NEMA Junction Box Sizing, Conductor Bending Radii & Fiber Optic Cable

from: NEC 2005 - Article 314.28, Article 110.74 & Article 770

WSDOT

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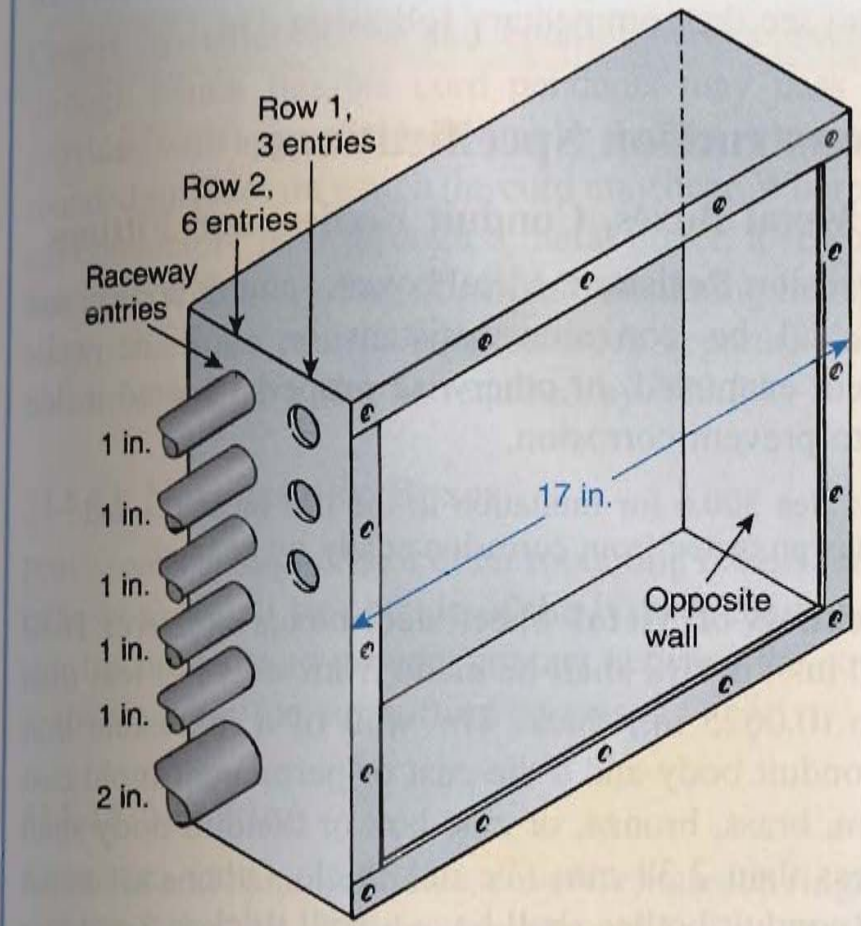
Per the NEC
NEMA Junction Box Lengths – Splices, Angles & U Pull

- The length is 6x the diameter of the largest conduit in the row plus the sum of all the other conduit diameters in the same row. (There are exceptions to this in the NEC which we are not likely to encounter. Use the direction given in slide 4 to size NEMA JB's on WSDOT projects..)
- Each row is calculated separately and the single row that provides the maximum distance shall be used.
- We seldom have more than 3 conduits in a side. This minimizes conductor bending problems.



6 × 2 in. (trade diameter of largest raceway) = 12 in.
12 in. + 5 in. (sum of diameters of other entries, row 2 only)
= 17 in. (min. required from each entry to opposite wall)

Exhibit 314.10 An example showing calculations required by 314.28(A)(2) for splices, angle pulls, or U pulls.

From 2005 NEC Handbook, page 333.

