

Electrical Design Training Class

Conduit Sizing

WSDOT

Fall / Winter 2004

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What is conduit fill?

- Conduit fill is the amount, in square inches, of conductors inside a section of conduit.
- NEC 2002 - Article 344 - Rigid Metal Conduit: Type RMC
- NEC 2002 – Article 352 - Rigid Nonmetallic Conduit: Type RNC (Note this Article includes PVC schedule 40 and PVC schedule 80 as well as HDPE schedule 40).

Why do we need to worry about Conduit fill?

- Dissipate heat.
- Pulling of wires.
- Potential high cost change orders when the conductors that you specified do not fit inside the conduit.

When do we need to worry about conduit fill?

- When you are installing new conduit and conductors.
- When you are adding new conductors to an existing conduit run.

Allowable conduit fill

- The maximum allowable fill for new conduit is 26% full. (Design Manual Chapter 850, page 840-15 (c) Conduit)
- The maximum allowable fill for existing conduits is 40% full. (NEC 2002 – Chapter 9, Table 1) and (Design Manual Chapter 850, page 840-15 (c) Conduit)



26% Conduit Fill → 1 1/2" Conduit
Conductors → 4 - #2
= 0.532 in²



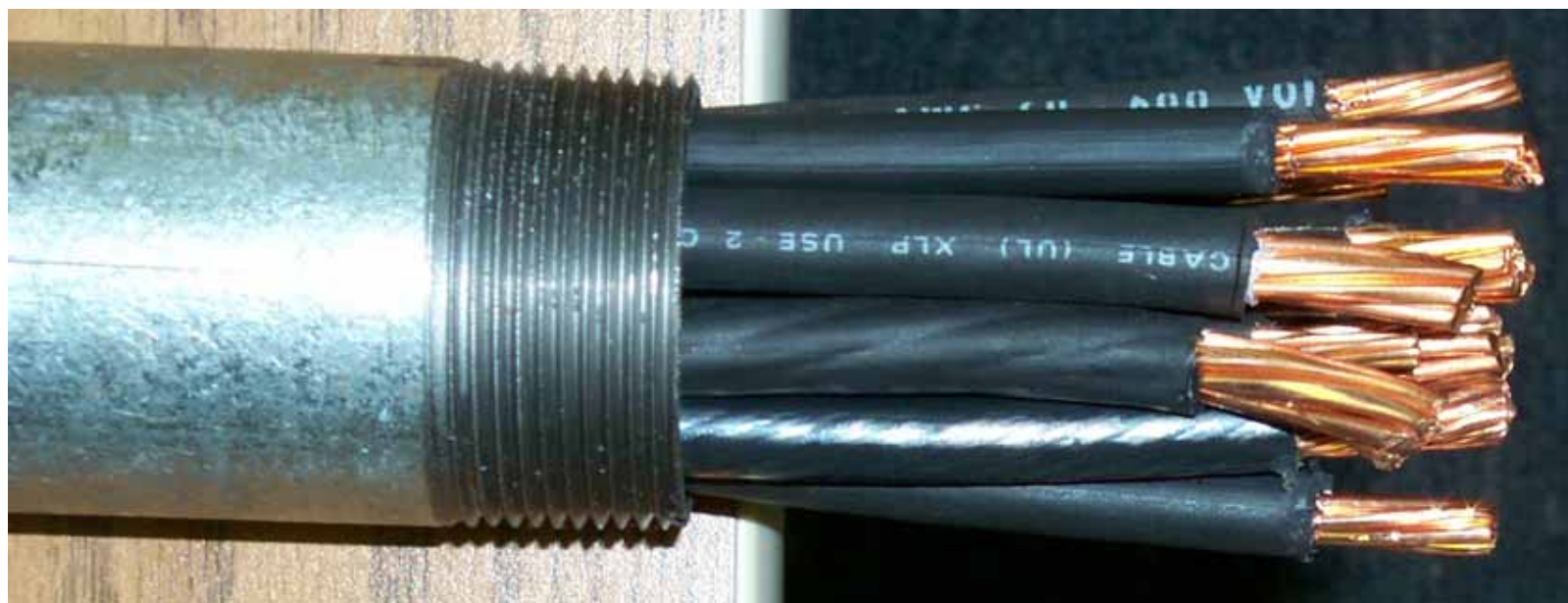


40% Conduit Fill → 1 ½" Conduit
Conductors → 4 - #2, 2 - #4, and 2 - #8
= 0.838 in²

