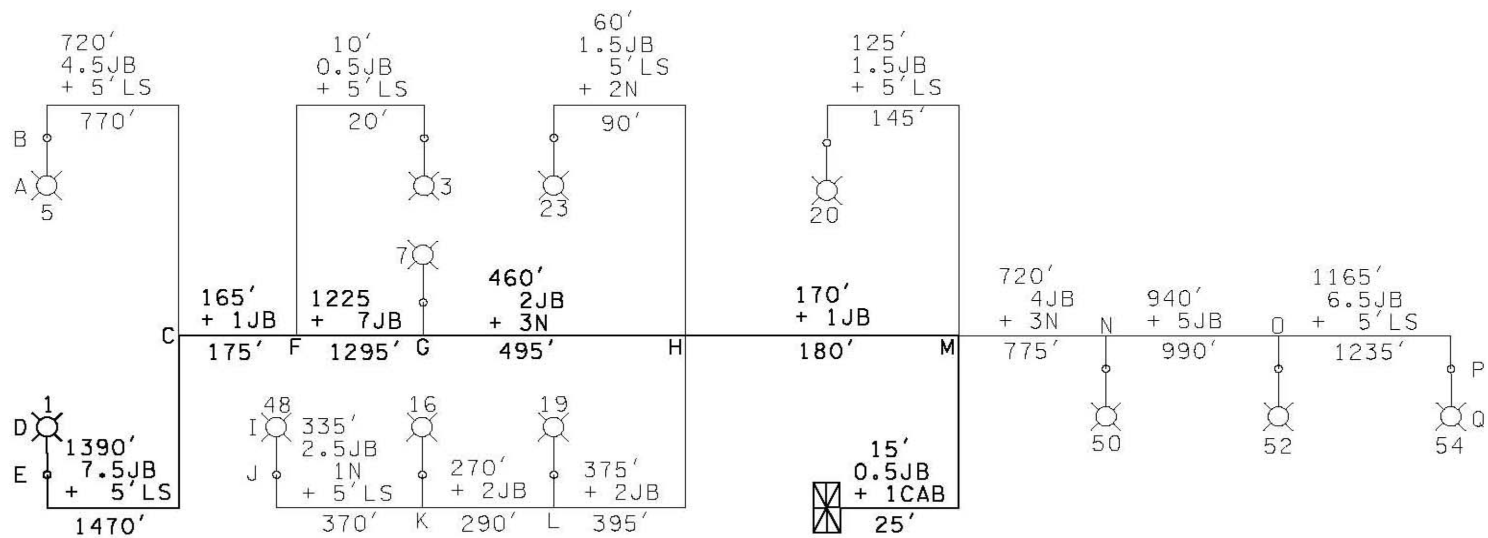

CIRCUIT A

LINE LOSS LEG 1

Circuit A Load calculations

Illumination Circuit A load

12-250 watt, HPS Luminaires, 480 VAC, 0.7 Amps per luminaire

12 x 0.7 amps = 8.4 Amps

Voltage Drop for Circuit A , Leg #1 – 1st try

Total load on Segment

Wire out and Back

Vd=2ALR

Total length of Segment

Resistance of #8 conductor

Service to M=2(8.4)(5cab+15+5(1/2jb)=25)(0.000809) =0.339780

M to H =2(5.6)(10(1jb)+170=180)(0.000809) =1.630944

H to G =2(2.8)(20(2jb)+460+15(3n)=495)(0.000809) =2.242548

G to F =2(2.1)(70(7jb)+1225 =1295)(0.000809) =4.400151

F to C =2(1.4)(10(1jb)+165 =175)(0.000809) =0.396410

C to E =2(0.7)(70(7jb)+1390+5(1/2jb)+5(ls) =1470)(0.000809)=1.664922

Hand hole to Light =2(0.7)(52)(0.001290) =0.093912

10.768667

10.768667/480=0.022434*100=2.2% Vd

2.2% < 5% - #8 wire is acceptable

Resistance of #8 conductor

Resistance of #10 conductor

* IDENTIFY YOUR LARGEST LEG
TO DETERMINE WIRE SIZE

NOTES:

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3) ADD 10′ TO WIRE LENGTH FOR ALL IN GRADE JUNCTION BOXES.
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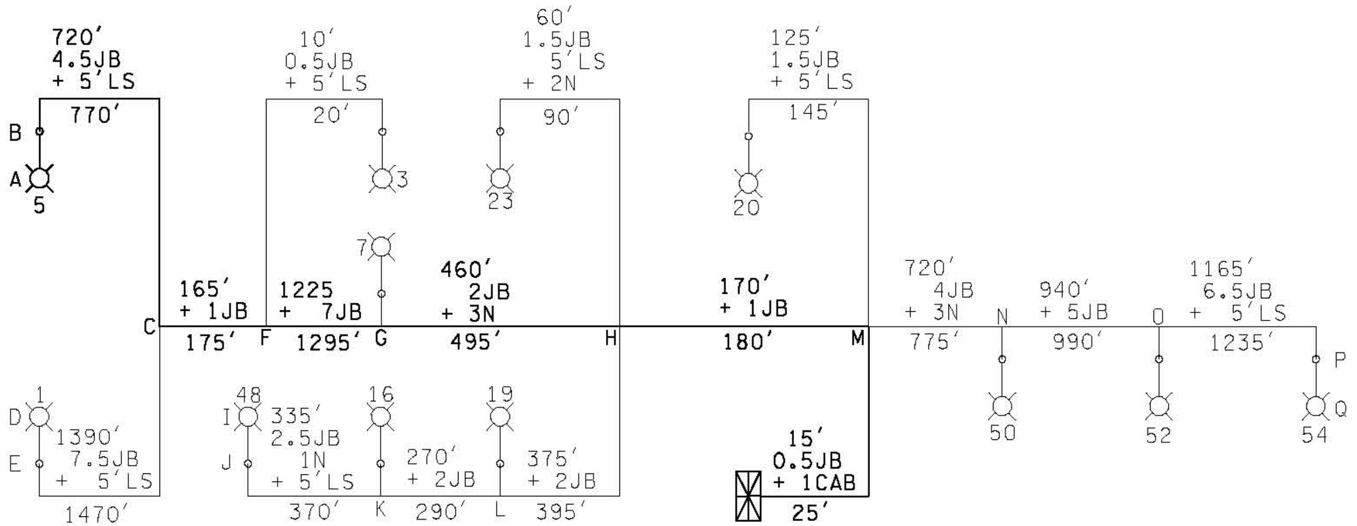

CIRCUIT A

LINE LOSS LEG 2

Voltage Drop for Circuit A , Leg #2 – 1st try

Total load on Segment

Wire out and Back

Vd=2ALR

Resistance of #8 conductor

Total length of Segment

Service to M	=2(8.4)(5cab+15+5(1/2jb)=25)(0.000809)	=0.339780
M to H	=2(5.6)(10(1jb)+170=180)(0.000809)	=1.630944
H to G	=2(2.8)(20(2jb)+460+15(3n)=495)(0.000809)	=2.242548
G to F	=2(2.1)(70(7jb)+1225 =1295)(0.000809)	=4.400151
F to C	=2(1.4)(10(1jb)+165 =175)(0.000809)	=0.396410
C to B	=2(0.7)(45(4.5jb)+720+5(ls)=770)(0.000809)	=0.872102
Hand hole to Light	=2(0.7)(52)(0.001290)	=0.093912
		9.975847

9.975847/480=0.020783*100=2.1% Vd

2.1% < 5% - #8 wire is acceptable

Resistance of #8 conductor

Resistance of #10 conductor

* IDENTIFY YOUR LARGEST LEG
TO DETERMINE WIRE SIZE

NOTES:

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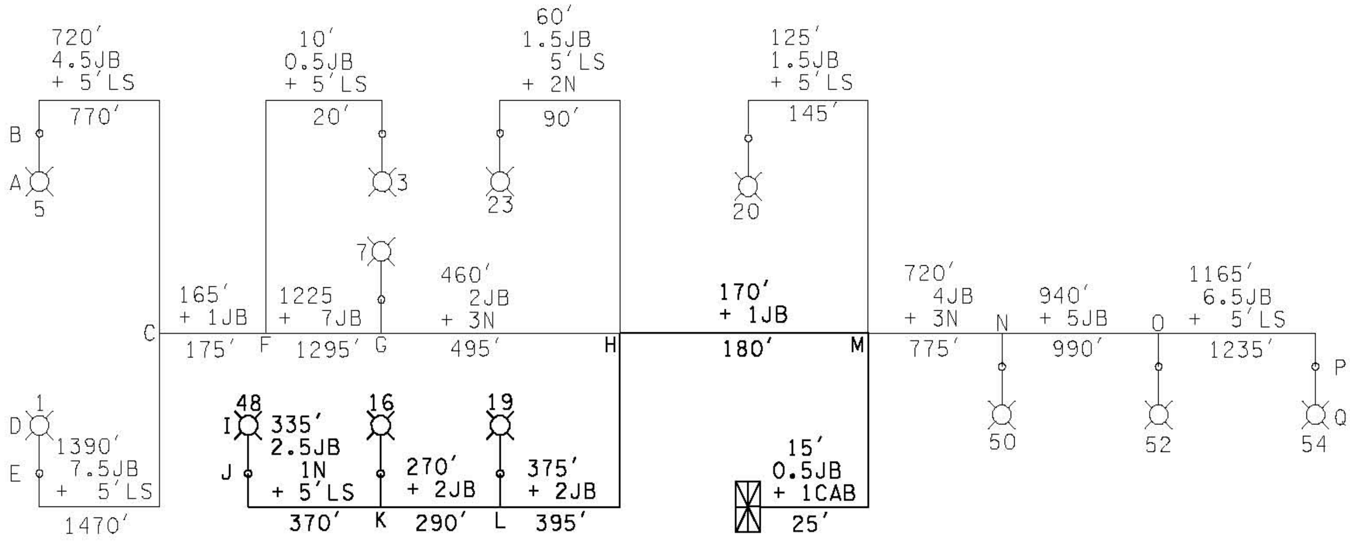


CIRCUIT A

LINE LOSS LEG 3

Voltage Drop for Circuit A , Leg #3 – 1st try

Vd=2ALR

Total load on Segment

Wire out and Back

Total length of Segment

Resistance of #8 conductor

Service to M	=2(8.4)(5cab+15+5(1/2jb)=25)(0.000809)	=0.339780
M to H	=2(5.6)(10(1jb)+170=180)(0.000809)	=1.630944
H to L	=2(2.1)(20(2jb)+375 =395)(0.000809)	=1.342131
L to K	=2(1.4)(20(2jb)+270 =290)(0.000809)	=0.656908
K to J	=2(0.7)(25(2.5jb)+335+5(1n)+5(ls) =370)(0.000809)	=0.419062
Hand hole to Light	=2(0.7)(52)(0.001290)	=0.093912
		4.482737

