

GROUNDING AND BONDING

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700.0 INTRODUCTION

Arizona Public Service Company recognizes the value of the Industry Uniform Grounding and Bonding requirements. We are pleased to share the following illustrations and data applicable to the requirements.

This information will provide assistance and guidance to person's installing Service Entrance equipment in areas served by APS with no municipal or county electrical inspection authority.

The methods of Grounding and Bonding of Service Entrance equipment shown in this manual are recommended by APS to maintain consistency throughout APS's service territory.

The following drawings and tables will assist in assuring a safe and adequate grounding installation, acceptable under any code.

If the area you are building in has a county or municipal inspection authority, please contact that authority for their regulations.

700.1 GENERAL INFORMATION

1. Customer wire shall not be run through utility sealed areas. This includes ground electrode conductors as well as any avoidable bond conductors.
2. Weatherproof hubs, jam nuts, etc., shall be used on any penetrations of equipment at the same height or above energized areas. A good rule of thumb is; that unless the penetration is on the bottom surface of a can, it shall be done with a weatherproof connection. Indoor equipment is an exception to this requirement.
3. Self-bonding hubs (Meyers or equivalent) shall not be used on multi-centric knockouts, unless the largest knockout is used.
4. Interior metal water piping systems shall be bonded to the service entrance enclosure with conductors sized to the ampacity of the main bus per NEC. (See Paragraph 701.0)
In multiple occupancy buildings where the interior metal water piping system for the individual occupancies is isolated from all other occupancies by the use of non-metallic pipe, each water system may be bonded to the panel board or switchboard enclosure supplying that occupancy, sized per NEC.
5. Other metal piping systems (E.G. Gas pipe) shall be bonded to the service equipment enclosure with a conductor sized to the largest branch circuit or feeder supplying the facility, sized per NEC (See Paragraph 701.0)
6. Nonconductive paint must be removed at threads, contact points and contact surfaces of any ground/bond lugs, terminal strips, etc., to assure a good electrical **connection**.

700.2 GROUNDING

The ground electrode conductor may be either bare or with green insulation. See **Paragraph 701.0** for ground electrode conductor size. Ground electrode conductors not encased in conduit shall be a minimum size of No. 4 copper or larger and must be securely fastened to the building or structure with approved fastening devices. The spacing of such devices shall not exceed 2 feet. If a ground rod is used as an electrode, at least 8 feet shall be in contact with the soil.

Ground Electrode conductors smaller than size No. 4 copper shall be solid copper wire, or shall be attached to the ground rod using the exothermic welding process.

700.3 BONDING (Unfused areas)

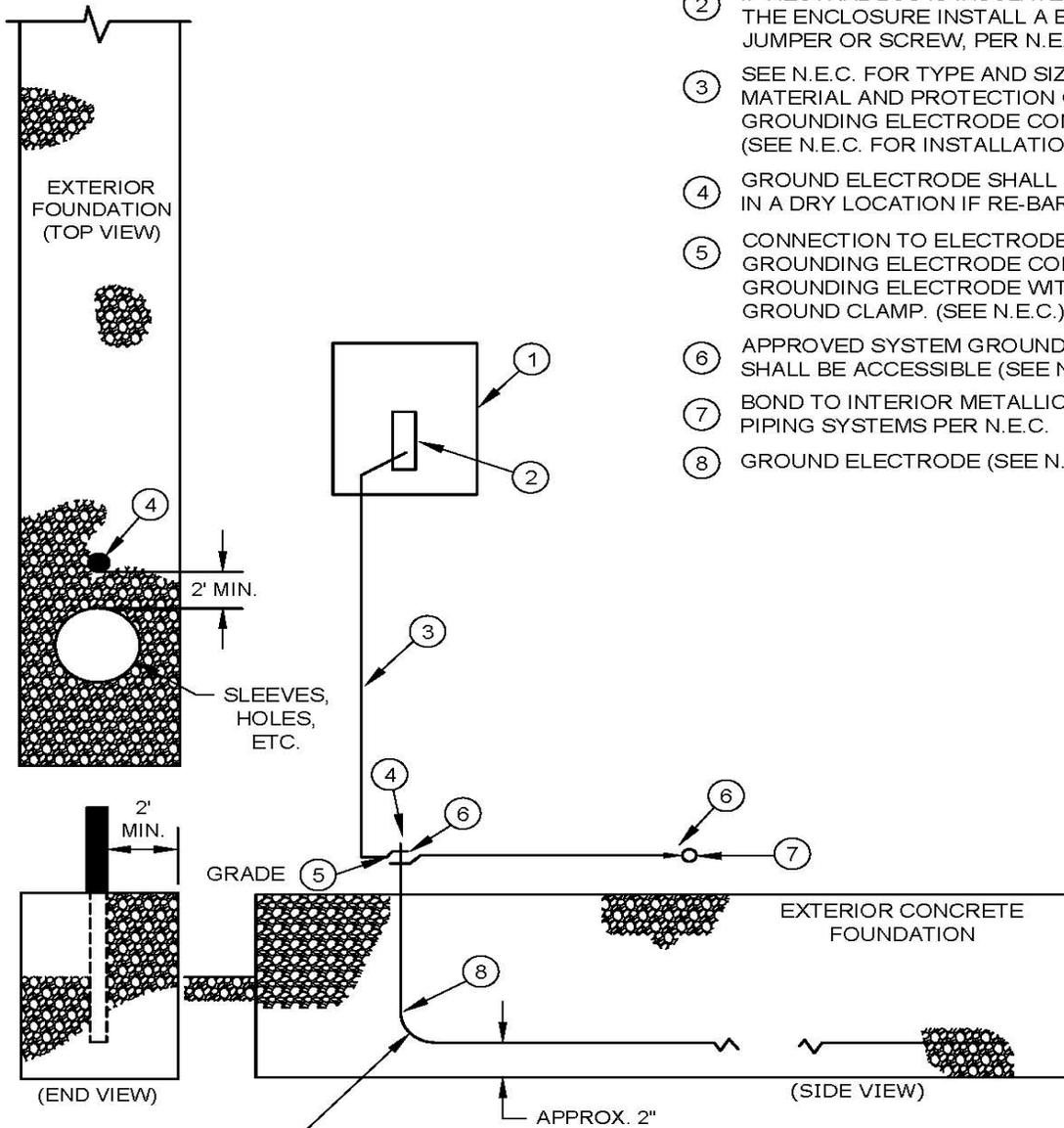
See **Paragraph 701.0 for bond conductor size**. Bonding is required on all enclosures, equipment, raceways, and fittings which contain unfused service conductors. Nipples and bushings installed with eccentric or concentric lock nuts must be bonded with ground bushings, wedges, or other approved devices. **Bond conductor size shall be determined by the ampere rating of the service entrance equipment.**

