10 Reasons Why Supplemental Protectors Can Not be Used to Provide Branch Circuit Protection

Why can’t Supplemental Protectors be used for branch circuit protection?

In order to provide an answer to this very popular question, a review of the standard used for evaluation of the device will have to be conducted. The standard used for evaluation of supplemental protectors is UL1077 Supplemental Protectors. Let’s look into the standard and analyze the requirements in order to provide an answer to this question.

What is the intended use of Supplemental Protectors?

In order to determine an answer to this question we need to look at the scope of UL1077. The scope is located in the first section and can be summarized as follows:

1 Scope
1.1 These requirements apply to supplementary protectors intended for use as:
   - overcurrent, or over- or under-voltage protection
   - within an appliance or other electrical equipment
   - where branch circuit overcurrent protection is already provided, or is not required.

Compliance with the following is acceptable for use as a component of an end product……

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The scope defines the overall considerations used for the development of the requirements in the standard and for the evaluation of the product to these requirements. Notice in the scope of UL1077 there are two main areas to consider in order to answer our question.

The first area describes the intended use of supplemental protectors evaluated to UL1077 and contains three assumptions or considerations.

Overcurrent or over- or under-voltage protection. This describes the purpose or function of the device, i.e. to provide overcurrent protection, within its intended use. It is not, for example, evaluated for performance as a disconnecting means, since it is not in the scope, and therefore the device would not be suitable for this function.
Supplemental protectors are limited to use **within an appliance or other electrical equipment**. This tells us that the devices are not intended to be field installable and cannot be purchased over the counter and installed anywhere. This also provides an indication that the devices will be NRTL (Nationally Recognized Testing Laboratory) Recognized or restricted rather than NRTL Listed.

Supplemental protectors are not intended to provide branch circuit protection and are limited to applications **where branch circuit protection is already provided or is not required**. Supplemental protectors, according to their scope of evaluation, are not evaluated for performance to provide branch circuit protection. This consideration alters the content in the performance requirements and in general would allow for more flexibility in the requirements than what would be allowed for a device being evaluated for branch circuit protection. Examples of this will be discussed later.

The second area indicates that compliance with the requirements in UL1077 allows for the use of supplemental protectors only as a **component of an end product**. This tells us that supplemental protectors can only be used as a part or component in a product not as a “stand alone” product in and of itself. This also indicates that the device will have to be installed in a product that will undergo further evaluation, per the phrase “end product”, which will provide assurance that the device is installed within the considerations and limitations provided in the scope. This also tells that the device will be NRTL Recognized rather than NRTL Listed and will have certain conditions of acceptability as a result of compliance with this standard. In addition this implies that a qualified representative of an NRTL will evaluate the use of the device in context of the equipment application and device capabilities. These conditions must be adhered to for proper application of the device.

**Reason #1: Supplemental Protectors are not intended to be used or evaluated for branch circuit protection in UL1077**

**How do the construction requirements of supplemental protectors compare to devices evaluated for branch circuit protection?**

The first part of the UL1077 standard provides the requirements for construction of supplemental protectors in sections 6 - 17. One of the more critical requirements for construction related to the suitability for branch circuit protection is the spacing of live metal parts contained in and on the device. The spacing requirements provide minimum distances for creepage, over surface, and clearance, through air, between live metal parts of opposite polarity and any live metal part to grounded metal which would be encountered upon installation of the device, see Figures 1 and 2. Spacing distances are intended to provide adequate isolation between live metal parts and to reduce the occurrence of the device creating a fault condition during normal operation or when the device operates as intended through the life of the device. Clearance distances, through air, evaluate the effects of one phase arcing over onto another phase and creating a fault condition. The distance required is directly related to the voltage between the phases and the medium through which the arc has to travel. The higher the voltage and the more conductive the medium, the larger the spacings required. Creepage distances, over surface, evaluate the effects of one phase tracking along a surface onto another phase and creating a fault condition. This distance required for proper isolation is affected by two main conditions. The first is the tracking properties of the surface material between the phases, including the reduction of the materials insulation properties due to increased
temperatures over time. The second is the amount and type of contaminants that may end up on the surface which could provide a path for tracking between phases, including deposits from venting when interrupting currents. As can be seen from the discussion above, the larger the spacing distance, the better the isolation provided by the device.

Taking this into account, let’s look at the spacing requirements for UL1077 supplemental protectors. Table 16.1 provides us with the minimum acceptable spacings for supplemental protectors.

