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DUKE ENERGY IS A “DIRECT BURIED” UTILITY. THIS MEANS THE COMPANY TYPICALLY DIRECTLY BURIES ALL 600 VOLT AND MEDIUM VOLTAGE PRIMARY CABLE IN THE GROUND WITHOUT THE USE OF CONDUIT.

ONE MAJOR EXCEPTION IS THE FACILITIES INSTALLED IN OHIO AND KENTUCKY. CABLES IN THOSE STATES ARE TYPICALLY INSTALLED IN CONDUIT, MUCH OF WHICH IS PROVIDED BY THE CUSTOMER. THIS IS DONE TO COMPLY WITH STATE REGULATIONS.

OTHER EXAMPLES OF SITUATIONS WHERE CABLE MAY BE INSTALLED IN CONDUIT OR AN EMPTY CONDUIT INSTALLED FOR FUTURE USE IS PROVIDED ON DWG. 22.03-100 (USES FOR CONDUIT).

CONDUIT IS NOT REQUIRED FOR DIRECTIONAL BORE INSTALLATIONS EXCEPT WHEN MANDATED BY THE PERMITTING AUTHORITY.

REFER TO SECTION 36 FOR THE FOLLOWING INFORMATION:

- CLEARANCES
- JOINT USE TRENCH DESIGNS
- TRENCHING NEAR STRUCTURES
- TRENCHING/DIRECTIONAL BORING NEAR TREES
### TABLE 1: MINIMUM CABLE COVER

<table>
<thead>
<tr>
<th>CABLE OR APPLICATION</th>
<th>MINIMUM COVER</th>
<th>SPECIFIC NOTES</th>
<th>JOINT TRENCH</th>
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<tr>
<td>SECONDARY / SERVICE</td>
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<td>SEE NOTES 2 AND 3</td>
<td>SEE SECTION 36 FOR JOINT TRENCH CONSTRUCTION</td>
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<td>ROAD CROSSINGS (ANY VOLTAGE)</td>
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<tr>
<td>RAILROAD CROSSINGS (ANY VOLTAGE)</td>
<td>PERMIT SPECIFIC</td>
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<td>PARKING LOT CROSSINGS (ANY VOLTAGE)</td>
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<td>SEE NOTES 2, 3 AND 5</td>
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### NOTES:

1. MINIMUM SEPARATION BETWEEN CABLES MAY BE OBTAINED EITHER HORIZONTALLY OR VERTICALLY.
2. IF REQUIRED MINIMUM DEPTH CANNOT BE OBTAINED, INSTALL CABLE IN SCHEDULE 40 OR GREATER CONDUIT WITH A MINIMUM OF TWO (2) INCHES OF CONCRETE ABOVE AND BESIDE THE CONDUIT AND A MINIMUM OF SIX (6) INCHES OF COVER.
3. RISER CONDUIT BENDS AND BRIDGE TRANSITIONS ARE EXCEPTIONS TO THE MINIMUM COVER REQUIREMENT.
4. REFER TO SECTION 36 FOR JOINT TRENCH INFORMATION AND CONSTRUCTION DETAILS.
5. IF PERMIT IS REQUIRED, MINIMUM DEPTH WILL BE PERMIT SPECIFIC RATHER THAN THE DEPTH LISTED, BUT NEVER LESS THAN NESC REQUIREMENTS.
6. FEEDERS (>200A) MUST BE SEPARATED HORIZONTALLY BY 36". VERTICAL SEPARATION ONLY IS NOT AN OPTION.
7. DEC REQUIRES A MINIMUM OF 12" VERTICAL SEPARATION BETWEEN 10 AND 30 CABLES AND BETWEEN SECONDARY/SERVICE AND 30 CABLES.
8. TABLES 2 AND 3 SPECIFY APPLICATIONS THAT REQUIRE SEPARATION BETWEEN CABLES. ALL OTHER APPLICATIONS WILL USE "RANDOM LAY" WHICH MEANS CABLES MAY BE PLACED INTO A TRENCH WITH NO REQUIRED SEPARATION.
9. EITHER ONE WIDE TRENCH OR TWO NARROW TRENCHES MAY BE USED, BASED ON ECONOMICS, TO OBTAIN REQUIRED HORIZONTAL SEPARATION.

### TABLE 2: REQUIRED MINIMUM SEPARATION BETWEEN CABLES WHEN SEPARATION IS TO BE OBTAINED HORIZONTALLY (CABLES ARE BURIED AT THE SAME DEPTH)

<table>
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<th>COLUMN 1</th>
<th>MINIMUM HORIZONTAL SEPARATION FROM CABLES IN COLUMN 1</th>
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<tr>
<td>FEEDER (&gt;200A)</td>
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* SEE NOTE 7 FOR ADDITIONAL DEC REQUIREMENT

### TABLE 3: REQUIRED MINIMUM SEPARATION BETWEEN CABLES WHEN SEPARATION IS TO BE OBTAINED VERTICALLY (CABLES ARE BURIED AT THE DIFFERENT DEPTHS)

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<tr>
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<td>FEEDER (&gt;200A)</td>
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</table>

* SEE NOTE 7 FOR ADDITIONAL DEC REQUIREMENT
TRENCH CONFIGURATIONS

FIGURE 1

SECONDARY/ SERVICE WITH 200A SINGLE-PHASE PRIMARY

FIGURE 2

SECONDARY/ SERVICE WITH 200A THREE-PHASE PRIMARY

FIGURE 3

SECONDARY/ SERVICE WITH TWO 200A SINGLE-PHASE PRIMARIES THAT ARE BOTH PART OF THE SAME LOOP

FIGURE 4

SECONDARY/ SERVICE WITH TWO 200A SINGLE-PHASE PRIMARIES THAT ARE BOTH PART OF THE SAME LOOP

FIGURE 5

ONE 200A SINGLE-PHASE PRIMARY WITH ONE 200A THREE-PHASE PRIMARY

NOTES:

1. SEE DWG. 22.01-102B FOR NOTES.
2. THESE CONFIGURATIONS ARE REQUIRED FOR DEC ONLY. THEY ARE OPTIONAL FOR ALL OTHER LOCATIONS.
3. CABLES AT THE SAME DEPTH CAN BE RANDOM LAY.
NOTES:

1. THE TRENCH CONFIGURATIONS SHOWN ON DWG. 22.01-102A AND THIS DRAWING WITH A SPECIFIED SEPARATION BETWEEN CABLES ARE THE ONLY APPLICATIONS THAT REQUIRE SEPARATION BETWEEN CABLES. SEPARATION MAY BE OBTAINED EITHER VERTICALLY AS SHOWN ON DWG. 22.01-102A OR HORIZONTALLY AS SHOWN ON THIS DRAWING. ALL OTHER APPLICATIONS WILL USE THE RANDOM LAY CONFIGURATION SHOWN ABOVE IN FIGURE 5. RANDOM LAY ALLOWS CABLES TO BE PLACED INTO A TRENCH WITH NO REQUIRED SEPARATION.

2. EITHER ONE WIDE TRENCH OR TWO NARROW TRENCHES MAY BE USED BASED ON ECONOMICS TO OBTAIN REQUIRED HORIZONTAL CABLE SEPARATION.

3. IF REQUIRED CABLE SEPARATION CANNOT BE OBTAINED DUE TO SPACE LIMITATIONS, PROVIDE MECHANICAL PROTECTION BY INSTALLING THE CABLE IN SCHEDULE 40 OR GREATER PVC CONDUIT WITH A MINIMUM OF TWO (2) INCHES OF CONCRETE ABOVE AND BESIDE THE CONDUIT.

4. JOINT TRENCH CONFIGURATIONS ARE PROVIDED IN SECTION 35: UNDERGROUND CLEARANCES AND JOINT USE.
TRENCH

RIGHTS-OF-WAY/EASEMENTS AND STREETS SHALL BE CLEARED AND TO FINAL GRADE BEFORE TRENCHING BEGINS.

STANDARD TRENCH DEPTHS ARE SHOWN ON DWGS. 21.01-102A AND 21.01-102B. DUKE ENERGY REQUIRES A MINIMUM COVER OF THIRTY (30) INCHES FOR 600V CABLE AND THIRTY-SIX (36) INCHES FOR MEDIUM VOLTAGE (PRIMARY) CABLE.

REFER TO DWG. 22.01-101 WHEN IT IS NOT POSSIBLE TO OBTAIN THE ABOVE DEPTHS.

THE BOTTOM OF THE TRENCH SHALL BE SMOOTH, UNDISTURBED EARTH, WELL-TAMPED CLEAN BACKFILL OR SAND, FREE OF ROCKS, DEBRIS OR ROOTS. WHEN EXCAVATION IS IN ROCK OR ROCKY SOIL, CABLE, CONDUITS OR CABLE-IN-CONDUIT SHALL BE LAID ON A WELL-TAMPED LAYER OF CLEAN BACKFILL AT LEAST FOUR (4) INCHES THICK.

SHORING

THE PERFORMANCE OF EXCAVATION WORK INCLUDING TRENCHING, SLOPING, BENCHING, AND SHORING MUST, AT MINIMUM, MEET THE REQUIREMENTS OF OSHA 1926 SUBPART P AND ANY LOCAL JURISDICTIONAL REQUIREMENTS.

REFER TO THE TRENCHING AND EXCAVATIONS SECTION OF THE HEALTH AND SAFETY HANDBOOK FOR DUKE ENERGY REQUIREMENTS.

BACKFILL

BACKFILL WITHIN SIX (6) INCHES OF THE CABLE OR CONDUIT SHALL BE FREE OF ROCK OR ANY MATERIAL THAT MAY DAMAGE THE CABLE OR CONDUIT. THE REMAINING BACKFILL SHOULD BE FREE OF MATERIAL GREATER THAN FOUR (4) INCHES IN MAXIMUM DIMENSION.

COMPACATION

BACKFILL MUST BE ADEQUATELY COMPACTED. BACKFILL SHALL BE COMPACTED SUCH THAT WASHING AND SETTLING OF THE TRENCH SURFACE WILL NOT OCCUR. ADDITIONAL BUILDUP OF THE BACKFILL MAY BE NECESSARY TO PREVENT SETTLING. FINAL SURFACE COMPACATION SHALL LIMIT THE AMOUNT OF SETTLING TO 1/2" OR LESS. ANY REWORK OF THE TRENCH IS THE RESPONSIBILITY OF THE INSTALLER.

MACHINE COMPACATION SHALL NOT BE USED WITHIN SIX (6) INCHES OF THE CABLE OR CONDUIT.

WHEN MACHINE COMPACATION IS REQUIRED, TRENCHES SHALL BE BACKFILLED BY ALTERNATING FILL AND TAMING THE FIRST 12 INCHES AND IN EACH ADDITIONAL 12 INCH INCREMENT.

COMPACATION FOR STREET CROSSINGS MUST COMPLY WITH LOCAL JURISDICTIONAL REQUIREMENTS.

EXTREME SLOPES OR OTHER UNUSUAL FIELD CONDITIONS MAY REQUIRE ADDITIONAL MECHANICAL TAMING OR SODDING AT THE DISCRETION OF THE FIELD ENGINEER OR COMPANY DESIGNATED REPRESENTATIVE.
NOTES:

1. THE USE OF MARKING TAPE DOES NOT GUARANTEE A REDUCTION IN DIG-INS. AS A RESULT, IT IS NOT RECOMMENDED FOR REGULAR USAGE. HOWEVER, MARKING TAPE IS AVAILABLE FOR INSTALLATION AT THE REQUEST OF A CUSTOMER OR GOVERNMENT AGENCY. NORMAL CHARGING PRACTICES WILL APPLY.