TABLE 701.0

MAXIMUM AMPERE RATING	COLUMN 1 LOAD SIDE		COLUMN 2 LINE SIDE		COLUMN 3	
	SIZE OF EQUIPMENT GROUNDING OR BONDING CONDUCTOR MINIMUM (AWG OR MCM) FROM NEC 250.122 SEE NOTE 1		SIZE OF GROUNDING ELECTRODE CONDUCTOR MINIMUM (AWG OR MCM) FROM NEC 250.66 SEE NOTE 2 & 4		SIZE OF MAIN BONDING JUMPER, MINIMUM (AWG OR MCM) FROM NEC 250.102(C)(1) SEE NOTE 3	
	COPPER	ALUMINUM	COPPER	ALUMINUM	COPPER	ALUMINUM
20	12	10	-	-	-	-
60	10	8	-	-	-	-
90	8	6	-	-	-	-
100	8	6	6	4	6	4
150	6	4	6	4	6	4
200	6	4	4	2	4	2
300	4	2	2	1/0	2	1/0
400	3	1	1/0	3/0	1/0	3/0
500	2	1/0	2/0	3/0	2/0	3/0
600	1	2/0	2/0	4/0	2/0	4/0
800	1/0	3/0	3/0	4/0	3/0	4/0
1000	2/0	4/0	3/0	250	3/0	300
1200	3/0	250	3/0	250	300	400
1600	4/0	350	3/0	250	400	600
2000	250	400	3/0	250	600	700
2500	350	500	3/0	250	700	900
3000	400	600	3/0	250	900	1250
4000	500	800	3/0	250	1250	1500
5000	700	1200	3/0	250	1500	1750
6000	800	1200	3/0	250	1750	2000

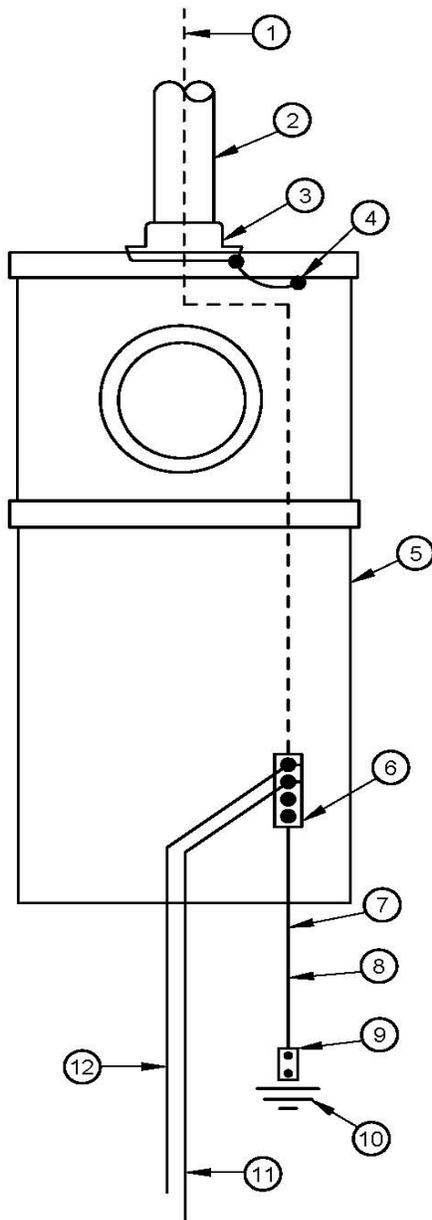
NOTES:

1. For sizing bonding conductor for gas line, per NEC. For sizing any bond conductor required on **the load side of fuses or circuit breakers**.
2. For sizing water bonds per NEC. For sizing conductor used for bonding unfused nipples and equipment.
3. For sizing main bonding jumper, system bonding jumpers, and supply-side bonding jumpers from equipment grounding bus to neutral bus, per NEC.
4. Grounding electrode conductors need not be larger than #4 (solid or stranded) copper if there is only one connection between the concrete encased electrode or manmade electrode (for example – ground rod) & grounded system conductor (neutral conductor), per NEC.



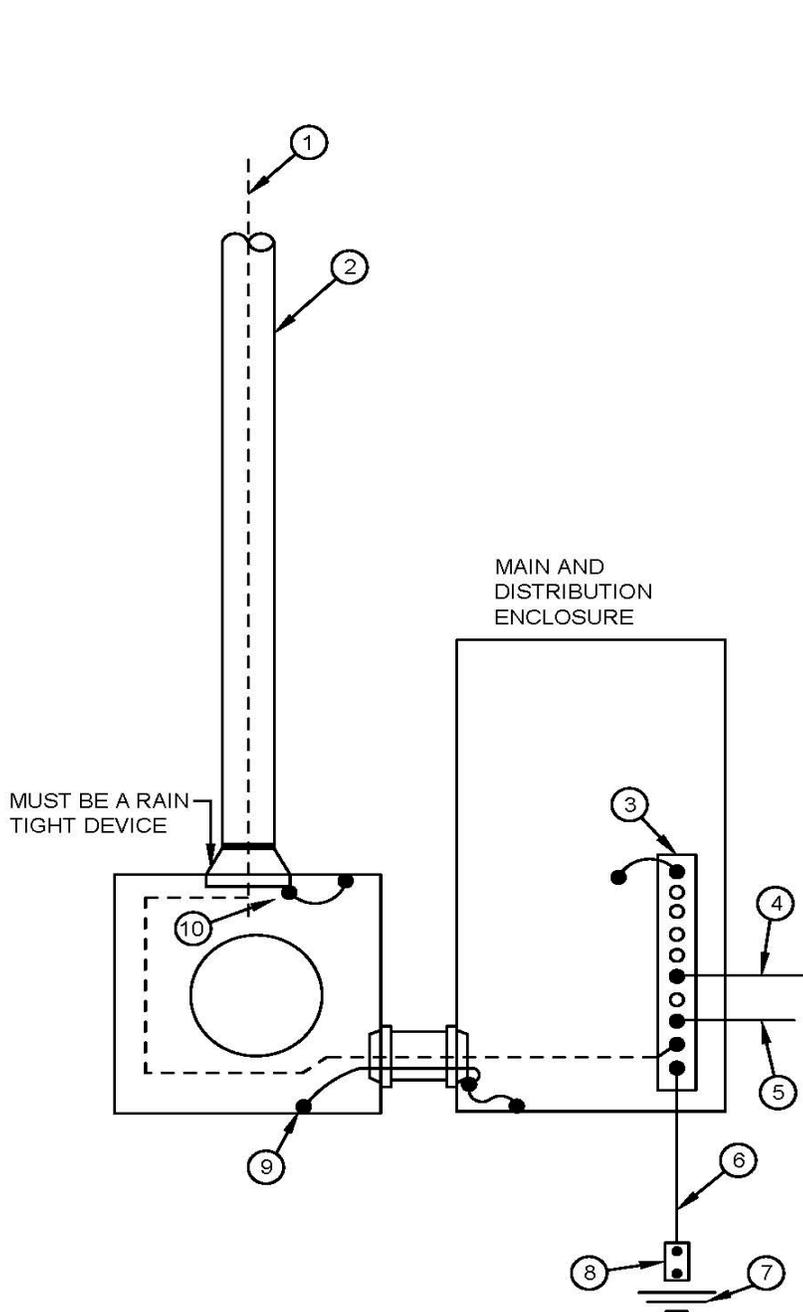
- ① SERVICE DISCONNECT
- ② IF NEUTRAL BUS IS INSULATED FROM THE ENCLOSURE INSTALL A BONDING JUMPER OR SCREW, PER N.E.C.
- ③ SEE N.E.C. FOR TYPE AND SIZE OF MATERIAL AND PROTECTION OF THE GROUNDING ELECTRODE CONDUCTOR. (SEE N.E.C. FOR INSTALLATION AND SIZE)
- ④ GROUND ELECTRODE SHALL BE TERMINATED IN A DRY LOCATION IF RE-BAR USED.
- ⑤ CONNECTION TO ELECTRODE. CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑥ APPROVED SYSTEM GROUND CLAMPS SHALL BE ACCESSIBLE (SEE N.E.C.)
- ⑦ BOND TO INTERIOR METALLIC COLD WATER PIPING SYSTEMS PER N.E.C.
- ⑧ GROUND ELECTRODE (SEE N.E.C.)

