Component Protection

Small Wire, NFPA 79

16 and 18 AWG Conductors
For Industrial Machinery Power Circuits

The 2002 edition of NFPA 79, Electrical Standard for Industrial Machinery, allows the use of 16 and 18 AWG as branch circuit conductors if specific protection requirements are met. Note, in general 14 AWG is the smallest branch circuit conductor allowed in the NEC®; 16 and 18 AWG branch circuit conductors are not allowed per the NEC® for building system conductors.

Why the change to permit 16 and 18 AWG conductors? One of the major objectives of NFPA 79-2002 was to harmonize, where possible, with IEC60204. This IEC standard allows for smaller conductors.

What is the challenge with using smaller conductors? Small conductors are a challenge to protect under short circuit conditions; some overcurrent protective devices are unable to provide protection. The smaller the conductor size, the lower the short-circuit current withstand. 16 and 18 AWG conductors have extremely low short-circuit current withstandability. Based on the ICEA (Insulated Cable Engineers Association) conductor withstand equation presented in a previous section, copper conductors, 75°C thermoplastic insulation have these short-circuit withstands:

<table>
<thead>
<tr>
<th>Conductor Gauge (AWG)</th>
<th>½ Cycle Short-Circuit Current Withstand (amps)</th>
<th>Short-Circuit Current Withstand (amps² seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>1500</td>
<td>19,000</td>
</tr>
<tr>
<td>18</td>
<td>900</td>
<td>7000</td>
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</table>

The NFPA 79 proposal for allowing 16 and 18 AWG for branch circuits was accepted based on a study conducted by the Small Wire Working Group formed by the NFPA 79 Committee. The Small Wire Working Group studied the critical application considerations for small conductors in industrial machinery, proposed the requirements and conducted UL witnessed tests to prove the proposed requirements are acceptable. After considering several damage criteria, the group decided to use the ICEA damage levels because they were the most conservative. All other methods allowed certain amounts of damage.

The Small Wire Working Group had to determine the requirements for a proposal to NFPA 79 on how the conductors would be protected. Their analysis and testing resulted in proposing different approaches or requirements for different type overcurrent protective devices. This allowance is conditional and limited to certain requirements such as: limited ampacity circuits, specific overcurrent protective device criteria, and limits for physical damage. Specific overcurrent protective devices must be selected in order to use 16 and 18 AWG for branch circuit conductors. These devices are:

**Fuse Protection**

1. Class CC, J, or T fuses, or
2. Other fuses listed and marked for protection of 16 or 18 AWG wire

**Circuit Breaker Protection**

3. Circuit breakers listed and marked for protection of 16 or 18 AWG conductors

They chose to segregate the Class J, CC and T fuses because the published UL/CSA/ANCE 248 Fuse Standards for these fuses (for applicable amp ratings) have established performance short circuit let-through limits that are lower than the ICEA conductor short-circuit withstand limits. This means that these fuses will let-through less energy than the ICEA damage threshold, so conductor protection is assured. Therefore, the task in this case was to prove this hypothesis. Testing was performed using special “umbrella” fuses with let-through values above the UL/CSA/ANCE fuse standard limits. The results: these fuses protected the 16 and 18 AWG conductors, passing both visual inspections and dielectric testing. UL issued a Special Service Investigation, An Investigation of the use of 16 and 18 AWG Conductors for Power Branch Circuits in Industrial Machinery Applications, file number E4273 to verify the test results. The analysis, test program and results can also be viewed in an IEEE paper presented at the 2002 IEEE Industrial and Commercial Power Systems Technical Conference titled, An Investigation of the Use of 16 and 18 AWG Conductors for Branch Circuits in Industrial Machinery Built to NFPA 79 2002. The report and paper can be found on www.cooperbussmann.com.

What about overcurrent protective devices other than Class J, CC, and T fuses? Other Classes of fuses, or circuit breakers must be evaluated, tested and listed to protect 16 and 18 AWG conductors in branch circuits. The electrical industry will revise the appropriate standards with procedures that evaluate these other overcurrent protective devices to the application considerations that the NFPA 79 Small Wire Working Group utilized.

The Small Wire Working Group noted some of the specific criteria that is necessary to evaluate overcurrent protection for protection of 16 and 18 AWG conductors for industrial machinery applications:

1. Conductor length can vary greatly: 1 foot, 4 feet and 100 feet lengths of conductor were tested to cover a wide variety of installations.
2. Short-circuit current tests with full L-L voltage on one pole of a circuit to insure the overcurrent protective device can protect conductors for various types of grounding schemes. L-G faults are very prevalent fault conditions. And full L-L system voltage can be present for single or multiple L-G faults on some grounding systems. For example, the let-through I²t for a 480 volt fault opened by only one pole is much greater than that same fault opened by two poles of that same device.
3. The damage level for conductors was selected as the ICEA Allowable Short-Circuit Currents For Insulated Conductors. After the overcurrent tests, to assess the conductor insulation integrity, a reliable test method (not just visual inspection) via dielectric insulation testing was used.
4. It is necessary to protect these small conductors for all levels of short-circuit current. Tests were conducted with 5000A, 10,000A and 50,000A of available short-circuit current to ensure protection at low, intermediate and high fault levels.

At the time of this updated publication, a new SPD for Industrial Control Panels and Industrial Machinery is being written. The specifics on the small wire requirements and sizing will be in this new publication. When completed this new publication will be available at www.cooperbussmann.com.