<table>
<thead>
<tr>
<th></th>
<th>General Industrial</th>
<th>Kitchen Appliances</th>
<th>Commercial Appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through Air</td>
<td>3/8”</td>
<td>3/32”</td>
<td>3/32”</td>
</tr>
<tr>
<td>Over Surface</td>
<td>1/2”</td>
<td>3/32”</td>
<td>3/32”</td>
</tr>
</tbody>
</table>

Table 16.1 provides a variety of spacing requirements depending on the intended application of the supplemental protector and the level of voltage for which the device will be applied. Two observations can be noted upon reviewing the spacing requirements:

1. The higher the intended application voltage, the larger the required spacings
2. The lighter the duty required in the intended application, the smaller the distances permitted.

For example, a supplemental protector intended for use in kitchen appliances will have smaller permitted spacings compared to a supplemental protector intended for use in a general industrial application. This is due to both the lower voltages encountered in a kitchen appliance application and the lighter duty loads encountered in this application. The reverse is true when looking at the spacings required for general industrial, which can be seen by the increased spacings in this category.

Now let’s compare the spacing requirements for supplemental protectors to those of devices which are suitable for branch circuit protection. For comparison we will use a popular application voltage of 480V. At this voltage level, branch circuit devices would be required to have spacings at their line terminals of 1” through air and 2” over surface. Compare this to the levels allowed under the general industrial category for 301-600V.

<table>
<thead>
<tr>
<th></th>
<th>Branch Circuit Devices</th>
<th>Supplemental Protectors – General Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through Air</td>
<td>1 inch</td>
<td>0.375 inches</td>
</tr>
<tr>
<td>Over Surface</td>
<td>2 inches</td>
<td>0.5 inches</td>
</tr>
</tbody>
</table>

Notice the drastic reduction in spacing allowed for supplemental devices compared to the level required for devices used for branch circuit protection. This supports the consideration given in the scope limiting the use of supplemental protectors to applications where branch circuit protection is already provided or is not required. The allowance of reduced spacing requirements for supplemental protectors exists due to the fact that separate branch circuit protection is required. The smaller spacings reduce the level of isolation and creates a situation in which the chances for fault, due to breakdown in isolation, have increased. This is allowed due to the fact that a branch circuit protective device, with adequate spacing, is applied ahead of the supplemental protector to clear the fault condition should the reduced spacings cause such an event.

Reason#2: Supplemental protectors have drastically reduced spacings, compared to branch circuit protective devices, which depend upon the aid of a separate branch circuit protective device upstream.

1 Values from spacing requirements in UL489 Molded Case Circuit Breakers, UL98 Disconnect Switches, and the combination controller section 76.12 of UL508 Industrial Control Equipment

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How do the performance requirements of supplemental protectors compare to devices evaluated for branch circuit protection?

The second part of the UL1077 standard provides the requirements for evaluation of the performance of supplemental protectors in sections 18 - 29. Let’s look at some specific performance requirements and analyze what they mean.

Section 19 of UL1077 covers the requirements for calibration testing.

19.1 Calibration

….An overcurrent protector shall trip within the limits of the manufacturers curve at 105 percent of its rated tripping current and at 300 percent of its rated current

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The requirements for calibration testing depend upon the limits set forth by the manufacturer not by the standard. This allows for a wide disparity in performance for supplemental protectors that are available in the market. There are no set performance levels required, therefore an investigation on a device by device basis will have to be conducted. Due to the fact that performance requirements can vary, supplemental protectors will have to be thoroughly investigated upon installation to insure that the performance of the device selected will provide adequate protection for the intended installation. Branch circuit overcurrent protective devices are evaluated based upon set performance levels, mandated in the product standard, to provide protection of branch circuits. Supplemental protectors may or may not be evaluated at these levels.

Reason #3: Supplemental protectors do not have standard calibration limits and cannot assure proper protection of branch circuits.

Section 21 of UL1077 covers testing used to evaluate the overload performance of a supplemental protector. The levels used for the testing are outlined in Table 21.1 of UL1077. A summary of the table is shown here:

<table>
<thead>
<tr>
<th>Device Used For</th>
<th>Rated In</th>
<th>Test Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across the line motor AC (HP)</td>
<td>6 X FLC</td>
<td></td>
</tr>
<tr>
<td>Starting General Use or incandescent Lamp control AC</td>
<td>1.5 X rated current</td>
<td></td>
</tr>
</tbody>
</table>

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The levels used for evaluation of overload protection for supplemental protectors are not set and vary based upon the intended use of the protector, as shown in Table 21.1. This indicates that not all supplemental protectors are tested the same for overload protection and proper protection of branch circuits can not be assured. Branch circuit overcurrent protective devices are evaluated based upon set overload performance levels, mandated in the product standard, to provide overload protection of branch circuits.