2. CONSIDERATION SHOULD BE GIVEN TO PLACING CABLES IN CONDUIT, CONCRETE ENCASED CONDUIT, OR DUCT BANK IN ORDER TO REDUCE DIG-INS.

3. MARKING TAPE IS A 3" (6" IN DEM) WIDE RED TAPE WITH "CAUTION ELECTRIC LINE BURIED BELOW" PRINTED REPEATEDLY ALONG ITS LENGTH AND IS SUPPLIED IN 1,000 FOOT ROLLS.

4. INSTALL MARKING TAPE 12" MINIMUM TO 24" MAXIMUM ABOVE THE PRIMARY CABLE.
NOTES:

1. TEMPORARY LIGHTING CABLE MARKERS WILL NOT BE USED IN DEP FOR SERVICE "END-RUNS". SECONDARY PEDESTALS WILL BE SPECIFIED FOR SERVICE APPLICATIONS.

2. TEMPORARY LIGHTING CABLE MARKERS/ PEDESTALS ARE USED TO END SECONDARY WHERE FUTURE STREET/ AREA LIGHTS WILL BE INSTALLED. SECONDARY CABLE SHALL NOT BE ENERGIZED INSIDE A TEMPORARY CABLE MARKER/ PEDESTAL.

3. INSTALL END CAPS ON PHASE CONDUCTORS TO PREVENT MOISTURE FROM ENTERING THE CABLE.

4. A PIECE OF #6 BARE CU, A MINIMUM OF 1 FOOT LONGER THAN THE MARKER/ PEDESTAL, SHALL BE SPLICED TO THE NEUTRAL CONDUCTOR AND DIRECT-BURIED TO FACILITATE CABLE LOCATION SHOULD THE MARKER/ PEDESTAL BE REMOVED OR DESTROYED. THE CONNECTOR SHALL BE COMPLETELY AQUASEALED AND TAPED TO PREVENT MOISTURE FROM ENTERING THE CABLE.

5. REMOVE THE MARKER/ PEDESTAL AND INSTALL A DIRECT-BURIED SPLICE WHEN STREET/ AREA LIGHT IS INSTALLED.

6. MARKER/ PEDESTAL SHOULD BE INSTALLED AFTER FINAL GRADE IS ESTABLISHED.
OVERVIEW

DIRECTIONAL BORING IS A STEERABLE TRENCHLESS METHOD OF INSTALLING UNDERGROUND CABLES, CONDUITS AND PIPES ALONG A PRESCRIBED PATH BY USING A SURFACE LAUNCHED DRILLING RIG. THIS METHOD HAS MINIMAL IMPACT ON THE SURROUNDING AREA. IT IS TYPICALLY USED WHEN TRENCHING OR EXCAVATING IS NOT PRACTICAL (I.E. UNDER CONCRETE OR PAVEMENT) OR WHEN CUSTOMER SATISFACTION (I.E. CABLE REPLACEMENT) IS A MAJOR CONCERN.

PROCESS


ONCE THE INITIAL BORE IS COMPLETE, THE OPERATOR Pulls a Reaming Head back through the bore toward the drilling rig. At the same time, cable, conduit or pipe is pulled back through the bore.

DUKE ENERGY REQUIREMENT

DIRECTIONAL DRILLING EQUIPMENT CAN APPLY EXCESSIVE TENSION WHICH CAN SERIOUSLY DAMAGE CABLE BEING PULLED THROUGH A BORE.

FOR THE ABOVE REASON, DUKE ENERGY REQUIRES DIRECTIONAL DRILLING CONTRACTORS TO UTILIZE A TENSION LIMITING DEVICE WHEN PULLING CABLE THROUGH A BORE. THIS CAN BE A PIECE OF BARE #6 AWG SOLID COPPER WIRE FOR 1/0 AWG MEDIUM VOLTAGE CABLE. TENSION LIMITING ATTACHMENTS (TYPICALLY BREAK-AWAY DEVICES) ARE AVAILABLE FROM VARIOUS TOOL MANUFACTURERS FOR USE WITH OTHER CABLES. MAXIMUM ALLOWABLE PULLING TENSIONS FOR ALL MEDIUM VOLTAGE CABLES ARE PROVIDED IN SECTION 23 (UNDERGROUND CABLES).

DIRECTIONAL BORING NEAR TREES

SEE SECTION 36, UNDERGROUND CLEARANCES AND JOINT USE, FOR DETAILS.
DUKE ENERGY TYPICALLY DIRECT BURIES ALL 600 VOLT AND MEDIUM VOLTAGE PRIMARY CABLE IN THE GROUND WITHOUT THE USE OF CONDUIT. HOWEVER, LISTED BELOW ARE SOME EXAMPLES OF SITUATIONS WHERE CABLE MAY BE INSTALLED IN CONDUIT OR SPARE (EMPTY) CONDUITS INSTALLED.

FUTURE MAINTENANCE (REPLACEMENT) CONSIDERATIONS
APPLICATIONS WHERE FUTURE REPLACEMENT OF CABLE WOULD NOT BE POSSIBLE USING TRENCHING OR DIRECTIONAL BORING METHODS. DIRECTIONAL BORING LIMITATIONS ARE AS FOLLOWS:
● BORE WOULD BE LONGER THAN MAXIMUM CABLE FOOTAGE ON A REEL
● BORE LENGTH EXCEEDS EQUIPMENT CAPABILITIES (TYPICALLY 500' BUT CONSULT WITH CONTRACTOR)
● EXCESSIVE CABLE PULLING TENSIONS THROUGH CONDUIT WOULD BE ENCOUNTERED
● NOT ADEQUATE "GREEN" SPACE FOR BORE PITS

PROJECT TIMING
CROSSINGS UNDER PAVEMENT WHERE CABLE CANNOT BE INSTALLED PRIOR TO THE PAVEMENT. EFFORT SHOULD BE MADE TO INSTALL CABLE IF TIMING AND FIELD CONDITIONS ALLOW.

CUSTOMER REQUEST
THE DUKE ENERGY STANDARD IS TO PROVIDE DIRECT-BURIED UNDERGROUND CABLES. CUSTOMER REQUESTS FOR A CONDUIT INSTALLATION SHOULD BE EVALUATED ON A CASE-BY-CASE BASIS AND WILL REQUIRE MANAGEMENT APPROVAL. THE CUSTOMER WILL BE RESPONSIBLE FOR PAYING ALL ADDITIONAL COSTS ASSOCIATED WITH THE REQUEST (I.E. CONDUIT, PULL BOXES, SPLICES, PULLING LABOR, ETC.)

SPECIFIC REGULATIONS
● RAILROAD AND GAS TRANSMISSION CROSSINGS
● CROSSING OTHER UTILITIES WHEN CODE CLEARANCES CANNOT BE MET
● REQUIRED BY DOT OR OTHER GOVERNMENTAL AGENCIES
● SUBSTATION EXITS TO THE TERMINATION POINT

FUTURE GROWTH
CONDUIT MAY BE NECESSARY TO ACCOMMODATE FUTURE PROJECT EXPANSIONS OR LOAD GROWTH. FOR LONGER TERM PROJECTS, AN ECONOMIC ANALYSIS SHOULD BE PERFORMED TO DETERMINE THE BEST OPTION (I.E. INSTALL CONDUIT NOW VS BORE IN THE FUTURE).

SHALLOW INSTALLATIONS
CABLE SHALL BE INSTALLED IN CONCRETE-ENCASED CONDUIT WHEN MINIMUM CABLE COVER REQUIREMENTS CANNOT BE MET. SEE DWG. 22.01-101 FOR DETAILS.

RADIAL PRIMARY FEEDS
WHEN THE MAJORITY OF THE CABLE SUPPLYING A SINGLE RADIAL-FED TRANSFORMER IS UNDER PAVEMENT OR CONCRETE, THE CABLE CAN BE INSTALLED IN CONDUIT OR AN EMPTY CONDUIT CAN BE INSTALLED ALONG THE ENTIRE ROUTE.

CABLE MAY ALSO BE INSTALLED IN CONDUIT AND EMPTY CONDUIT INSTALLED FOR FUTURE CABLE INSTALLATION WHEN IT IS SERVING A "SHORT-TERM RADIALLY-FED TRANSFORMER" (THE LOOP WILL BE COMPLETED AT SOME POINT IN THE FUTURE) WHEN IT WILL NOT BE POSSIBLE TO TRENCH AROUND THE TRANSFORMER OR DIRECTIONALLY BORE IN THE AREA TO INSTALL THE FUTURE CABLE.

DUCT BANK
MANY CITIES REQUIRE UTILITIES TO INSTALL THEIR FACILITIES UNDERGROUND IN DESIGNATED INNER-CITY AREAS. CABLE WOULD BE INSTALLED IN CONCRETE ENCASED DUCT BANK IN THESE DESIGNATED AREAS. SEE THE DUCT BANK PORTION OF THIS SECTION FOR DETAILS.

THERE MAY ALSO BE HEAVILY CONGESTED URBAN AREAS OUTSIDE OF THE INNER-CITY AREA WHERE EITHER DUKE ENERGY CHOOSES OR THE CITY MANDATES FOR UTILITIES TO INSTALL FACILITIES UNDERGROUND. CABLE WOULD BE INSTALLED IN CONCRETE ENCASED DUCT BANK IN THESE DESIGNATED AREAS. SEE SUBSECTION 22.06 FOR DETAILS.

DIRECTIONAL BORING
● WHEN CABLE PLACEMENT HAS TO BE DEEPER THAN 48"
● IF ANY OF THE ABOVE APPLICATIONS APPLY

MISCELLANEOUS
● ROCKY SOIL
● ROUGH TERRAIN

USES FOR CONDUIT
**SCHEDULE 40 PVC**
- Pole and Building Risers
- Road Crossings (except as noted below)
- Duct Banks
- Bridge Attachments

SEE DWG. 22.04-100 FOR SCHEDULE 40 PVC CONDUIT INFORMATION.

**CELLULAR CORE PVC**
- Pole and Building Risers
- Road Crossings (except as noted below)
- Duct Banks
- Bridge Attachments

SEE DWG. 22.04-134 FOR CELLULAR CORE PVC CONDUIT INFORMATION.

**HIGH DENSITY POLYETHYLENE (HDPE)**
- 2", 4" and 6": Directional Bore Projects
- 7" SDR 13.5 (Def Only): Directional Bore Projects Where Fused Pipe is Required by the Permitting Authority
- 7" SDR 11 (Def Only): Directional Bore Projects Where Fused Pipe and SDR Grade is Required by the Permitting Authority

SEE DWG. 22.04-136 FOR HDPE CONDUIT INFORMATION.

**FIBERGLASS**
- Jack & Bore Steel Encased Duct Systems
- Bridge Attachments

SEE DWG. 22.04-142 FOR FIBERGLASS CONDUIT INFORMATION.

**STEEL**
- Railroad Crossings
- Bridge Crossings
- Gas Transmission Crossings
- Where Required by Local Jurisdictions

SEE DWG. 22.04-140 FOR STEEL CONDUIT INFORMATION.