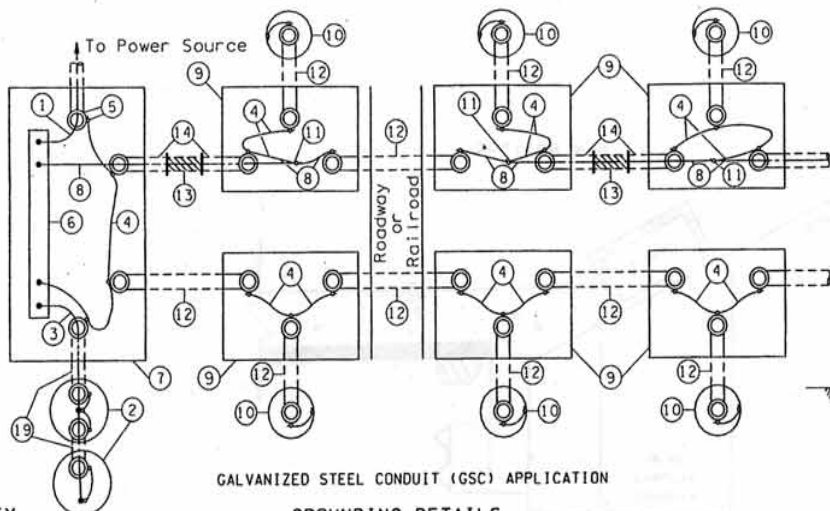




60% Conduit Fill → 1 ½" Conduit
 Conductors → 5 - #2, 2 - #4, 2 - #6,
 3 - #8, 1 - #10, and 1 - #12
 = 1.232 in²



COMBINATION GALVANIZED STEEL CONDUIT (GSC)
AND NON-METALLIC CONDUIT (NMC) APPLICATION



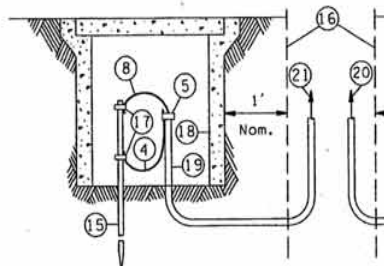
KEY

- ① Service Neutral
- ② Service Ground
- ③ Grounding Electrode Conductor
- ④ Bonding Jumper
- ⑤ Grounding Bushing (typ. all conduit terminations)
- ⑥ Service Neutral Bus (Copper)
- ⑦ Service Enclosure
- ⑧ Equipment Grounding Conductor
- ⑨ Junction Box
- ⑩ Electrical Load Support (luminaire pole)
- ⑪ Copper Split Bolt Clamp
- ⑫ Galvanized Steel Conduit (GSC)
- ⑬ Non-metallic Conduit (NMC)
- ⑭ Option A - 10' GSC with Field Bend
 - Approved Adapter Fitting
 - Grounding Bushing
- Option B - 10' GSC
 - GS Factory Elbows
 - Approved Adapter Fitting
 - GS Coupling
 - Grounding Bushing
- ⑮ Ground Rod
- ⑯ Edge of Foundation, Pole or Service Support
- ⑰ Clamp
- ⑱ Junction Box or 8" Drain Tile with Approved Cover
- ⑲ Code Sized GSC
- ⑳ To Service Neutral Bus
- ㉑ To Grounding Terminal or Connection to Equipment Grounding System

NOTES

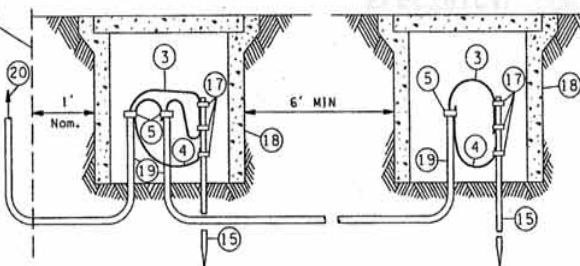
1. If parallel circuits of different sizes are contained in one conduit, the size of the grounding conductor shall be determined on the basis of the largest conductor. Only one grounding conductor is required for each conduit regardless of the number of circuits contained.
2. Service ground per serving utility requirement. If the utility uses aluminum service conductors, an approved Al-Cu pressure type ground connector shall be used to secure the service neutral to the copper neutral bar in the service enclosure. Except for the above, all grounding conductors shall be copper.
3. Equipment grounding conductors and grounding electrode conductors shall be sized in accordance with the National Electric Code (No. 8 minimum).

SUPPLEMENTAL GROUND



Required to supplement equipment grounding for luminaire standards with direct burial, aerial feeds, or where required in plans.