NOTE:
 20 FT. OR MORE #4 REINFORCING STEEL , OR 3/4 IN. RIGID METALLIC CONDUIT OR NO. 4 BARE COPPER WIRE (OR LARGER). (SEE N.E.C.)



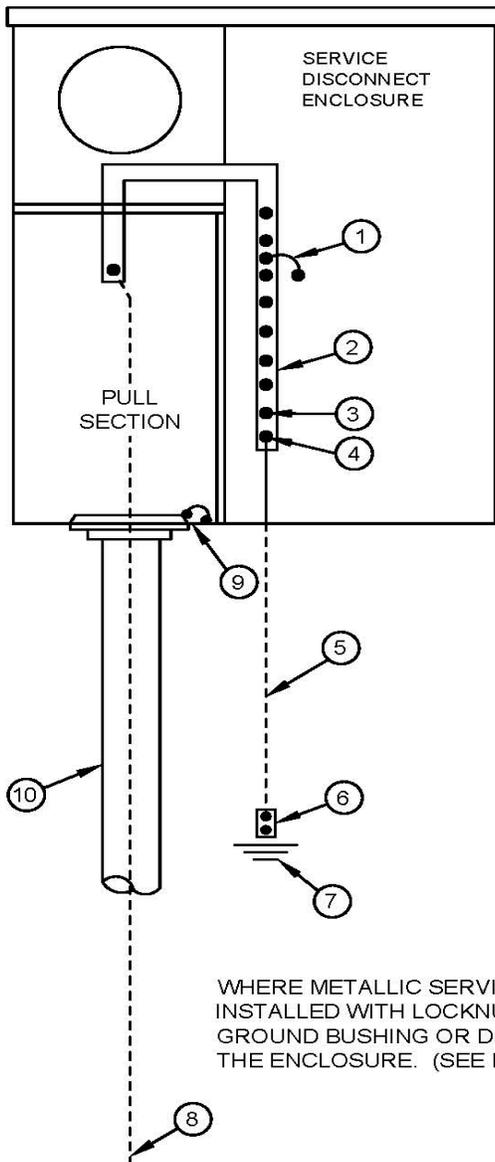
- ① GROUNDED (NEUTRAL) SERVICE ENTRANCE CONDUCTOR.
- ② SERVICE ENTRANCE RACEWAY.
- ③ MUST BE A RAIN TIGHT DEVICE.
- ④ IF BOLTED HUB OR SELF BONDING HUB IS USED BONDING JUMPER IS NOT REQUIRED PER N.E.C. SIZE BONDING JUMPER PER **TABLE 701.0, COLUMN 3, ESRM.**
- ⑤ SERVICE DISCONNECT ENCLOSURE.
- ⑥ NEUTRAL TERMINAL BUS. WHERE NEUTRAL TERMINAL IS INSULATED FROM THE ENCLOSURE, INSTALL A BONDING JUMPER OR SCREW. (SEE N.E.C.) NEUTRAL DISCONNECT MEANS SEE N.E.C.
- ⑦ BARE OR INSULATED GROUNDING ELECTRODE CONDUCTOR (SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE)
- ⑧ SIZE PER **TABLE 701.0, COLUMN 2, ESRM.**
- ⑨ CONNECTION TO ELECTRODE, CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑩ GROUNDING ELECTRODE SYSTEM. (SEE N.E.C.)
- ⑪ OTHER METAL WATER - (SEE N.E.C.) SIZE BOND CONDUCTOR PIPING PER **TABLE 701.0 COLUMN 1, ESRM.**
- ⑫ SIZE BOND CONDUCTOR FOR METAL WATER PIPING PER **TABLE 701.0 COLUMN 2, ESRM.**

703.2 TYPICAL RESIDENTIAL OVERHEAD SERVICE - SEPARATE METER AND DISTRIBUTION CAN.
MAX 200 AMP. (SINGLE PHASE)



- ① NEUTRAL
- ② SERVICE ENTRANCE RACEWAY
- ③ WHERE NEUTRAL TERMINAL BUS IS INSULATED FROM THE ENCLOSURE, INSTALL A BOND JUMPER OR SCREW.
- ④ METAL WATER PIPING PER **TABLE 701.0, COLUMN 2, ESRM.** (SEE N.E.C.)
- ⑤ OTHER METAL PIPING PER **TABLE 701.0, COLUMN 1, ESRM.** (SEE N.E.C.)
- ⑥ GROUNDING ELECTRODE CONDUCTOR. (SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE.)
- ⑦ GROUNDING ELECTRODE SYSTEM. (SEE N.E.C.)
- ⑧ CONNECTION TO ELECTRODE CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑨ BONDING JUMPERS SIZE PER **TABLE 701.0, COLUMN 3, ESRM.** (SEE N.E.C.)
- ⑩ IF BOLTED HUB OR SELF BONDING HUB IS USED. BONDING JUMPER IS NOT REQUIRED. SIZE BONDING JUMPER PER **TABLE 701.0, COLUMN 3, ESRM.** (SEE N.E.C.)

