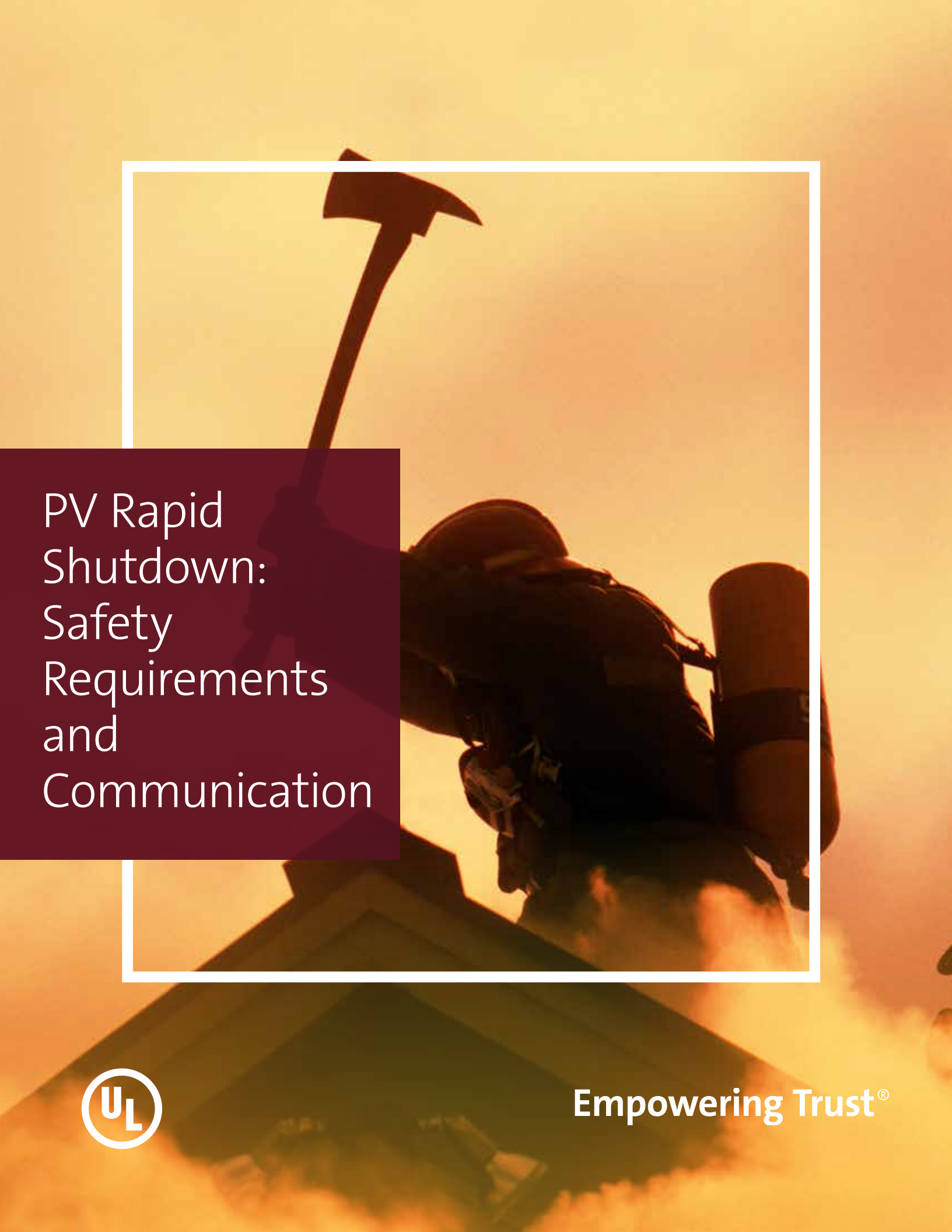

# PV Rapid Shutdown: Safety Requirements and Communication

Empowering Trust®

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# Imagine this:

You are standing on the sidewalk of a suburban neighborhood and it's a scorching hot day in California. On this beautiful day you have at least 45 pounds worth of personal protective equipment on and you are sizing up the risk of electrical hazards before you and your crew enter a burning home to save lives and property. Welcome to a day in the life of your local firefighter.

