Conductors and Raceway Design

Blair Sackney, Southwire Canada
George Morlidge SMIEEE, Fluor Canada

May 12, 2014
Conductors, Cables, and Raceways

• Appendix A
  – Safety standards for electrical equipment, *Canadian Electrical Code*, Part II
Test methods for electrical wires and cables
C22.2 No. 0.3-09

• Test methods for electrical wires and cables
  - Scope
    • This standard describes the apparatus, test methods, and formulas to be used in carrying out the tests and calculations required by CSA electrical wire and cable Standards.
5 Test methods and calculations

5.1 Uninsulated conductors

5.1.1 General

5.1.2 Resistance

5.1.3 Physical properties

5.1.4 Continuity of metal coating on copper conductor

5.1.5 Adherence of metallic coating

5.2 Thickness of insulation, jackets, and similar coverings

5.2.1 Extruded insulation

5.2.2 Taped insulation

5.2.3 Mineral insulation — Minimum thickness

5.2.4 Thermoplastic lacquered cotton braid or thermoplastic lacquered glass braid insulation

5.2.5 Tubing — Minimum internal diameter

5.2.6 Jackets and similar coverings

5.3 Mechanical properties of extruded insulation, jackets, and similar coverings

5.3.1 Tensile properties

5.3.2 Accelerated aging

5.3.3 Exposure to liquids

5.3.4 Recovery

5.3.5 Deformation of insulation and jackets

5.3.6 Tensile stress

5.3.7 Shrinkage

5.4 Metallic sheaths — Thickness

5.5 Nonmetallic tapes, braids, and servings as coverings

5.5.1 Thickness

5.5.2 Braid and serving characteristics

5.6 Metal tape coverings

5.7 Braided shields
Thermoset-insulated wires and cables
C22.2 No. 38-14

• Thermoset-insulated wires and cables
  – Scope
    • This Standard specifies the requirements for single-conductor and multiple-conductor thermoset-insulated wires and cables rated 600V, 1000V, 2000V, and 5000V ....(tri-national standard)
• Thermoset-insulated wires and cables
  – Definition
  • An insulating or jacketing polymeric material which, when cross-linked, will not flow on subsequent heating. Cross-linking is accomplished by either chemically or by radiation.
  • Example - RW90 XLPE
4 Construction ............................................................................................................ 13
  4.1 Conductors ........................................................................................................ 13
  4.2 Insulation .......................................................................................................... 17
  4.3 Jackets or fibrous coverings over single conductors ....................................... 18
  4.4 Shielding (optional) ......................................................................................... 19
  4.5 Multiple-conductor cables .............................................................................. 19
  4.6 Color coding .................................................................................................... 20
  4.7 Fillers and protective materials ...................................................................... 21
  4.8 Jacket separators ............................................................................................. 21
  4.9 Jackets ................................................................................................................ 22
  4.10 Evaluation of new materials – Establishment of dry temperature rating of alternative insulation and jacketing materials for use in this standard .......................................................... 22
  4.11 Assemblies that include single-conductor thermoset-insulated wires ............ 23
Test requirements

5.1 General
5.2 Conductor resistance
5.3 Tests of aluminum conductors
5.4 Long-term insulation resistance in water
5.5 Long-term insulation resistance in air for 90°C rated conductors
5.6 Capacitance and relative permittivity
5.7 Conductor corrosion
5.8 Insulation fall-in
5.9 Heat shock of thermoplastic jacket
5.10 Flexibility of separator under a thermoplastic jacket
5.11 Cold bend and cold impact
5.12 Deformation
5.13 Hot-creep elongation and hot-creep set
5.14 Flame and smoke
5.15 Weather (sunlight) resistance (optional)
5.16 Oil resistance (optional)
5.17 Gasoline and oil resistance (optional)
5.18 Crushing resistance
5.19 Dielectric breakdown after glancing impact
Armoured cables
• Armoured Cables
  – Scope
  • This standard specifies requirements for single- and multi-conductor insulated cable having metallic interlocking armour without an overall jacket (Type AC90 or ACG90) or with an overall jacket (Type ACWU90 or ACGWU90) that are intended for installation in accordance with the CEC Part 1 on systems having a nominal voltage of 600v or less. ACG90 and ACGWU90 apply to multi-conductor insulated cables only.
ACWU90 Construction

END VIEW

- Aluminum Conductor
- Insulation
- Ground Conductor
- Oil Impregnated Kraft Paper Binder
- Aluminum Interlock Armour
- Overall PVC Jacket
5 Construction 3
5.1 Conductors 3
5.1.1 General 3
5.1.2 Aluminum conductors 4
5.1.3 Copper conductors 4
5.1.4 Sizes 4
5.1.5 Stranding 4
5.1.6 Diameter and area 5
5.1.7 Joints 5
5.1.8 Neutral conductor 5
5.2 Insulation 5
5.3 Assembly 5
5.4 Colour coding of conductors 6
5.4.1 Circuit conductors of multi-conductor cables 6
5.4.2 Single-conductor cables for bonding purposes only 7
5.5 Armour 7
5.5.1 AC90 and ACWU90 types 7
5.5.2 ACG90 and ACGWU90 types 7
5.6 Jacket on Type ACWU90 and ACGWU90 cables 7
5.7 Other cable components 7
6 Tests 7
6.1 Performance tests on bare conductors 7
6.1.1 Electrical resistance 7
6.1.2 Tensile strength and elongation of aluminum conductors 8
6.1.3 Bending test on aluminum conductors 8
6.1.4 High-current heat cycling — ACM sizes 12 and 10 AWG solid conductors and 12 to No. 2 AWG Class B stranded conductors 8
6.2 Performance tests on insulated conductors 8
6.2.1 Physical tests 8
6.2.2 Electrical tests 11
6.3 Performance tests on armour 13
6.3.1 Protective coating on steel strip 13
6.3.2 Interior surface 13
6.4 Performance tests on ACWU90 and ACGWU90 jackets 14
6.4.1 Cutting 14
6.4.2 Physical properties 14
6.4.3 Spark test 15
6.5 Performance tests on completed cable 15
6.5.1 Mechanical 15
6.5.2 Electrical 19
6.6 Fault-current test (Types ACG90 and ACGWU90 only) 20
## Annex A (informative) – Conductor types covered by this Standard
(See Clause 1.1)