TYPICAL RESIDENTIAL UNDERGROUND SERVICE (SINGLE FAMILY)
 MAX 200 AMP. SINGLE PHASE

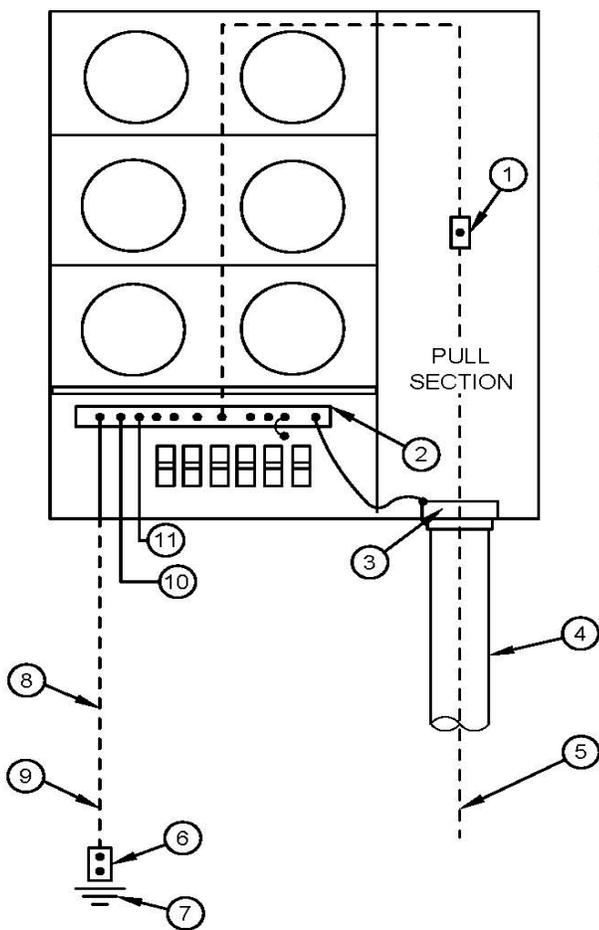


- ① WHERE NEUTRAL BUS IS INSULATED FROM THE ENCLOSURE, INSTALL A BONDING JUMPER OR SCREW. (SEE N.E.C.)
- ② NEUTRAL DISCONNECT MEANS SEE N.E.C.
- ③ METAL WATER PIPING PER TABLE 701.0, COLUMN 2, ESRM. (SEE N.E.C.)
- ④ OTHER METAL PIPING PER TABLE 701.0, COLUMN 1, ESRM. (SEE N.E.C.)
- ⑤ BARE OR INSULATED GROUNDING ELECTRODE CONDUCTOR. (SEE N.E.C. FOR MATERIAL INSTALLATION AND SIZE.) SEE TABLE 701.0, COLUMN 2, ESRM.
- ⑥ CONNECTION TO ELECTRODE. CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑦ GROUNDING ELECTRODE SYSTEM. (SEE N.E.C.)
- ⑧ GROUNDED (NEUTRAL) SERVICE CONDUCTOR.
- ⑨ IF BOLTED HUB OR SELF BONDING HUB IS USED, BONDING JUMPER IS NOT REQUIRED. (SEE N.E.C.)
- ⑩ SERVICE ENTRANCE RACEWAY

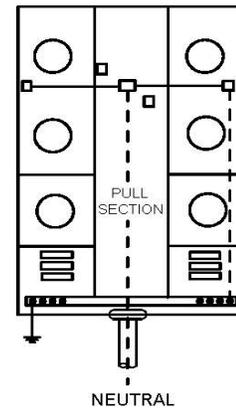
WHERE METALLIC SERVICE RACEWAY IS INSTALLED WITH LOCKNUTS, INSTALL A GROUND BUSHING OR DEVICE AND BOND TO THE ENCLOSURE. (SEE N.E.C.)

704.1 UNDERGROUND MULTI-FAMILY RESIDENTIAL SERVICE - SINGLE PHASE
(400 AMP AND LARGER)

- ① NEUTRAL LANDING TERMINAL (INSULATED FROM ENCLOSURE)
- ② WHERE NEUTRAL BUS IS INSULATED FROM THE ENCLOSURE, INSTALL A BONDING JUMPER OR SCREW. (SEE N.E.C.) NEUTRAL DISCONNECT MEANS SEE N.E.C.
- ③ IF BOLTED HUB OR SELF BONDING BUSHING IS USED. BONDING JUMPER IS NOT REQUIRED. (SEE TABLE 701.0, COLUMN 3, FOR BOND WIRE SIZE, ESRM.)
- ④ SERVICE ENTRANCE RACEWAY
- ⑤ GROUNDED (NEUTRAL) SERVICE CONDUCTOR
- ⑥ CONNECTION TO ELECTRODE. CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP (SEE N.E.C.)
- ⑦ GROUNDED ELECTRODE SYSTEM (SEE N.E.C.)
- ⑧ GROUNDING ELECTRODE CONDUCTOR SEE N.E.C. (SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE.)
- ⑨ SIZE PER TABLE 701.0, COLUMN 2. ESRM.
- ⑩ OTHER METAL PIPING PER TABLE 701.0, COLUMN 1, ESRM. (SEE N.E.C.)
- ⑪ METAL WATER PIPING PER TABLE 701.0, COLUMN 2, ESRM. (SEE N.E.C.)