## Keeping firefighters safe

Photovoltaic (PV) technology is developing rapidly and we are seeing rooftop solar PV arrays become more commonly installed on residential homes and commercial properties. While PV array equipment is required to be certified for safety from risk of shock and fire, those certifications do not account for all of the specific interactions with firefighters working around the array while fighting a fire. During a fire, the firefighting interactions with the PV array can pose electric shock hazards to firefighters who have to perform their duty. When these firefighters enter a burning building, there are precautions that they need to take not only with the electricity supplied from the local utility but also with electricity from the PV modules on a rooftop. While there is no foolproof way to prevent building fires and PV solutions are vital to maintaining power in some areas, what is the solution to keep firefighters safe?

## The missing solution

Enter the missing safety solution: a photovoltaic rapid shutdown system (PVRSS). A PVRSS provides a means for firefighters to stop or reduce the voltage and current from the PV array, so they can stay as safe from electrical hazards while still doing their jobs efficiently.

Starting in 2014, the U.S. National Electric Code® (NEC®), also known as National Fire Protection Association 70® (NFPA 70®), added section 690.12. This section included requirements for PV rapid shutdown (PVRS) functions to be installed on buildings where PV arrays are installed. These requirements were intended to reduce the firefighter electric shock hazards posed from energized PV array conductors located outside the array boundary. NEC 690.12 defined which conductors had to be controlled, the allowable voltage and the allowable maximum time to reach that reduced voltage. The NEC required that equipment performing these new rapid shutdown functions "shall be Listed," but at that time there was no safety standard addressing rapid shutdown equipment or systems implementing this function. Through Empowering Trust® and making the world a safer place, UL published the PV Rapid Shutdown Certification Requirement Decision (CRD) to fill the certification requirements gap between NEC 690.12 and UL 1741, the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources. That CRD was further developed by a PV rapid shutdown industry task group that proposed the addition of the PV rapid shutdown section to UL 1741.