Reason #4: Supplemental protectors do not have standard overload characteristics performance levels and cannot assure proper protection of branch circuits.
Section 25 of UL1077 covers the requirements for supplemental protector short circuit testing and evaluation criteria. Short-circuit performance is one of the most important functions of an overcurrent protective device. Short circuits can impose enormous amounts of energy upon electrical installations in a few thousandths of a second. Proper interruption of short circuits is essential to eliminate damage to equipment or even personnel. If the device is installed outside of its performance limitations or is relied upon for short circuit protection outside its intended use, it could lead to a very unsafe situation.

In light of this, let’s review the performance requirements of supplemental protectors as provided in section 25 of UL1077. An important aspect to consider when evaluating a device’s short circuit performance is the details of the test configuration used when conducting the short circuit testing. UL1077 provides specific details for the configuration of the test circuit used in the short circuit testing. These details are summarized in Figure 3 and Table 25.2.

Note that Figure 3 shows the test setup for a 3 pole device intended for use in a 3 phase system, other test setups exist depending upon the intended use of the supplemental protector. The one real difference in these various test setups has to do with the way that the device is connected to the test circuit. For now we will concentrate on the 3 phase application. Reviewing Figure 3 some important information relating to the performance of a supplemental protector during a short circuit can be gathered.

The first point to consider is the creation of the short circuit. Notice that all three phases are connected together on the load side of the supplemental protector. This is typically referred to as a bolted three phase fault condition and generally represents the situation that generates the maximum amount of short circuit current. Keep in mind this also means that all three poles will be working together to clear the fault. This requirement is stated in section 25.6 of UL1077.

Partial Representation of Table 25.2
Limited short-circuit test current

<table>
<thead>
<tr>
<th>Appliance Protector Rating</th>
<th>Horsepower</th>
<th>Voltage</th>
<th>Test Current, Amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 or less</td>
<td>more than 250</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>More than 1</td>
<td>more than 250</td>
<td>5000</td>
</tr>
</tbody>
</table>

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Also note that three devices are required for the testing program, we will discuss the implications of this later in the paper. Section 25.6 also mandates only a three phase bolted fault for the short circuit testing of a multipole device. This does not provide an evaluation of the device under a line to ground fault condition where only one pole of the device will be called upon to clear the fault. Overcurrent protective devices used for branch circuit protection need to provide overcurrent protection for all overcurrents that could exist. Evaluation of a supplemental protector’s performance is incomplete and therefore supplemental protectors can not provide branch circuit protection.
The next point to consider is the inclusion of a branch circuit protective device ahead of the supplemental protector in the test circuit. Section 25.9 of UL1077 mandates this portion of the test circuit setup.

**Reason #5: Multipole supplemental protectors for use in 3 phase systems are not evaluated for protection against all types of overcurrents.**

25.9 A fuse or a molded case circuit breaker suitable for branch circuit protection shall be wired in series with the protector during the short-circuit test . . .

*Exception: The short circuit test may be conducted without a fuse or molded case circuit breaker wire in series with the supplementary protector at the request of the manufacturer.*

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Note the exception to this requirement which allows the manufacturer to request the short circuit test to be conducted without the branch circuit device upstream. This again adds another parameter to check when applying supplemental protectors. This also typically leads to lower short circuit current ratings for the device. When supplemental protectors are able to legitimately be used, it is important that the branch circuit device ahead of it be the appropriate size and type. The majority of supplemental protectors are tested with a branch circuit protective device ahead of them in the test circuit. This means the supplemental protector and the branch circuit protective device work together to interrupt the short circuit. This also shows how the scope and consideration therein effect the requirements in a standard. The inclusion of the branch circuit overcurrent device is allowed since the scope of the document states the underlying assumption that these devices are limited to installations where branch circuit protection already exists.

**Reason#6: Most supplemental protectors are tested with a branch circuit overcurrent device ahead of them and rely upon this device for proper performance.**

Now that we have reviewed the test circuit lets look at the short circuit testing criteria. Devices that are resettable are typically selected based upon the fact that they can be reset following an overcurrent. This is not always true, and in order to determine if a device will truly perform this function a look at the testing requirements needs to be conducted. The modes of operation for a supplemental protector under the short circuit testing are outlined in Table 25.1 of UL1077.