4.482737/480=0.009339*100=0.93% Vd

0.93% < 5% - #8 wire is acceptable

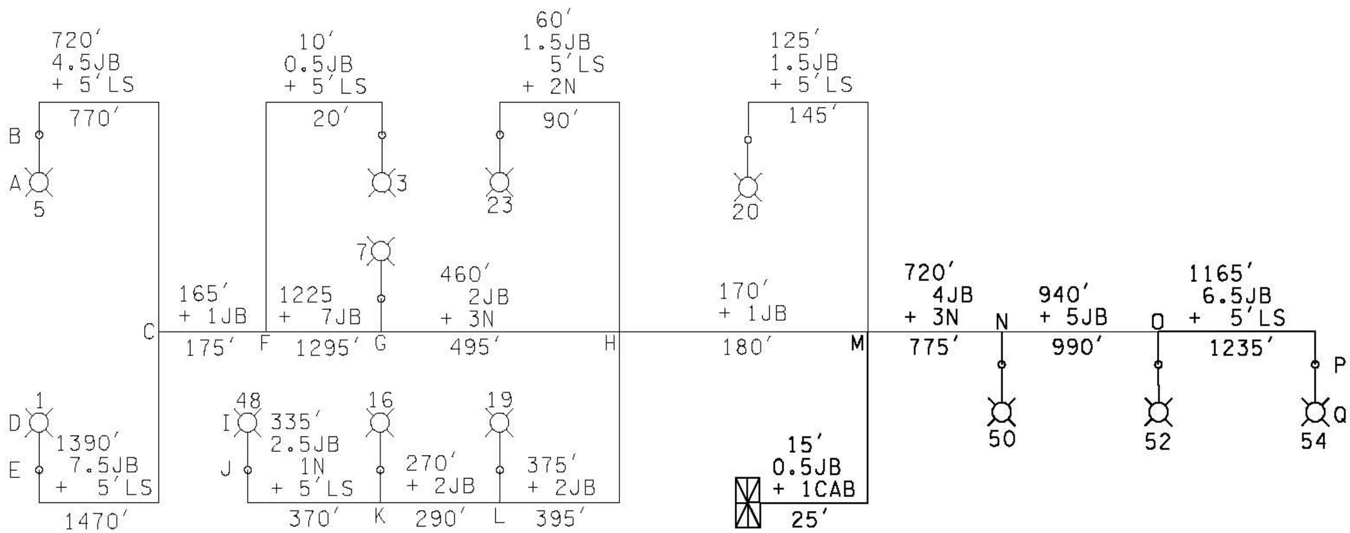
Resistance of #8 conductor

Resistance of #10 conductor

* IDENTIFY YOUR LARGEST LEG
TO DETERMINE WIRE SIZE

NOTES:

1) ALL IN GRADE LUMINAIRES ARE 40' MOUNTING HEIGHT, 16' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (52' TOTAL WIRE LENGTH).
2) ALL STRUCTURE MOUNTED LUMINAIRES ARE 40' MOUNTING HEIGHT, 10' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (46' TOTAL WIRE LENGTH).
3) ADD 10' TO WIRE LENGTH FOR ALL IN GRADE JUNCTION BOXES.
4) ADD 5' TO WIRE LENGTH FOR ALL NEMA JUNCTION BOXES.
5) ADD 5' TO WIRE LENGTH FOR ALL CABINET TERMINATIONS.
6) ADD 5' FOR THE CONDUIT SWEEP INTO LUMINAIRE.



CIRCUIT A

LINE LOSS LEG 4

Voltage Drop for Circuit A , Leg #4 – 1st try

Total load on Segment

Wire out and Back

Vd=2ALR

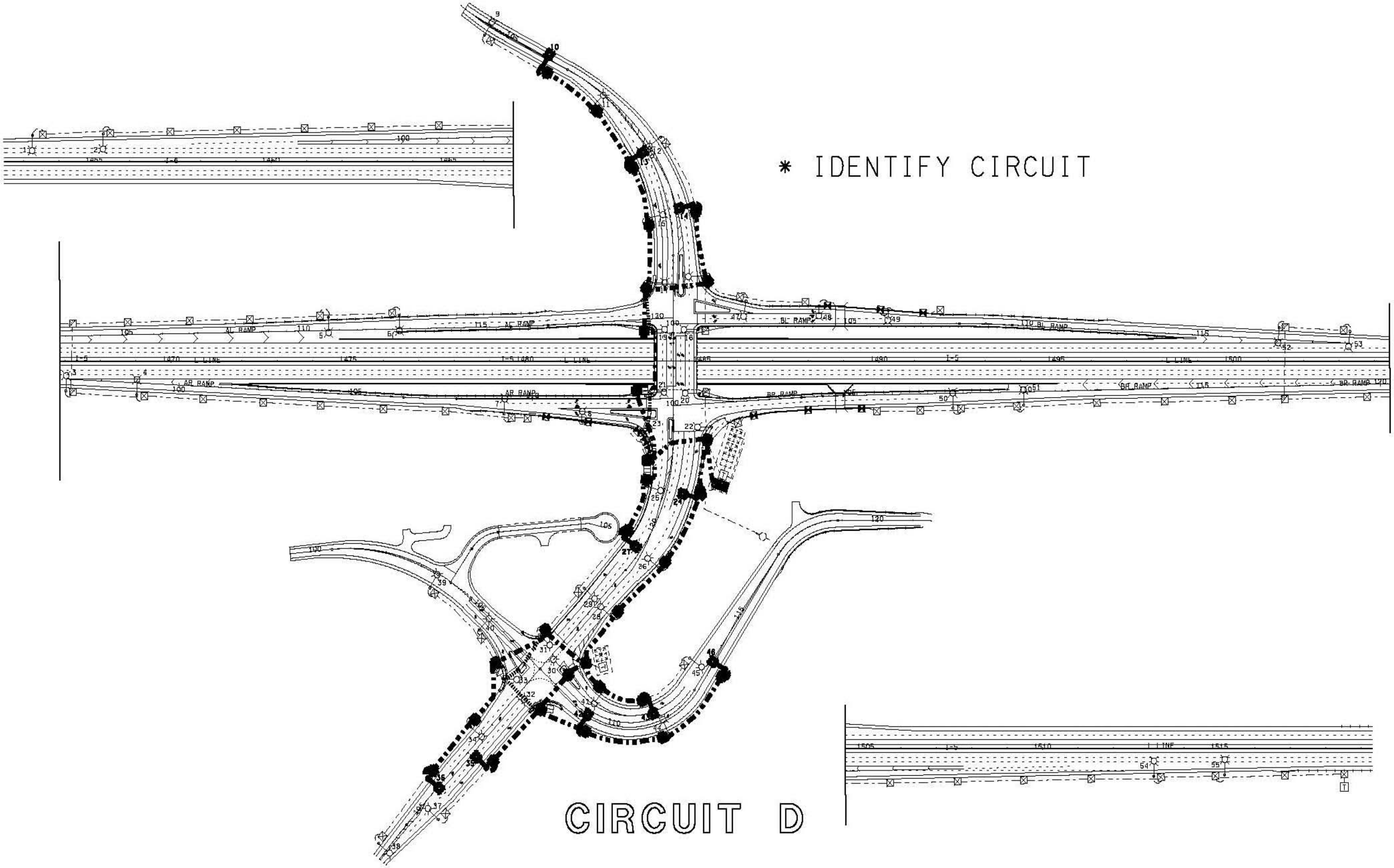
Total length of Segment

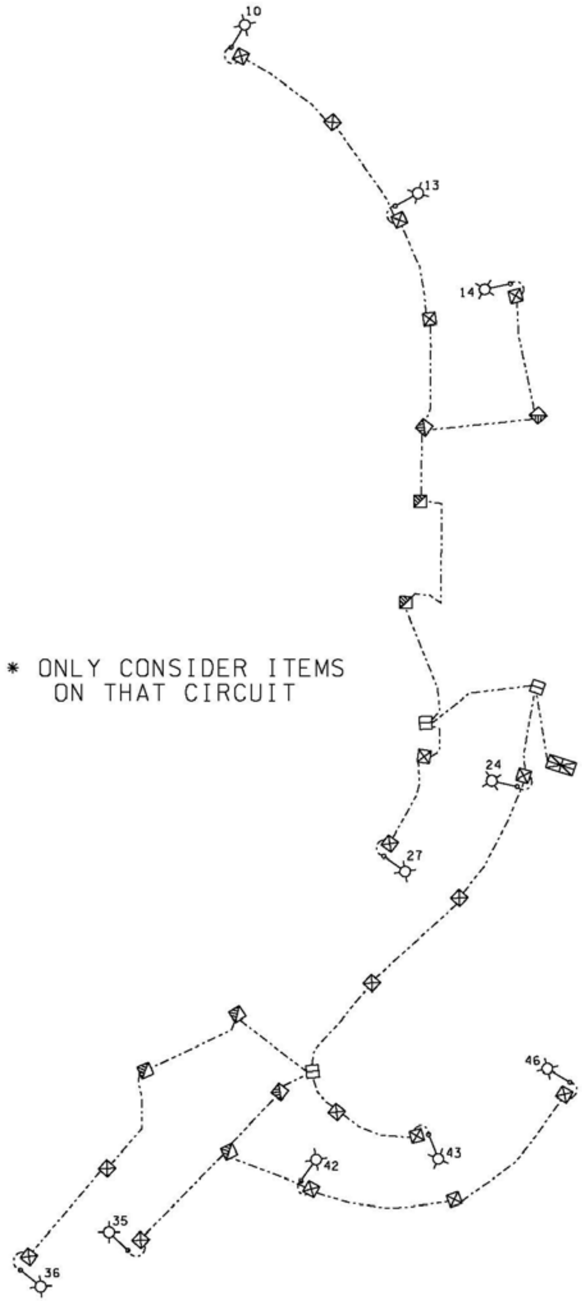
Resistance of #8 conductor

Service to M=2(8.4)(5cab+15+5(1/2jb)=25)(0.000809) =0.339780
M to N =2(2.1)(40(4jb)+725+10(2n)=775)(0.000809) =2.633295
N to O =2(1.4)(50(5jb)+940=990)(0.000809) =2.242548
O to P =2(0.7)(60(6jb)+1165+5(1/2jb)+5(ls)=1235)(0.000809)=1.398761
Hand hole to Light =2(0.7)(52)(0.001290) =0.093912
6.708296