# Updates and revisions to requirements for PV rapid shutdown equipment and systems

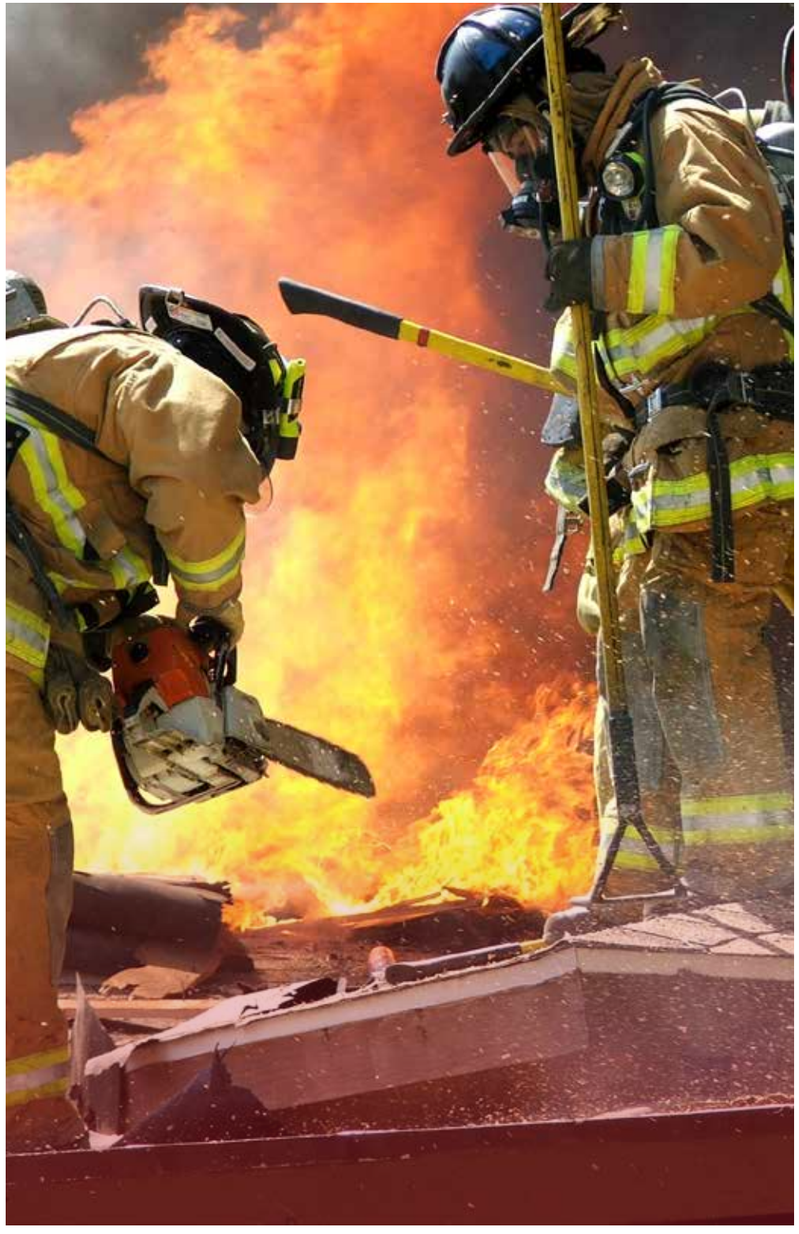
After some revisions, the UL 1741 Standards Technical Panel (STP) accepted the proposal to update the UL 1741 Standard and added the new requirements for PV rapid shutdown equipment and systems on Dec. 22, 2017. The updated Standard defined requirements for PV rapid shutdown equipment (PVRSE) and PV rapid shutdown systems (PVRSS) to reduce hazards for firefighters while performing their duties on or in buildings with PV arrays. This update also requires all PVRSS and PVRSE to be evaluated to functional safety standards to increase reliability, which made the optional "High Reliability" certification and marking from the CRD obsolete. These requirements are used in conjunction with section 690.12 of the NEC to reduce the voltage on controlled conductors exiting a PV array.

*In the event of a failure, the equipment is required to transition to a controlled state.*

The added requirements are for electrical isolation/attenuation equipment, initiators, disconnects, status indicators, reset devices and combinations of devices making up PVRSS. They also specify the required ratings, markings and instructions needed so that these functions are installed and understood by installers. PVRSE and PVRSS are required to comply with functional safety standards that evaluate and verify that critical hardware and software used to implement the PV rapid shutdown functions operate as intended. In the event of a failure, the equipment is required to transition to a controlled state.

These requirements also included several new tests for PVRSE and PVRSS as noted below:

- PVRSS and PVRSE that include PV disconnect functionality
- Operational tests of PVRSS and PVRSE that verify levels of controlled conductors and response time
- Verification testing of PVRSS and PVRSE at rated extremes, e.g., temperature, humidity, voltage, etc.
- Power supply ride through testing for inverters certified as PVRSE
- Functional safety testing for software and hardware faults during safety critical functions
- Environmental stress testing including but not limited to: voltage surges, radiated immunity, electrostatic discharging (ESD), thermal and humidity cycling, dust, vibration, over/under voltage, etc.
- Compatibility of PVRSE and PVRSS with PV DC arc fault circuit interrupter (AFCI) equipment and detection functionality



# What is the difference between PVRSE and PVRSS?

Two new terms were added to UL 1741 when the PV rapid shutdown requirements were added. These terms are PV rapid shutdown equipment (PVRSE) and PV rapid shutdown system (PVRSS) that are defined as follows:

**PVRSE** – Equipment intended to be used in a PVRSS to initiate, disconnect, isolate or attenuate the controlled conductors of a PV system. [1]

**PVRSS** – System consisting of PVRSE intended to initiate, in addition to disconnect, isolate or attenuate the controlled conductors of a PV system. [2]

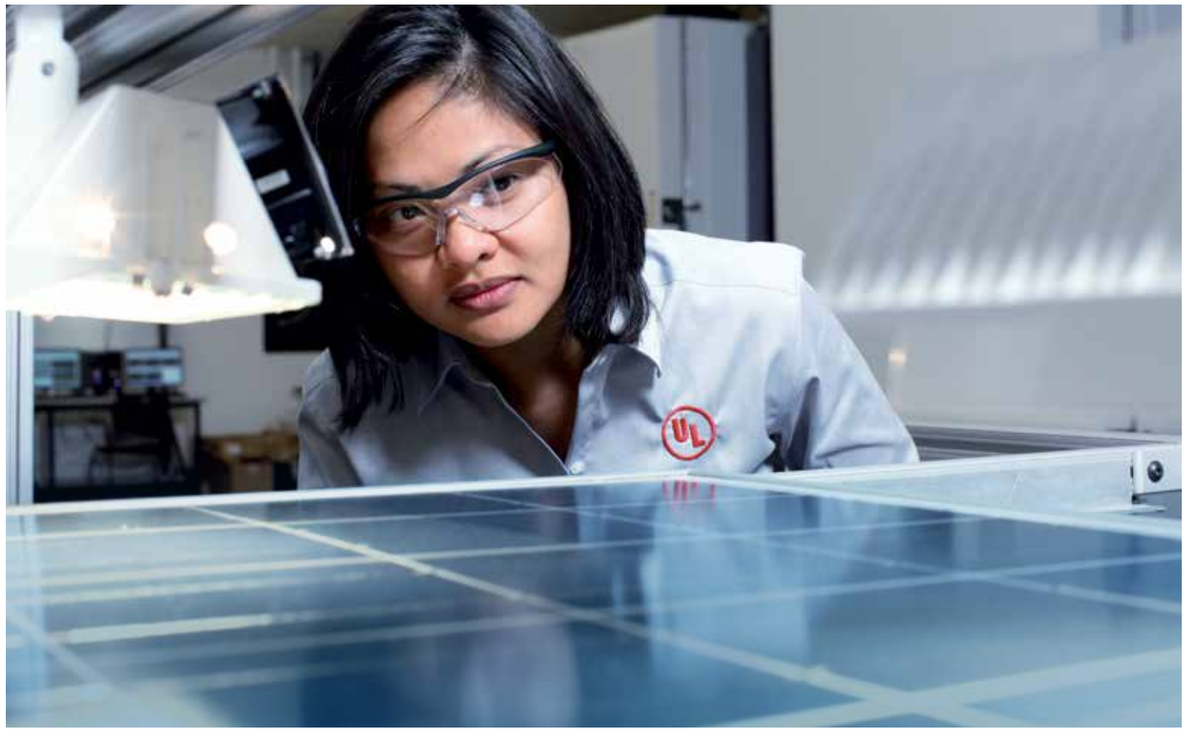
These terms were added to quantify two types of product configurations to which PV rapid shutdown requirements can be applied to and certified under UL 1741. While section 690.12 of the NEC® refers to rapid shutdown of PV systems on buildings, it was unlikely that every solution brought to market would be complete in design to constitute a comprehensive PV rapid shutdown system. Manufacturers produce specific pieces of PV rapid shutdown equipment that could be utilized in the creation of complete PV rapid shutdown systems.