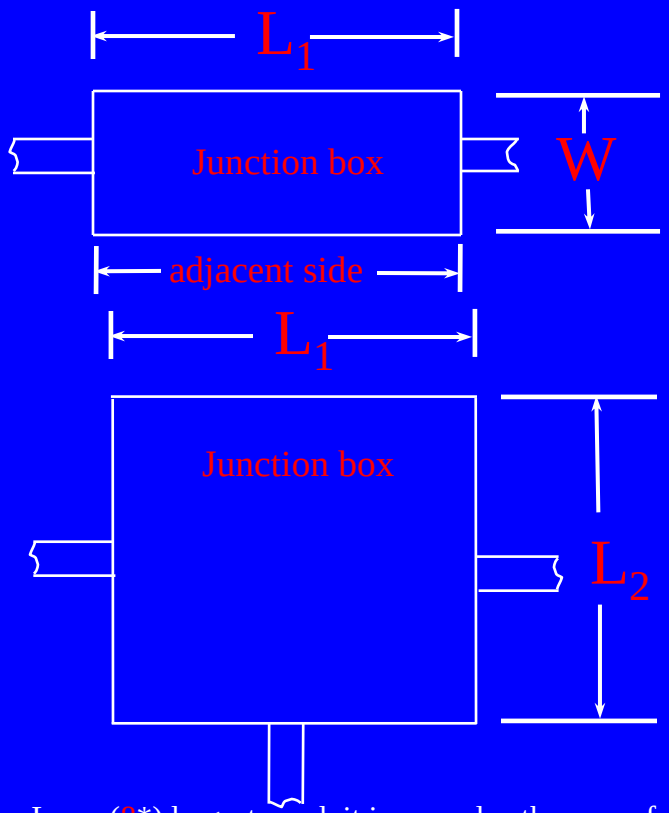
NEMA Junction Box Length - straight pull

- If one or more of the conductors is a # 4 or larger, then the length is not less than 8x the diameter of the largest conduit if a through pull, regardless of the number of conduits or conductors. WSDOT uses this multiplier: (8x the largest conduit plus the sum of all the other trade size conduit diameters in the same row) for all wire sizes to avoid future undersized junction box problems.
- This assumes no bending and minimal wire storage.

- (NEC 2005 - Article 314.28 for sizing of junction boxes, Article 110.74 directs us to use methods in Article 314.28.)

The WSDOT clear catinkus for NEMA Junction Box Sizing and Depth

- The definition of length and width. Note:
- L is always parallel to the conduit.
- W is always perpendicular to the conduit.



$L_{(1)}$ or $L_{(2)}$ = (8*) largest conduit in row plus the sum of all other conduit diameters in row. Calculate for all rows and use sum of largest row.

W=(6) largest conduit in row plus the sum of all other conduit diameters in row. Calculate for all rows and use sum of largest row. NOTE: If no conduit enters the adjacent sides of the box the dimension is width. *Per slide 4.