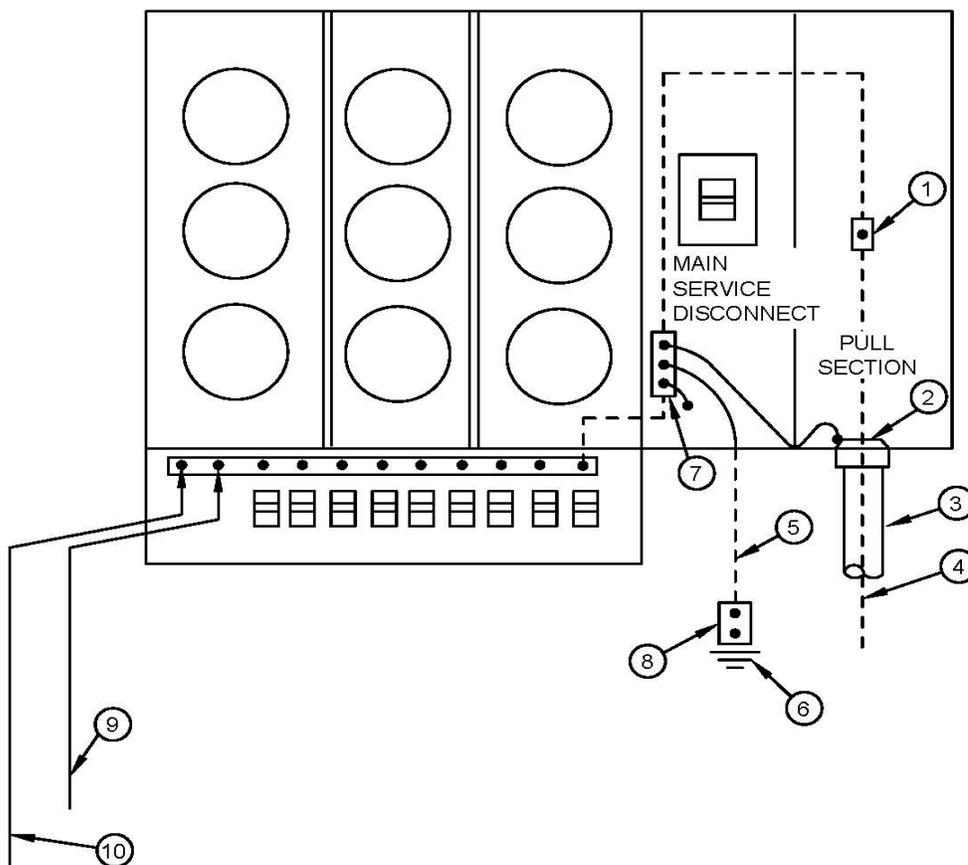


WHERE METALLIC SERVICE RACEWAY IS INSTALLED WITH LOCKNUTS, INSTALL A GROUND BUSHING OR DEVICE AND BOND TO THE ENCLOSURE. (SEE N.E.C.)

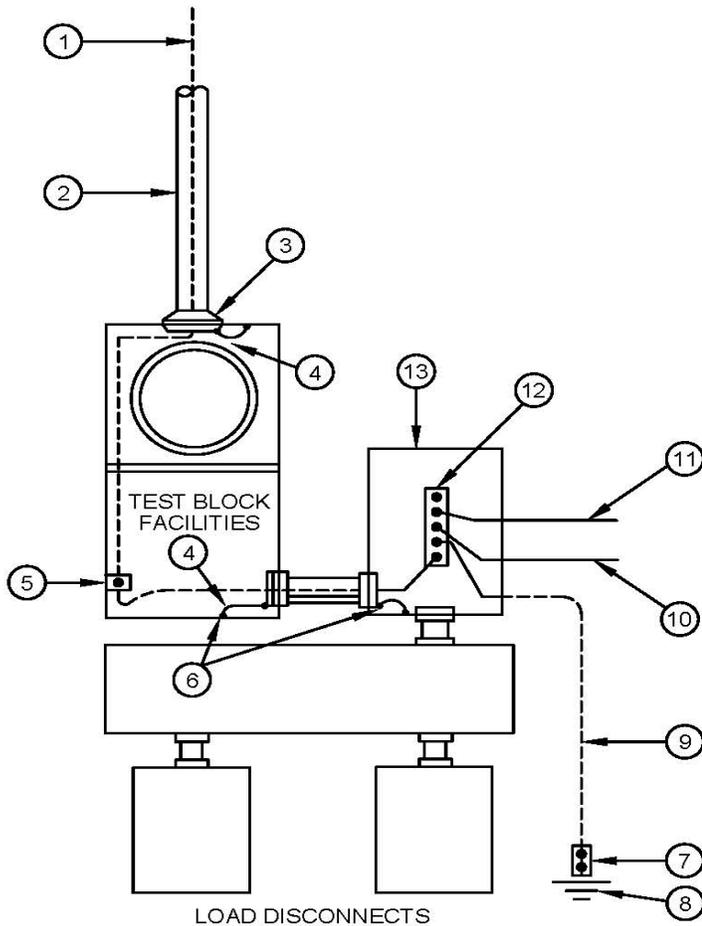


UNDERGROUND MULTI-FAMILY RESIDENTIAL SERVICE - MORE THAN DISCONNECTS
(SUBDIVISIONS) - SINGLE PHASE

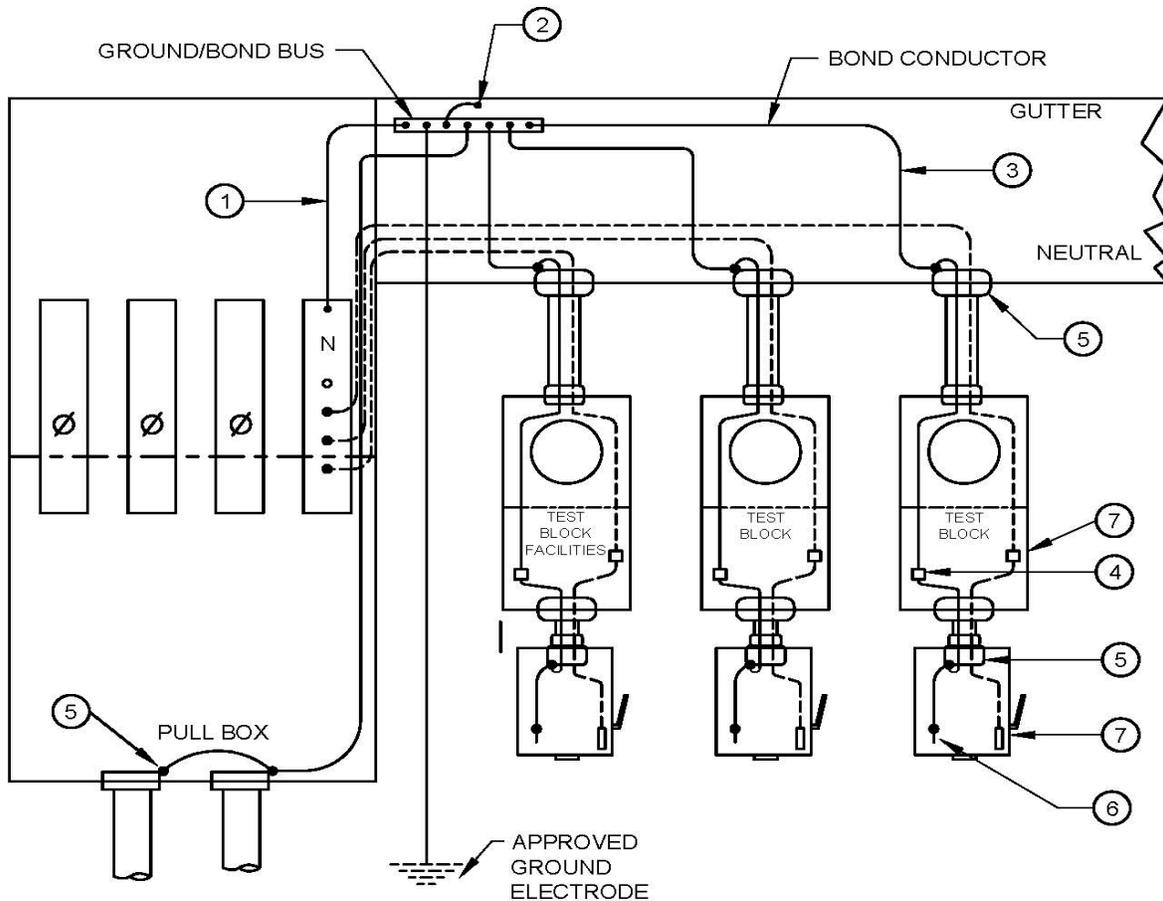
- ① NEUTRAL LANDING TERMINAL (INSULATED FROM ENCLOSURE)
- ② IF BOLTED HUB OR SELF BONDING HUB IS USED, BOND JUMPER IS NOT REQUIRED. (SEE TABLE 701.0, COLUMN 3, ESRM FOR BOND WIRE SIZE.)
- ③ SERVICE ENTRANCE RACEWAY.
- ④ GROUNDED (NEUTRAL) SERVICE CONDUCTOR
- ⑤ GROUNDING ELECTRODE CONDUCTOR (SEE N.E.C.) (SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE.) SEE TABLE 701.0, COLUMN 2, ESRM.
- ⑥ GROUNDING ELECTRODE SYSTEM (SEE N.E.C.)
- ⑦ WHERE NEUTRAL BUS IS INSULATED FROM THE ENCLOSURE, INSTALL A BONDING JUMPER OR SCREW. (SEE N.E.C.) NEUTRAL DISCONNECT MEANS SEE N.E.C.
- ⑧ CONNECTION TO ELECTRODE, CONNECT GROUNDING ELECTRODE CONDUCTOR TO THE GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑨ METAL WATER PIPING, PER TABLE 701.0, COLUMN 2, ESRM. (SEE N.E.C.)
- ⑩ OTHER METAL PIPING, PER TABLE 701.0, COLUMN 1, ESRM. (SEE N.E.C.)