**BORE-GARD**
- Directional Bore Projects
- BoreGuard 6" (Def Only): Directional Bore Projects Where Fused Pipe is Not Required by the Permitting Authority

SEE DWG. 22.04-144 FOR BORE-GARD INFORMATION.
<table>
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<th>CONDUIT SIZE</th>
<th>REGION</th>
<th>COMPATIBLE UNIT</th>
<th>ITEM NUMBER</th>
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<th>MAX. O.D. (IN)</th>
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**DUKE ENERGY.**
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# PVC Bends - 45 Degrees - Schedule 40

**Diagram:**

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45°
- R
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**RISER EXTENSION**

22° PIECE OF CONDUIT WITH A 22-1/2 DEGREE BEND WITH ONE BELLED END

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**OFFSET BEND**

A 35 DEGREE BEND WITH ONE BELLED END

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**REVISED BY CK'D APPR.**
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CELLULAR CORE PVC CONDUIT IS TYPICALLY A COEXTRUDED PVC PIPE HAVING A CELLULAR CORE SURROUNDED BY THIN CONCENTRIC INNER AND OUTER LAYERS. DUKE ENERGY REQUIRES ITS CELLULAR CORE CONDUIT TO HAVE THE SAME PHYSICAL PROPERTIES AS SCHEDULE 40 PVC CONDUIT AND THEY ARE PROVIDED TO DUKE ENERGY UNDER THE SAME ITEM NUMBERS AS SCHEDULE 40 PVC CONDUIT.

THE SAME CONDUIT ACCESSORIES ARE USED FOR BOTH SCHEDULE 40 PVC CONDUIT AND CELLULAR CORE CONDUIT.

CELLULAR CORE CONDUIT MAY BE RECEIVED FOR ANY OF THE ITEMS LISTED BELOW.

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**HIGH DENSITY POLYETHYLENE (HDPE) CONDUIT**

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**DUKE ENERGY**

**REVISED**

**APPR.**

**22.04-136**
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**NOTES:**

1. SEE DWG. 22.03-102 FOR STEEL CONDUIT APPLICATIONS.
FIBERGLASS CONDUIT IS TYPICALLY USED IN JACK & BORE INSTALLATIONS WHERE CONDUITS HAVE TO BE INSTALLED IN LARGE STEEL PIPES. THIS IS NECESSARY BECAUSE THE HEAT GENERATED BY THE CURING OF CONCRETE, FLOWABLE FILL, ETC. THAT IS USED TO FILL THE GAPS AROUND DUCTS IS HIGH ENOUGH TO DEFORM OR COLLAPSE PVC CONDUIT. FIBERGLASS CONDUIT IS ALSO AN OPTION FOR BRIDGE CROSSINGS.

FIBERGLASS CONDUIT IS NOT A STANDARD DUKE ENERGY PRODUCT DUE TO ITS VERY LIMITED USE; THEREFORE, IT HAS TO BE ORDERED FROM THE MANUFACTURER WHENEVER IT IS NEEDED FOR A PROJECT. CHAMPION FIBERGLASS, INC. IS ONE OF THE MAJOR US SUPPLIERS OF FIBERGLASS CONDUIT AND DUKE ENERGY HAS PURCHASED CONDUIT FROM THEM IN THE PAST. CONTACT INFORMATION FOR CHAMPION’S SALES REPRESENTATIVE AGENCIES MAY BE FOUND AT WWW.CHAMPIONFIBERGLASS.COM

THIS WEBSITE ALSO PROVIDES INFORMATION REGARDING FIBERGLASS CONDUIT AND THE RANGE OF PRODUCTS CHAMPION OFFERS.
NEW CONDUIT CONNECTIONS

NOTES:

1. EXAMINE EACH LENGTH OF CONDUIT AND ENSURE THERE ARE NO INTERIOR OR EXTERIOR IMPERFECTIONS, CRACKS, ETC. REMOVE ANY FOREIGN MATTER (SAND, DEBRIS, ETC.) FROM INSIDE THE CONDUIT.

2. REMOVE ANY BURRS AND BEVEL ANY SHARP EDGES. WIPE DRY WITH A CLEAN, DRY CLOTH.

3. APPLY AN EVEN COAT OF PVC CEMENT TO THE OUTSIDE OF THE PLAIN CONDUIT END AND THE INSIDE OF THE BELLED CONDUIT END. DO NOT POUR OR SPLASH CEMENT ON CONDUIT.

4. IMMEDIATELY PUSH AND TWIST THE CONDUITS TOGETHER UNTIL THE DEPTH MARKER IS FLUSH WITH THE BELLED END. TWIST THEM APPROXIMATELY 1/4 TURN TO SPREAD THE CEMENT EVENLY.

5. HOLD JOINT TOGETHER FOR 15 SECONDS TO ALLOW INITIAL SET.

CUTTING CONDUIT AND CONNECTING WITH A COUPLING

NOTES:

6. EXAMINE EACH LENGTH OF CONDUIT ALONG WITH THE COUPLING AND ENSURE THERE ARE NO INTERIOR OR EXTERIOR IMPERFECTIONS, CRACKS, ETC. REMOVE ANY FOREIGN MATTER (SAND, DEBRIS, ETC.) FROM INSIDE THE CONDUIT.

7. CUT PIPE SQUARELY. REMOVE ANY BURRS AND BEVEL ANY SHARP EDGES. WIPE DRY WITH A CLEAN, DRY CLOTH.

8. APPLY AN EVEN COAT OF PVC CEMENT TO THE OUTSIDE OF THE PLAIN CONDUIT END AND THE INSIDE OF THE BELLED CONDUIT END. DO NOT POUR OR SPLASH CEMENT ON CONDUIT.

9. IMMEDIATELY PUSH AND TWIST THE CONDUITS TOGETHER UNTIL THE DEPTH MARKER IS FLUSH WITH THE BELLED END. TWIST THEM APPROXIMATELY 1/4 TURN TO SPREAD THE CEMENT EVENLY.

10. HOLD JOINT TOGETHER FOR 15 SECONDS TO ALLOW INITIAL SET.

CUTTING AND JOINING PVC CONDUIT

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NOTES:
1. ALL CONDUIT JOINTS SHOULD BE COMPLETED AND THE CEMENT SHOULD BE DRY BEFORE THE SECTIONS ARE PLACED IN TRENCH.

2. CAREFULLY LOWER CONDUIT INTO THE TRENCH. DO NOT KICK, OR THROW IT IN THE TRENCH.

3. SURROUNDING TRENCH BACKFILL MUST BE FREE OF ROCKS, CINDERS, OR OTHER DEBRIS THAT MIGHT DAMAGE THE CONDUIT DURING BACKFILL OR OVER TIME AS THE SOIL COMPRESSES.

4. INSTALL PROPER CONDUIT PLUGS AS LISTED ON DWG. 22.04-112.

5. ALL CONDUITS MUST BE KEPT PARALLEL TO EACH OTHER AND LEVEL.

6. ENCASE ALL 90° BENDS AND SWEEPS IN CONCRETE IN DEP AND DEF. DEC AND DEM SHOULD CONSIDER CONCRETE ENCASEMENT WHEN HIGH CABLE PULLING TENSIONS WILL BE ENCOUNTERED.

7. IN DEP, POWER MARKERS ARE TO BE USED TO IDENTIFY ALL PVC DEADENDS THAT ARE BURIED WITHOUT CABLE.

CIC INSTALLATION PROCEDURES

NOTES:
1. PAYOUT CIC CONDUIT FROM REEL TO AVOID "REVERSE BENDING" CONDUIT.

2. POSITION PAYOUT REEL TO MINIMIZE POSSIBILITY OF CONDUIT DAMAGE AND KINKING.
REPAIRING EXISTING PVC CONDUIT WITH CABLE

1. CUT DAMAGED PVC SQUARELY USING EXTREME CARE TO PREVENT DAMAGE TO CONDUCTORS.
2. REMOVE SAND AND FOREIGN DEBRIS FROM CONDUIT ENDS.
3. CUT SPLIT DUCT THE EXACT LENGTH OF DAMAGED AREA AND INSTALL IN EXPOSED AREA.
4. INSTALL TWO SPLIT DUCT COUPLINGS ON EACH END BY CENTERING OVER BUTT JOINTS.
5. SECURE SPLIT DUCT COUPLINGS WITH STAINLESS STEEL HOSE CLAMPS OR STAINLESS STEEL BANDING.
6. SECURE SPLIT DUCT SPLICE AT 12" INTERVALS.

NOTES:
1. CUT DAMAGED PVC SQUARELY USING EXTREME CARE TO PREVENT DAMAGE TO CONDUCTORS.
2. REMOVE SAND AND FOREIGN DEBRIS FROM CONDUIT ENDS.
3. CUT SPLIT DUCT THE EXACT LENGTH OF DAMAGED AREA AND INSTALL IN EXPOSED AREA.
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5. SECURE SPLIT DUCT COUPLINGS WITH STAINLESS STEEL HOSE CLAMPS OR STAINLESS STEEL BANDING.
6. SECURE SPLIT DUCT SPLICE AT 12" INTERVALS.

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</tr>
<tr>
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<td>-</td>
</tr>
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</tr>
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</tr>
<tr>
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</tr>
<tr>
<td>6&quot; COUPLING - 10&quot; LG</td>
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</tr>
</tbody>
</table>
**REPAIRING EXISTING PVC CONDUIT**

**WHEN CONDUIT DOES NOT CONTAIN CABLE**

1. **CUT DAMAGED PVC SQUARELY.**
2. **REMOVE SAND AND FOREIGN DEBRIS FROM CONDUIT ENDS.**
3. **CUT REPAIR PVC TO PROPER LENGTH (LESS WIDTH OF STOP).**
4. **SLIDE SLIP COUPLING ON CONDUIT. SEE DWG. 22.04-104 FOR AVAILABLE COUPLINGS.**
5. **APPLY PVC GLUE ON INSIDE OF PVC COUPLING WITH STOP AND OUTSIDE OF REPAIR PVC. SEE DWG. 22.04-102 FOR AVAILABLE COUPLINGS.**
6. **SLIDE AND TWIST TOGETHER UNTIL REPAIR PVC IS FLUSH WITH STOP.**
7. **CREATE DEPTH MARKER ON OPPOSITE END OF REPAIR PVC FOR CENTERING SLIP COUPLING.**
8. **APPLY PVC GLUE ON INSIDE OF PVC COUPLING WITH STOP AND OUTSIDE OF EXISTING CONDUIT.**
9. **SLIDE AND TWIST TOGETHER UNTIL EXISTING PVC IS FLUSH WITH COUPLING STOP.**
10. **APPLY PVC GLUE ON OUTSIDE OF EXISTING PVC AND OUTSIDE OF REPAIR PVC.**
11. **SLIDE AND TWIST SLIP COUPLING TO CENTERED LOCATION (DEPTH MARKER).**

---

**EXPANSION COUPLING FOR PVC CONDUIT REPAIR (IN DEP ONLY)**

- **EXPANDS 12”**

---

**EXPANSION COUPLINGS FOR PVC CONDUIT REPAIR**

<table>
<thead>
<tr>
<th>COMPATIBLE UNIT</th>
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<tr>
<td>2” EXP. COUPLING</td>
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<td>CDEXPPVC60C</td>
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NOTES:

1. INSTALL PLASTIC PLUGS TO KEEP DIRT OUT OF CONDUIT WHEN CABLE IS NOT IN CONDUIT. REPLACE WITH CABLE PROTECTORS WHEN CABLE IS INSTALLED.