**Partial Representation of Table 25.1**

<table>
<thead>
<tr>
<th>Poles</th>
<th>Voltage Rating</th>
<th>Operations per Pole</th>
<th>Common Operation</th>
<th>Circuit Used On Voltage</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>480Y/277</td>
<td>X X X X</td>
<td>O CO CO</td>
<td>Single Phase</td>
<td>277</td>
</tr>
<tr>
<td>3</td>
<td>240,480,600</td>
<td>X X X X</td>
<td>O CO CO</td>
<td>Three Phase</td>
<td>480</td>
</tr>
</tbody>
</table>

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For a multipole device, the column titled common operation is used. Note that there are three columns under the this category named O, CO, and CO. A short circuit test consisting of an O shot is where the device is placed in the test circuit with contacts in the closed (ON) position and the test lab closes the circuit to create a short circuit. This would simulate a short circuit occurring in an electrical installation via a breakdown in one of the components downstream with the supplemental protector in the closed (ON) position. The CO shot is where the device is placed in the circuit with contacts in the open position and the device is closed into the short circuit. This would simulate a condition where the device has opened due to a fault and is reset into a short circuit. Looking at Table 25.1 it appears that supplemental protectors are evaluated for one O shot followed by two CO shots. This however is not always the case as can be seen in the requirements of section 25.30 of UL1077.

### 25.30

If the results of the first or second operation of the short circuit test...are such that the device is rendered inoperable, but is otherwise intact as described in 25.27 and 25.29, the remaining operations need not be performed.

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Section 25.30 would allow for a device to be rendered inoperable following an O shot and terminate the rest of the short circuit testing; the device is considered acceptable. Therefore, the supplemental protector may have never been evaluated for closing itself into a short circuit or handling more than one short circuit operation. This eliminates the resettability feature of the device and would mandate replacement of the device in the field after the device has seen one fault! This also creates a serious safety hazard. A supplemental protector appears on the surface to be resettable. When encountered in an installation where it has tripped due to a fault, it presents an invitation for the maintenance worker or electrician to reset the device. The device is being used beyond its conditions of acceptability, or conditions of use, and thus eliminating the assurance of protection from spread of fire and shock. Often the maintenance worker or electrician do not have or know the conditions of acceptability for the device, and the use of a recognized or restricted product in the design or assembly creates an undesired safety hazard. Resettable devices that are suitable for branch circuit protection, such as UL489 molded case circuit breakers, are required to undergo testing with both an O and CO shot.

### Reason#7: Supplemental protectors are not required to be tested for closing into a fault.

Continuing the discussion of resettability, let’s investigate if supplemental protectors are checked for calibration following a short circuit operation, or recalibrated. A representation of Table 18.2 of UL1077 provides an overview of the performance testing that a supplemental protector goes through.
There are three testing sequences, A, B, and C shown in Table 18.2. Each sequence evaluates the suitability of the device for a specific purpose. Test sequence A provides an investigation for calibration of the device in order to assure that the device will perform within the limits claimed by the manufacturer. Test sequence B provides an investigation of the device for its performance, durability, and suitability for installation. Test sequence C provides an investigation of the performance of the device under fault conditions. Notice that the testing in Sequence C does not require a recalibration test following a short circuit. There is no assurance that the device will provide any level of protection following a short circuit. This eliminates the resettability feature of the device since there is no assurance that the device will operate properly following a short circuit. Even though recalibration is not required, UL1077 does allow recalibration if specified by the manufacturer.

25.28 Where the manufacturer specifies that recalibration testing has been conducted after the short circuit test.….  

However, this does not provide assurance that all supplemental protectors maintain calibration and it shows the dependency on the manufacturer’s preference. This creates an extra level of investigation into the proper use of the device.

**Reason#8: Recalibration of a supplemental protector is not required and depends upon manufacturer’s preference. There is no assurance of performance following a fault or resettability of the device.**

Now that we have investigated the short circuit testing, let’s look into the evaluation criteria used to determine if a device is acceptable or not. Sections 25.27 and 25.29 provide us this information.

25.27 The protector shall complete the short circuit test without igniting the cotton indicator. No breakage of the protector case shall be apparent. There shall be no opening of the ground fuse described in 25.2, during the short circuit test.