<table>
<thead>
<tr>
<th>Wire type designation</th>
<th>Voltage rating, V</th>
<th>Electrical code recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Canadian</td>
</tr>
<tr>
<td>XHHW-2</td>
<td>600</td>
<td>No</td>
</tr>
<tr>
<td>XHHW</td>
<td>600</td>
<td>No</td>
</tr>
<tr>
<td>XHH</td>
<td>600</td>
<td>No</td>
</tr>
<tr>
<td>RHH</td>
<td>600 or 2000</td>
<td>No</td>
</tr>
<tr>
<td>RW-2</td>
<td>600 or 2000</td>
<td>No</td>
</tr>
<tr>
<td>RHW</td>
<td>600 or 2000</td>
<td>No</td>
</tr>
<tr>
<td>CA</td>
<td>600</td>
<td>No</td>
</tr>
<tr>
<td>SF</td>
<td>600</td>
<td>No</td>
</tr>
<tr>
<td>SIS</td>
<td>600</td>
<td>No</td>
</tr>
<tr>
<td>R90</td>
<td>600, 1000, 2000, or 5000</td>
<td>Yes</td>
</tr>
<tr>
<td>RW/5</td>
<td>600, 1000, 2000, or 5000</td>
<td>Yes</td>
</tr>
<tr>
<td>RW90</td>
<td>600, 1000, 2000, or 5000</td>
<td>Yes</td>
</tr>
<tr>
<td>RWU/5</td>
<td>1000</td>
<td>Yes</td>
</tr>
<tr>
<td>RWU90</td>
<td>1000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Note: See Annex B for a summary of construction and test requirements and the grouping of different wire types with identical requirements.*
# C22.2 No. 51-09

## Table 9
Diameter of Class B, C, and D round concentric-lay-stranded conductors
(See Clause 4.1.6.1 and Annex B)

<table>
<thead>
<tr>
<th>Conductor size</th>
<th>Nominal diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm²</td>
<td>AWG or kcmil</td>
</tr>
<tr>
<td>2.08</td>
<td>14 AWG</td>
</tr>
<tr>
<td>3.31</td>
<td>12</td>
</tr>
<tr>
<td>5.26</td>
<td>10</td>
</tr>
<tr>
<td>8.37</td>
<td>8</td>
</tr>
<tr>
<td>13.3</td>
<td>6</td>
</tr>
<tr>
<td>21.2</td>
<td>4</td>
</tr>
<tr>
<td>26.7</td>
<td>3</td>
</tr>
<tr>
<td>33.6</td>
<td>2</td>
</tr>
<tr>
<td>42.4</td>
<td>1</td>
</tr>
<tr>
<td>53.5</td>
<td>1/0</td>
</tr>
<tr>
<td>67.4</td>
<td>2/0</td>
</tr>
<tr>
<td>85.0</td>
<td>3/0</td>
</tr>
<tr>
<td>107</td>
<td>4/0</td>
</tr>
<tr>
<td>127</td>
<td>250 kcmil</td>
</tr>
<tr>
<td>152</td>
<td>300</td>
</tr>
<tr>
<td>177</td>
<td>350</td>
</tr>
<tr>
<td>203</td>
<td>400</td>
</tr>
<tr>
<td>228</td>
<td>450</td>
</tr>
<tr>
<td>253</td>
<td>500</td>
</tr>
</tbody>
</table>
Table 12 – Thickness of insulation on 600 V Types XHHW-2, XHHW, XHH, and Types RW75a, R90a, and RW90a
(See Clause 4.2.3, Tables 35, 36, and 45, and Annex B)

<table>
<thead>
<tr>
<th>Size of conductor</th>
<th>AWC or komil</th>
<th>Minimum average thickness</th>
<th>Minimum thickness at any point</th>
<th>Minimum average thickness</th>
<th>Minimum thickness at any point</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm²</td>
<td></td>
<td>mm</td>
<td>mils</td>
<td>mm</td>
<td>mils</td>
</tr>
<tr>
<td>2.08 = 5.26</td>
<td>14 = 10 AWG</td>
<td>0.76</td>
<td>0.69</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>0.37 – 33.6</td>
<td>0 – 2</td>
<td>1.14</td>
<td>1.02</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>42.4 – 107</td>
<td>1 – 4/0</td>
<td>1.40</td>
<td>1.27</td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>Larger than 107 = 263</td>
<td>Larger than 4/0 – 500 komil</td>
<td>1.65</td>
<td>1.47</td>
<td>65</td>
<td>58</td>
</tr>
<tr>
<td>Larger than 253 = 50/</td>
<td>Larger than 500 – 1000</td>
<td>2.03</td>
<td>1.83</td>
<td>80</td>
<td>72</td>
</tr>
<tr>
<td>Larger than 507 = 1010</td>
<td>Larger than 1000 – 2000</td>
<td>2.41</td>
<td>2.16</td>
<td>95</td>
<td>86</td>
</tr>
</tbody>
</table>

a For types employing silicone insulation, see Table 15.
Shielded power cable for commercial and industrial applications, 5–46 kV
C68.10-08