2. WHEN CABLE CAN BE INSTALLED AT THE SAME TIME AS TRENCH, LAY CABLE IN TRENCH RATHER THAN PULLING THROUGH CONDUIT. INSTALL CONDUIT FOR FUTURE USE. PACK EARTH AROUND CABLE.

3. USE SCHEDULE 40 FOR STREET CROSSINGS.

4. CHECK LOCAL ORDINANCES FOR ADDITIONAL REGULATIONS.

5. MECHANICAL TAMPING IS REQUIRED FOR ALL PAVED AREAS AND UNPAVED DRIVEWAY ACCESSES.
DUCT BANK DESIGN CRITERIA

DUCT BANK APPLICATIONS

DUCT BANKS ARE TYPICALLY INSTALLED IN THE FOLLOWING APPLICATIONS:
- DESIGNATED INNER-CITY AREAS WHERE DUKE ENERGY HAS AGREEMENT WITH THE CITY TO INSTALL ITS FACILITIES UNDERGROUND.
- CONGESTED AREAS OF HIGH LOAD, SIMILAR TO INNER-CITY AREAS, WHERE DUKE ENERGY DETERMINES A DUCT BANK SYSTEM WOULD BE THE MOST BENEFICIAL DESIGN.
- AREAS TO BE SERVED UNDERGROUND WHERE THE POTENTIAL FOR A DIG-IN IS HIGH OR WHERE THE ABILITY TO ADD FUTURE CIRCUITS IS REQUIRED.
- SOLELY AS A RESULT OF A CUSTOMER'S REQUEST. THESE INSTALLATIONS WILL NORMALLY BE INSTALLED AT THE CUSTOMER'S EXPENSE.

DUCT BANK DESIGN CRITERIA

- PVC CONDUIT WITH A MINIMUM WALL THICKNESS OF SCHEDULE 40 SHALL BE USED FOR ALL DUCT BANK INSTALLATIONS. CONDUIT HAVING A THICKER WALL MAY BE SUBSTITUTED BASED ON AVAILABILITY AND OTHER FACTORS. IN ADDITION, HIGH DENSITY POLYETHYLENE (HDPE) FLEXIBLE CONDUIT CAN BE USED BASED ON DISTRIBUTION STANDARDS APPROVAL. SEE THE CONDUIT AND CONDUIT ACCESSORIES PORTION OF THIS MANUAL SECTION TO FIND AVAILABLE CONDUIT.
- SIX (6) INCH CONDUIT IS REQUIRED FOR ALL NEW PRIMARY DUCT BANK INSTALLATIONS. SMALLER SIZES OF CONDUITS (2", 3' OR 4") WOULD TYPICALLY BE USED FOR SECONDARY OR STREET LIGHT DUCT BANK INSTALLATIONS.
- WHERE POSSIBLE, DUCT BANKS SHOULD BE ROUTED WITH SLOW, GRADUAL BENDS. FOR SHARPERTurns, PVC BEND FITTINGS WITH A MINIMUM WALL THICKNESS OF SCHEDULE 40 AND A MINIMUM BEND RADIUS OF 36" MAY BE USED. REFER TO THE CONDUIT ACCESSORIES PAGES IN THIS SECTION FOR AVAILABLE BENDS.
- TYPICAL PRIMARY DUCT BANKS ARE EITHER TWO (2) OR THREE (3) CONDUITS WIDE AND HAVE AS MANY AS SIX (6) CONDUITS HIGH. THE NUMBER AND SIZE OF CONDUITS TO BE INSTALLED IN THE DUCT BANK SHOULD BE DETERMINED BY THE QUANTITY AND SIZE OF CABLES BEING INSTALLED PLUS ADDITIONAL SPACE FOR EMERGENCY USE, FUTURE EXPANSION, AND FUTURE FIBER OPTIC CABLE INSTALLATION. THE NUMBER AND SIZE OF CONDUITS FOR PRIMARY DUCT BANK INSTALLATIONS SHOULD BE APPROVED BY LOCAL SUPERVISION. TYPICAL CROSS SECTIONS FOR 2-WIDE DUCT BANKS ARE SHOWN ON DWG. 22.06-102. TYPICAL CROSS SECTIONS FOR 3-WIDE DUCT BANKS ARE SHOWN ON DWG. 22.06-104.
- TYPICAL SECONDARY DUCT BANKS HAVE ONLY ONE OR TWO CONDUITS; HOWEVER, MORE CONDUITS MAY BE NEEDED FOR CERTAIN APPLICATIONS. TYPICAL CROSS SECTIONS FOR 2-WIDE SECONDARY DUCT BANKS ARE SHOWN ON DWG. 22.06-106.
- CONSIDERATION SHALL BE GIVEN DURING THE PLANNING STAGES TO ALLOW FOR ADDITIONAL DUCT SPACE FOR FUTURE FIBER OPTIC CABLE. FIBER OPTIC CABLE MAY EVENTUALLY NEED TO EXTEND TO ALL SWITCHGEAR AS A MINIMUM AND POSSIBLY TO ALL TRANSFORMERS.
- PRIOR TO BEGINNING DESIGN, THE ENGINEER SHOULD HAVE AN UNDERGROUND LOCATE PERFORMED IN ORDER TO TAKE INTO ACCOUNT THE LOCATION OF EXISTING UTILITIES IN THE DESIGN AREA. IN ADDITION, IT MIGHT BE NECESSARY TO SPOT-CHECK (POTHOLE) THE DEPTHS OF EXISTING UTILITIES. GROUND PENETRATING RADAR IS ALSO AN OPTION THAT CAN BE USED TO MORE ACCURATELY LOCATE EXISTING UTILITIES. DUKE ENERGY HAS AN APPROVED VENDOR TO PERFORM THIS SERVICE. THE PROJECT ENGINEER WILL NEED TO DETERMINE THE LEVEL OF DETAIL REQUIRED FOR THE PROJECT. CONTACT DISTRIBUTION STANDARDS FOR ASSISTANCE.
● EACH CONDUIT RUN SHALL BE AS STRAIGHT AS POSSIBLE. THE TOTAL ANGULAR DEFLECTION OF ALL BENDS IN A CONDUIT RUN SHALL NOT EXCEED 180 DEGREES UNLESS PULLING CALCULATIONS ARE MADE AND THEY VERIFY THAT NO PROBLEM WILL BE ENCOUNTERED. INFORMATION REGARDING Cable Pulling SOFTWARE MAY BE FOUND ON DWG. 22.07-114.

● ENGINEERS MUST BE CAREFUL TO LIMIT THE OVERALL LENGTH OF CONDUIT RUNS. PERFORM Cable Pulling CALCULATIONS FOR ALL RUNS GREATER THAN 450 FEET BETWEEN TERMINATION POINTS.

● THE PROJECT ENGINEER SHOULD CONSIDER MANY FACTORS WHEN DETERMINING THE LOCATION OF MANHOLES, HANDHOLES, EQUIPMENT, AND RISER POLES. FOR EXAMPLE, IT IS A GOOD PRACTICE TO KEEP RISER POLES CLOSE TO A MANHOLE TO ALLOW FUTURE EXPANSION OF THE SYSTEM AND INSTALLATION OF CABLE. CONSIDERATION SHOULD ALSO BE GIVEN TO THE TYPE OF CABLE PullING EQUIPMENT AND METHODS THAT WILL BE REQUIRED WHEN DESIGNING THE SYSTEM. CONSULT WITH C&M SUPERVISION REGARDING THE DISTANCE BETWEEN A RISER POLE AND THE FIRST MANHOLE OR PIECE OF PAD-MOUNTED EQUIPMENT.

● DUCT BANK SHOULD BE INSTALLED ON PRIVATE PROPERTY WHENEVER POSSIBLE IN ORDER TO AVOID FUTURE RELOCATION.

● DUCT BANK SHALL BE INSTALLED IN SUCH A LOCATION AS TO REMAIN ACCESSIBLE TO STANDARD DUKE ENERGY EQUIPMENT.

● EFFORT SHOULD BE MADE TO INSTALL THE DUCT BANK AT LEAST THREE FEET AWAY FROM FOREIGN UTILITIES WHEN POSSIBLE TO HELP PROVIDE CLEAR WORKING SPACE FOR MAINTENANCE OF FACILITIES. THE NATIONAL ELECTRICAL SAFETY CODE (NESC) ALLOWS FOR LESS SEPARATION WHEN NECESSARY DUE TO SPACE CONSTRAINTS.

● IF THE DUCT BANK IS TO BE INSTALLED IN THE PUBLIC RIGHT-OF-WAY, ALL MUNICIPAL REQUIREMENTS FOR PERMITTING WORK AND CUTTING AND REPAIRING ROADWAYS SHALL BE FOLLOWED.

● JOINT-USE DUCT BANKS CONTAINING A COMBINATION OF ELECTRIC, SIGNALIZATION AND/OR COMMUNICATIONS INFRASTRUCTURE REQUIRE ADVANCE APPROVAL BY THE DUKE ENERGY PROJECT ENGINEER. GUIDELINES FOR JOINT-USE DUCT BANKS REQUIRE A MINIMUM OF THREE INCHES OF CONCRETE SEPARATION BETWEEN CONDUITS CONTAINING DUKE ENERGY FACILITIES AND CONDUIT CONTAINING OTHER INFRASTRUCTURE PER NESC SECTION 320-B. CONDUITS FOR JOINT-USE UTILITIES SHALL BE LOCATED BESIDE THE DUKE ENERGY DUCT BANK AND NEVER ABOVE IT. IN ADDITION, FOREIGN UTILITIES ARE NOT ALLOWED TO ENTER DUKE ENERGY MANHOLES OR VAULTS. THESE CONDUITS MUST SPLIT AWAY FROM THE DUCT BANK AND ROUTE AROUND MANHOLE, HANDHOLE, OR VAULT LOCATIONS. CARE SHOULD BE TAKEN TO INSTALL THESE FOREIGN CONDUITS IN A LOCATION AND ELEVATION THAT WILL NOT BLOCK THE CONDUIT OPENINGS IN THE MANHOLE OR VAULT THAT COULD BE USED FOR FUTURE EXPANSION. EXAMPLE CROSS SECTIONS OF JOINT-USE DUCT BANKS ARE PROVIDED ON DWG. 22.06-108.

### TWO COLUMN DUCT BANK OUTSIDE DIMENSIONS

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<thead>
<tr>
<th>CONDUIT SIZE</th>
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<tr>
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<td>1 ROW</td>
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<tr>
<td>4&quot;</td>
<td>17-1/4&quot;</td>
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<td>5&quot;</td>
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</tr>
<tr>
<td>6&quot;</td>
<td>21-1/2&quot;</td>
<td>12-3/4&quot;</td>
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</table>

### CUBIC YARDS OF CONCRETE REQUIRED PER FOOT OF TWO COLUMN DUCT BANKS

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<tr>
<th>CONDUIT SIZE</th>
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**NOTES:**

1. SEE DWG. 22.06-112A FOR GROUNDING REQUIREMENTS.
2. "Ø" INDICATES THE END VIEW OF THE #2 BARE COPPER WIRE.
3. ALTERNATE THE POSITION OF THE #2 BARE COPPER WIRE FROM "A" TO "B" IN THE CONDUIT SPACERS.
NOTES:

1. SEE DWG. 22.06-112A FOR GROUNDING REQUIREMENTS.

2. "Q" INDICATES THE END VIEW OF THE #2 BARE COPPER WIRE.