SERVICE GROUND



Required at all services and separately derived systems.

GROUND ROD DETAILS



EXPIRES JUNE 4, 1999

TYPICAL
GROUNDING DETAILS

STANDARD PLAN J-9a



4-98	Note 3, change "connectors" to "conductors".	ABN	WMS
DATE	REVISION	BY	APPR'D

Conductor Sizes

<u>Conductor Type</u>	<u>Conductor Size (in²)</u>
2C(sh)-#14	0.090
3C(sh)-#20	0.070
4C(sh)-#18	0.060
5C-#14	0.140
7C-#14	0.170
10C-#14	0.290
6pcc-#19	0.320
RG59Ucc	0.046
24 (SM) fiber	0.196
48 (SM) fiber	0.196
72 (SM) fiber	0.196
96 (SM) fiber	0.478
144 (SM) fiber	0.478

<u>Conductor Type USE</u>	<u>Conductor Size (in²)</u>
#12	0.026
#10	0.033
#8	0.056
#6	0.073
#4	0.097
#3	0.113
#2	0.133
#1	0.190

<u>Conductor Type USE</u>	<u>Conductor Size (in²)</u>
1/0	0.222
2/0	0.262
3/0	0.312
4/0	0.372
250	0.460
300	0.528
350	0.596
400	0.662

Conduit Sizes-GRS (2002 NEC chapter 9, table 4 - Article 344 RMC)

Conduit Size (inches)	Max Fill 26% (square inches)	Max fill 40% (square inches)
1/2"	0.082	0.125
3/4"	0.143	0.220
1"	0.231	0.355
1 1/4"	0.397	0.610
1 1/2"	0.539	0.829
2"	0.886	1.363
2 1/2"	1.265	1.946
3"	1.950	3.000
3 1/2"	2.603	4.004

Conduit Sizes – **PVC schedule 40, and HDPE**

Conduit Size (inches)	Max Fill 26% (square inches)	Max fill 40% (square inches)
1/2"	0.074	0.114
3/4"	0.132	0.203
1"	0.216	0.333
1 1/4"	0.378	0.581
1 1/2"	0.516	0.794
2"	0.856	1.316
2 1/2"	1.221	1.878
3"	1.890	2.907
3 1/2"	2.532	3.895

(2002 NEC
chapter 9, table
4 - Article 352
RNC)

Conduit Sizes – **PVC schedule 80**

Conduit Size (inches)	Max Fill 26% (square inches)	Max fill 40% (square inches)
1/2"	0.056	0.087
3/4"	0.106	0.164
1"	0.179	0.275
1 1/4"	0.322	0.495
1 1/2"	0.445	0.684
2"	0.747	1.150
2 1/2"	1.071	1.647
3"	1.675	2.577
3 1/2"	2.259	3.475

(2002 NEC
chapter 9, table
4 - Article 352
RNC)

Examples

New 1" **GRS** conduit with 3-#8

1" conduit 26% fill is 0.231 sq.in.

#8-0.056 sq.in. - $3 \times 0.056 = 0.168$ sq.in.

$0.168 \text{ sq.in.} < 0.231 \text{ sq.in.}$

Conduit fill OK.

Existing 1" **GRS** conduit with 5-#8

1" conduit 40% fill is 0.355 sq.in.

#8-0.056 sq.in. - $5 \times 0.056 = 0.280$ sq.in.

$0.280 \text{ sq.in.} < 0.355 \text{ sq.in.}$

Conduit fill OK.

Examples

New 2" **GRS** conduit with 6-#8, 3-#6, 4-#4, 3-#2

2" **GRS** conduit 26% fill is 0.89 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
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#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
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#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
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#2-0.133 sq.in.	-	<u>3*0.133=0.399 sq.in.</u>
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1.342 sq.in.

1.342 sq.in. > 0.89 sq.in. Conduit fill is **NOT OK**

Try 3" **GRS** conduit 6-#8, 3-#6, 4-#4, 3-#2

3" **GRS** conduit 26% fill is 1.95 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
-----------------	---	----------------------

#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
-----------------	---	----------------------

#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
-----------------	---	----------------------

#2-0.133 sq.in.	-	<u>3*0.133=0.399 sq.in.</u>
-----------------	---	-----------------------------

1.342 sq.in.

1.342 sq.in. < 1.95 sq.in.

Examples

New 2" **PVC Schedule 40** conduit with 6-#8, 3-#6, 4-#4, 3-#2

2" **PVC Schedule 40** conduit 26% fill is 0.856 sq.in.

#8-0.056 sq.in. - $6 \times 0.056 = 0.336$ sq.in.