• Shielded power cable for commercial and industrial applications, 5 – 46 kV
  – Scope
    • This Standard applies to the materials, construction, and testing of one- to four-conductor cross-linked polyethylene or ethylene propylene rubber-insulated shielded power cables, rated 5 to 46 kV, that are used for the distribution of electrical energy under normal conditions of installation and service in indoor, outdoor, aerial, underground, or underwater locations.
C68.10-08

• Shielded power cable for commercial and industrial applications, 5 – 46 kV

  – Definitions

  • See a long list of definitions pertinent to medium voltage power cables such as insulation level etc
C68.10-08

- A Standard specifying the construction of Shielded Power Cable
  - TOC
    - 4.0 Conductors
    - 5.0 Conductor shield (stress control layer)
    - 6.0 Insulation
    - 7.0 Extruded insulation shields and coverings
    - 8.0 Metallic shielding
    - 9.0 Jackets and metallic and associated covering
    - 10.0 Construction of specific types of cable
    - 11.0 Cable assembly and fillers
    - 12.0 Cable identification
    - 13.0 Production tests
    - etc
Thermoplastic-insulated wires and cables
C22.2 No. 75-08

• Thermoplastic-insulated wires and cables
  – Scope
    • This Standard specifies the requirements for 600V, single-conductor, thermoplastic-insulated wires and cables, ....(tri-national standard)....
    • In Canada and the United States, requirements for multi-conductor thermoplastic-insulated and –jacketed cables rated 600V are covered in other Standards. ....
C22.2 No. 75-08

• Thermoplastic-insulated wires and cables
  – Definitions
  • PVC – a thermoplastic compound whose characteristics constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate. (Type TW)
C22.2 No. 75-08

• Referenced CSA Standards
  – CEC Part 1
  – C22.2 No. 0.3-96 Test methods for electrical wires and cables
  – C22.2 No. 131M89 Type TECK 90 cable
  – C22.2 No. 230 M1988 Tray cables
  – C22.2 No. 239 -97 Control and instrument cables
  – C22.2 No. 2556 -05 Wire and cable test methods
  – Plus many U.S. and European standards
# Table A1

Wire Type/Electrical Code Cross-Reference Chart

(See Clause 1.1.)

<table>
<thead>
<tr>
<th>Wire type designation</th>
<th>Canada Electrical code (CEC)</th>
<th>Mexico Standard for Electrical Installations (NOM-001-CEDEC)</th>
<th>United States National Electrical Code (NEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>TWU</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>TWU75</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>THW</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>TW75</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>THW-2</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>THW-L5</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>THHW</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>THHW-LS</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>THHN</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>T90 NYLON</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>THWN-2</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>THWN</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>TWIN-5</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

**Note:**

(1) This table is accurate at the date of publication. Subsequent changes in any national code will supersede this table. See Clause 6.1.3.7 for multiple type designation markings.
### Table B2
Minimum Size of Equipment-Grounding Conductor
(See Clause B3.)

<table>
<thead>
<tr>
<th>Size of circuit conductor (phase)</th>
<th>AWG or kcmil</th>
<th>Minimum size of grounding conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional area mm²</td>
<td></td>
<td>Cross-sectional area mm²</td>
</tr>
<tr>
<td>2.08 - 5.26</td>
<td>14 - 10</td>
<td>The same size as circuit conductor</td>
</tr>
<tr>
<td>8.37</td>
<td>8</td>
<td>5.26</td>
</tr>
<tr>
<td>13.3 - 21.2</td>
<td>6 - 4</td>
<td>8.37</td>
</tr>
<tr>
<td>33.6 - 67.4</td>
<td>2 - 2/0</td>
<td>13.3</td>
</tr>
<tr>
<td>89.0 - 203</td>
<td>3/0 - 4/0</td>
<td>33.6</td>
</tr>
<tr>
<td>253 - 507</td>
<td>500 - 1000</td>
<td>42.4</td>
</tr>
</tbody>
</table>
Figure 1
Cable Test Enclosure and Exhaust Duct
(See Clauses 8.2.6.1.2 and 8.2.6.2.2.)

- Front view
  - Wired-glass
  - 343 mm ± 6 mm
  - 559 mm ± 6 mm
  - 914 mm ± 6 mm
  - 2438 mm ± 25 mm (inside)
  - 559 mm ± 6 mm
  - 1295 mm ± 25 mm

- Rear view
  - 3353 mm ± 25 mm
  - 1143 mm ± 25 mm
  - 457 mm ± 25 mm
  - Nominal 610 mm x 610 mm baffle centred over cable-tray specimens
  - 2438 mm ± 25 mm (inside)
  - 1295 mm ± 25 mm
  - 1295 mm ± 25 mm
  - 305 mm ± 5 mm
Portable power cables
C22.2 No. 96-13

• Portable power cables
  – Scope
    • This standard specifies construction and testing requirements for portable power cables normally used in applications where the cables are subject to frequent flexing and where installation is in accordance with CSA M421 and/or the CEC Part 1.