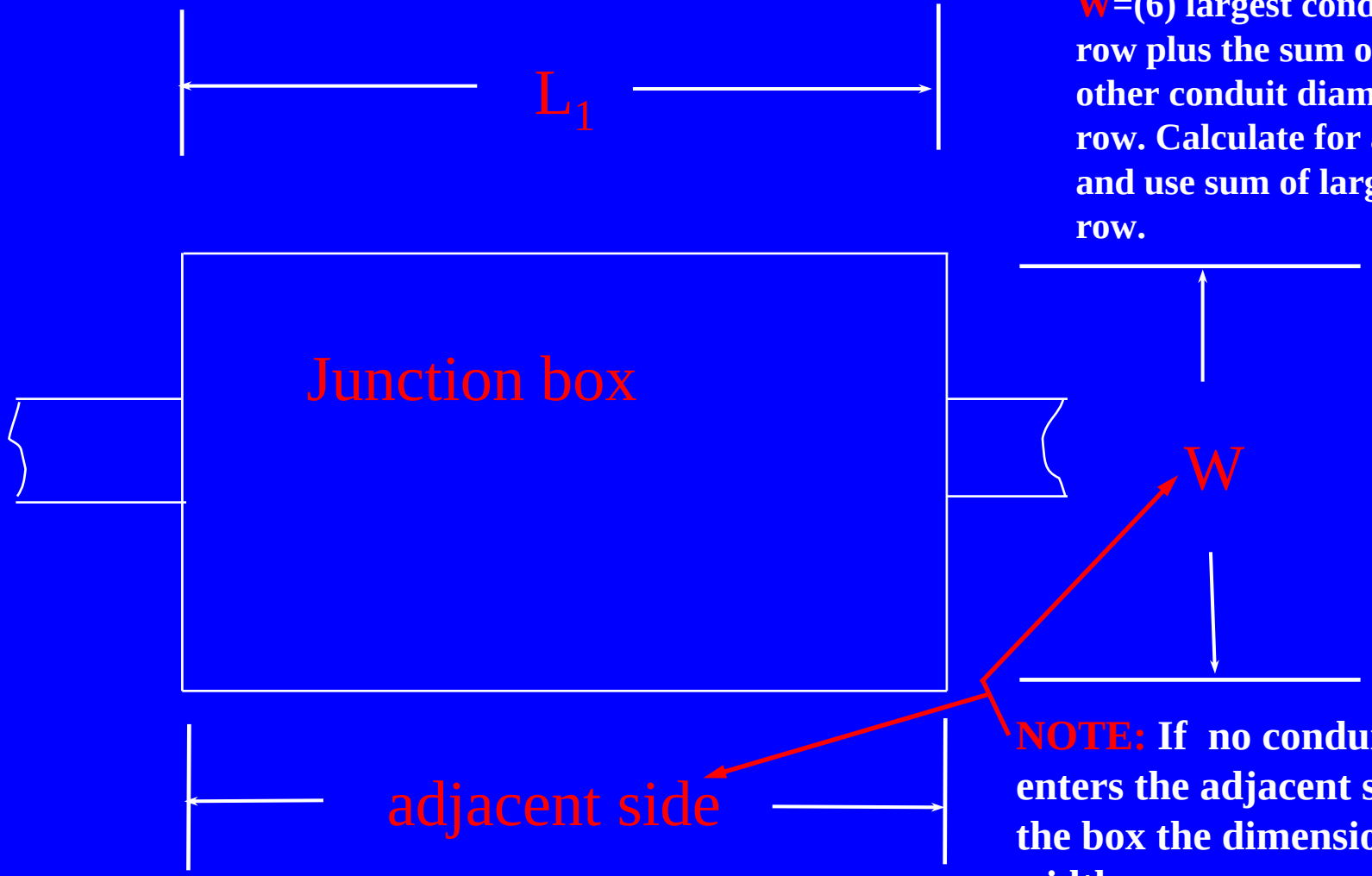
Use this table to determine Depth

GRS conduit grounded end bushing size table			
Size	diameter inches		
Inches	External	add this number for end bushing size - then round up to nearest quarter	end bushing outside diameter
1/2	0.840	0.75	1 1/2
3/4	1.050	0.75	1 3/4
1	1.315	0.75	2
1 1/4	1.660	0.75	2 1/2
1 1/2	1.900	0.75	2 3/4
2	2.375	0.75	3 1/4
2 1/2	2.875	1.00	4
3	3.500	1.25	4 3/4
3 1/2	4.000	1.25	5 1/4
4	4.500	1.75	6 1/4
5	5.563	2.00	7 1/2
6	6.625	2.00	8 3/4

Example: A1 1/4" GRS conduit is 1.660" + 0.75" = 2.410". Round 2.410" up to 2.5" or 2 1/2 inches.

NEMA Junction Box Length - straight pull

$L_{(1)}$ or $L_{(2)}$ = (8) largest conduit in row plus the sum of all other conduit diameters in row. Calculate for all rows and use sum of largest row.



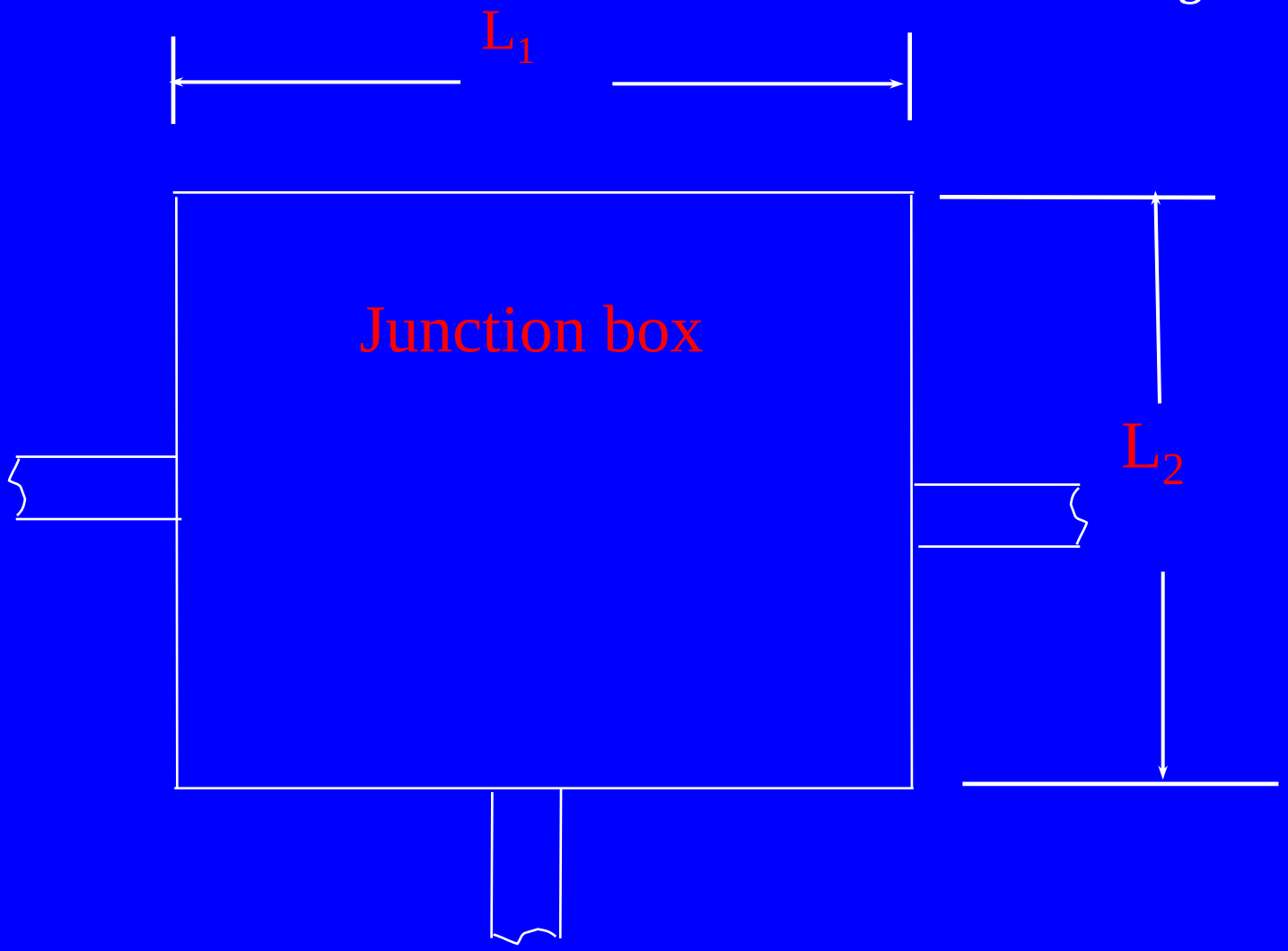
W=(6) largest conduit in row plus the sum of all other conduit diameters in row. Calculate for all rows and use sum of largest row.