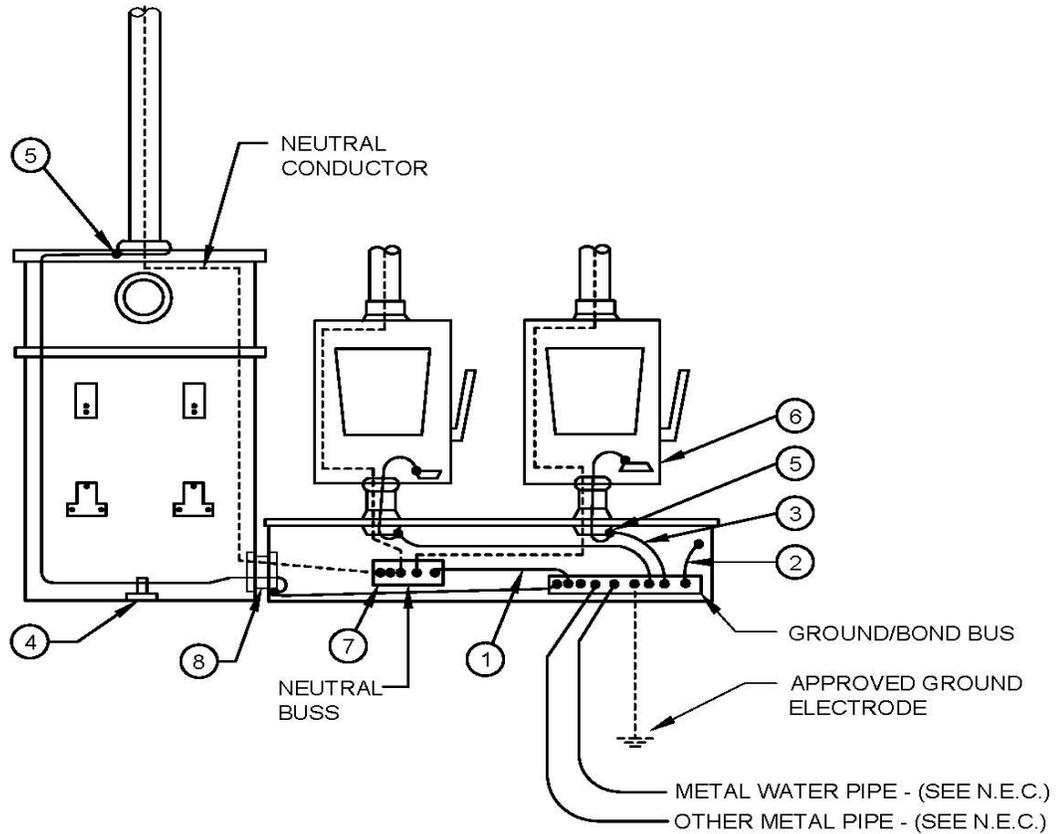
705.1 TYPICAL NON-RESIDENTIAL OVERHEAD SERVICE (SINGLE METER) SINGLE OR THREE PHASE. 200 AMP MINIMUM.



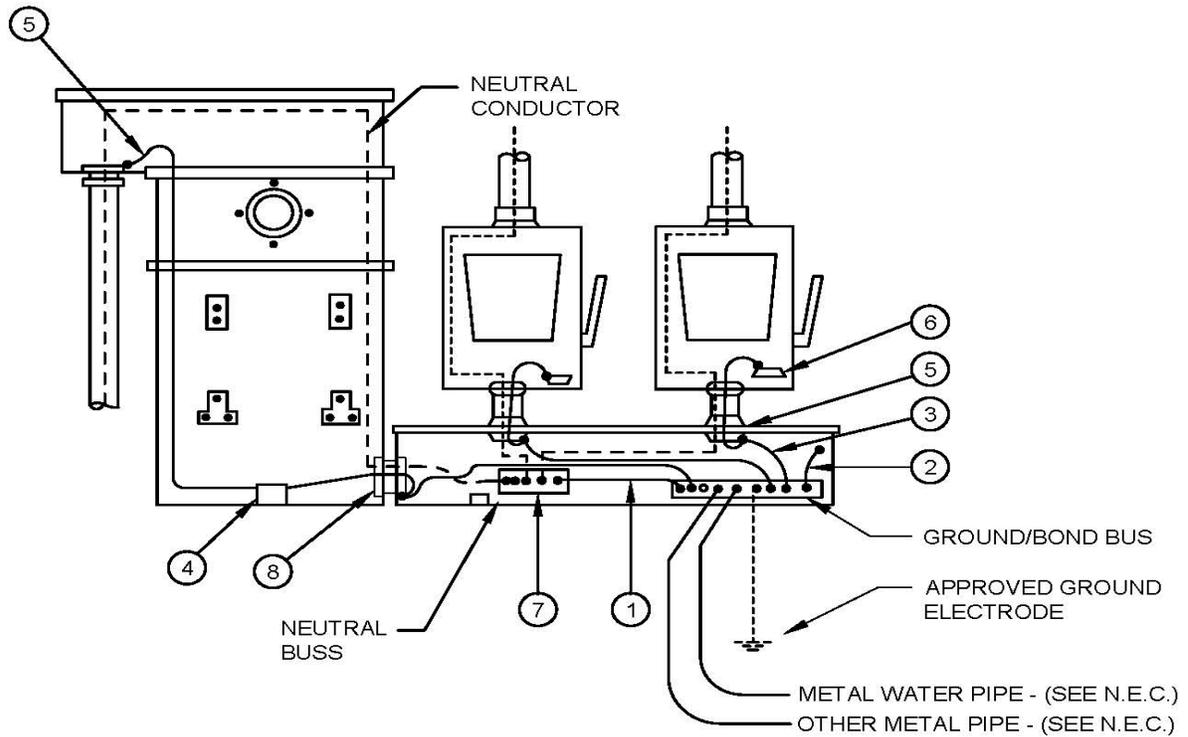
- ① GROUNDED (NEUTRAL) SERVICE ENTRANCE CONDUCTOR
- ② SERVICE ENTRANCE RACEWAY
- ③ MUST BE A RAIN TIGHT DEVICE
- ④ IF BOLTED HUB OR SELF BONDING HUB IS USED BOND JUMPER IS NOT REQUIRED. (SEE TABLE 701.0, COLUMN 3, ESRM FOR BOND WIRE SIZE.)
- ⑤ NEUTRAL LAY IN LUG SHALL BE INSULATED FROM ENCLOSURE.
- ⑥ BONDING JUMPERS (SEE N.E.C.)
- ⑦ CONNECTION TO ELECTRODE, CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑧ GROUNDING ELECTRODE SYSTEM. (SEE N.E.C.)
- ⑨ GROUNDING ELECTRODE CONDUCTOR (SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE.) SEE TABLE 701.0, COLUMN 2, ESRM.
- ⑩ OTHER METAL PIPING PER TABLE 701.0, COLUMN 1, ESRM (SEE N.E.C.)
- ⑪ METAL WATER PIPING PER TABLE 701.0, COLUMN 2, ESRM (SEE N.E.C.)
- ⑫ WHERE NEUTRAL TERMINAL BUS IS INSULATED FROM THE ENCLOSURE, INSTALL A BONDING JUMPER OR SCREW. (SEE N.E.C.) NEUTRAL DISCONNECT MEANS SEE N.E.C.
- ⑬ MAIN SERVICE DISCONNECT ENCLOSURE