6.708296/480=0.013976*100=1.40% Vd
1.40% < 5% - #8 wire is acceptable

Resistance of #8 conductor
Resistance of #10 conductor


* IDENTIFY CIRCUIT
CIRCUIT D

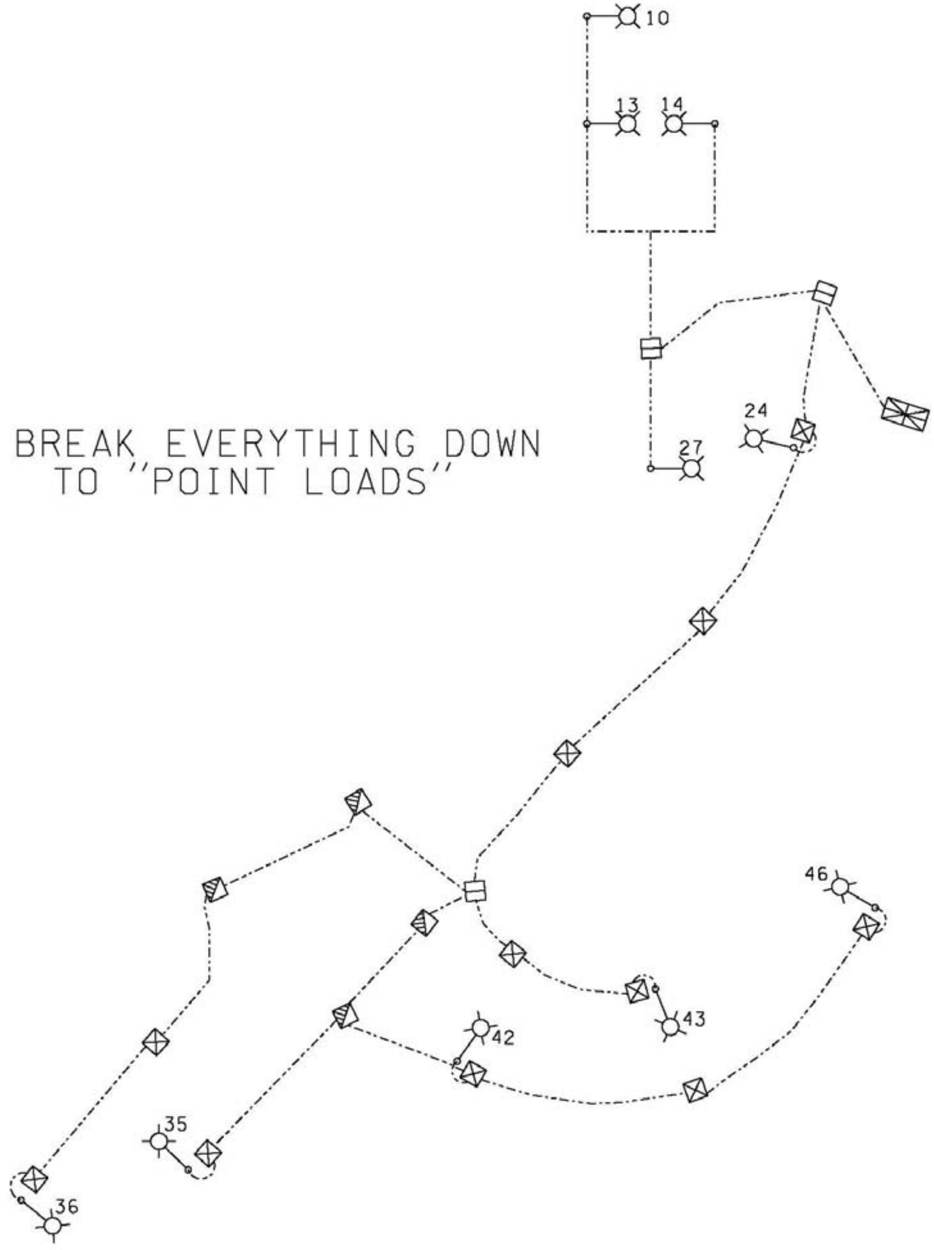


* ONLY CONSIDER ITEMS
ON THAT CIRCUIT

CIRCUIT D

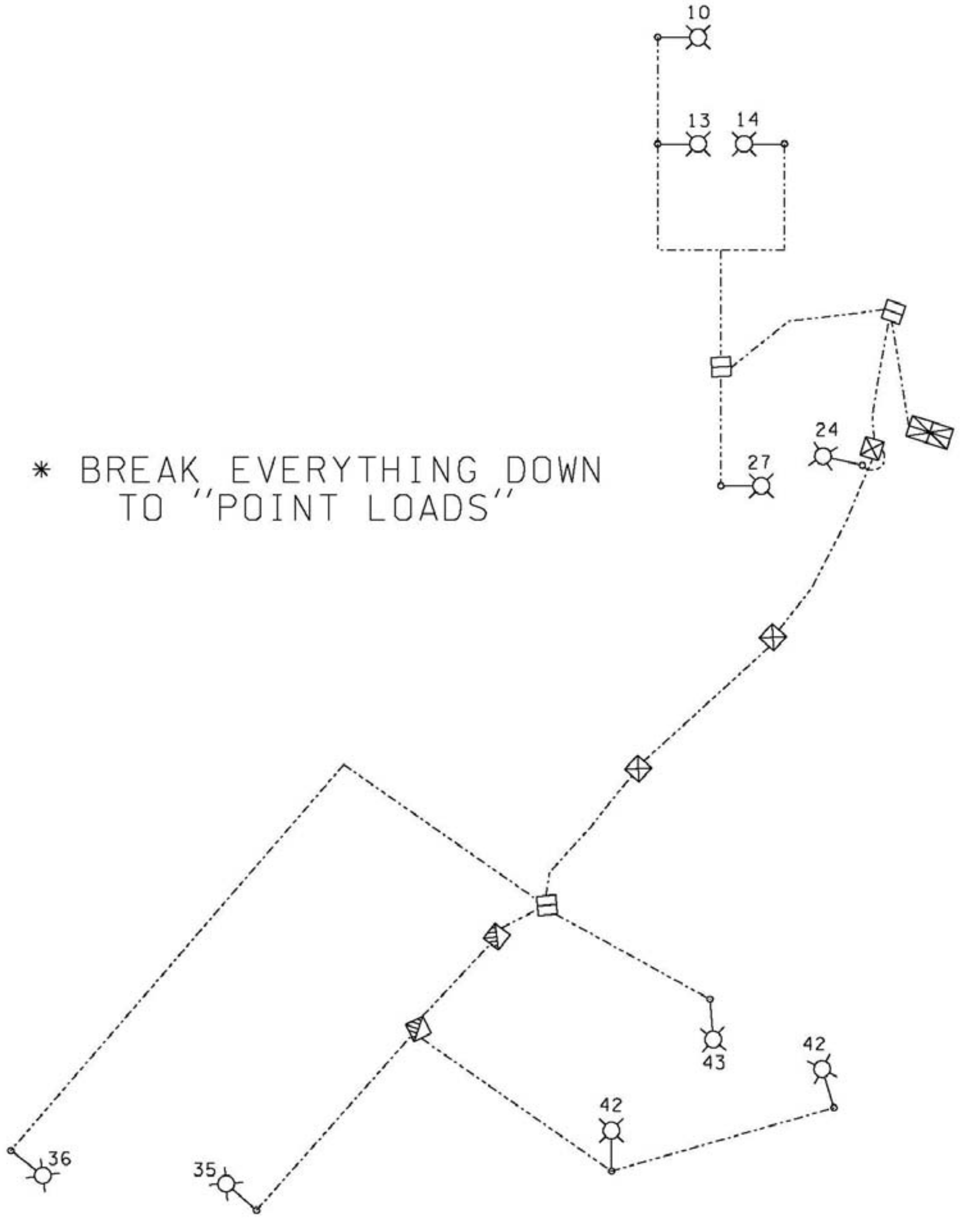
ONE-LINE DIAGRAM

* BREAK EVERYTHING DOWN
TO "POINT LOADS"