3. ALTERNATE THE POSITION OF THE #2 BARE COPPER WIRE FROM "A" TO "B" IN THE CONDUIT SPACERS.

DUCT BANK CONFIGURATIONS
THREE WIDE
2 WAY - 2 INCH

2 WAY - 3 INCH

2 WAY - 4 INCH

NOTES:

1. SEE DWG. 22.06-112A FOR GROUNDING REQUIREMENTS.

2. "Ø" INDICATES THE END VIEW OF THE #2 BARE COPPER WIRE.

3. ALTERNATE THE POSITION OF THE #2 BARE COPPER WIRE FROM "A" TO "B" IN THE CONDUIT SPACERS.
NOTES:

1. THE INTENT OF THIS STANDARD IS TO SHOW THAT PARALLEL, NON-DUKE ENERGY DUCT BANKS ARE TO BE POSITIONED BESIDE DUKE ENERGY DUCT BANKS AND NOT OVER OR UNDER THEM.

2. JOINT USE DUCT BANKS SHALL NOT ENTER DUKE ENERGY MANHOLES OR VAULTS.

3. THESE DRAWINGS ARE INTENDED TO BE EXAMPLES. ACTUAL SPECIFICATIONS WILL VARY BASED ON CONDUIT SIZE, QUANTITY AND ENCASEMENT REQUIREMENTS OF THE JOINT USE ENTITY.
NOTES:

1. SPACERS ARE ASSEMBLED BY PUSHING THEM TOGETHER.

2. BASE SPACERS AND INTERMEDIATE SPACERS INTERLOCK BOTH VERTICALLY AND HORIZONTALLY.

3. SPACERS SHOULD BE INSTALLED APPROXIMATELY EVERY FIVE FEET.

4. USE A BASE SPACER TURNED UPSIDE DOWN FOR TOP WHEN INSTALLING FIELD BENDS.

5. SEE DWGS. 22.06-102 AND 22.06-104 FOR PREFERRED CONFIGURATIONS OF DUCT BANK SPACERS AND FOR SPECIFIC INSTALLATION INSTRUCTIONS.

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DUKE ENERGY UTILIZES A UFER GROUNDING SYSTEM FOR ITS DUCT BANK INSTALLATIONS. AN EXPLANATION OF THIS SYSTEM IS PROVIDED ON DWG. 22.06-112B.

A #2 AWG BARE COPPER GROUND WIRE SHALL BE INSTALLED IN THE CONCRETE OF THE DUCT BANK INSTALLATION FOLLOWING THE INSTRUCTIONS BELOW. A TEN FOOT TAIL OF THE #2 COPPER SHOULD BE LEFT EXPOSED INSIDE EACH VAULT/ MANHOLE WITH THE ENTRY LOCATION GROUTED AND SEALED. A THREE FOOT TAIL SHOULD BE LEFT AT HAND HOLES.

1. INSTALL THE BOTTOM SPACERS AND THE BOTTOM ROW OF PVC CONDUITS IN THE TRENCH.

2. INSTALL THE #2 COPPER GROUND WIRE ALTERNATING THE WIRE FROM POSITION "A" TO POSITION "B" IN THE CONDUIT SPACERS. THE #2 COPPER GROUND WIRE SHOULD BE SAGGED WITH A MINIMUM TWO INCH CLEARANCE FROM THE BOTTOM OF THE TRENCH. REFER TO FIGURE 1 BELOW FOR DETAILS.

3. IF THE COPPER GROUND WIRE HAS TO BE SPLICED IN THE DUCT BANK BETWEEN MANHOLES, A COMPRESSION TYPE COPPER CONNECTOR OR EXOTHERMIC WELD SHALL BE USED.

4. INSTALL THE REMAINING SPACERS AND PVC CONDUITS AS SHOWN BELOW.

---

**FIGURE 1**

GROUND WIRE IN DUCT BANK

---

A #2 AWG BARE COPPER GROUND WIRE SHALL BE INSTALLED IN THE CONCRETE OF THE DUCT BANK INSTALLATION FOLLOWING THE INSTRUCTIONS BELOW. A TEN FOOT TAIL OF THE #2 COPPER SHOULD BE LEFT EXPOSED INSIDE EACH VAULT/ MANHOLE WITH THE ENTRY LOCATION GROUTED AND SEALED. A THREE FOOT TAIL SHOULD BE LEFT AT HAND HOLES.

1. INSTALL THE BOTTOM SPACERS AND THE BOTTOM ROW OF PVC CONDUITS IN THE TRENCH.

2. INSTALL THE #2 COPPER GROUND WIRE ALTERNATING THE WIRE FROM POSITION "A" TO POSITION "B" IN THE CONDUIT SPACERS. THE #2 COPPER GROUND WIRE SHOULD BE SAGGED WITH A MINIMUM TWO INCH CLEARANCE FROM THE BOTTOM OF THE TRENCH. REFER TO FIGURE 1 BELOW FOR DETAILS.

3. IF THE COPPER GROUND WIRE HAS TO BE SPLICED IN THE DUCT BANK BETWEEN MANHOLES, A COMPRESSION TYPE COPPER CONNECTOR OR EXOTHERMIC WELD SHALL BE USED.

4. INSTALL THE REMAINING SPACERS AND PVC CONDUITS AS SHOWN BELOW.
EXPLANATION OF THE UFER GROUNDING SYSTEM:

THE FOLLOWING INFORMATION WILL ASSIST THE ENGINEER IN DETERMINING THE AMOUNT OF CONCRETE REQUIRED FOR A DUCT BANK PROJECT.

1. WORK WITH CM TO DETERMINE THE WIDTH OF THE TRENCH THAT WILL ACTUALLY BE EXCAVATED FOR THE DUCT BANK.

2. ESTIMATE THE VOLUME OF THE TRENCH OCCUPIED BY THE DUCT BANK.

   \[
   \text{VOLUME} = \frac{\text{TRENCH WIDTH (INCHES)}}{36} \times \frac{\text{DUCT BANK HEIGHT (INCHES)}}{36} \times \frac{\text{TRENCH LENGTH (FEET)}}{3}
   \]

3. DETERMINE THE VOLUME OF SPACE THAT WILL BE OCCUPIED BY THE CONDUIT BY MULTIPLYING THE APPROPRIATE VALUE IN THE TABLE BELOW BY THE TOTAL LENGTH OF THE DUCT BANK IN FEET.

<table>
<thead>
<tr>
<th>DUCT BANK CONFIGURATION</th>
<th>CONDUIT SIZE</th>
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<th>4&quot;</th>
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</table>

4. SUBTRACT THE VALUE OBTAINED IN STEP 3 FROM THE VALUE ESTIMATED IN STEP 2. THE DIFFERENCE IS THE NUMBER OF CUBIC YARDS OF CONCRETE THAT WILL BE NEEDED FOR THE DUCT BANK.

IN DEC, CONCRETE IS ESTIMATED BY USING THE "CONCRETE" CU. THIS CU PROVIDES NO MATERIAL, BUT REPRESENTS ONE DOLLAR OF CONCRETE COST. CONTACT A LOCAL CONCRETE COMPANY OR PREFERRED CONTRACTOR TO OBTAIN THE CURRENT COST OF CONCRETE. THEN ADD THIS NUMBER OF THE CONCRETE CU TO YOUR ESTIMATE. THE ACTUAL CONCRETE WILL NEED TO BE ORDERED FROM THE CONCRETE COMPANY.

THE ENGINEER WILL ALSO NEED TO WORK WITH CM TO IDENTIFY THE PROPER QUANTITY AND TYPE OF MATERIAL REQUIRED TO HOLD THE CONDUIT IN POSITION DURING THE CONCRETE POUR. THIS MATERIAL WILL BE ORDERED LOCALLY AS WELL.
1. Mark the duct bank route on the surface by chalking or otherwise indicating the outer limits of the trench to be cut. Each duct run should be as straight as possible.

2. If asphalt pavement is to be removed, it should be cut a minimum of six inches wider than the trench in order to provide at least a three-inch shelf of undisturbed earth on each side of the trench.

3. Remove the surface between the marks. If the surface is sod, remove it in squares and save for later replacement.

4. When digging underneath foreign utilities, care should be taken to adequately support these facilities so they will not collapse into the trench.

5. The trench should be excavated to depth with the bottom smooth and free of rocks. A four inch bed of sand should be added if the bottom of the trench is rocky. The trench should be deep enough to allow the top of the duct bank encasement to be a minimum of two feet below grade. The typical maximum depth for a duct bank installation is four feet from grade to the top of the duct bank, except where the duct bank is angled down into a manhole or vault. Also, it is occasionally necessary to get additional depth when crossing under another utility or obstacle.

6. The trench shall be angled down to manholes and vaults at a minimum slope of 1 inch every 20 feet to allow water to drain out of the conduits as shown in the figure below. When tying the duct bank into manholes, the conduits shall be installed into the lowest available holes on the manhole with the space around them grouted and sealed. When tying duct bank into vaults, the conduits shall be installed into the vault at a height and location determined by the Duke Energy project engineer.
7. DUCT SPACERS SHOULD BE INSTALLED APPROXIMATELY EVERY FIVE FEET ALONG THE DUCT BANK ROUTE.

8. LARGE RADIUS BENDS (FIELD BENDS WITH A RADIUS GREATER THAN 35 FEET) CAN BE INSTALLED BY THE GUIDELINES PROVIDED ON DWG. 22.06-118.

9. CONDUITS SHOULD BE PLACED ON SPACERS AND EACH JOINT PREPARED AND CEMENTED ACCORDING TO THE CEMENT MANUFACTURER’S REQUIREMENTS. THE CONDUITS MUST THEN BE SECURED IN POSITION TO PREVENT THEM FROM FLOATING TO THE TOP WHEN CONCRETE IS Poured INTO THE TRENCH. TYPICALLY, THIS IS ACCOMPLISHED BY DRIVING REBAR INTO THE TRENCH WALLS APPROXIMATELY EVERY TEN FEET AS SHOWN IN THE DRAWING BELOW.

10. READY MIX CONCRETE WITH A MINIMUM 28 DAY COMpressive STRENGTH OF 3,000 PSI, A 3/8” MAXIMUM AGGREGATE SIZE, WITH A SLUMP OF 5” IS TO BE PLACED INTO THE TRENCH AROUND THE DUCT BANK. THE CONCRETE SHALL BE VIBRATED IN ORDER TO FILL ALL THE SPACES AROUND THE CONDUITS. THERE MUST BE A MINIMUM OF THREE (3) INCHES OF CONCRETE ENCASMENT SURROUNDING THE PERIMETER OF THE DUCT BANK.

11. THE REMAINING TRENCH SHOULD BE BACKFILLED AND PROPERLY COMPACTED WITH EARTH THAT IS FREE OF VEGETATION, LARGE ROCKS, PIECES OF PAVEMENT AND OTHER FOREIGN MATERIAL. CONTROLLED DENSITY BACKFILLS SUCH AS FLOWABLE FILL CAN ALSO BE USED TO FILL IN THE TRENCH ON TOP OF THE DUCT BANK, IF NEEDED, DUE TO COMPACTION REQUIREMENTS AND/OR LOCAL MUNICIPAL GUIDELINES.