SHD-GC
C22.2 No. 96-13

- Portable power cables
  - Definitions
    - See a long list of definitions pertinent to portable power cables such as mine trailing cables etc
C22.2 No. 96-13

• Contents

– This is an extensive standard that includes much detail on construction and testing of different types of Portable Power Cable.
C22.2 No. 123-08

• Metal Sheathed Cables
  – Scope
  • This Standard applies to single-conductor and multi-conductor Type RA90 and RC90 cables having a maximum temperature rating of 90 degrees C in both dry and wet locations and intended for installation in accordance with the Rules of the CEC Part 1.
• Metal Sheathed Cables
  – Definition
    • RA90 – an aluminum sheathed cable incorporating a thermostet insulated conductor(s) having 90 degree C temperature rating
    • RC90 – a copper sheathed cable incorporating a thermostet insulated conductor(s) having 90 degree C temperature rating
C22.2 No. 123-08

• Contents

– This is an extensive standard that includes much detail on construction and testing of different types of Metal Sheathed Cable.
Type TECK 90 cable
C22.2 No. 131-07

- Type TECK 90 cable
  - Scope
    - This standard applies to single- and multi-conductor Type TECK 90 armoured cable intended for installation in accordance with the rules of the CEC Part 1 on systems having nominal voltages of 5000V and less and having a maximum temperature rating of 90 degrees C in both dry and wet locations.
TECK90 Construction
5 Construction 2
5.1 Circuit conductors 2
5.1.1 Material 2
5.1.2 Joints 2
5.1.3 Sizes 2
5.1.4 Conductor shield 2
5.2 Bonding conductors 3
5.2.1 General 3
5.2.2 Multi-conductor cable 3
5.2.3 Single-conductor cable 3
5.3 Insulation 4
5.3.1 General 4
5.3.2 Thickness 4
5.4 Coverings and separators 4
5.5 Insulation shielding 4
5.6 Assembly of multi-conductor cab
5.7 Fillers 5
5.8 Binder 5
5.9 Inner jacket 5
5.9.1 General 5
5.9.2 Thickness of inner jacket 5
5.10 Tape over inner jacket (optional)
5.11 Armour 6
5.11.1 General 6
5.11.2 Splices 6
5.11.3 Interior surface 6
5.11.4 Strip 6
5.12 Optional outer jacket 7
5.13 Coding of conductors 7
Tests

7 Tests
7.1 Properties of concentric bonding conductors
7.1.1 Tensile strength of aluminum wires removed from
7.1.2 Bending test on aluminum wires removed from a cable
7.2 Physical properties of inner jacket
7.3 Heat shock test — Thermoplastic inner jacket
7.4 Deformation test — Thermoplastic inner jacket
7.5 Protective coating on steel strip
7.6 Condition of interior surface of armour
7.7 Flexibility of armour
7.8 Physical properties of outer jacket
7.9 Flexibility at low temperatures
7.10 Low temperature test — Impact test
7.11 Deformation — Outer thermoplastic jacket
7.12 Flame tests — Finished cable
7.12.1 Vertical flame test — FT1 (mandatory)
7.12.2 Vertical flame test — Cables in cable tray — FT4
7.13 Dielectric strength test — Finished cable
7.14 Insulation resistance — Finished cable
7.15 Continuity of conductors — Finished cable
7.16 Acid gas evolution (optional)
7.17 Weather resistance test
7.17.1 Inner jacket (optional)
7.17.2 Outer jacket (optional)
7.18 Compatibility test — Single conductors and individual
multiple-conductor cables insulated with ethylene
7.19 Spark test
Tray cables
C22.2 No. 230-09

• Tray Cables

  – Scope

  • This standard applies to single conductor and multi-conductor constructions, without metal sheath or armour, suitable for use in cable trays and other applications when installed in accordance with the CEC Part 1.

  • (a very brief Standard – does not include construction details, only references other Standards and includes testing for same)
C22.2 No. 230-09

• Construction
  – Constructions include types specified in the following Standards:
    • (a) CAN/CSA 22.2 No. 38 Thermoset-insulated wires and cables
    • (b) CSA 22.2 No. 75 Thermoplastic-insulated wires and cables
    • (c) CSA 22.2 No. 96 Portable power cables
    • (d) Can/CSA-22.2 No. 239 Control and instrumentation cables; and
    • (e) CSA C68.10 Shielded power cables for commercial and industrial applications 5-46kV
C22.2 No. 230-09

• Tests
  – 5.1 General
  – 5.2 Flame
  – 5.3 Abnormal low temperature – impact
  – 5.4 Mechanical damage – impact
  – 5.5 Mechanical damage – crushing
  – 5.6 Weather resistance
  – 5.7 Oil resistance (optional)
  – 5.8 Explosion on cables with bundled subassemblies
Control and instrumentation cables
C22.2 No. 239-09

• Control and instrumentation cables
  – Scope
    • This Standard applies to multiple-conductor control and instrumentation cables (including thermocouple cables and thermocouple extension cables) having a voltage rating not exceeding 1000V and intended for installation in accordance with the CEC Part1.
    • Note: The designations for such cables are CIC for unarmoured cables and ACIC for armoured cables.
C22.2 No. 239-09