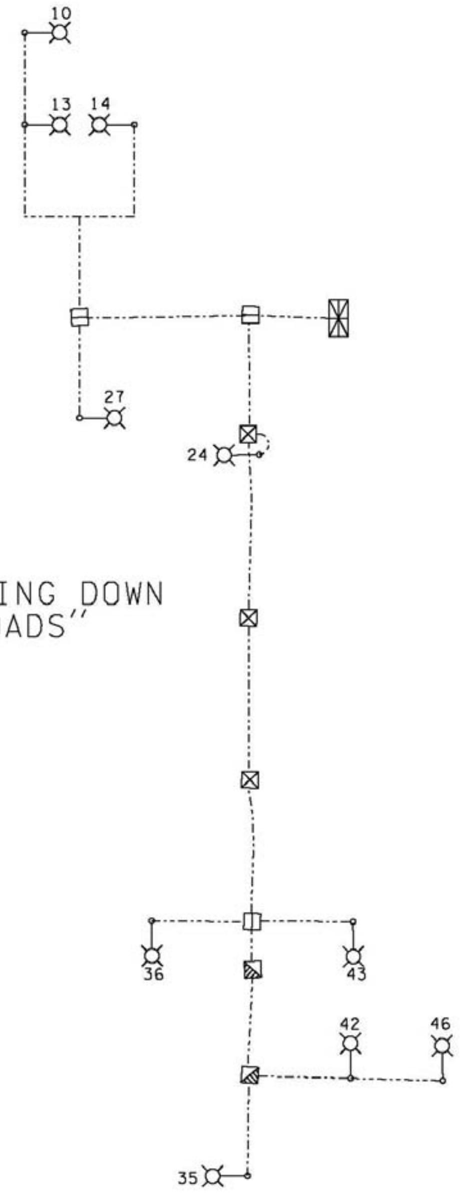
CIRCUIT D

ONE-LINE DIAGRAM



CIRCUIT D

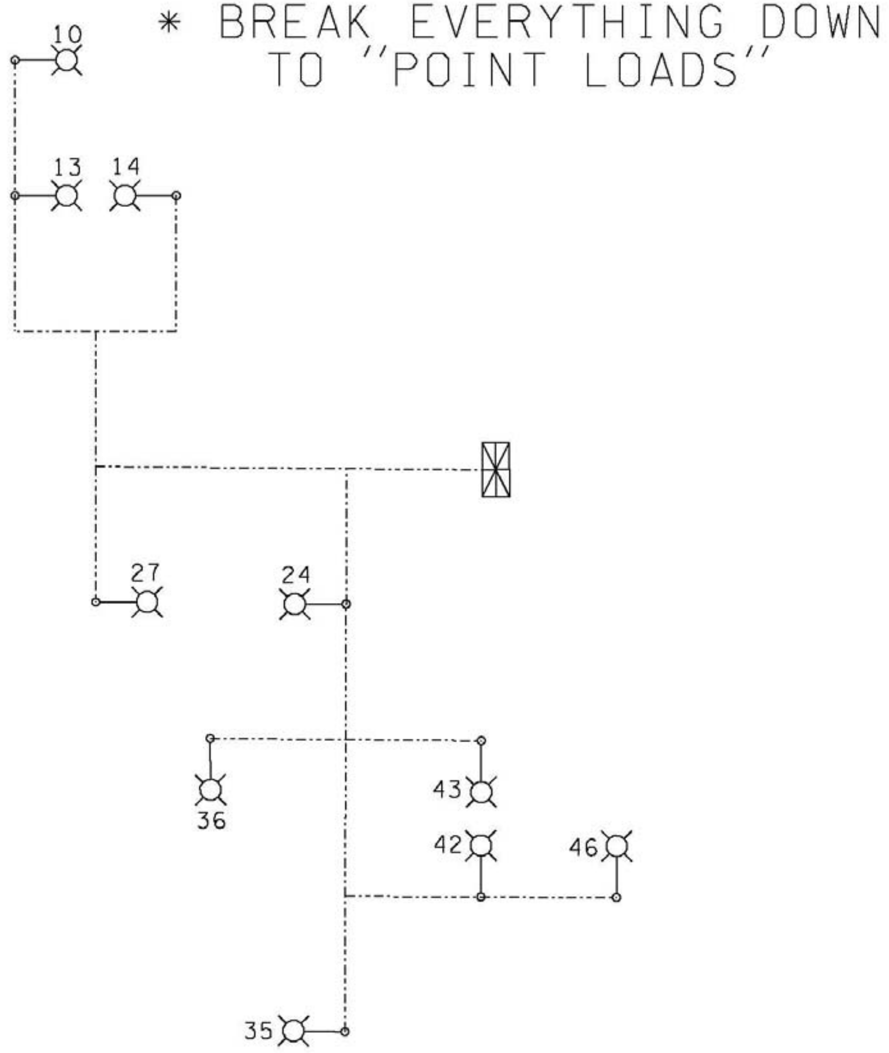
ONE-LINE DIAGRAM



* BREAK EVERYTHING DOWN
TO "POINT LOADS"

CIRCUIT D

ONE-LINE DIAGRAM



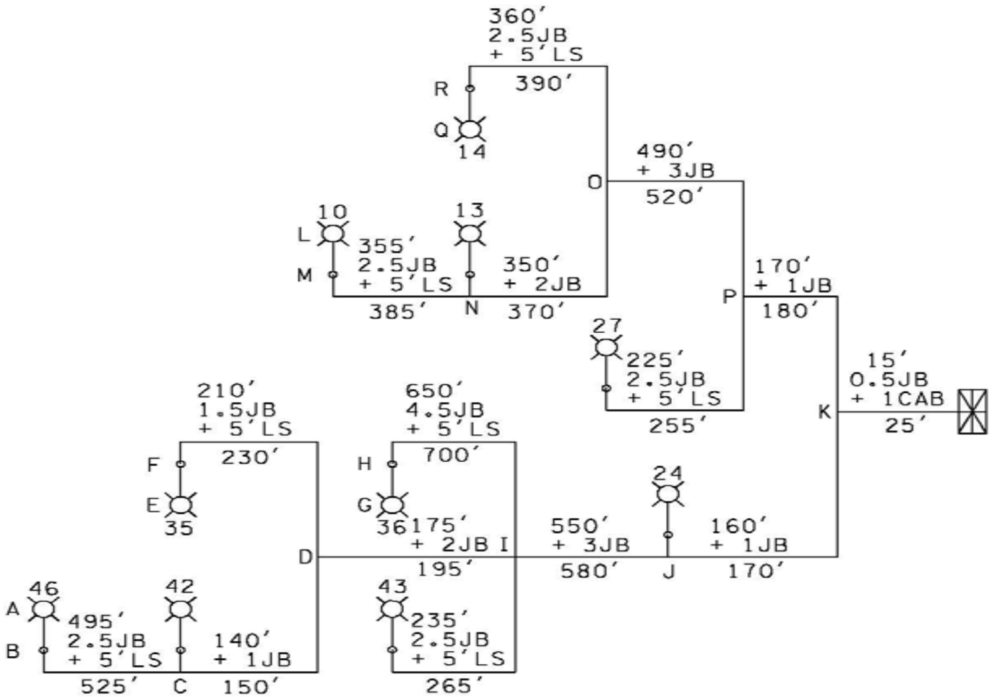
CIRCUIT D

ONE-LINE DIAGRAM

* LAY IN YOUR DISTANCES

NOTES:

1) ALL IN GRADE LUMINAIRES ARE 40' MOUNTING HEIGHT, 16' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (52' TOTAL WIRE LENGTH).
2) ALL STRUCTURE MOUNTED LUMINAIRES ARE 40' MOUNTING HEIGHT, 10' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (46' TOTAL WIRE LENGTH).
3) ADD 10' TO WIRE LENGTH FOR ALL IN GRADE JUNCTION BOXES.
4) ADD 5' TO WIRE LENGTH FOR ALL NEMA JUNCTION BOXES.
5) ADD 5' TO WIRE LENGTH FOR ALL CABINET TERMINATIONS.
6) ADD 5' FOR THE CONDUIT SWEEP INTO LUMINAIRE.



CIRCUIT D

ONE-LINE DIAGRAM

* IDENTIFY YOUR LARGEST LEG
TO DETERMINE WIRE SIZE

NOTES:

1) ALL IN GRADE LUMINAIRES ARE 40' MOUNTING HEIGHT, 16' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (52' TOTAL WIRE LENGTH).
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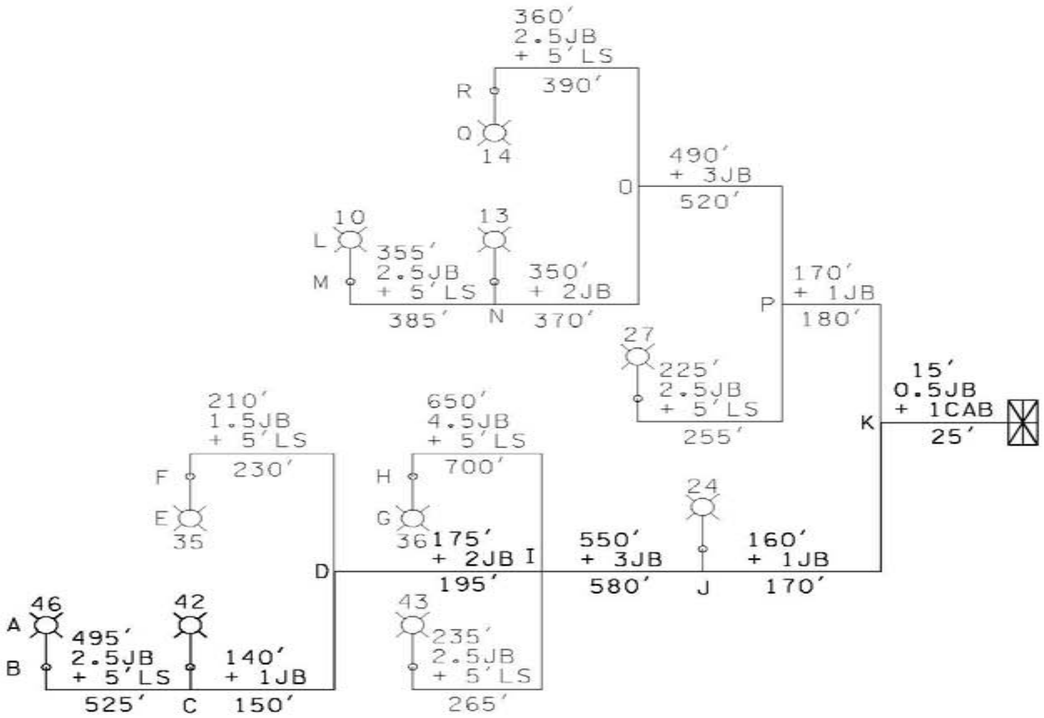

CIRCUIT D

LINE LOSS LEG 1

Circuit D Load calculations

Illumination Circuit D load

10-250 watt, HPS Luminaires, 480 VAC, 0.7 amps per luminaire

10 x 0.7 amps = 7.0 amps

Voltage Drop for Circuit D , Leg #1 – 1st try

Total load on Segment

Wire out and Back

Vd=2ALR

Resistance of #8 conductor

Total length of Segment

Service to K	=2(7.0)(5cab+15+5(1/2jb)=25)(0.000809)	=0.283150
K to J	=2(4.2)(10(1jb)+160=170)(0.000809)	=1.155252
J to I	=2(3.5)(30(3jb)+550=580)(0.000809)	=2.580710
I to D	=2(2.1)(20(2jb)+175 =195)(0.000809)	=0.662571
D to C	=2(1.4)(10(1jb)+140 =150)(0.000809)	=0.339780
C to B	=2(0.7)(25(2.5jb)+495+5(ls) =525)(0.000809)	=0.594615
Hand hole to Light	=2(0.7)(52)(0.001290)	=0.093912
		5.709990

5.709990/480=0.011896*100=1.2% Vd

1.2% < 5% - #8 wire is acceptable

Resistance of #8 conductor

Resistance of #10 conductor

* IDENTIFY YOUR LARGEST LEG
TO DETERMINE WIRE SIZE

NOTES:

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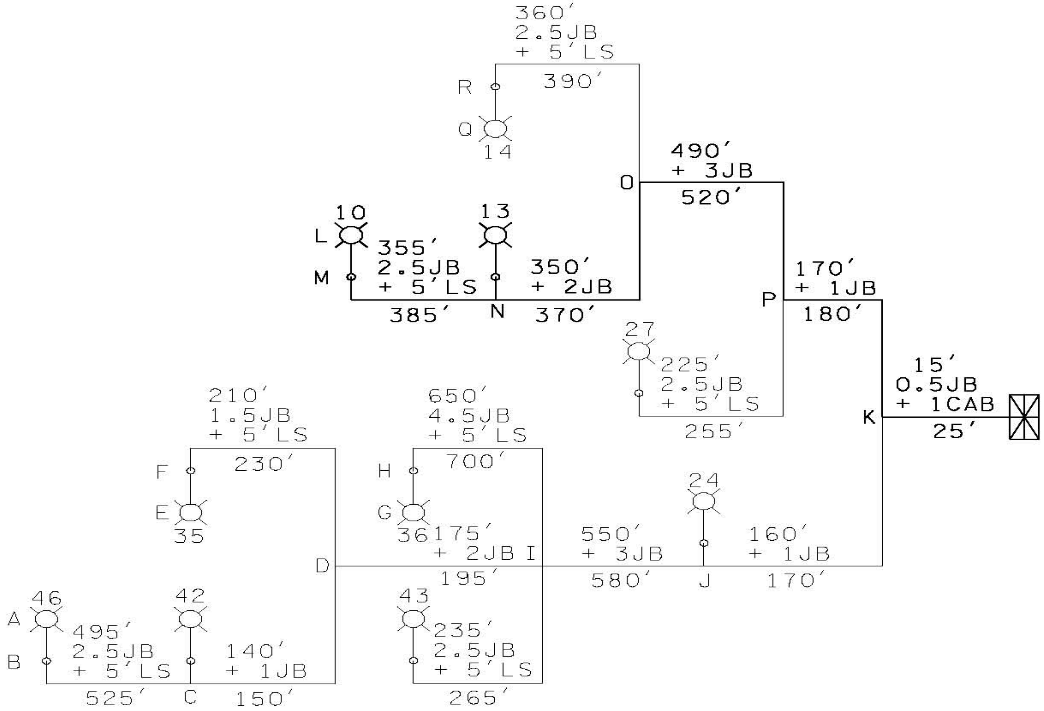
3) ADD 10' TO WIRE LENGTH FOR ALL IN GRADE JUNCTION BOXES.
4) ADD 5' TO WIRE LENGTH FOR ALL NEMA JUNCTION BOXES.
5) ADD 5' TO WIRE LENGTH FOR ALL CABINET TERMINATIONS.
6) ADD 5' FOR THE CONDUIT SWEEP INTO LUMINAIRE.