#6-0.073 sq.in. - $3 \times 0.073 = 0.219$ sq.in.

#4-0.097 sq.in. - $4 \times 0.097 = 0.388$ sq.in.

#2-0.133 sq.in. - $3 \times 0.133 = 0.399$ sq.in.

1.342 sq.in.

1.342 sq.in. > 0.856 sq.in. Conduit fill is **NOT OK**

Try 3" **PVC Schedule 40** conduit 6-#8, 3-#6, 4-#4, 3-#2

3" **PVC Schedule 40** conduit 26% fill is 1.890 sq.in.

#8-0.056 sq.in. - $6 \times 0.056 = 0.336$ sq.in.

#6-0.073 sq.in. - $3 \times 0.073 = 0.219$ sq.in.

#4-0.097 sq.in. - $4 \times 0.097 = 0.388$ sq.in.

#2-0.133 sq.in. - $3 \times 0.133 = 0.399$ sq.in.

1.342 sq.in.

1.342 sq.in. < 1.890 sq.in. Conduit fill is OK.

Examples

New 2" **PVC Schedule 80** conduit with 6-#8, 3-#6, 4-#4, 3-#2

2" **PVC Schedule 80** conduit 26% fill is 0.747 sq.in.

#8-0.056 sq.in. - $6 \times 0.056 = 0.336$ sq.in.

#6-0.073 sq.in. - $3 \times 0.073 = 0.219$ sq.in.

#4-0.097 sq.in. - $4 \times 0.097 = 0.388$ sq.in.

#2-0.133 sq.in. - $3 \times 0.133 = 0.399$ sq.in.

1.342 sq.in.

342 sq.in. > 0.747 sq.in. Conduit fill is **NOT OK**

Try 3" **PVC Schedule 80** conduit 6-#8, 3-#6, 4-#4, 3-#2

3" **PVC Schedule 80** conduit 26% fill is 1.675 sq.in.

#8-0.056 sq.in. - $6 \times 0.056 = 0.336$ sq.in.

#6-0.073 sq.in. - $3 \times 0.073 = 0.219$ sq.in.

#4-0.097 sq.in. - $4 \times 0.097 = 0.388$ sq.in.

#2-0.133 sq.in. - $3 \times 0.133 = 0.399$ sq.in.

1.342 sq.in.

1.342 sq.in. < 1.675 sq.in. Conduit fill is OK

Examples

New 1 1/2" **GRS** conduit with 3-#8, 3-#4

1 1/2" **GRS** conduit 26% fill is 0.539 sq.in.
#8-0.056 sq.in. - $3 \times 0.056 = 0.168$ sq.in.
#4-0.097 sq.in. - $3 \times 0.097 = 0.291$ sq.in.
0.459 sq.in.
0.459 sq.in. < 0.539 sq.in. Conduit fill is **OK**

New **PVC Schedule 40** conduit with 3-#8, 3-#4

1 1/2" **PVC Schedule 40** conduit 26% fill is 0.516 sq.in.
#8-0.056 sq.in. - $3 \times 0.056 = 0.168$ sq.in.
#4-0.097 sq.in. - $3 \times 0.097 = 0.291$ sq.in.
0.459 sq.in.
0.459 sq.in. < 0.516 sq.in. Conduit fill is **OK**

1 1/2" **PVC Schedule 80** conduit 26% fill is 0.445 sq.in.
#8-0.056 sq.in. - $3 \times 0.056 = 0.168$ sq.in.
#4-0.097 sq.in. - $3 \times 0.097 = 0.291$ sq.in.
0.459 sq.in.
0.459 sq.in. > 0.445 sq.in. Conduit fill is **NOT OK**

Examples

Existing 2" **GRS** conduit with 6-#8, 3-#6, 4-#4, 3-#2

2" **GRS** conduit 40% fill is 1.36 sq.in.

8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. < 1.36 sq.in.

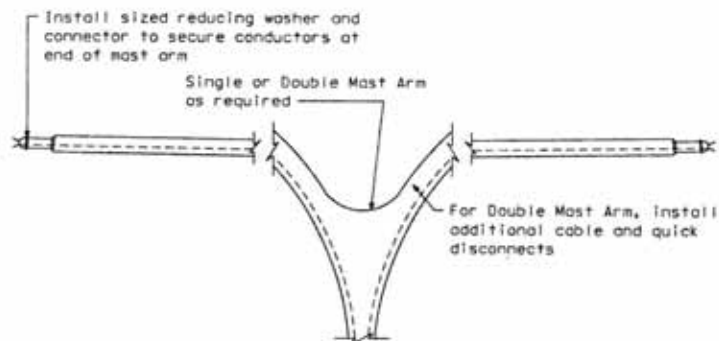
Conduit fill is OK.