NOTE: If no conduit enters the adjacent side of the box the dimension is width.

Note: Don't forget to size your Depth, using slide 5

NEMA Junction Box Length – straight pull & angle

$L_{(1)}$ or $L_{(2)}$ = (8) largest conduit in row plus the sum of all other conduit diameters in row. Calculate for all rows and use sum of largest row.



Note: Don’t forget to size your Depth, using slide 5


5/7/2002


L_1
W
D
DANGER
HIGH VOLTAGE
KEEP OUT


10


L_1
L_2
8 AMP Fuse
INSide BOX
D
Water tight conduit fitting (Meyers Hub)


JCT

NEMA Junction Box Depth

- The box needs only to be as deep as is needed to install the conduits and their fittings.
- Consider grounded end bushing size (diameter) in relationship to the conduit.
- Always round up to the nearest even dimension. Unless space is restricted, round up to the next (second) even dimension. (for a 1¼ inch conduit with a 2¼ inches O.D. grounded end bushing round up to 4 inches as a minimum but in most cases round up again and call out 6” as the depth)
- Junction boxes should be positioned to allow all conduits to enter from the ends.
- This reduces the effort required by the contractor during construction, allows for easier conductor installation and allows us to use smaller boxes.

1) For field bending of GRS. (NEC 344.24 & see Table 2 – Chapter 9)
2) For field bending of PVC. (NEC 352.24 & see Table 2 –Chapter 9)
3) The radius is measured at the centerline of the conduit.

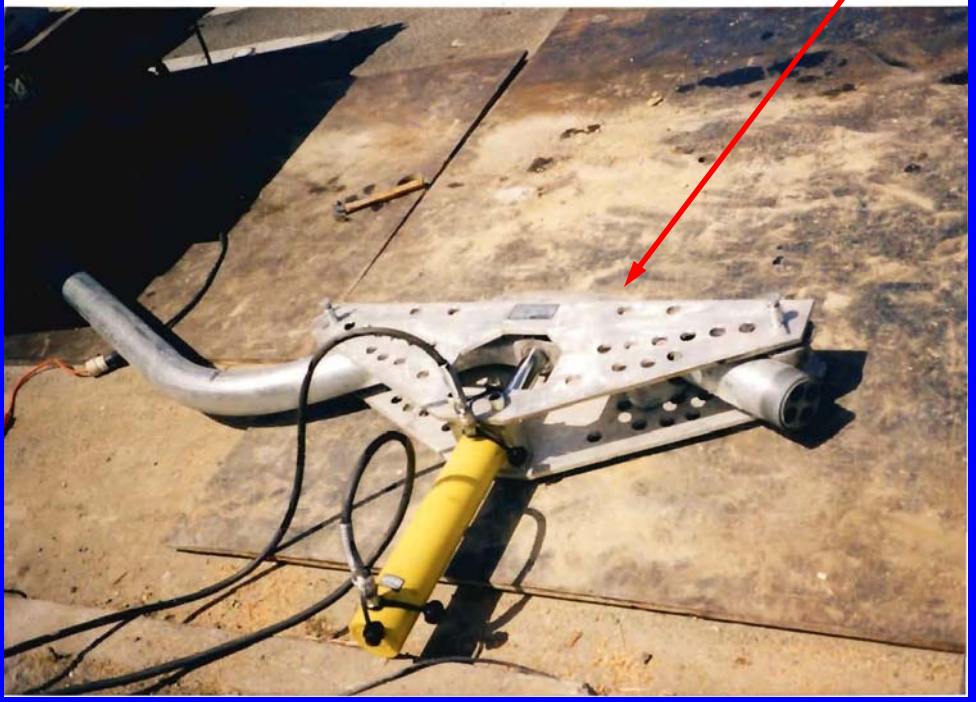
Table 2 Radius of Conduit and Tubing Bends