CIRCUIT D

LINE LOSS LEG 2

Voltage Drop for Circuit D , Leg #2 – 1st try

Total load on Segment

Wire out and Back

Vd=2ALR

Resistance of #8 conductor

Total length of Segment

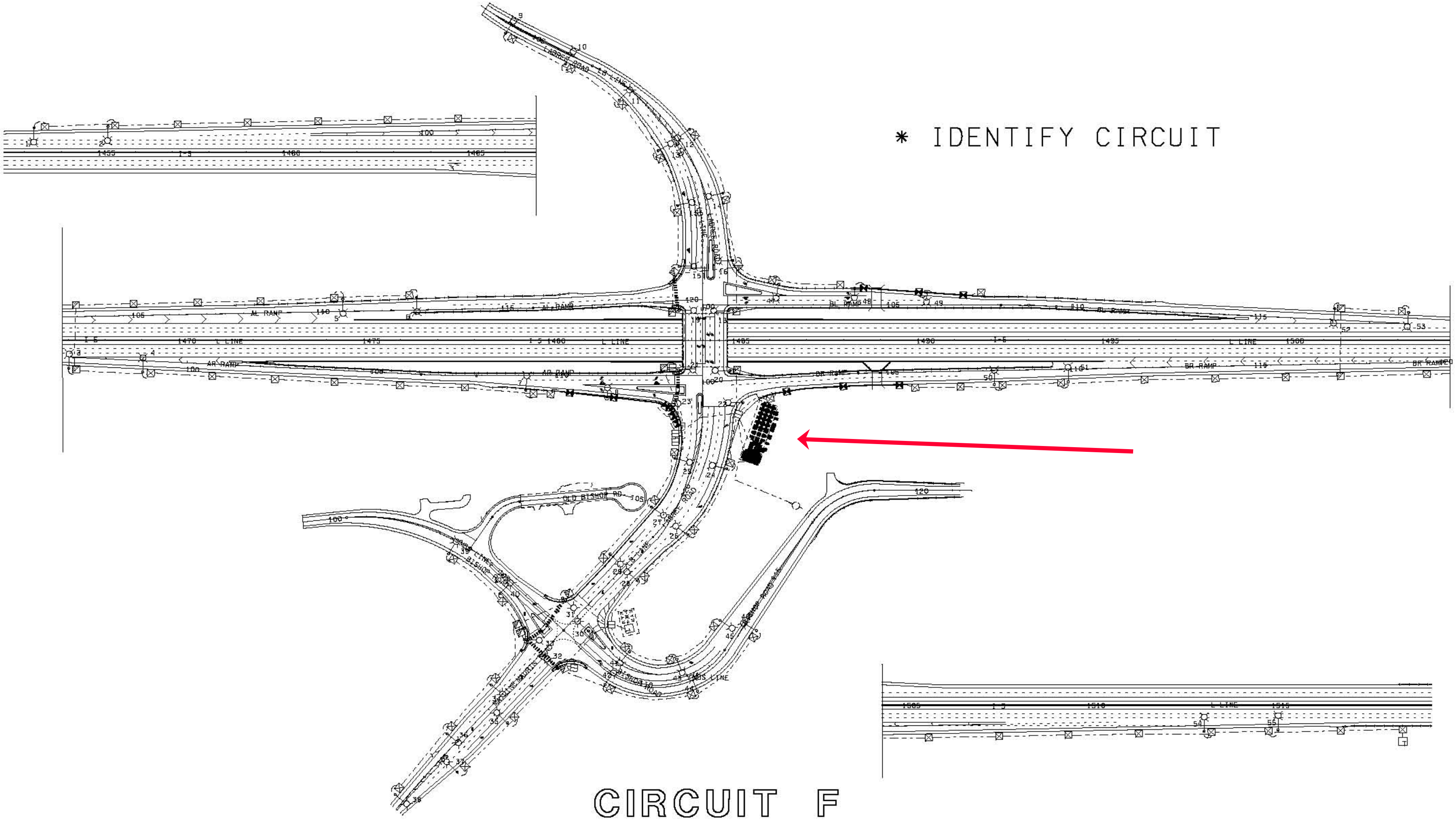
Service to K	=2(7.0)(5cab+15+5(1/2jb)=25)(0.000809)	=0.283150
K to P	=2(2.8)(10(1jb)+170=180)(0.000809)	=0.815472
P to O	=2(2.1)(30(3jb)+490)=520)(0.000809)	=1.766856
O to N	=2(1.4)(20(2jb)+350 =370)(0.000809)	=0.838124
N to M	=2(0.7)(20(2jb)+355+5(1/2jb)+5(ls)=385)(0.000809)	=0.436051
Hand hole to Light	=2(0.7)(52)(0.001290)	=0.093912
		4.233565

4.233565/480=0.008820*100=0.88% Vd

0.88% < 5% - #8 wire is acceptable

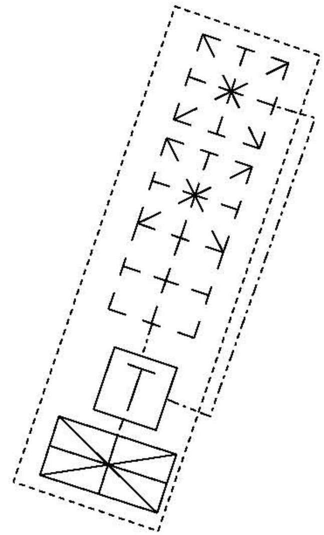
Resistance of #8 conductor

Resistance of #10 conductor



* IDENTIFY CIRCUIT
CIRCUIT F

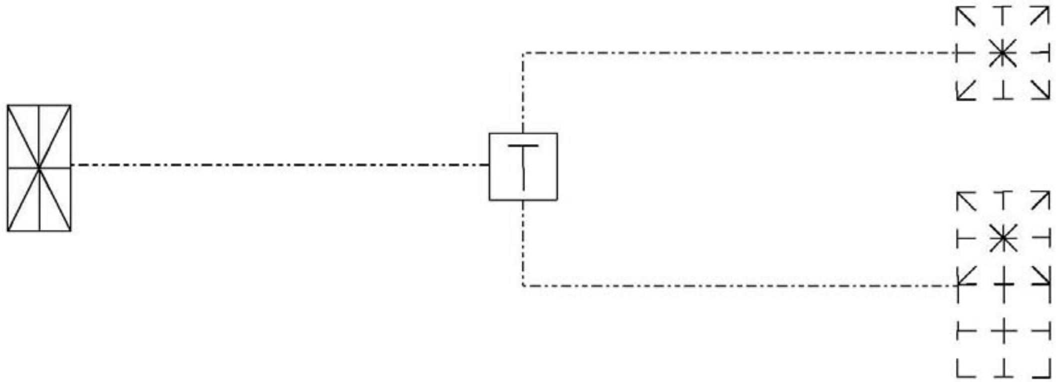
* ONLY CONSIDER ITEMS ON THAT CIRCUIT



CIRCUIT F

ONE-LINE DIAGRAM

* BREAK EVERYTHING DOWN
TO "POINT LOADS"



CIRCUIT F

ONE-LINE DIAGRAM

* LAY IN YOUR DISTANCES, THIS INCLUDES ALL ADDITIONS FOR JUNCTION BOXES, CABINETS, ETC.

NOTES:

1) ALL IN GRADE LUMINAIRES ARE 40' MOUNTING HEIGHT, 16' MAST ARMS, 250W HPS, III MEDIUM CUT OFF (52' TOTAL WIRE LENGTH).
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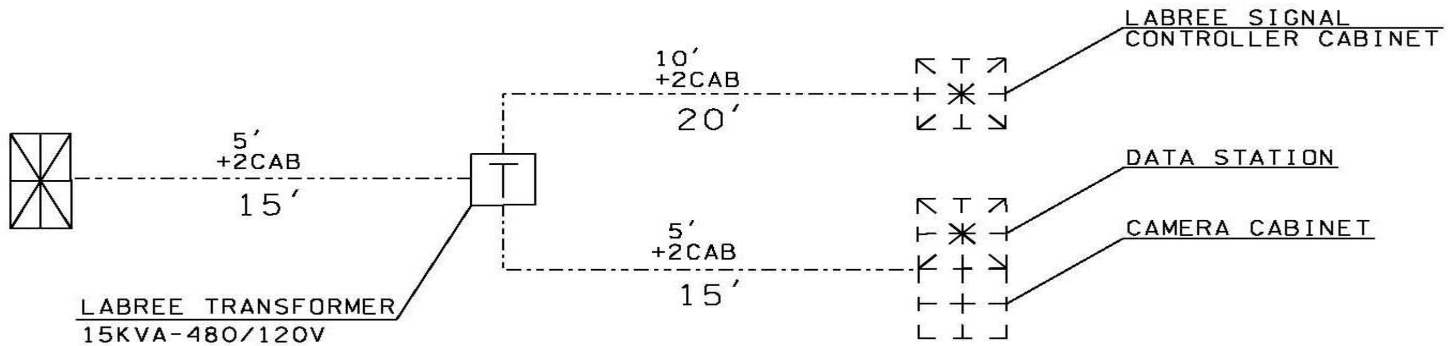
5) ADD 5' TO WIRE LENGTH FOR ALL CABINET TERMINATIONS.
6) ADD 5' FOR THE CONDUIT SWEEP INTO LUMINAIRE.