25.29 The opening of the series fuse, welding of the contacts, inability of the device to be reset, inability of the device to indicate the circuit being open or closed, or the inability of the protector to trip the circuit shall not be considered unacceptable test results.
Notice in section 25.27 that surgical cotton and a ground fuse are discussed in the list of criteria. The cotton investigates the possibility of the spread of fire outward from the device. The ground fuse verifies that the ionized gas released by the device during its short circuit operation does not cause a ground fault condition. Section 25.29 shows that a tremendous amount of damage is allowed following a short circuit test.

Let’s discuss the implications of this allowable damage:

- **Welding of the Contacts . . . and . . . Inability . . . to indicate the circuit being open or closed**
  
  Note: Devices that are intended and listed for disconnecting means are not permitted to have welded contacts and must provide indication of circuit status (ON/OFF) as a result of the short circuit test procedure. *Supplemental Protectors CAN NOT be used as a branch circuit disconnecting means or motor circuit disconnecting means (UL508)* since they are permitted to have welded contacts and provide no indication of the circuits status (ON/OFF) following a short circuit.

- **Opening of the Series Fuse . . . and . . . Inability of the protector to trip the circuit**
  
  Following a short circuit, the supplemental protector may not even operate and the circuit may be cleared completely by the series fuse, branch circuit overcurrent protective device as can be seen from the list of allowable damage. *Supplemental Protectors are not intended to be used for branch circuit protection* and therefore considerable damage is allowed.

<table>
<thead>
<tr>
<th>Reason#9: Considerable damage to a supplemental protector is allowed following short circuit testing. Supplemental protectors are not intended to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provide Branch Circuit Protection</td>
</tr>
<tr>
<td>• Be used as a Disconnecting Means</td>
</tr>
</tbody>
</table>

In addition, notice that following the short circuit testing, evaluation of the device’s performance by investigating either the let through energy (I2t) and peak current (Ip), or investigation of damage to the conductors used in the test setup does not exist. This provides a clear indication that the device is not evaluated for protection of branch circuits and can not be used for protection of them.

| Reason#10: Supplemental protectors are not evaluated for short circuit performance criteria, such as energy let through limits or protection of test circuit conductors. |

Why *can’t* Supplemental Protectors be used for branch circuit protection?

The answer to this question is provided in the 10 reasons provided by this paper:

1. Intended Use
2. Reduced Spacings
3. No set Calibration Limits
4. No set Overload Levels
5. Not investigated for Line to Ground Faults
6. Tested with Branch Circuit Device Upstream
7. Not investigated for Closing into a Fault
8. May Loose Calibration
9. Considerable Damage to Supplemental Protector is Allowed
10. No Short Circuit Performance Criteria

The use of supplemental protectors for branch circuit protection is a violation of the devices intended use, and creates a situation of increased liability and compromised design. If a supplemental protector is accidentally being misapplied as a branch circuit overcurrent protective device, the simplest and safest solution is to replace the supplemental protector with a proper branch circuit protective device.

**IMPORTANT NOTES:**

Where supplemental protectors are utilized as intended it is very important to verify the following factors:

- ✓ Check the conditions of acceptability of the supplemental protector to assure it meets or exceeds the application conditions
- ✓ BE SURE the supplemental protector has a short circuit current ratings equal to or greater than the available short circuit current of the installation.
- ✓ CHECK THE VOLTAGE RATING of the supplemental protector against the system voltage. If the supplemental protector has a slash voltage rating, i.e. 480Y/277, be sure it will be properly applied. For instance, a supplemental protector rated 480Y/277 volts can not be used on a 480 volt high resistance grounded wye system, 480V corner grounded delta system, or a 480V ungrounded system. It can only be applied on a 480/277 volt solidly grounded wye system.
- ✓ The supplemental protector is not intended to be used as a disconnect!
- ✓ Check to insure the specific time current characteristics of the supplemental protector provides the intended protection for the circuit component under ALL CONDITIONS.
- ✓ Check to insure the supplemental protector is NOT BEING MISAPPLIED as BRANCH CIRCUIT PROTECTION
- ✓ Check to insure the proper branch circuit protective device is ahead of the supplemental protector. Most supplemental protectors are evaluated under short circuit conditions with a branch circuit fuse or circuit breaker ahead of them. Be sure to adhere to any specific requirements relating to the size or type of the proper branch circuit protective device to be installed ahead of the supplemental protector.