5 Construction
5.1 Conductors
5.1.1 Materials
5.1.2 Sizes
5.1.3 Stranding
5.1.4 Diameter and area
5.1.5 Joints
5.1.6 DC resistance
5.1.7 Thermocouples
5.2 Insulation
5.2.1 Materials
5.2.2 Thickness
5.3 Non-metallic insulation covering
5.3.1 General
5.3.2 Thermoplastic insulated conductors
5.3.3 EP insulated conductors
5.3.4 XLPE insulated conductors
5.3.5 Silicone rubber insulated conductors
5.4 Shields
5.4.1 Material
5.4.2 Alternative material
5.4.3 Drain wires
5.4.4 Shield isolation

5.5 Assembly and identification
5.5.1 Assembly
5.5.2 Identification of conductors
5.6 Non-metallic jackets
5.6.1 General
5.6.2 Inner jackets
5.6.3 Outer non-metallic coverings
5.6.4 Non-metallic jacket materials
5.7 Metallic outer coverings
5.7.1 General
5.7.2 Aluminum sheath
5.7.3 Interlocked armour
5.7.4 Galvanized steel wire armour
5.8 Jackets over metallic sheath or armour
5.9 Optional components
5.10 Temperature rating of cable
6 Tests 12
6.1 Electrical 12
6.1.1 Spark 12
6.1.2 Insulation resistance 12
6.1.3 Circuit continuity of conductors 12
6.1.4 Dielectric withstand 13
6.2 Physical and flammability tests on complete cable 13
6.2.1 Low-temperature impact test — No. 14 AWG and larger (optional) 13
6.2.2 Cold bend test 13
6.2.3 Flammability 13
6.2.4 Weathering (optional) 14
6.3 Tests on interlocked armoured cable 14
6.3.1 Flexibility 14
6.3.2 Tension 14
6.3.3 Elongation 15
6.4 Flexibility tests on aluminum sheathed cables 15
6.5 Mechanical damage — Impact (for corrugated sheath only) 15
6.6 Mechanical damage — Crushing (for corrugated sheath only) 16
Wire and cable test methods
• Wire and cable test methods
  – Scope
    • This standard describes the apparatus, test methods, and formulas to be used in carrying out the tests and calculations required by wire and cable Standards.
C22.2 No. 2556-13

- This Standard is very similar to C22.2 No. 0.3-09, Test methods for electrical wires and cables. It is the tri-national equivalent and is referenced in many new Standards instead of C22.2 No. 0.3-09.
Cables and cable glands for use in hazardous locations
C22.2 No. 174-M1984

• Cables and cable glands for use in hazardous locations
  – Scope
    • This Standard applies to cables and cable glands intended for (a) fixed wiring in Class 1, Groups A, B, C, and D; Class II, Groups E, F, and g; and Class III hazardous locations in accordance with the Rules of the CEC Part 1; and (b) fixed wiring and portable cables in gaseous mines in accordance with the Rules of the CEC Part V; and is in addition to the basic electrical requirements applicable to such cables and cable glands for use in other hazardous locations.
C22.2 No. 174-M1984

• Cables and cable glands for use in hazardous locations
  – Scope cont’d
  • *Note: The requirements of this Standard for cables and cable glands for use in hazardous locations in accordance with the Rules of the CEC, Part 1, are based on the premise that the basic electrical requirements for such cables and cable glands exist in other published CSA documents.*
4. Cables for Use in Hazardous Locations 10
   4.1 Construction 10
   4.2 Marking 10
   4.3 Tests 10
   4.3.1 Mechanical (Cables for Fixed Installations) 10
   4.3.2 Flame Retardant Properties (Cables for Fixed Installation) 12
   4.3.3 Flame Resistance (Portable Cables for Use in Underground Workings)
C22.2 No. 174-M1984

5. Cable Glands for Use in Hazardous Locations 13
  5.1 Specific Requirements 13
  5.2 Bonding Continuity 13
  5.3 Materials 13
  5.4 Flame Path Characteristics 13
  5.5 Construction 13
  5.6 Attachment of Cables and Cords 14
    5.6.1 Metal-Covered Cables 14
    5.6.2 Extra-Hard Usage Flexible Cords and Power Supply Cables 14
    5.6.3 Shielded Flexible Cord 14
  5.7 Marking 14
  5.8 Tests 14
    5.8.1 General 14
    5.8.2 Dimensional 14
    5.8.3 Torque 14
    5.8.4 Strain Relief (Cable Pull) 15
    5.8.5 Twist—Cable Glands for Use with Portable Cords and Cables 15
    5.8.6 Flammability 15
    5.8.7 Explosion—Class I Cable Glands with Integral Seals Only 15
    5.8.8 Hydrostatic—Class I Cable Glands with Integral Seals Only 16
    5.8.9 Dust-Tightness—Dust Ignition-Proof Cable Glands Only 16
Metal cable tray systems
C22.2 No. 126.1-09

Metal cable tray systems

September 2009
C22.2 No. 126.1-09

• Metal cable tray systems
  – Scope
  – This Standard specifies the requirements for metal cable trays and associated fittings designed for use in accordance with the rules of the CEC Part 1, and the National Electrical Code (NEC)
C22.2 No. 126.1-09

• Metal cable tray systems
  – Preface
    • This is the common CSA and NEMA Standard for metal cable tray systems. It is the third edition of CSA C22.2 No. 126.1, superseding the previous edition published in 2002 and 1998, and the fifth edition of NEMA VE 1, superseding the previous edition published in 2002.
    • (CANENA Technical Harmonization committee)
Legend:
1 = Ladder cable tray
2 = Ventilated cable tray
3 = Solid-bottom cable tray
4 = Rigid connector
5 = Horizontal elbow
6 = Horizontal tee
7 = Horizontal cross
8 = Vertical elbow
9 = Vertical tee
10 = Reducer
11 = Channel cable tray
12 = Divider
13 = Cover
14 = Tray-to-box connector
15 = Channel vertical elbow
16 = Blind end
17 = Dropout
### Cable Tray Loading