CIRCUIT F

ONE-LINE DIAGRAM

Voltage Drop for Circuit F – 1st try Vd=2ALR

Given: 480/120 volt - 15 kVA transformer.

Find Load: 15 kVA x 1000 = 15,000 watts

15,000watts / 480 volts = 31.25 Amps. Load = 31.25 Amps

Total length of Segment

Resistance of #8 conductor

Total load on Segment

Wire out and Back

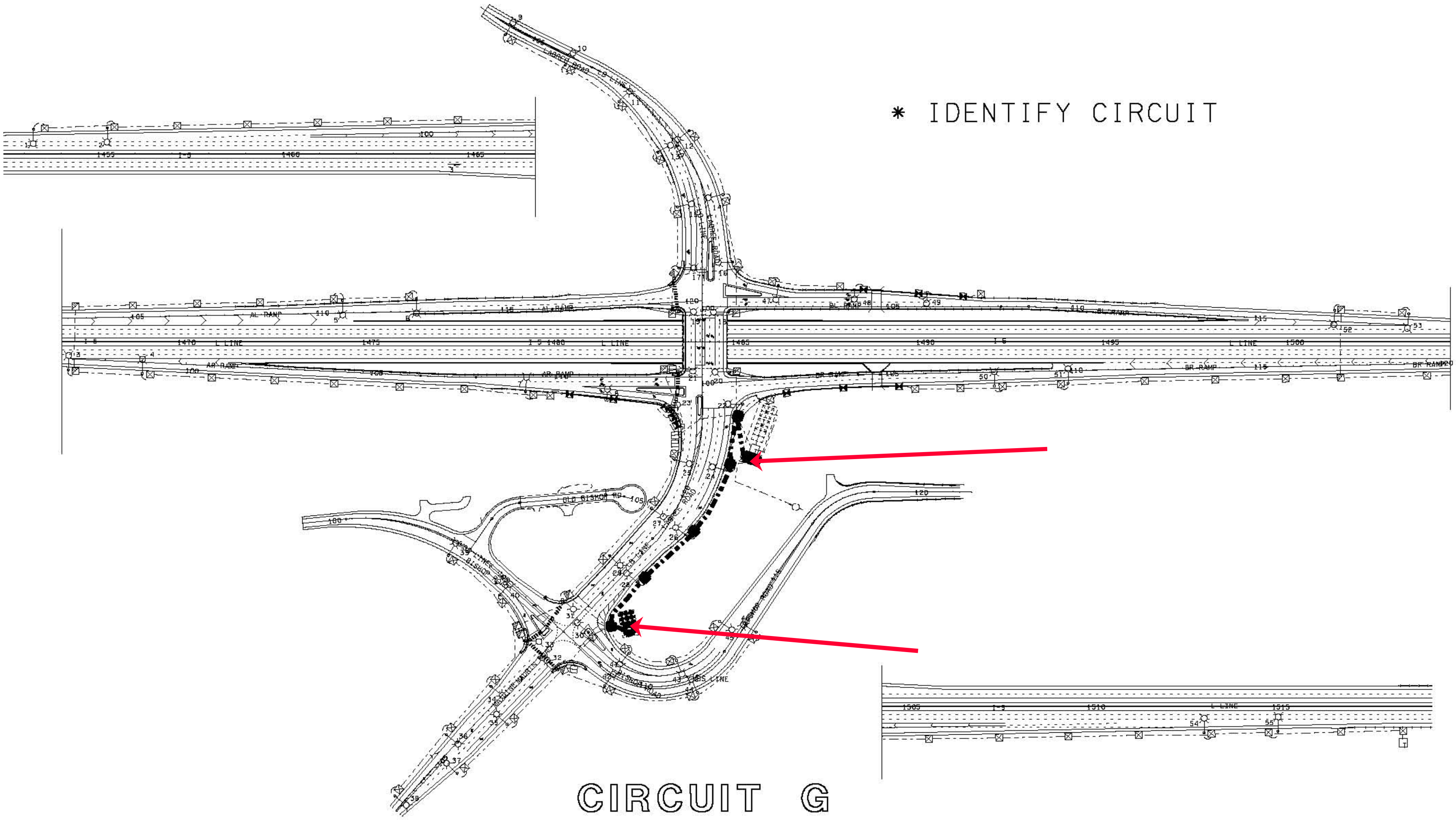
Service to Labree=2(31.25)(10(2cab)+5=15)(0.000809)=0.758438

0.758438/480=0.001580*100=0.16% Vd

0.16% < 5% - #8 wire is OK

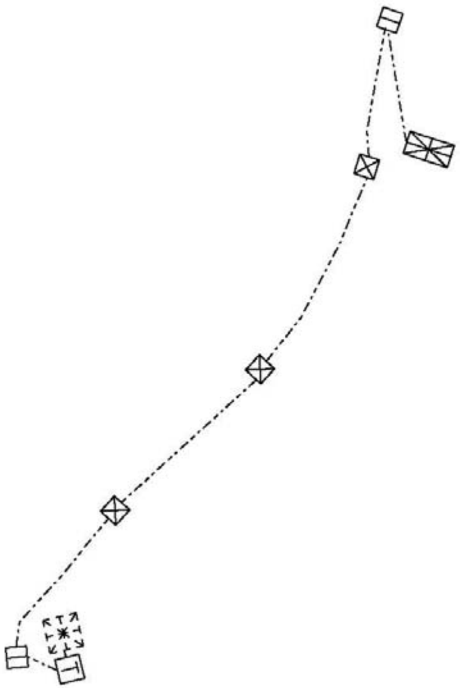
Note: This is a transformer that has GFCI's included in the loading calculations, so we used 5% Vd instead of 3% Vd.

* IDENTIFY CIRCUIT



CIRCUIT G

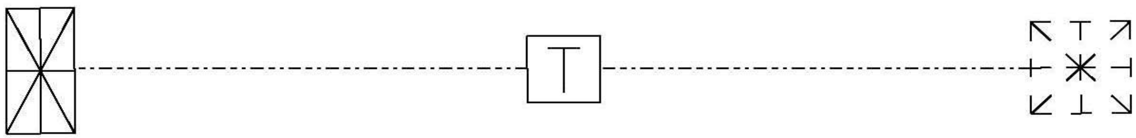
* ONLY CONSIDER ITEMS ON THAT CIRCUIT



CIRCUIT G

ONE-LINE DIAGRAM

* BREAK EVERYTHING DOWN
TO "POINT LOADS"



CIRCUIT G

ONE-LINE DIAGRAM

* LAY IN YOUR DISTANCES, THIS INCLUDES ALL ADDITIONS FOR JUNCTION BOXES, CABINETS, ETC.

NOTES:

1) ALL IN GRADE LUMINAIRES ARE 40′ MOUNTING HEIGHT, 16′ MAST ARMS, 250W HPS, III MEDIUM CUT OFF (52′ TOTAL WIRE LENGTH).
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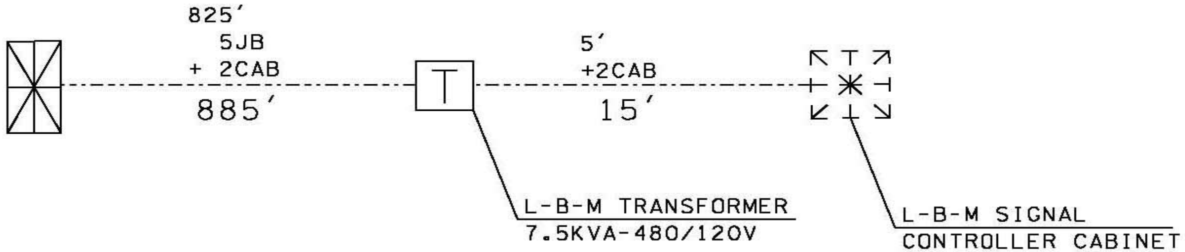
3) ADD 10′ TO WIRE LENGTH FOR ALL IN GRADE JUNCTION BOXES.
4) ADD 5′ TO WIRE LENGTH FOR ALL NEMA JUNCTION BOXES.
5) ADD 5′ TO WIRE LENGTH FOR ALL CABINET TERMINATIONS.
6) ADD 5′ FOR THE CONDUIT SWEEP INTO LUMINAIRE.



CIRCUIT G

ONE-LINE DIAGRAM

Voltage Drop for Circuit G - Vd=2ALR

<u>Given:</u> 480/120 volt – 7.5 kVA LBM Transformer.