- ① MAIN BONDING JUMPER SIZED PER **TABLE 701.0 COLUMN 3** (per NEC)
- ② GROUND BOND BUS TO BE TIED TO METAL GUTTER. PER **TABLE 701.0 COLUMN 3** (per NEC)
- ③ INSULATED BOND CONDUCTOR SIZED PER NEC. SIZED PER **TABLE 701.0 COLUMN 3 ESRM.**
- ④ INSULATED BOND CONDUCTOR TO BE TIED TO METAL ENCLOSURE.
- ⑤ ALL UNFUSED NIPPLES TO BE BONDED PER NEC. SIZE PER **TABLE 701.0 COLUMN 3 ESRM.**
- ⑥ BOND TERMINAL BAR TO BE TIED TO METAL ENCLOSURE.
- ⑦ NEUTRAL TERMINAL SHALL BE INSULATED FROM METAL ENCLOSURE.

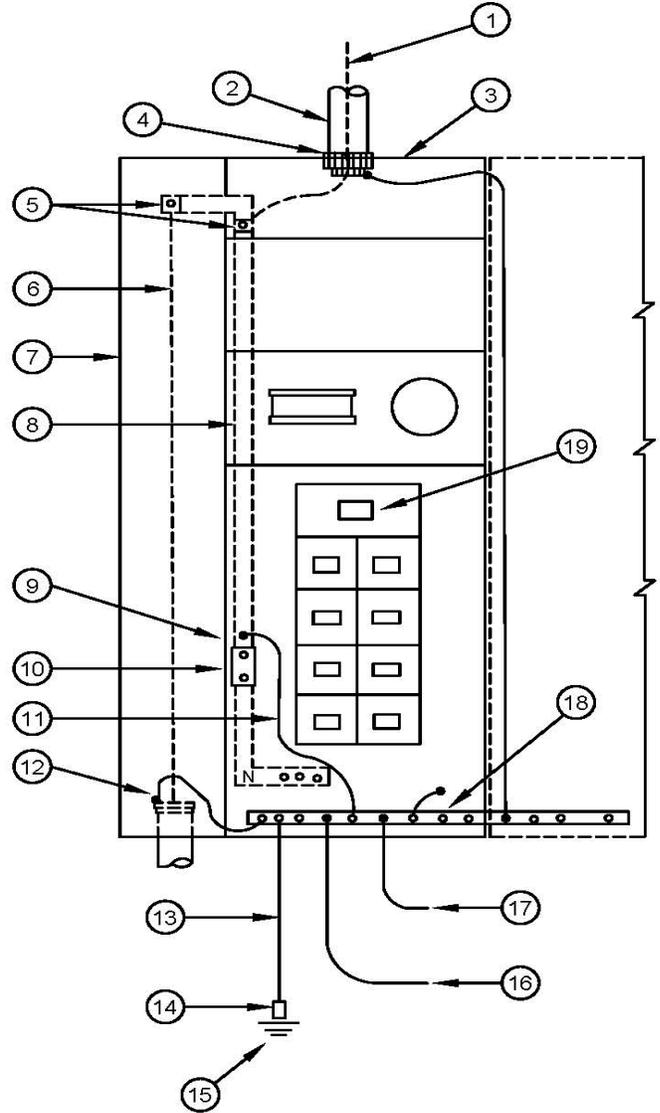


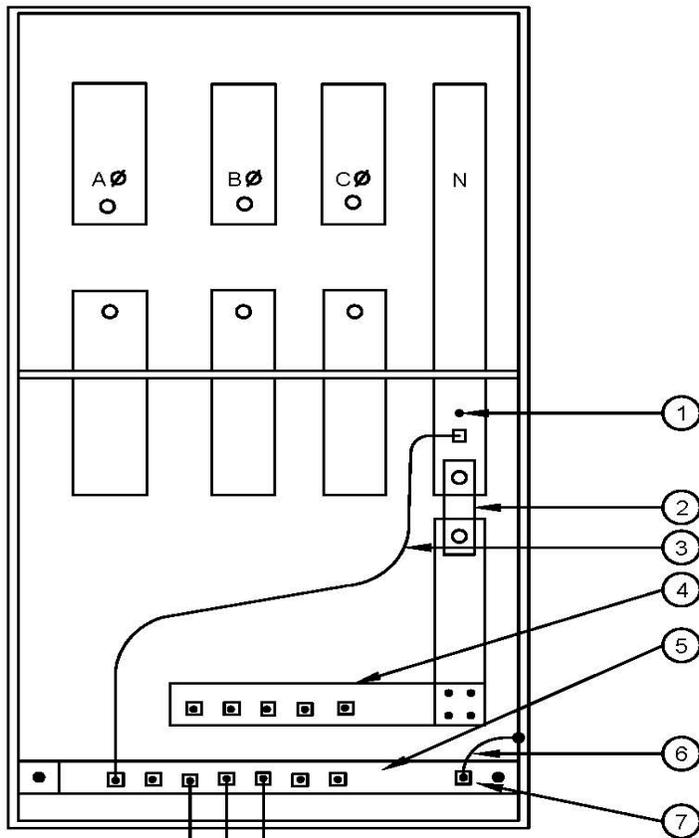
- ① MAIN BONDING JUMPER SIZED PER NEC. SIZE PER **TABLE 701.0 COLUMN 3, ESRM.**
- ② GROUND BOND BUS TO BE TIED TO METAL GUTTER.
- ③ BOND CONDUCTOR SIZED PER NEC. SIZED PER **TABLE 701.0 COLUMN 3, ESRM.**
- ④ BOND CONDUCTOR TO BE TIED TO METAL ENCLOSURE.
- ⑤ ALL UNFUSED NIPPLES TO BE BONDED. SIZE PER **TABLE 701.0 COLUMN 3, ESRM.**
- ⑥ BOND TERMINAL BAR TO BE TIED TO METAL ENCLOSURE.
- ⑦ NEUTRAL TERMINAL SHALL BE INSULATED FROM METAL ENCLOSURE.
- ⑧ IF PARALLEL CONDUCTORS RUN FROM THE CAN INTO THE GUTTER A BOND WIRE MUST BE INSTALLED IN EACH CONDUIT (PER NEC). SEE SECTION 300 PAGE 60 FOR PARALLEL REQUIREMENTS.



- ① MAIN BONDING JUMPER SIZED PER NEC. SIZE PER **TABLE 701.0 COLUMN 3, ESRM.**
- ② GROUND BOND BUS TO BE TIED TO METAL GUTTER.
- ③ BOND CONDUCTOR SIZED PER NEC. SIZED PER **TABLE 701.0 COLUMN 3, ESRM.**
- ④ BOND CONDUCTOR TO BE TIED TO METAL ENCLOSURE.
- ⑤ ALL UNFUSED NIPPLES TO BE BONDED. SIZE PER **TABLE 701.0 COLUMN 3, ESRM.**
- ⑥ BOND TERMINAL BAR TO BE TIED TO METAL ENCLOSURE.
- ⑦ NEUTRAL TERMINAL SHALL BE INSULATED FROM METAL ENCLOSURE.
- ⑧ IF PARALLEL CONDUCTORS RUN FROM THE CAN INTO THE GUTTER A BOND WIRE MUST BE INSTALLED IN EACH CONDUIT (PER NEC). SEE SECTION 300 PAGE 60 FOR PARALLEL REQUIREMENTS.

- ① GROUNDED (NEUTRAL) SERVICE CONDUCTOR.
- ② OVERHEAD SERVICE ENTRANCE CONDUIT
- ③ BONDING JUMPER (NOT REQUIRED IF HUB IS USED.)
- ④ MUST BE RAIN TIGHT DEVICE
- ⑤ NEUTRAL LANDING TERMINAL
- ⑥ NEUTRAL SERVICE CONDUCTOR