<table>
<thead>
<tr>
<th>LOAD (kg/m)</th>
<th>SPAN, m (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37 (25)</td>
<td>2.4 (8) A</td>
</tr>
<tr>
<td>67 (45)</td>
<td>3.0 (10) A</td>
</tr>
<tr>
<td>74 (50)</td>
<td>3.7 (12) A</td>
</tr>
<tr>
<td>97 (65)</td>
<td>4.9 (16) B</td>
</tr>
<tr>
<td>112 (75)</td>
<td>6.0 (20) D</td>
</tr>
<tr>
<td>149 (100)</td>
<td>2.4 (8) C</td>
</tr>
<tr>
<td>179 (120)</td>
<td>3.0 (10) C</td>
</tr>
<tr>
<td>299 (200)</td>
<td>3.7 (12) C</td>
</tr>
</tbody>
</table>

**Note:** 8A/B/C, 12A/B/C, 16A/B/C, and 20A/B/C are the traditional NEMA designations. A, C, D, and E are the conventional CSA designations.
Cable Tray Support

Couplers at Supports - Not Recommended

Couplers at 1/4 Span From Supports - Ideal Layout
Conductors

• CEC
  – Section 4 Conductors
  – Section 12 Wiring Methods
Conductors

4-004 Ampacity of wires and cables (see Appendices B and I)

(1) The maximum current that a copper conductor of a given size and insulation may carry shall be as follows:

(a) single-conductor and single-conductor metal-sheathed or armoured cable, in a free air run, with a cable spacing not less than 100% of the larger cable diameter, as specified in Table 1;

(b) one, two, or three conductors in a run of raceway, or 2- or 3-conductor cable, except as indicated in Subrule (1)(d), as specified in Table 2;

(c) four or more conductors in a run of raceway or cable, as specified in Table 2 with the correction factors applied as specified in Table 5C;

(d) single-conductor and 2-, 3-, and 4-conductor cables and single-conductor and 2-, 3-, and 4-conductor metal-armoured and metal-sheathed cables, in conductor sizes No. 1/0 AWG and larger, installed in accordance with configurations described in Diagrams B4-1 to B4-4 in an underground run, directly buried or in a raceway, as specified in Tables D8A through D15B.

(e) underground configurations not specified in Item (d), in conductor sizes No. 1/0 AWG and larger, as calculated by the IEEE 835 calculation method; and

(f) underground configurations in conductor sizes smaller than No. 1/0 AWG, as specified in Item (b) or as calculated by the IEEE 835 calculation method.
# Conductors

## Table 2
Allowable ampacities for not more than three copper conductors in raceway or cable (based on an ambient temperature of 30 °C)

(See Rules 4-004, 8-104, 12-2210, 14-104, 26-147, 42-008, and 42-016 and Tables 5A, 5C, 19, and D3.)

<table>
<thead>
<tr>
<th>Size, AWG or mm²</th>
<th>Allowable ampacity†††</th>
<th>60 °C‡‡</th>
<th>75 °C‡‡</th>
<th>90 °C‡‡</th>
<th>110 °C‡‡</th>
<th>125 °C‡‡</th>
<th>200 °C‡‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>14§</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>12§</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>10§</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>43</td>
<td>43</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>40</td>
<td>55</td>
<td>65</td>
<td>65</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>6</td>
<td>55†††</td>
<td>65</td>
<td>75</td>
<td>80</td>
<td>90</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>95</td>
<td>105</td>
<td>115</td>
<td>115</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>3</td>
<td>85</td>
<td>100</td>
<td>115</td>
<td>125</td>
<td>135</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>115</td>
<td>130</td>
<td>145</td>
<td>155</td>
<td>280</td>
<td>280</td>
</tr>
<tr>
<td>1</td>
<td>110</td>
<td>130</td>
<td>145</td>
<td>165</td>
<td>175</td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>150</td>
<td>170</td>
<td>190</td>
<td>200</td>
<td>375</td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>145</td>
<td>175</td>
<td>195†††</td>
<td>220</td>
<td>235</td>
<td>435</td>
<td></td>
</tr>
<tr>
<td>000</td>
<td>165</td>
<td>200</td>
<td>225</td>
<td>255</td>
<td>270</td>
<td>510</td>
<td></td>
</tr>
<tr>
<td>0000</td>
<td>185</td>
<td>230</td>
<td>260</td>
<td>290</td>
<td>310</td>
<td>590</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>215</td>
<td>255</td>
<td>290</td>
<td>320</td>
<td>345</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>240</td>
<td>275</td>
<td>320</td>
<td>360</td>
<td>385</td>
<td></td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>260</td>
<td>310</td>
<td>350</td>
<td>390</td>
<td>420</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>335</td>
<td>380</td>
<td>425</td>
<td>450</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>320</td>
<td>380</td>
<td>430</td>
<td>480</td>
<td>510</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>350</td>
<td>420</td>
<td>475</td>
<td>530</td>
<td>565</td>
<td></td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>385</td>
<td>460</td>
<td>520</td>
<td>580</td>
<td>620</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Col. 1 | Col. 2 | Col. 3 | Col. 4 | Col. 5 | Col. 6 | Col. 7
Conductors