12. THERE ARE OCCASIONS WHEN PORTIONS OF A CONCRETE POUR FOR A SECTION OF DUCT BANK HAVE TO BE INSTALLED AT DIFFERENT TIMES. THIS COULD OCCUR WHEN THE CUSTOMER INSTALLS DUCT BANK TO THE PROPERTY LINE AND THEN DUKE EXTENDS THE DUCT BANK TO A MANHOLE AT A LATER TIME. IT ALSO HAPPENS WHEN DUKE IS INSTALLING A DUCT BANK SECTION AND THE ENTIRE LENGTH CANNOT BE COMPLETED WITHIN ONE DAY. WHEN THIS OCCURS, DUCT BANK JOINTS SHOULD BE INSTALLED AS DESCRIBED ON DWG. 22.06-120.

13. FOR ALL NEW DUCT BANK INSTALLATIONS, IT IS REQUIRED TO PULL A SOLID MANDREL THROUGH EACH CONDUIT IN THE DUCT BANK TO VERIFY THAT IT IS IN GOOD CONDITION AND FREE OF ANY OBSTACLES. THE MANDREL SHALL BE NO MORE THAN ONE HALF (1/2) INCH SMALLER THAN THE DIAMETER OF THE CONDUIT. A PULL STRING SHALL BE INSTALLED INSIDE EACH CONDUIT IN THE DUCT BANK. THE PULL STRING SHALL BE MADE FROM HIGH-STRENGTH POLYPROPYLENE OR EQUIVALENT AND BE MILDEW AND ROT RESISTANT. IF THE DUCT BANK IS INSTALLED BY A CUSTOMER, THEY ARE REQUIRED TO CONTACT THE DUKE ENERGY REPRESENTATIVE TO ALLOW THE DUCT BANK TO BE INSPECTED PRIOR TO CONCRETE BEING POURED AND AGAIN UPON COMPLETION OF CONSTRUCTION TO WITNESS THE MANDREL BEING PULLED THROUGH THE CONDUITS. SEE DWG. 22.06-124 FOR THE REQUIRED DUCT BANK INSPECTION CHECKLIST.
2. BENDS OF LESS THAN 35' RADIUS CAN BE ACCOMPLISHED USING FACTORY BENDS. BENDS GREATER THAN 150' GENERALLY REQUIRE NO SPECIAL TECHNIQUE.

3. JOINTS WHICH FALL WITHIN THE RADIUS OF THE CURVE ARE SUBJECTED TO THE SAME BENDING FORCES AS THE CONDUIT ITSELF. TO PREVENT THE TENSION SIDE (OUTSIDE OF CURVE) OF THE JOINT FROM FAILING, CAUTION MUST BE TAKEN TO ALLOW SUFFICIENT CURING TIME FOR ALL JOINTS IN THE RADIUS IN THE BEND. TWO HOURS CURING TIME IS REQUIRED AT 70°F. SHORTER TIMES MAY BE ADEQUATE IN HOTTER WEATHER AND LONGER TIMES MAY BE REQUIRED IN COLD WEATHER. SEE DWG. 22.05-100 FOR DETAILS ON JOINING PVC CONDUIT.

4. FOR BENDS WHERE THE RUNNING LENGTH OF DUCT REQUIRED IS 150' OR LESS, THE BENDING OPERATION IS SIMPLIFIED IF THE ENTIRE LENGTH IS PREASSEMBLED AND ALLOWED TO CURE PRIOR TO BENDING, PARTICULARLY IN INSTALLATIONS WHERE THE RADIUS OF CURVATURE IS LESS THAN 80'.

5. DRIVE REBAR INTO THE GROUND AT EACH SPACER LOCATION TO HOLD THE ASSEMBLY IN THE PROPER RADIUS.

NOTES:

1. SEE DWG. 22.06-102 OR 22.06-104 FOR CONFIGURATION DETAILS.

2. JOINTS WHICH FALL WITHIN THE RADIUS OF THE CURVE ARE SUBJECTED TO THE SAME BENDING FORCES AS THE CONDUIT ITSELF. TO PREVENT THE TENSION SIDE (OUTSIDE OF CURVE) OF THE JOINT FROM FAILING, CAUTION MUST BE TAKEN TO ALLOW SUFFICIENT CURING TIME FOR ALL JOINTS IN THE RADIUS IN THE BEND. TWO HOURS CURING TIME IS REQUIRED AT 70°F. SHORTER TIMES MAY BE ADEQUATE IN HOTTER WEATHER AND LONGER TIMES MAY BE REQUIRED IN COLD WEATHER. SEE DWG. 22.05-100 FOR DETAILS ON JOINING PVC CONDUIT.

4. FOR BENDS WHERE THE RUNNING LENGTH OF DUCT REQUIRED IS 150' OR LESS, THE BENDING OPERATION IS SIMPLIFIED IF THE ENTIRE LENGTH IS PREASSEMBLED AND ALLOWED TO CURE PRIOR TO BENDING, PARTICULARLY IN INSTALLATIONS WHERE THE RADIUS OF CURVATURE IS LESS THAN 80'.

5. DRIVE REBAR INTO THE GROUND AT EACH SPACER LOCATION TO HOLD THE ASSEMBLY IN THE PROPER RADIUS.
THERE ARE OCCASIONS WHEN PORTIONS OF A CONCRETE POUR FOR A SECTION OF DUCT BANK HAVE TO BE INSTALLED AT DIFFERENT TIMES. THIS COULD OCCUR WHEN DUKE IS INSTALLING A DUCT BANK SECTION AND THE ENTIRE LENGTH CANNOT BE COMPLETED WITHIN ONE DAY. IN THESE SITUATIONS, THE FOLLOWING ACTIONS SHOULD BE TAKEN TO PROVIDE SUPPORT AND A STRONG BOND BETWEEN THE TWO DUCT BANK SECTIONS:

A. THE BARRICADE USED TO CONTAIN THE CONCRETE POUR FOR THE FIRST PORTION OF THE DUCT BANK SHOULD BE ANGLED FROM THE GROUND BACK TOWARD THE AREA BEING POURED. AN ANGLE OF 45 TO 60 DEGREES FROM THE BOTTOM OF THE TRENCH IS REQUIRED. THIS WILL PROVIDE SOME SUPPORT FOR THE CONCRETE THAT WILL BE INSTALLED WHEN THE DUCT BANK IS CONTINUED DURING THE SECOND CONCRETE POUR.

B. FIVE FOOT PIECES OF #5 GALVANIZED REBAR (5/8") SHOULD BE EMBEDDED 2'-6" INTO THE EDGE OF THE FIRST CONCRETE POUR. THIS WILL PROVIDE SUPPORT FOR THE SECOND CONCRETE POUR. INSTALL ONE PIECE OF REBAR ON EACH SIDE OF THE CENTER COLUMN OF CONDUIT ABOVE THE BOTTOM ROW OF CONDUIT AND BELOW THE TOP ROW OF CONDUIT. ONLY TWO PIECES OF REBAR ARE REQUIRED FOR 6-WAY OR LESS DUCT BANK SYSTEMS.

C. BE CERTAIN THAT THE FACE OF THE FIRST CONCRETE POUR IS CLEAN BEFORE MAKING THE SECOND POUR. THIS FACE COULD BECOME CONTAMINATED IN SITUATIONS SUCH AS WHEN IT RAINS BETWEEN POURS AND MUD ATTACHES TO THE FIRST CONCRETE FACE. IF THIS OCCURS, USE A WIRE BRUSH TO REMOVE ANY CONTAMINATION THAT IS PRESENT.

D. CONDUITS SHALL BE CAPPED OR SEALED TO PREVENT DIRT AND DEBRIS FROM ENTERING THE CONDUIT UNTIL THE DUCT BANK IS JOINED.
TABLE 1

<table>
<thead>
<tr>
<th>DUCT SIZE, O.D. (INCHES)</th>
<th>QUANTITY LIQUID FOAM SEALANT</th>
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<tr>
<td></td>
<td>0% CABLE FILL</td>
</tr>
<tr>
<td>2</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>3</td>
<td>3 cm</td>
</tr>
<tr>
<td>4</td>
<td>2 + 2.5 cm</td>
</tr>
<tr>
<td>5</td>
<td>3 + 4 cm</td>
</tr>
<tr>
<td>6</td>
<td>3 + 3 + 4 cm</td>
</tr>
<tr>
<td>8</td>
<td>4 + 4.5 cm</td>
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</tbody>
</table>

THERE ARE APPROXIMATELY 8.5 CM PER FST-250 CARTRIDGE. USE SIDE MARKINGS TO MEASURE QUANTITY BY DIFFERENCE. USE AS A STARTING POINT ONLY, ACTUAL REQUIRED QUANTITY WILL VARY.

STEP 1:

IF CONDUIT HAS LOOSE DEBRIS OR RUST, USE A WIRE BRUSH TO REMOVE ALL LOOSE MATERIAL. ABRIDE THE SURFACES WITH SANDPAPER OR STEEL WOOL TO INCREASE EFFECTIVENESS OF THE FST SEALANT.

CLEAN CABLE(S) AND DUCT WITH TYPE HP CLEANING WIPE AS PROVIDED IN THE KIT. THIS WILL REMOVE CONTAMINANTS AND ANY ORGANIC RESIDUE.

CREATE A FOAM DAM BY LOOSELY WRAPPING FOAM STRIP AROUND CABLE(S) SO THAT IT FILLS THE SPACE BETWEEN THE CABLE(S) AND DUCT. IT SHOULD BE SLIGHTLY WIDER THAN DUCT AND COMPRESS SLIGHTLY WHEN INSERTED. (IF MORE THAN ONE CABLE, SEPARATE CABLES WITH FOAM STRIP.)
STEP 2:

Using the positioning rod, push foam 5 inches into duct. Make sure there are no voids in the foam dam for FST sealant to flow through.

Wrap the second foam strip around cable. (If more than one cable, separate cables with foam strip.) Tail end of foam strip should be at top of wrap. Push second foam strip into the duct until the edge is flush with the duct entrance.

STEP 3:

Remove foam cartridge from pouch. Note: Do not remove cartridge from protective foil until ready to use. Wear impermeable gloves and eye protection. Holding cartridge upright, remove nut and plug. (Plug can be saved for re-use of cartridge.) Attach mixing nozzle and tighten nut back into place. Nut must be replaced or mixing nozzle will detach from cartridge and material may spill.

Use a heavy-duty, high-ratio caulk gun tool for best performance. Dispense and discard the first liquid run through the nozzle (about 1 squirt with the application tool). This initial material will not be well mixed or have the proper ratio of material.

STEP 4:

Insert mixing nozzle into top wrap of foam dam so that tip extends into space between foam strips. Inject sealant above cables for better coverage. Use desired amount of foam sealant (see Table 1 on DWG. 22.06-122A).

For large ducts, use multiple injections.

Remove cartridge with the static mixer attached. Sealant may seep between the crevices of the foam dam as it expands. After cure, excess foam may be trimmed and removed.

Sealant will expand fully in 2 to 5 minutes
Sealant will harden (set) in 10 to 15 minutes.

Mixing nozzle is reusable 7 to 10 minutes after injection.