Conduit or Tubing Size		One Shot and Full Shoe Benders		Other Bends	
Metric Designator	Trade Size	mm	in.	mm	in.
16	½	101.6	4	101.6	4
21	¾	114.3	4½	127	5
27	1	146.05	5¾	152.4	6
35	1¼	184.15	7¼	203.2	8
41	1½	209.55	8¼	254	10
53	2	241.3	9½	304.8	12
63	2½	266.7	10½	381	15
78	3	330.2	13	457.2	18
91	3½	381	15	533.4	21
103	4	406.4	16	609.6	24
129	5	609.6	24	762	30
155	6	762	30	914.4	36

Radius of Conduit Bends – NEC 353.24 (2005)

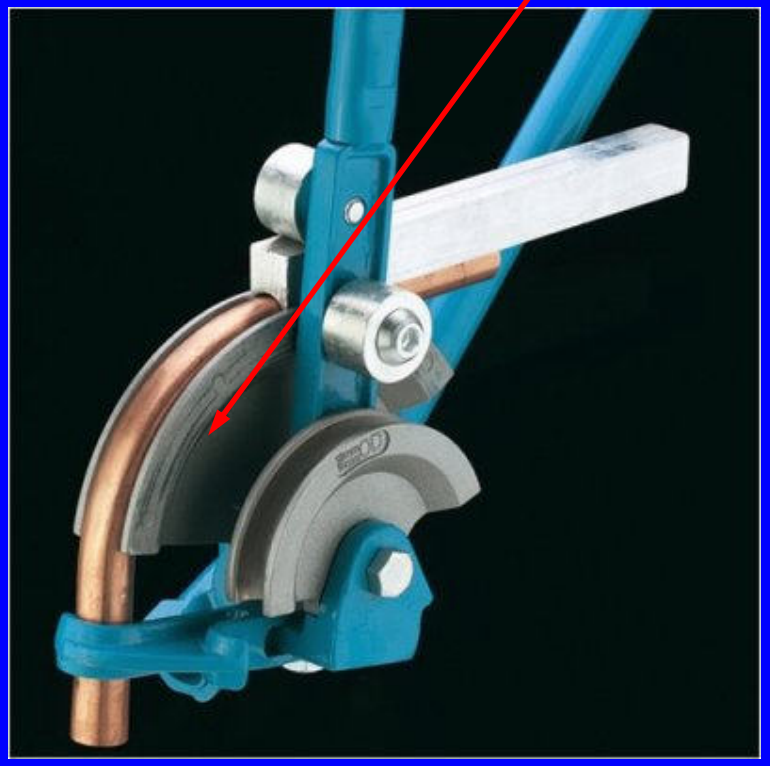
Metric Designator	Trade Size	mm	inch
16	1/2	250	10
21	3/4	300	12
27	1	350	14
35	1 1/4	450	18
41	1 1/2	500	20
53	2	650	26
63	2 1/2	900	36
78	3	1200	48
103	4	1500	60

1) Use this chart (from NEC Table 354.24) for HDPE conduit only.
2) The measurement is to the centerline of the conduit.



There is no “shoe” on these hydraulic bending tools - Use the “other bends” column.