(2) The maximum current that an aluminum conductor of a given size and insulation may carry shall be as follows:

(a) single-conductor and single-conductor metal-sheathed or armoured cable, in a free air run, with a cable spacing not less than 100% of the larger cable diameter, as specified in Table 3;

(b) one, two, or three conductors in a run of raceway, or 2- or 3-conductor cable, except as indicated in Subrule (2)(d), as specified in Table 4;

(c) four or more conductors in a run of raceway or cable, as specified in Table 4 with the correction factors applied as specified in Table 5C;

(d) single-conductor and 2-, 3-, and 4-conductor cables and single-conductor and 2-, 3-, and 4-conductor metal-armoured and metal-sheathed cables, in conductor sizes No. 1/0 AWG and larger, installed in accordance with configurations described in Diagrams B4-1 to B4-4 in an underground run, directly buried or in a raceway, as specified in Tables D8A through D15B.

(e) underground configurations not specified in Item (d), in conductor sizes No. 1/0 AWG and larger, as calculated by the IEEE 835 calculation method; and

(f) underground configurations in conductor sizes smaller than No. 1/0 AWG, as specified in Item (b) or as calculated by the IEEE 835 calculation method.
Conductors

(8) The ampacity correction factors of Table 5A shall apply where conductors are installed in an ambient temperature exceeding or anticipated to exceed 30 °C.

(9) Where the free air spacing between adjacent single conductor cables is maintained at not less than 25% nor more than 100% of the diameter of the largest cable, the ampacity shall be obtained from Subrules (1)(a) and (2)(a) for copper and aluminum conductors respectively, multiplied by the correction factor obtained from Table 5D.

(10) Where up to and including four single conductor cables in free air are spaced at less than 25% of the diameter of the largest conductor or cable, the ampacity shall be the same as that obtained from Subrules (1)(b) and (2)(b) for copper and aluminum conductors respectively, multiplied by the correction factor obtained from Table 5B.

(11) Notwithstanding Subrule (10), where not more than four non-jacketed single-conductor mineral-insulated cables are grouped together in conformance with Rule 4-010(3) and are installed on a messenger or as open runs with a maintained free air space of not less than 2.15 times the diameter of the largest cable contained within the group and adjacent groups or cables, the ampacity of each conductor in the group shall be permitted to be determined in accordance with Subrule (1)(a) without applying the factors of Table 5B.

(12) More than four single conductor cables in free air, when spaced at less than 25% of the largest cable diameter, shall have an ampacity obtained from Tables 2 and 4 for copper and aluminum conductors respectively, multiplied by the correction factor obtained from Table 5C.

(13) Notwithstanding Subrule (12), when the length of a multiple conductor cable run is less than 600 mm, the correction factor from Table 5C shall not apply.

(14) The ampacity of conductors of different temperature ratings installed in the same raceway shall be
Conductors

4-006 Temperature limitations (see Appendix B)

(1) Where equipment is marked with a maximum conductor termination temperature, the maximum allowable ampacity of the conductor shall be based on the corresponding temperature column from Table 1, 2, 3, or 4.

(2) Where equipment is not marked with a maximum conductor termination temperature, 90 °C shall be used by default.
### IEEE 835 Table

25 to 46 kV Shielded Single Conductor Extruded Dielectric Power Cable

*In Underground Duct Bank - Triplexed - Three Circuits*

25°C Earth Ambient

<table>
<thead>
<tr>
<th>Conds Neut. Size</th>
<th>60 Rho</th>
<th>90 Rho</th>
<th>120 Rho</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 LF 100 LF 75 LF 100 LF 75 LF 100 LF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Size | Full | 1/2 | 1/3 | 1/6 | 1/0 | 1/2 | 1/3 | 1/6 | 1/0 | 1/2 | 1/3 | 1/6 | 1/0 | 1/2 | 1/3 | 1/6 | 1/0 | 1/2 | 1/3 | 1/6 |
|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1    | 140  | 127 | 128 | 114 | 119 | 104 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/2  | 140  | 127 | 128 | 114 | 119 | 104 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/3  | 140  | 127 | 129 | 114 | 119 | 104 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/6  | 140  | 127 | 129 | 114 | 119 | 104 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/0  | 159  | 143 | 145 | 128 | 134 | 117 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/2  | 159  | 144 | 145 | 129 | 135 | 117 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/3  | 159  | 144 | 145 | 129 | 135 | 117 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1/6  | 159  | 144 | 146 | 129 | 135 | 117 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2/0  | 179  | 162 | 164 | 145 | 151 | 131 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2/1  | 180  | 163 | 165 | 145 | 152 | 132 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2/3  | 180  | 163 | 165 | 145 | 152 | 132 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2/6  | 180  | 163 | 165 | 146 | 152 | 132 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 3/0  | 203  | 183 | 185 | 163 | 170 | 147 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 3/1  | 204  | 184 | 186 | 164 | 171 | 148 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 3/3  | 204  | 184 | 186 | 164 | 172 | 148 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 3/6  | 204  | 184 | 187 | 164 | 172 | 149 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 4/0  | 220  | 205 | 208 | 183 | 191 | 165 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 4/1  | 230  | 207 | 210 | 184 | 193 | 166 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 4/3  | 231  | 208 | 210 | 185 | 193 | 167 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 4/6  | 232  | 208 | 211 | 185 | 194 | 167 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 250  | 252  | 226 | 229 | 201 | 210 | 181 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 250  | 253  | 227 | 230 | 202 | 211 | 182 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 250  | 253  | 228 | 231 | 202 | 212 | 182 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 250  | 253  | 228 | 231 | 202 | 212 | 183 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
## Conductors