To seal large conduits (4 inch or larger), inject FST in parts. After each injection, wait 5 minutes for sealant to rise. Excess foam may be trimmed and removed.
DURING CONSTRUCTION

A PRE-CONSTRUCTION MEETING SHALL BE HELD BETWEEN THE CUSTOMER’S CONTRACTOR AND DUKE ENERGY REPRESENTATION PRIOR TO BEGINNING DUCT BANK INSTALLATION. THE CUSTOMER SHALL THEN CONTACT DUKE ENERGY FOR INSPECTION DURING CONDUIT INSTALLATION AND AGAIN PRIOR TO PLACEMENT OF CONCRETE.

1. ______ DUCT BANK INSTALLATION ROUTE FOLLOWS PLAN APPROVED BY DUKE ENERGY PROJECT ENGINEER.

2. ______ 180° MAXIMUM ANGULAR DEFLECTION BETWEEN TERMINATION POINTS.

3. ______ GRAY, ELECTRICAL GRADE PVC CONDUIT WITH A MINIMUM WALL THICKNESS OF SCHEDULE 40.

4. ______ GREATER THAN OR EQUAL TO 36” RADIUS BENDS (MINIMUM OF SCHEDULE 40).

5. ______ PROPER CONDUIT SIZE (GLUED TO MANUFACTURE SPECS) AND DUCT BANK CONFIGURATION AS SPECIFIED BY PROJECT ENGINEER.

6. ______ DUCT BANK DOES NOT EXCEED 450' BETWEEN TERMINATION POINTS OR 100’ BETWEEN A TERMINATION POINT AND A RISER POLE UNLESS APPROVED BY PROJECT ENGINEER.

7. ______ MINIMUM 3” CONCRETE BOUNDARY AROUND THE PERIMETER OF THE DUCT BANK.

8. ______ MINIMUM 3” CONCRETE SEPARATION BETWEEN OTHER UTILITIES.

9. ______ DITCHES ARE FREE FROM DEBRIS AND ROCKS PRIOR TO INSTALLING DUCT BANK.

10. ______ DUCT BANK IS INSTALLED AT PROPER DEPTH AS SPECIFIED BY PROJECT ENGINEER.

11. ______ TRENCH IS SLOPED ACCORDING TO DUKE ENERGY SPECIFICATIONS ON DWG. 22.06-116A.

12. ______ SPACERS EVERY 5’ AND CONDUITS ARE SECURED PROPERLY. SPACERS MUST PROVIDE MINIMUM SPACING. (SEE DWG. 22.06-110).

13. ______ CONDUITS ENTER INTO THE LOWEST POSITIONS AVAILABLE IN MANHOLES OR ENTER VAULTS AT LOCATION SPECIFIED BY DUKE ENERGY PROJECT ENGINEER AND ARE GROUTED AND SEALED PROPERLY.

14. ______ CONDUITS AT EQUIPMENT AND DIP POLE LOCATIONS ARE INSTALLED IN CONCRETE AND IN THE PROPER CONFIGURATION AS SPECIFIED BY THE PROJECT ENGINEER.

15. ______ #2 BARE COPPER GROUND WIRE IS PROPERLY INSTALLED THROUGHOUT DUCT BANK AND INTO MANHOLE. ENSURE THAT COPPER COMPRESSION CONNECTORS OR EXOTHERMIC WELDS ARE USED TO CONNECT GROUND WIRE SECTIONS TOGETHER. (SEE DWG. 22.06-112A).

16. ______ 3,000 PSI OR GREATER CONCRETE ORDERED WITH A 3/8” MAXIMUM AGGREGATE SIZE AND A SLUMP OF 5”.

17. ______ NESC, STATE AND LOCAL ORDINANCES ON SEPARATION REQUIREMENTS BETWEEN UTILITIES ARE MET.

18. ______ NESC, STATE AND LOCAL ORDINANCES FOR PROPER BACKFILL AND COMPACTION OF THE DITCH AND RESTORATION OF THE GROUND AND/OR PAVEMENT ARE MET.

FINAL INSPECTION PRIOR TO DUKE ENERGY INSTALLING CABLE

19. ______ VERIFY ALL CONDUITS ARE CLEAR AND FREE FOR PROPER OPERATING CONDITIONS AFTER CONCRETE HAS BEEN PLACED. DUKE ENERGY REPRESENTATIVE MUST BE PRESENT TO WITNESS SOLID MANDREL BEING PULLED THROUGH CONDUITS BY CONTRACTOR.

20. ______ VERIFY PULL STRINGS HAVE BEEN INSTALLED IN EACH CONDUIT IN THE DUCT BANK BETWEEN ALL MANHOLE, EQUIPMENT AND/OR RISER POLE LOCATIONS.

21. ______ PROVIDE FINAL AS-BUILT “PLAN VIEW” DRAWINGS SHOWING LOCATION OF INSTALLED DUCT BANK. IN ADDITION, AS-BUILT "PROFILE VIEW" DRAWINGS WILL BE REQUIRED ON MORE COMPLEX PROJECTS AT THE DIRECTION OF THE DUKE ENERGY PROJECT ENGINEER.

THE CUSTOMER AND DUKE ENERGY CONTRACTORS ARE RESPONSIBLE FOR FOLLOWING ALL GUIDELINES RELATED TO DUCT BANK INSTALLATION PROVIDED ON THIS CHECKLIST AND IN THIS MANUAL. DUKE ENERGY WILL NOT ACCEPT ANY INSTALLATIONS THAT DO NOT MEET THESE REQUIREMENTS AND WILL REQUIRE THE CUSTOMER OR DUKE ENERGY CONTRACTOR TO REPAIR ANY DEFICIENCIES PRIOR TO DUKE ENERGY INSTALLING CABLE.
JAMMING

THE JAM RATIO (J) IS DEFINED AS THE RATIO OF THE INSIDE DIAMETER OF THE DUCT (D) TO THE CABLE DIAMETER (d), i.e J = D/d.

WHEN THIS RATIO IS CLOSE TO 3.0, ONE OF THE CABLES IN A THREE-CABLE PULL MAY SLIP BETWEEN THE OTHER TWO CABLES CAUSING THE CABLES TO JAM IN THE DUCT. THIS IS MOST LIKELY TO OCCUR WHEN THE CABLES ARE PULLED AROUND A BEND. JAMMING IS NOT USUALLY A PROBLEM FOR ESSENTIALLY STRAIGHT CABLE PULLS.

IF J IS BETWEEN 2.8 AND 3.0, JAMMING COULD OCCUR AND IT IS NOT RECOMMENDED THAT CABLE PULLS WITH THIS JAM RATIO BE PERFORMED UNLESS THE CONDUIT RUN IS FREE OF ELBOWS OR SHARP BENDS.

CABLE CLEARANCE

IT IS IMPORTANT TO HAVE ADEQUATE CLEARANCE (C) TO ENSURE THAT CABLES WILL PHYSICALLY FIT IN THE CONDUIT INTENDED FOR INSTALLATION. DUKE ENERGY REQUIRES A MINIMUM CLEARANCE OF 0.5 INCHES WHICH IS CONSISTENT WITH VARIOUS INDUSTRY STANDARDS. A SLIGHTLY LESSER CLEARANCE MAY BE ACCEPTABLE FOR ESSENTIALLY STRAIGHT PULLS. THIS ALLOWS FOR VARIATIONS IN CABLE AND DUCT DIMENSIONS AND THE OVALITY OF BENDS.

MINIMUM BENDING RADIUS

IF A POWER CABLE, 600V OR PRIMARY, IS BENT IN A RADIUS THAT IS TOO SEVERE, THE CABLE STRUCTURE MAY BE DAMAGED. THE MINIMUM BENDING RADIUS FOR CABLES USED AT DUKE ENERGY MAY BE FOUND IN SECTION 23, UNDERGROUND CABLES.

SIDEWALL BEARING PRESSURE

SIDEWALL BEARING PRESSURE (SWBP) IS A RADIAL FORCE PER UNIT LENGTH EXERTED ON A CABLE BEING PULLED AROUND A BEND. EXCEEDING THE MAXIMUM ALLOWABLE SWBP MAY SUBJECT THE CABLE TO CRUSHING DAMAGE. FOR THIS REASON, SIDEWALL BEARING PRESSURE MAY BE THE MOST RESTRICTIVE FACTOR FOR INSTALLATIONS HAVING BENDS AND HIGH TENSIONS. THE RECOMMENDED MAXIMUM SIDEWALL BEARING PRESSURE RATINGS FOR ALL DUKE ENERGY CABLES ARE PROVIDED IN SECTION 23, UNDERGROUND CABLES.

TENSION - DESIGN LIMITS

THE MAXIMUM PULLING TENSION THAT CAN BE APPLIED TO A GIVEN CABLE SYSTEM IS DICTATED BY THE PHYSICAL LIMITATIONS OF THE CABLE (BOTH TENSILE AND CRUSHING STRENGTH), RATINGS OF THE PULLING ATTACHMENTS (PULLING EYES, GRIPS, ETC.) AND WHETHER A SINGLE PULLING ATTACHMENT IS PLACED OVER MULTIPLE CABLES OR IF A PULLING ATTACHMENT IS PLACED ON EACH CABLE.

A GRIP OR ATTACHMENT PLACED ON MULTIPLE CABLES DOES NOT SEAT AS WELL AS ONE THAT IS PLACED ON A SINGLE CABLE. THEREFORE, DIFFERENT RATINGS ARE NECESSARY FOR BOTH APPLICATIONS.

MAXIMUM PULLING TENSIONS FOR CABLES ARE PROVIDED IN SECTION 23, UNDERGROUND CABLES AND THE RATINGS FOR PULLING ATTACHMENTS ARE PROVIDED ON DWGS. 22.07-112A AND 22.07-112B.

TENSION - INSTALLATION LIMITS

EXCESSIVE PULLING TENSION CAN CAUSE SEVERE DAMAGE TO 600V OR PRIMARY UNDERGROUND CABLE. BECAUSE OF THIS, DUKE ENERGY REQUIRES THAT ONE OF THE FOLLOWING OPTIONS BE UTILIZED TO LIMIT TENSION APPLIED WHENEVER CABLE IS BEING PULLED INTO A DUCT.

1. INSTALL A "BREAK-AWAY" DEVICE THAT SHEARS APART AT A TENSION THAT IS LESS THAN THE MAXIMUM ALLOWABLE TENSION FOR THE CABLE AND PULLING ATTACHMENT BEING USED. THESE DEVICES CAN BE OBTAINED FROM MOST ALL OF THE MANUFACTURERS OF CABLE PULLING EQUIPMENT.

2. FOR 1/0 AWG CABLE, ATTACH A PIECE OF BARE #6 AWG COPPER HD WIRE BETWEEN THE CABLE AND THE PULLING LINE.

3. UTILIZE PULLING EQUIPMENT THAT:
   1) ALLOWS TENSION TO BE LIMITED TO DESIRED VALUES AND
   2) PROVIDES DOCUMENTATION OF ACTUAL TENSIONS ENCOUNTERED THROUGHOUT THE PULL.