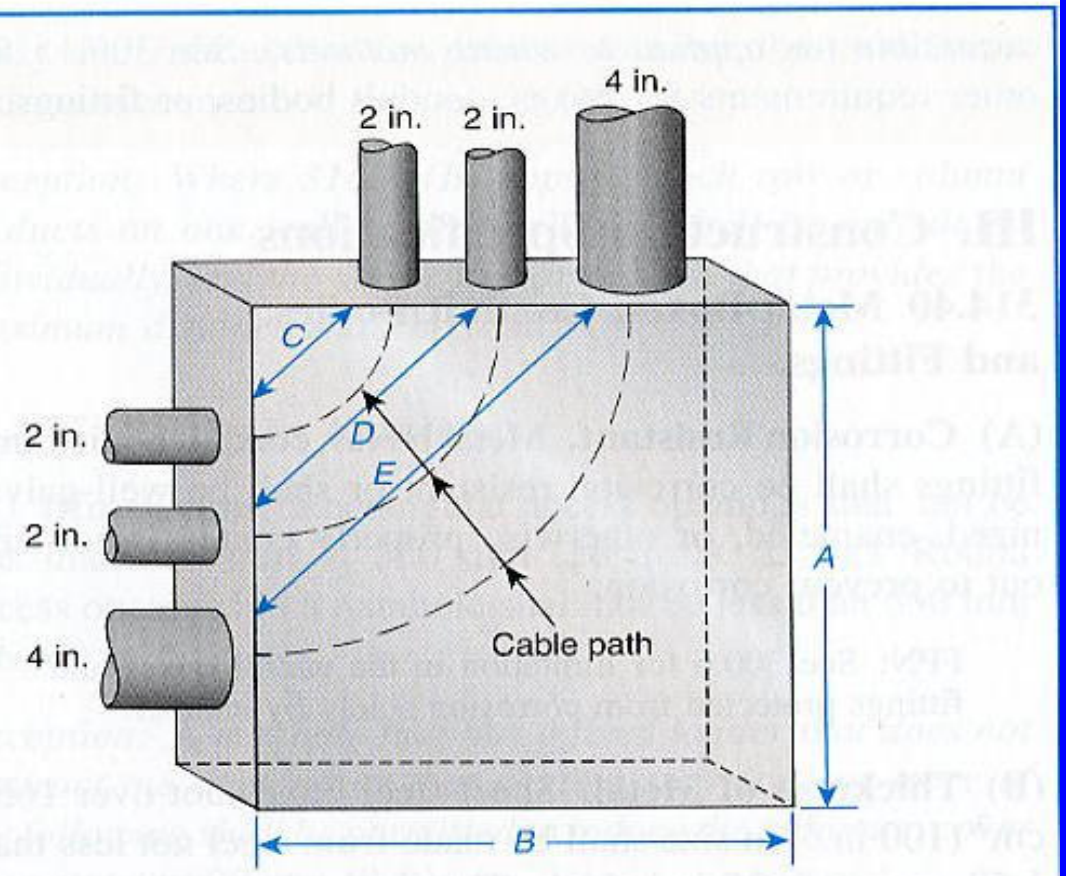
A Full “shoe” bender.



Conductor Bending Radii

- There should be consideration given to the minimum bending radii of the conductors.
- When the junction box is sized properly this will not usually be a problem.
- This must still be checked to insure there is proper space for conductor bend Radii.

Conductor Bending Radii



A = (6 × 4 in.) + 2 in. + 2 in. = 28 in. min.
B = (6 × 4 in.) + 2 in. + 2 in. = 28 in. min.
C = 6 × 2 in. = 12 in. min. required between raceways enclosing the same conductor
D = 6 × 2 in. = 12 in. min. required between raceways enclosing the same conductor
E = 6 × 4 in. = 24 in. min. required between raceways enclosing the same conductor

A =(6 x 4 In.) + 2 in.+2 In. +28 In. minimum

B =(6 x 4 In.) + 2 In. +2in.+ 28 In. minimum

C = 6 x 2 In. = 12 In. minimum required between raceways enclosing the same conductor

D = 6 x 2 In. = 12 In. minimum required between raceways enclosing the same conductor

E = 6 x 4 In. = 24 In. minimum required between raceways

enclosing the same conductor

Exhibit 314.11 *Raceway entries enclosing the same conductors are required to have a minimum separation between them. The intent is to provide adequate space for the conductor to make the bend.*

Conductors

2005 NEC 300.34 Conductor Bending Radius. The conductor shall not be bent to a radius less than 8 times the overall diameter for nonshielded conductors or 12 times the diameter for shielded or lead covered conductors during or after installation. For multicolor or multiplexed single conductor cables having individually shielded conductors, the minimum bending radius is 12 times the diameter of the individually shielded or 7 times the overall diameter, whichever is greater.