### Table 19 (Continued)

<table>
<thead>
<tr>
<th>Conditions of use</th>
<th>Trade designation</th>
<th>CSA type designation</th>
<th>Maximum allowable conductor temperature, °C</th>
<th>Reference Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>For use in raceways, except cable trays, in wet locations</td>
<td>Rubber (thermoset) insulated cable</td>
<td>RW75, RWW75</td>
<td>75</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RW90, RWW90</td>
<td>90</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Thermoplastic-insulated cable</td>
<td>TW, TWU</td>
<td>60</td>
<td>4, 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TW75, TWW75, TWU75</td>
<td>75</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Solar photovoltaic cable</td>
<td>RPV90, RPVU90</td>
<td>90</td>
<td>5, 8, 9, 34</td>
</tr>
<tr>
<td>For use in ventilated, non-ventilated, and ladder-type cable trays in dry locations only</td>
<td>Armoured cable</td>
<td>AC90</td>
<td>90</td>
<td>8, 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACG90</td>
<td>90</td>
<td>8, 9, 33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TECK90</td>
<td>90</td>
<td>8, 9</td>
</tr>
<tr>
<td>For use in ventilated, non-ventilated, and ladder-type cable trays in wet locations</td>
<td>Armoured cable</td>
<td>TECK90</td>
<td>90</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACWU90</td>
<td>90</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACGWU90</td>
<td>90</td>
<td>5, 8, 9, 33</td>
</tr>
<tr>
<td></td>
<td>Aluminum-sheathed cable</td>
<td>RA75</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RA90</td>
<td>90</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Copper-sheathed cable</td>
<td>RC90</td>
<td>90</td>
<td>5, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Mineral-insulated cable</td>
<td>MI, LWM1</td>
<td>90</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Rubber (thermoset) insulated lead-sheathed cable</td>
<td>RL90</td>
<td>90</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td>For use in ventilated and non-ventilated cable trays in vaults and switch rooms</td>
<td>Rubber (thermoset) insulated cable</td>
<td>RW75</td>
<td>75</td>
<td>8, 9, 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RW90</td>
<td>90</td>
<td>8, 9, 10</td>
</tr>
<tr>
<td>For direct earth burial (with protection as required by inspection authority)</td>
<td>Armoured cable</td>
<td>ACWU90</td>
<td>90</td>
<td>3, 8, 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACGWU90</td>
<td>90</td>
<td>3, 8, 9, 33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TECK90</td>
<td>90</td>
<td>3, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Non-metallic-sheathed cable</td>
<td>NW6U</td>
<td>60</td>
<td>3, 20</td>
</tr>
<tr>
<td></td>
<td>Rubber (thermoset) insulated cable</td>
<td>RW75</td>
<td>75</td>
<td>3, 6, 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RL90, RWW90</td>
<td>90</td>
<td>3, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Aluminum-sheathed cable</td>
<td>RA75</td>
<td>75</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RA90</td>
<td>90</td>
<td>3, 7, 8</td>
</tr>
<tr>
<td></td>
<td>Copper-sheathed cable</td>
<td>RC90</td>
<td>90</td>
<td>3, 7, 8, 9</td>
</tr>
</tbody>
</table>
Conductors

Diagram of circuits, control, and protective devices for motors

Rule 14-010(b)

Rule 28-204, 28-208

Rule 28-108, 28-110

Rule 28-110(2), 28-108

Rule 28-600(1)(h), (2), (3), (4)

Rule 28-200, 28-202, 28-206, 28-208, 28-210

Rule 28-110(4)

Rule 28-600X1(b), (2), (3), (4), 28-600X1(2), (4)

Rule 28-300, 28-302, 28-306, 28-308, 28-310

Rule 28-402

Rule 28-600X1(c), (2), (3), 28-602(3), (4)

Rule 28-104, 28-106

Rule 28-312, 28-314, 28-316, 28-318

Rule 28-112

Rule 28-117, 28-642

Secondary controller

Secondary resistors

Secondary circuit overloads

Undervoltage protection

Motor circuit overload protection

Motor controller

Motor controller conductors

Remote control conductors

Motors conductors disconnect

Motor branch circuit disconnect

MCC bus

Feeder tap conductors

Motor feeder conductors

Motor feeder overcurrent protection

Motor feeder disconnect

To supply
Underground Duct Banks

- Native Backfill
- Continous Marker Ribbons
- Sand or Fine Gravel Backfill
- Cables Direct Buried in Sand
Underground Duct Banks

Native Backfill

Continuous Marker Ribbons

Sand or Fine Gravel Backfill

French Drain
6" Perforated Pipe (PVC)
Sloped to Drain to Scump
Underground Duct Banks

Cables installed in continuous PE duct sized to suit & sloped to drain to sump.

French drain 6" perforated pipe (PVC) sloped to drain to sump.

Native backfill & continuous marker ribbons.

Sand or fine gravel backfill.
Underground Duct Banks

Native Backfill 14

Continuous Marker Ribbons
Mechanical Protection Slabs (Prefabricated Red Concrete)

Sand or Fine Gravel Backfill

French Drain
6" Perforated Pipe (PVC)
Sloped to Drain to Sump
Underground Duct Banks