- ⑦ UNDERGROUND PULL SECTION
- ⑧ NEUTRAL BUS
- ⑨ CONNECTION FOR MAIN BOND JUMPER, MUST BE ON LINESIDE OF NEUTRAL DISCONNECT LINK.
- ⑩ NEUTRAL DISCONNECT LINK
- ⑪ MAIN BOND JUMPER (SEE N.E.C.)
- ⑫ WHERE METALLIC CONDUIT IS USED, INSTALL A BOND BUSHING AND BOND PER N.E.C.
- ⑬ GROUNDING ELECTRODE CONDUCTOR. (SEE N.E.C.) (SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE.)
- ⑭ CONNECTION TO ELECTRODE, CONNECT GROUNDING ELECTRODE CONDUCTOR TO GROUNDING ELECTRODE WITH APPROVED GROUND CLAMP. (SEE N.E.C.)
- ⑮ GROUNDING ELECTRODE SYSTEM (SEE N.E.C.)
- ⑯ OTHER METAL PIPING PER N.E.C. SIZE PER TABLE 701.0, COLUMN 1, ESRM.
- ⑰ METAL WATER PIPING PER N.E.C. SIZE PER TABLE 701.0, COLUMN 2, ESRM.
- ⑱ GROUND/BOND BUS
- ⑲ MAIN SERVICE DISCONNECT





- ① CONNECTION FOR MAIN BOND JUMPER AHEAD OF NEUTRAL DISCONNECT LINK.
- ② NEUTRAL DISCONNECT LINK.
- ③ MAIN BOND JUMPER(S) (SEE N.E.C.) **SIZE PER TABLE 701.0, COLUMN 3, ESRM.**
- ④ ALL NEUTRAL WIRES, TO BE PLACED ON NEUTRAL BUS
- ⑤ ALL BOND WIRES PER N.E.C. - TO BE PLACED ON BOND BUS.
- ⑥ ENCLOSURE GROUNDED PER N.E.C.
- ⑦ (A WIRE MAY NOT BE NECESSARY IF GROUNDING BUSBAR HAS BEEN INSTALLED ON A CLEANED SURFACE OF THE FRAME WITH BOLTS OF ADEQUATE SIZE AND STRENGTH.)

TO GROUNDING ELECTRODE N.E.C. **SIZE PER TABLE 701.0, COLUMN 2, ESRM.**
PIPING SYSTEMS PER N.E.C.
 METAL WATER PIPING PER N.E.C. **SIZE PER TABLE 701.0, COLUMN 2, ESRM.**
 OTHER METAL PIPING PER N.E.C. **SIZE PER TABLE 701.0, COLUMN 1, ESRM.**

- ① WHERE NEUTRAL BUS IS INSULATED FROM THE ENCLOSURE, INSTALL A BONDING JUMPER OR SCREW TO THE PEDESTAL. (SEE N.E.C.)
NEUTRAL DISCONNECT MEANS (SEE N.E.C.)
- ② NEUTRAL LANDING TERMINAL
- ③ GROUNDING (NEUTRAL) SERVICE CONDUCTOR
- ④ GROUNDING ELECTRODE CONDUCTOR
(SEE N.E.C. FOR MATERIAL, INSTALLATION AND SIZE)
SIZE PER TABLE 701.0, COLUMN 2, ESRM.
- ⑤ CONNECTION TO ELECTRODE CONNECT
GROUNDING ELECTRODE CONDUCTOR
WITH APPROVED GROUND CLAMP. SEE N.E.C.
(CHECK WITH AHJ).
- ⑥ GROUNDING ELECTRODE SYSTEM
SEE N.E.C. (CHECK WITH AHJ).
(SEE DWG 303.13 NOTE 10).