<u>Find Load:</u> 7.5 kVA x 1000 = 7,500 watts

7,500watts / 480 volts = 15.6 Amps. <u>Load = 15.6 Amps</u>

Total length of Segment

Resistance of #8 conductor

Total load on Segment

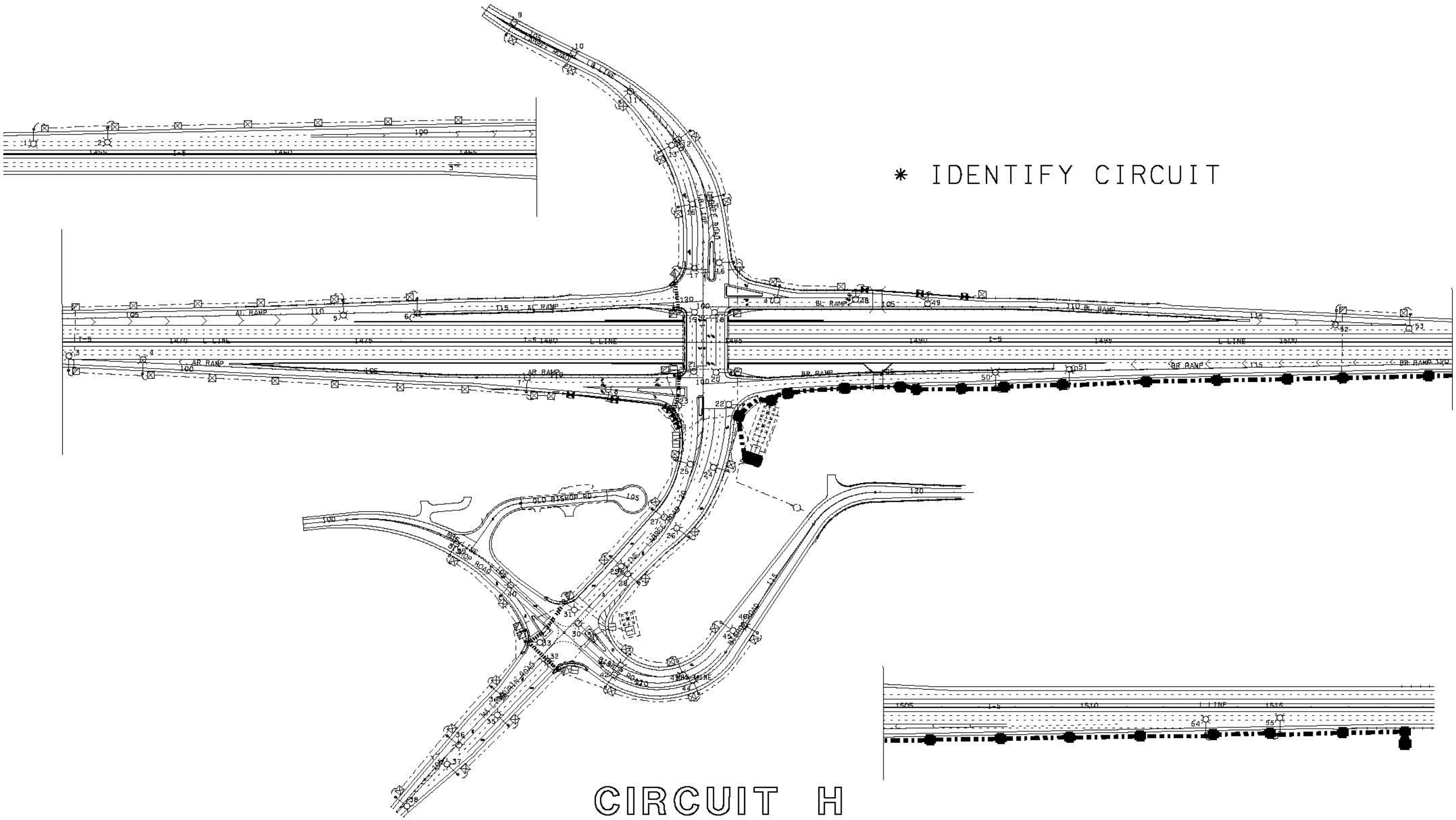
Wire out and Back

Service to LBMTran=2(15.6)(10(2cab)+50(5jb)+825=885)(0.000809)=22.338108

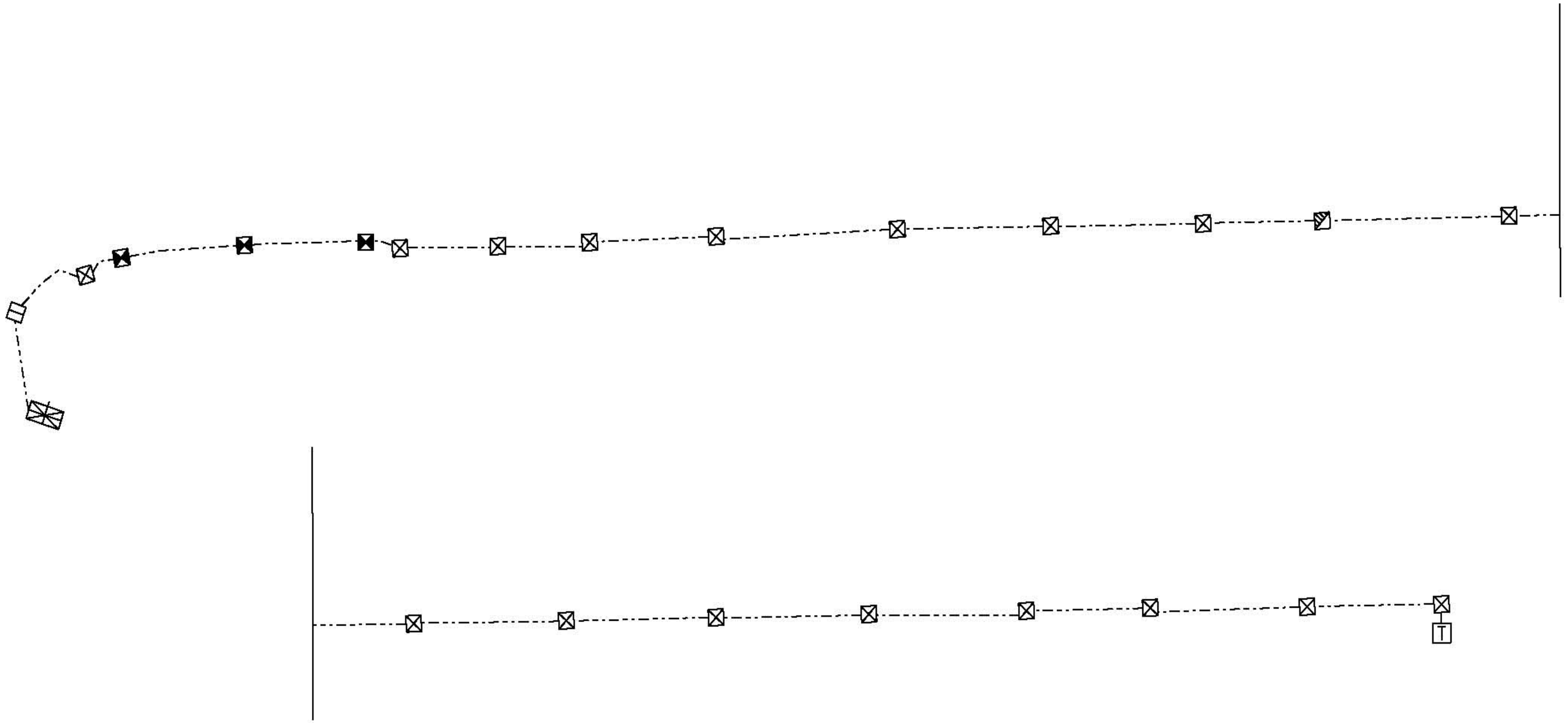
22.338108/480=0.046538*100=4.7% Vd

4.7% < 5% - #8 wire is acceptable.

Note: This is a transformer that has GFCI's included in the loading calculations, so we used 5% Vd instead of 3% Vd.


* IDENTIFY CIRCUIT
I-5
L LINE
AL RAMP
AR RAMP
BL RAMP
BR RAMP
OLD BISHOP RD
CIRCUIT H

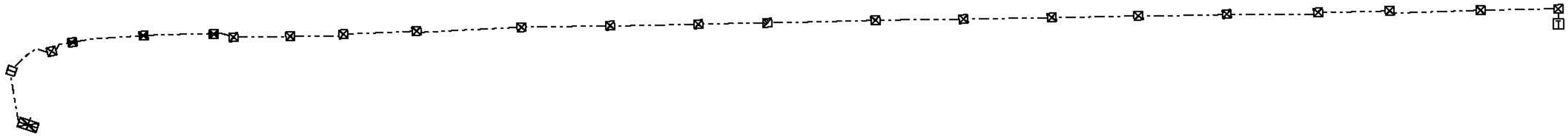
* ONLY CONSIDER ITEMS ON THAT CIRCUIT



CIRCUIT H

ONE-LINE DIAGRAM

* BREAK EVERYTHING DOWN TO "POINT LOADS"



CIRCUIT H

ONE-LINE DIAGRAM

* LAY IN YOUR DISTANCES, THIS INCLUDES ALL ADDITIONS FOR JUNCTION BOXES, CABINETS, ETC.

NOTES:

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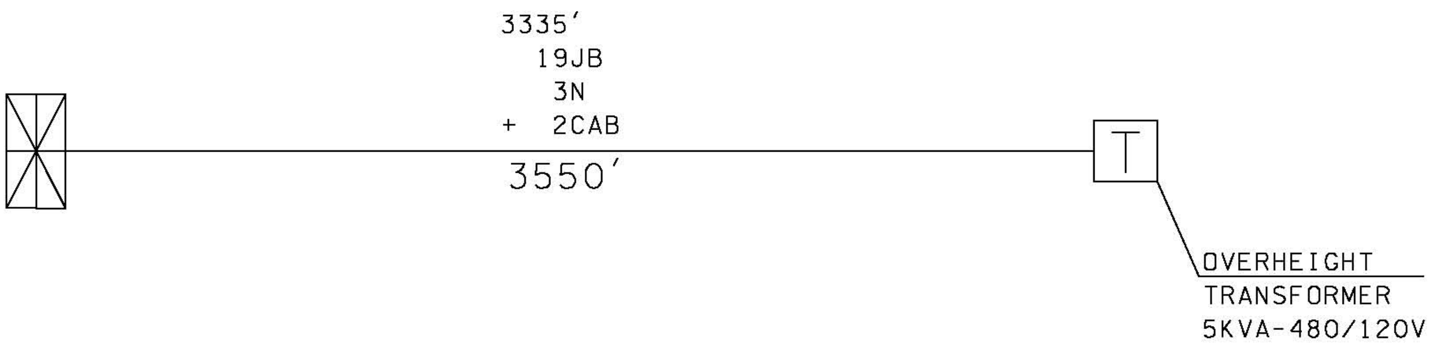


CIRCUIT H

ONE-LINE DIAGRAM

Voltage Drop for Circuit H - Vd=2ALR

Given: 480/120 volt - 5 kVA overheight vehicle detector transformer.

Find Load: 5 kVA x 1000 = 5,000 watts

5,000watts / 480 volts = 10.4 Amps. Load = 10.4 Amps

Total length of Segment

Resistance of #8 conductor

Total load on Segment

Wire out and Back

Service to OHVTran=2(10.4)(10(2cab)+190(19jb)15(3n)+3335=3550)(0.000809)=59.736560

59.736560/480=0.124451*100=12.4% Vd

12.4% > 5% - #8 wire is not acceptable.

Service to OHVTran=2(10.4)(10(2cab)+190(19jb)15(3n)+3335=3550)(0.000510)=37.658400

37.658400/480=0.078455*100=7.8% Vd

Resistance of #6 conductor

7.8% > 5% - #6 wire is not acceptable.

Service to OHVTran=2(10.4)(10(2cab)+190(19jb)15(3n)+3335=3550)(0.000321)=23.702640

23.702640/480=0.049380*100=4.9% Vd

4.9% < 5% - #4 wire is acceptable.