Conductors & Cable bending radius

CONDUCTOR	OUTSIDE DIA	(ind.cond.)	MULTIPLIER	(ind.conductor)	BENDING RADIUS
# 8	0.266		8		2.128’’
# 6	0.304		8		2.432’’
# 4	0.352		8		2.816’’
# 2	0.412		8		3.296”
#2cs(#14)	0.326	(0.14)	7	(12) x 0.14=1.68”	2.282’’
#3cs(#20)	0.35	(0.07)	7	(12) x 0.07=0.84”	2.45’’
#4c(#18)	0.41	(0.09)	7	(12) x 0.09=1.08”	2.87’’
#5c(#14)	0.51	(0.14)	7	(12) x 0.14=1.68”	3.57’’
#7c(#14)	0.55	(0.14)	7	(12) x 0.14=1.68”	3.85’’
6prs(#19)	0.56	(0.08)	7	(12) x 0.08=0.96”	3.92’’
24 (SM) fiber	0.47		20		9.40”
48 (SM) fiber	0.47		20		9.40”
72 (SM) fiber	0.47		20		9.40”
96 (SM) fiber	0.78		20		15.60”
144 (SM) fiber	0.78		20		15.60”

Conductors

- There should be consideration given for the slack required in the conductors.
- Standard specification 8-20.3(8) requires sufficient slack wire be installed to allow any conductor to be raised 18’’ outside of the junction box.
- Discuss this with the electrical inspectors if you have many circuits in one junction box / conduit run.
- If you had a through pull and 4 circuits, which does happen, you would need space for 24’ of slack.

Conductors - continued

- There was a case with 2 conduits passing through one junction box carrying 11 conductors; that's 33' of slack in an 8''x 8'' x 18'' JB.
- The electrical inspectors will usually hold the contractor to the slack called for in a standard structure mounted (traffic barrier) junction box (8''x 8'' x 18'') because there are usually not many conductors in the run.
- Standard concrete junction boxes have the same slack requirements as surface mounted boxes.

Fiber Optic Cable

- The greater the radius of the conduit, the easier the pull.
- Use cable vaults and pull boxes wherever possible – the conduit then enters from the side of the box and eliminates 180 degrees of sweep at each box.
- Use 36” radius conduit sweeps wherever possible. This is the WSDOT standard for all jobs.
- When unable to use a 36” radius sweep, use a minimum of 20 times the outside diameter of the cable to calculate the smallest radius that WSDOT will allow to be used. (See slide 22) Note: This recommendation to allow use of the 20 times sweep usually only applies inside a building or cabinet.

Any questions?

Have class add “NEMA” to quiz question 4

QUIZ #1 QUESTIONS

- 1) Given: one 400watt HPS luminaire @ 480VAC w/50’ pole and 16’ mast arm, #6 copper conductor, 500’ run of wire to base of luminaire pole. (all service cabinet terminations, junction boxes, luminaire sweeps & splice distances included in these lengths)
- Find: what is the voltage drop in this circuit?
- 2) Given: ITS cabinet @120VAC - 1750 watt total load.
- Find: size branch breaker
- 3) Given: 10 Kva transformer @ 240VAC - 8500 watt ITS service cabinet.
- Find: size transformer branch breaker in service cabinet.
- 4) Given: 1 each 2 inch dia, 1 each 1 1/2inch, 1 each 1 inch conduit - straight pull with splices. Assume all conduits are in one row.
- Find: size NEMA junction box.

Quiz #2 Questions

- 1) Given: one 400watt HPS luminaire @ 240VAC w/40’ pole and 16’ mast arm, #6 copper conductor, 350’ run of wire to base of luminaire pole. (all service cabinet terminations, junction boxes, luminaire sweeps & splice distances included in these lengths)
- Find: what is the voltage drop in this circuit?
- 2) Given: ITS cabinet @120VAC - 1750 total watt load.
- Find: size branch breaker
- 3) Given: 15 Kva transformer @ 480VAC - 10748 watt load for 5 ITS cabinets. (1 ramp meter, 1 Camera Cabinet, 2 Data Stations & 1 HAR Station)
- Find: size transformer branch breaker in service cabinet.
- 4) Given: 1 each 2 1/2 inch dia, 2 each 2 inch, 1 each 1 1/2 inch conduit - straight pull with splices. Assume all conduits are in one row.
- Find: size NEMA junction box.