DUKE ENERGY WOULD REQUIRE COPIES OF THE DOCUMENTATION SHOWING THAT ONLY ACCEPTABLE TENSIONS WERE APPLIED TO THE CABLE.
PULLING SPEED

Typical cable pulling speeds for power cables range between 10 and 50 feet per minute. At the higher speeds, additional care should be taken to assure that cable from the feed-in reel(s) does not backlash when the pull is interrupted or completed. This can be accomplished by using brakes on the cable reel stands. High pulling speeds also result in an increased rate of frictional heating in bends and can result in additional wear in PVC bends.

PULLING DIRECTION

The tension required to perform a cable pull can change significantly by simply changing the pull direction. In general, lower pulling tensions are encountered when feeding the cable into the end of the duct run that contains the largest number of bends, or when cable is fed into the uphill side of a cable run. The DSTAR CPA cable pulling software automatically provides calculations for pulls in both directions. Engineers must consult with construction prior to installation when it is necessary for a cable to be pulled in one direction only. This is necessary to verify that there are no obstacles that would prevent pulling in the desired direction, construction is aware of the required direction of the pull and that the pull will not damage the cable.

PULLING LINES AND DUCT WEAR

There are a wide variety of pulling lines being used in the utility industry. Duct wear is strongly affected by the diameter of the line. As the diameter of the line is reduced, the wear is increased. This occurs because the force per unit area of the line on the duct increases as the line diameter decreases. The surface condition of the pulling line also affects duct wear. A coarsely braided fiber pulling line or stranded steel rope will wear through duct much more rapidly than a nylon jacketed pulling line.

MISCELLANEOUS PULLING EQUIPMENT

Proper feed-in devices are essential to avoid severe scraping of the cable jacket as it is pulled over manhole cover frames, against the top of the manhole, and into ducts. The same precautions also exist at the pulling end. These devices include:

- Softeners: Metal raceways with a large, smooth radius that sits on the edge of the manhole frame.
- Tubes: Flexible metal tubes that extend over the softener and into the duct.
- Pulleys: Only wide radius pulleys should be used to minimize stress on cable.

POWERGLIDE CABLE JACKETS

The DEC cables listed in the table below have a special jacket that allows them to be pulled with little to no cable lubricant applied.

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<tr>
<th>CABLE DESCRIPTION</th>
<th>DEC CABLES</th>
<th>COMPATIBLE UNIT</th>
<th>ITEM NUMBER</th>
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### Minimum Conduit Size (Inches) - See Note 2

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<tr>
<th>Cable Size</th>
<th>Cable Diameter (See Note 1)</th>
<th>PVC or Steel 1 SVC</th>
<th>PVC or Steel 2 SVC/Sec's</th>
<th>Polyethylene 1 SVC</th>
<th>Polyethylene 2 SVC/Sec's</th>
<th>Fiberglass 1 SVC</th>
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<tr>
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<td>2.15</td>
<td>3&quot;</td>
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<td>6&quot;</td>
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<td>6&quot;</td>
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<tr>
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<td>2.69</td>
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### Minimum Conduit Inside Diameter (Inches)

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<tr>
<th>Conduit Size</th>
<th>PVC or Steel</th>
<th>High Density Polyethylene</th>
<th>Fiberglass</th>
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<td>1.558</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2&quot;</td>
<td>2.015</td>
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<td>2.235</td>
</tr>
<tr>
<td>2-1/2&quot;</td>
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<td>-</td>
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<td>3&quot;</td>
<td>3.001</td>
<td>-</td>
<td>3.360</td>
</tr>
<tr>
<td>4&quot;</td>
<td>3.920</td>
<td>3.794</td>
<td>4.320</td>
</tr>
<tr>
<td>6&quot;</td>
<td>5.947</td>
<td>5.585</td>
<td>6.435</td>
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</tbody>
</table>

### Notes:

1. Cable diameters were established assuming cable diameters were 1.05% the manufacturer's published nominal diameters.

2. Use the next larger size of conduit if the one shown on this table is not available in your area.
# Recommended Conduit Fill

## Primary Cables

### Minimum Conduit Size (Inches) - See Note 2

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Cable Size</th>
<th>PVC or Steel</th>
<th>Polyethylene</th>
<th>Fiberglass</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1 Cable</td>
<td>2 Cables</td>
<td>3 Cables</td>
</tr>
<tr>
<td>15 KV</td>
<td>1/0 AWG</td>
<td>2*</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4/0 AWG</td>
<td>2</td>
<td>4</td>
<td>4</td>
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<tr>
<td></td>
<td>500 KCML</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
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<td>6</td>
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<tr>
<td></td>
<td>1000 KCML</td>
<td>-</td>
<td>-</td>
<td>6</td>
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<td>-</td>
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</tr>
<tr>
<td></td>
<td>750 KCML</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1000 KCML</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>35 KV</td>
<td>1/0 AWG</td>
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<td>4</td>
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<tr>
<td></td>
<td>750 KCML</td>
<td>-</td>
<td>-</td>
<td>6</td>
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</tbody>
</table>

* A single 15KV, 1/0 AWG cable may be pulled into existing 1-1/2" spare conduits in Duke Energy Florida if the conduit and any bends are in good condition and the pull will not pass through excessive angular deflection.

### Minimum Conduit Inside Diameter

<table>
<thead>
<tr>
<th>Conduit Size</th>
<th>PVC or Steel</th>
<th>High Density Polyethylene</th>
<th>Fiberglass</th>
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</thead>
<tbody>
<tr>
<td>1-1/2&quot;</td>
<td>1.558</td>
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<td>-</td>
</tr>
<tr>
<td>2&quot;</td>
<td>2.015</td>
<td>2.002</td>
<td>2.235</td>
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<tr>
<td>3&quot;</td>
<td>3.001</td>
<td>-</td>
<td>3.360</td>
</tr>
<tr>
<td>4&quot;</td>
<td>3.920</td>
<td>3.794</td>
<td>4.320</td>
</tr>
<tr>
<td>6&quot;</td>
<td>5.947</td>
<td>5.585</td>
<td>6.435</td>
</tr>
</tbody>
</table>

### Notes:

1. Cable diameters were established assuming cable diameters were 1.05% the manufacturer’s published nominal diameters.

2. Use the next larger size of conduit if the one shown on this table is not available in your area.
### AVAILABLE PULLING LUBRICANTS

<table>
<thead>
<tr>
<th>REGION</th>
<th>PACKAGE</th>
<th>COMPATIBLE UNIT</th>
<th>ITEM NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEC</td>
<td>5 GAL PAIL</td>
<td>0468015</td>
<td>468015</td>
</tr>
<tr>
<td>DEM</td>
<td>5 GAL PAIL</td>
<td>LUB BLK SOAP 40LB</td>
<td>468015</td>
</tr>
<tr>
<td></td>
<td>5 GAL PAIL</td>
<td>CBL LUBE POLY J</td>
<td>1412519</td>
</tr>
<tr>
<td>DEP</td>
<td>QUART PACK 1-3/4&quot;D X 24&quot; L</td>
<td>-</td>
<td>30525307</td>
</tr>
<tr>
<td></td>
<td>HALF GALLON PACK 3&quot;D X 14&quot;L</td>
<td>-</td>
<td>30524706</td>
</tr>
<tr>
<td>DEF</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### NOTES:

1. FOR USE IN 2" AND 3" CONDUIT.
2. FOR USE IN 4" AND 6" CONDUIT.

### REQUIRED LUBRICANT IN GALLONS (G) - WHEN USING PAILS

<table>
<thead>
<tr>
<th>PULL LENGTH IN FEET (L)</th>
<th>2&quot; (CONDUIT I.D. IN INCHES)</th>
<th>3&quot;</th>
<th>4&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2&quot;</td>
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<td></td>
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<tr>
<td>100</td>
<td>0.30</td>
<td>0.45</td>
<td>0.60</td>
<td>0.75</td>
<td>0.90</td>
</tr>
<tr>
<td>500</td>
<td>1.50</td>
<td>2.25</td>
<td>3.00</td>
<td>3.75</td>
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<td>6.00</td>
<td>7.50</td>
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</table>

\[ G = L \times D \times 0.0015 \]

### AVERAGE NUMBER OF LUBRICANT PACKS RECOMMENDED

<table>
<thead>
<tr>
<th>PULL LENGTH</th>
<th>2&quot; (QUART PACK)</th>
<th>3&quot; (QUART PACK)</th>
<th>4&quot; (1/2 GAL. PACK)</th>
<th>6&quot; (1/2 GAL. PACK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 FT.</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>200 FT.</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>300 FT.</td>
<td>6</td>
<td>9</td>
<td>6</td>
<td>9</td>
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<tr>
<td>400 FT.</td>
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<td>12</td>
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<tr>
<td>500 FT.</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>15</td>
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</tbody>
</table>

* PULL LENGTHS AND QUANTITIES ARE ADDITIVE FOR PULL LENGTHS ABOVE 500 FT. QUANTITIES MAY VARY DEPENDING ON LENGTH OF PULL.
1. Rod and clean conduit prior to pulling.
2. Pulls with more than two bends or long (straight) pulls (greater than 500') require pre-lubrication of conduit. Attach a swab (spoon or thick rag) to a pullwire. Attach lubricant packs in front of the swab. Continuously pull the swab back and forth to lubricate the conduit. Add new lubricant packs as needed.
3. Use the pullwire to pull in winch rope to make the actual cable pull.
4. Cable(s) should be pulled in a slow, continuous operation. Avoid jerking cable!
5. Attach front end lubricant pack(s) to winch rope in front of the cable. Fasten with tape or cable tie inserted through the rope strands and tighten behind the metal clip.
6. For pulls requiring multiple lubricant packs, the packs should be attached to the winch rope in tandem.
7. Start the pull and slit open the entire length of the pack(s) just as each pack enters the conduit.
8. The opened lubricant packs will deposit lubricant in front of the cable as they are pulled through the conduit.
9. Pour a small amount of lubricant by hand directly on the cable(s) as they enter the conduit. Adequate cable lubrication is essential to prevent cable damage and to make pulling easier.
10. Lubricant is available in two sizes:
   A. Quart pack (1-3/4" D x 24" L) (DEP ITEM NUMBER 30525307) for use in 2" and 3" conduit.
   B. Half gallon pack (3" D x 14" L) (DEP ITEM NUMBER 30524706) for use in 4" and 6" conduit.
11. See table on DWG. 22.07-108 for the average number of lubricant packs recommended for various pull lengths.
## Pulling Grip

<table>
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<tr>
<th>Working Diameter</th>
<th>Region</th>
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<th>Secondary Cable</th>
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<td>1-500 KCmil AL</td>
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<td>1-500 KCmil CU</td>
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## Pulling Harness

<table>
<thead>
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<tbody>
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<td>DEM</td>
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</tbody>
</table>

### Notes:

1. See DWG. 22.07-112B for notes.
NOTES:

1. DO NOT ATTEMPT TO USE ONE CABLE GRIP FOR ALL CONDUCTORS IN TRIPLEX OR QUADRUPLEX: IT WILL NOT GRIP PROPERLY. USE A SEPARATE CABLE GRIP FOR EACH CONDUCTOR. SECURE PULLING ENDS OF ALL GRIPS TOGETHER AND PULL AS A UNIT.

2. WHEN MORE THAN ONE GRIP IS USED, STAGGER THE GRIPS AT LEAST ONE (1) FOOT.

3. WHEN PULL IS COMPLETE, CUT OFF AND SCRAP CABLE DIRECTLY UNDER THE GRIP AND AT LEAST THREE (3) FEET BEHIND THE GRIP.
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