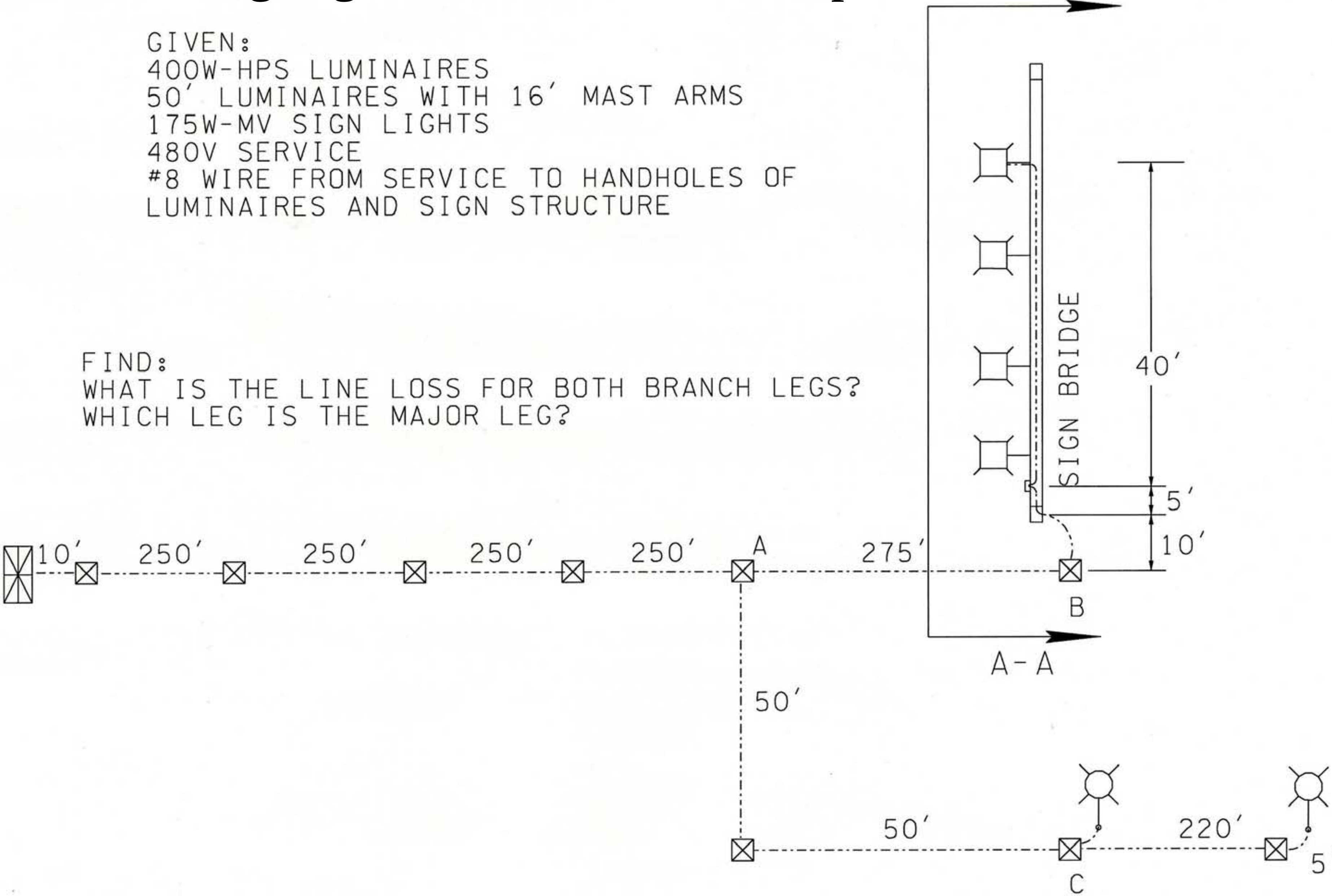
Resistance of #4 conductor

Note: This is a transformer that has GFCI's included in the loading calculations, so we used 5% Vd instead of 3% Vd.

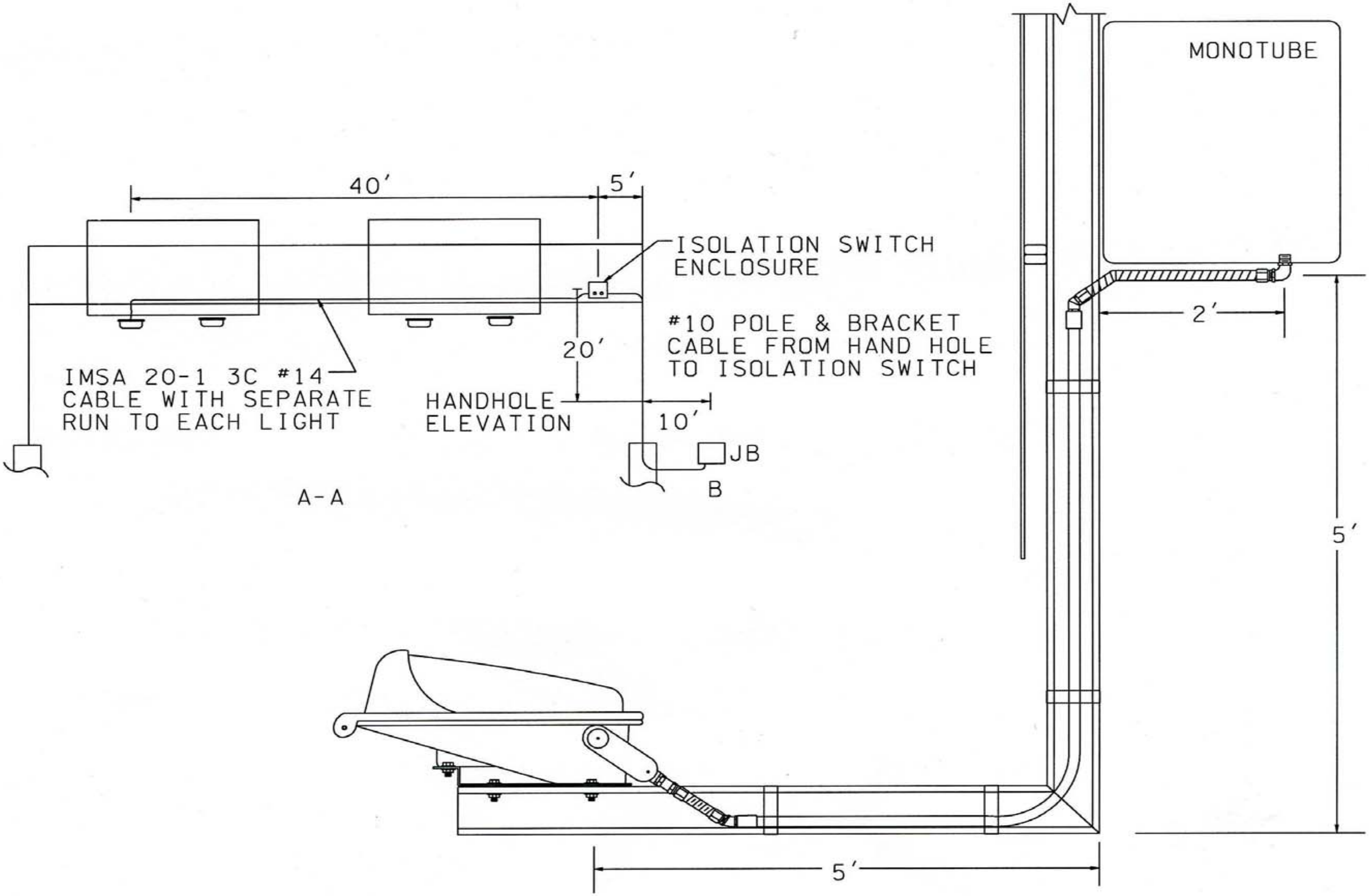
Signlighter & 480 Volt example

GIVEN:
400W-HPS LUMINAIRES
50′ LUMINAIRES WITH 16′ MAST ARMS
175W-MV SIGN LIGHTS
480V SERVICE
#8 WIRE FROM SERVICE TO HANDHOLES OF LUMINAIRES AND SIGN STRUCTURE

FIND:
WHAT IS THE LINE LOSS FOR BOTH BRANCH LEGS?
WHICH LEG IS THE MAJOR LEG?



Signlighter @ 480 Volt example – cont.



Sign lighter & 480 Volt example – cont.

Calculating loads for this circuit

- 400 watt HPS luminaire at 480 volts = 1.1 amps
- 175 watt MV luminaire at 480 volts = 0.5 amps
- Total load for circuit = 2 (1.1) + 4 (0.5)
- Total Load = 4.2 amps

Voltage Drop for 2 Luminaire Circuit

Vd=2ALR

Wire out and Back

Resistance of #8 conductor

Total load on Segment

Total length of Segment

Service to A= (1060)

2(4.2)(5+10+10+250+10+250+10+250+10+250+5)(0.000809) =7.203336

A to C =2(2.2)(5+50+10+50+5=120)(0.000809) =0.427152

C to hand hole =2(1.1)(5+220+10+5+5=245)(0.000809) =0.436051

Hand hole to light =2(1.1)(62)(0.001290) =0.175956

8.242495

8.242495/480=0.017172*100=1.7% Vd

1.7% < 5% - #8 wire is acceptable

Resistance of #10 conductor

Voltage Drop for 4 Sign Light Circuit

Resistance of #8 conductor

Resistance of #10 conductor

Service to A= (1060)

2(4.2)(5+10+10+250+10+250+10+250+10+250+5)(0.000809) =7.203336

A to B =2(2)(5+275+5=285)(0.000809) =0.922260

B to hand hole =2(2)(5+10+5=20)(0.000809) =0.064720

Hand hole to ISO box = 2(2)(20+5+2=27)(0.001290) =0.139320

ISO box to out signlight =2(0.5)(2+40+2+5+5+2=56)(0.003261) =0.182616

8.512252

8.512252/480=0.017734*100=1.8% Vd

1.8% < 5% - #8 wire is acceptable

Resistance of #14 IMSA conductor

Sign lighter & 480 Volt example – cont.

- The leg supplying the sign lights has a voltage drop of 1.8%.
- The leg supplying the luminaires has a voltage drop of 1.7%.
- The major leg is the one supplying the sign lights.

When laying out wire, keep this in mind:

- **Keep all conductors from any one service in the junction boxes for that service. Do not ever combine conductors from one service with conductors from another service. Do not share conduit or junction boxes between services.**
- **Run 2 wires in the conduit when you are going cabinet to cabinet.**

(There is always a third wire running in all conduits – the equipment grounding conductor. This wire is minimum size #8 AWG, sized per NEC Article 250 - 122 – table 250.122)

- **The quick disconnects for the luminaire poles can only handle a #4, #6 or #8 conductor, so make sure you bring one of these sizes into the luminaire from the nearest junction box, and nothing larger.**
- **The splice kits for Wye splices or inline splices can only handle up to a #2 without going to a special, more expensive splice kit.**
- **The smallest size conductor we are allowed to use on an illumination circuit is a #8 (in the conduit) , except for the pole & bracket cable which is a #10 or the #14 3C IMSA cable from the isolation switch to the sign light luminaire. The largest you want to use is a #2 for ease of installation.**
- **As you move out from the service to the load end of the circuit, the size of the conductors should get smaller as you go. Do not go from a smaller conductor to a larger conductor.**

Any Questions?