QUIZ #1 QUESTION ANSWERS

- 1) Given: one 400watt HPS luminaire @ 480VAC w/50’ pole and 16’ mast arm, #6 AWG copper conductor, 500’ run of wire to base of luminaire pole. (all service cabinet terminations, junction boxes & splice distances included in these lengths)
- Find: what is the voltage drop in this circuit?
- Within LINE LOSS section, see illumination load chart, slide 27, for luminaire load (amperage).
- Answer: 400watt luminaire @ 480 volts = 1.1 amp
- Vd #6 AWG =2ALR Vd= 2 x 1.1 x 500 x 0.000510
- Vd #10 AWG =2ALR Vd= 2 x 1.1 x 62 x 0.001290
- Vd #6 AWG=0.561000 volts.Vd #10 AWG=0.175956 volts
- Vd total = 0.736956 volts

QUIZ #1 QUESTION ANSWERS

- 2) Given: ITS cabinet @120 VAC - 1750 watt load.
- Find: size branch breaker
- Answer:
- Unit load=1750watts/120volts=14.58amps.
- ITS breaker= 14.583333 amps continuous load x 125% factor = 18.229167amps.
- Branch breaker = 20 amps

QUIZ #1 QUESTION ANSWERS

- 3) Given: 10 Kva transformer @ 240 VAC - 8500 watt ITS service cabinet.
- Find: size transformer branch breaker in service cabinet.
- Answer:
- Unit load = 10000watts/240volts = 41.666667amps.
- ITS breaker = 41.666667 amps load x 125% factor = 52.083333 amps.
- Branch breaker = 60 amps

QUIZ #1 QUESTION ANSWERS

- 4) Given: one each 2 inch dia, one each 1 1/2inch, one each 1 inch conduit - straight pull with splices.
- Find: size NEMA junction box.
- Answer: Length = 2” x 8 + 1 1/2” + 1”
- Length = 16” + 1 1/2” + 1”. Length = 18 1/2”
- Width=2” x 6 + 1 1/2” + 1”. Width=12” +1 1/2” +1”
- Width=14 1/2”
- Depth = largest conduit is 2” in dia. Outside dia. of 2” conduit is 2.375” or 2 3/8”. A 2” Grounded end bushing is + or - 3 1/4” dia.
- Box size = 18 1/2L x 14 1/2W x 4”D (use 6” for depth to allow clearance for ground lug on j-box)

QUIZ #2 QUESTION ANSWERS

- 1) Given: one 400watt HPS luminaire @ 240VAC w/40’ pole and 16’ mast arm, #6 AWG copper conductor, 350’ run of wire to base of luminaire pole. (all service cabinet terminations, junction boxes & splice distances included in these lengths)
- Find: what is the voltage drop in this circuit?
- Within LINE LOSS section, see illumination load chart, slide 27, for luminaire load (amperage).
- Answer: 400watt luminaire @ 240 volts = 2.1 amp
- Vd #6 AWG =2ALR Vd= 2 x 2.1 x 350 x 0.000510
- Vd #10 AWG =2ALR Vd= 2 x 2.1 x 52 x 0.001290
- Vd #6 AWG=0.749700 volts.Vd #10 AWG=0.281736 volts
- Vd total = 1.031436 volts

QUIZ #2 QUESTION ANSWERS

- 2) Given: ITS cabinet @120 VAC - 1750 watt load.
- Find: size branch breaker
- Answer:
- Unit load=1750watts/120volts=14.583333amps.
- ITS breaker= 14.583333 amps continuous load x 125% factor = 18.229167amps.
- Branch breaker = 20 amps

QUIZ #2 QUESTION ANSWERS

- 3) Given: 15 Kva transformer @ 480VAC - 10748 watt load for 5 ITS cabinets. (1 ramp meter, 1 Camera Cabinet, 2 Data Stations & 1 HAR Station)
- Find: size transformer branch breaker in service cabinet.
- Answer:
- Unit load = 15000watts/480volts = 31.25amps.
- ITS breaker = 31.25 amps load x 125% factor = 39.0625 amps.
- Branch breaker = 40 amps

QUIZ #2 QUESTION ANSWERS

- 4) 4) Given: 1 each 2 1/2 inch dia, 2 each 2 inch, 1 each 1 1/2 inch conduit - straight pull with splices. Find: size NEMA junction box.
- Answer: Length = 2 1/2” x 8 + (2) 2” + 1 1/2”
- Length = 20” + 4” + 1 1/2”. Length = 25 1/2”
- Width=2 1/2” x 6 +(2) 2” + 1 1/2”. Width=15” +4” +1 1/2”
- Width=20 1/2”
- Depth = largest conduit is 2 1/2” in dia. Outside dia. of
- 2 1/2” conduit is 2.875” or 2 7/8”. A 2 1/2” Grounded end bushing is + or - 4” dia.
- Box size = 25 1/2L x 20 1/2W x 6”D (use 6” for depth to allow clearance for ground lug on j-box)

Any questions?