Things to remember when sizing conduit

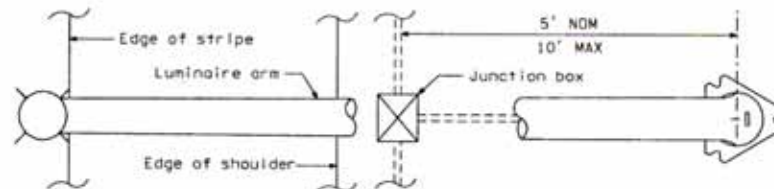
- Every time you cross a roadway put a spare conduit in.
- If the conduit crossing is for illumination or power supply, put in a spare 2" conduit.
- If the conduit crossing is for signal conduits at an intersection put in a spare 3" conduit. If the crossing is not at the intersection put in a spare 2" conduit.
- A 2" conduit should be the minimum size used for all crossings.
- Install a spare 2" conduit into a service cabinet.
- Install a spare 2" conduit between all transformers and the improvement the transformer is serving. (ITS cabinet, VMS cabinet, etc.)

Things to remember when sizing conduit

- Try not to use too many different sizes of conduit. It makes it easier to design your job and makes it easier for the contractor to build when you use less conduit sizes. Stick with even sized conduits (1", 2" 3", or 4").
- Leave room for future conductors. Running 2" conduit near the service or where there is potential for future expansion usually provides plenty of future room.
- The conduit from the luminaire pole to the adjacent junction box 5'-10' away shall be 1". This is usually the only place you would ever run a 1" conduit in grade (except the grounded electrode conductor).

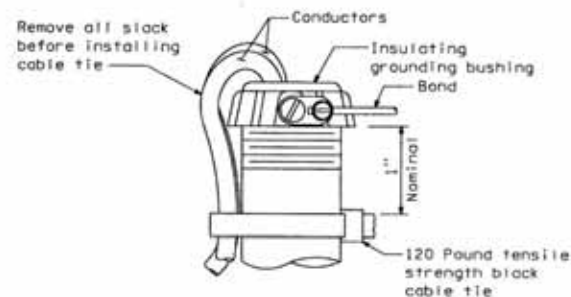


MAST ARM WIRING DETAIL

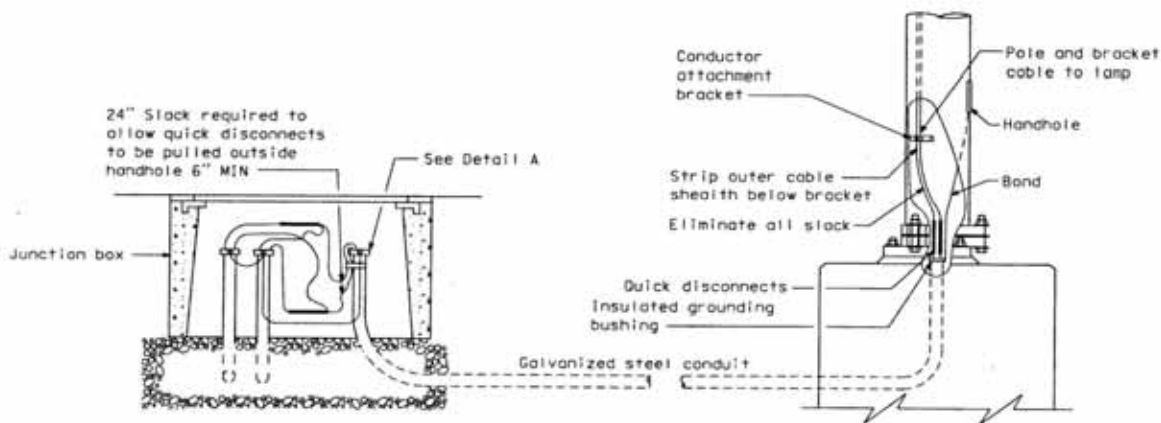


Alternate locations allowed provided junction box to base distance does not exceed 10'

TYPICAL JUNCTION BOX LOCATION



DETAIL A



WIRING DETAIL LIGHT STANDARD SLIP BASE•

•Application for fixed base similar except no cable tie is required at junction box.

LIGHT STANDARDS WIRING DETAILS



STANDARD PLAN J-1e

APPROVED FOR PUBLICATION	
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Any
Questions?