The intent of creating the PVRSE term was to allow for individual pieces of rapid shutdown equipment to be evaluated for specific PVRS functions, for example, an initiation device or the rapid shutdown device that controls the conductor. Equipment, such as inverters, that connects to controlled conductors may also have a PVRSE marking identifying the port that was evaluated to cease to energize the controlled conductors when the rapid shutdown has been activated.

The UL 1741 Standard requires markings and instructions to be provided with a PVRSE. These items address field installation with other listed PVRSE or disconnect devices as required by the manufacturer's instructions to form a PVRSS. It is good practice for a functional check to be performed on the installed equipment to verify that it functions correctly when the initiation device is activated.

1 Note that UL certifications for PVRSE are under the category control number (CCN) of QIJW

2 Note that UL certifications for PVRSS are under the category control number (CCN) of QIJS



## Considerations of Nationally Recognized Testing Laboratory (NRTL)[1] Certification Programs

When NRTLs conduct certifications of PVRSE, they are evaluated to the extent possible as afforded by the design and specific functionality. This way, listed PVRSE can more easily be evaluated for use in defined groupings as an overall PVRSS. A system level evaluation can be conducted for a defined grouping of PVRSE and this configuration can be independently certified as a PVRSS meeting section 690.12 of the NEC. The UL 1741 PVRS requirements published on Dec. 22, 2017, include an option to evaluate combinations of PVRSE together as a PVRSS that provides the basis for a NRTL system certification. Within the context of a NRTL system certification, PVRSE are building blocks of a PVRSS and UL 1741 requirements include additional testing for a complete system evaluation, e.g. system level timing requirements, end-to-end functionality, etc.

A successful system evaluation including successful testing results in a PVRSS NRTL certification that simplifies the acceptance tasks and responsibilities of the authority having jurisdiction (AHJ) in the field.

Alternative options to the NRTL PVRSS certification described above are available to AHJs. These options are at the discretion of the AHJ for a given installation site.

Currently, the PVRSS NRTL certified solution option described above is the only complete system level solution independently tested and certified by third party NRTLs meeting the published UL 1741 requirements for a complete PVRSS.

1 UL is a NRTL accredited by OSHA and can issue safety certifications under a Listing program for PVRSE and PVRSS devices.





# How does communication play a role in PVRSE and PVRSS devices?

Understanding the difference between PVRSE and PVRSS is an important basis for the discussion of communication protocols for rapid shutdown devices. A complete PVRSS, comprised of multiple PVRSE component groupings using communication between the components, must function under a cohesive protocol once combined. Examples of PVRSE may include switches and inverters that fall into communication categories of: initiators, transmitters and receivers. Typically, the initiator triggers the rapid shutdown function and other PVRSE within the PVRSS take action to switch or attenuate to reduce the output voltage of the PV array.

The SunSpec Communication Signal for Rapid Shutdown Interoperability Specification is an example of a standard keep-alive signal that can be used between two or more separately listed PVRSE in a PVRSS communication methodology to facilitate a near simultaneous rapid shutdown action. The SunSpec Rapid Shutdown System (RSS) Protocol explicitly defines the method in which initiators, transmitters and receivers communicate using a standard language to facilitate the shutdown process.

PVRSE using a common communication protocol can facilitate the UL 1741 evaluation and listing certification of the PVRSE for use in a PVRSS to comply with NEC 690.12. A common communication protocol assists PVRSE from different manufacturers to operate together which would be a critical functional safety building block of the overall UL Listing evaluation of the PVRSE and PVRSS.

## Future state of communication signals and UL 1741

Currently, there is consideration of a revision proposal within the UL 1741 STP to apply functional safety requirements in combination with standardized communication methods. If this proposal is accepted into the UL 1741 Standard, it is anticipated to result in a new NRTL certification process supporting the pairing of PVRSE together in a plug-and-play style methodology based on functional safety methods to increase system reliability. As a reminder, a Listing specifically refers to a safety certification through a NRTL that is accredited through OSHA.

While there are many other developments in process for increasing firefighter safety while performing their duties, the current safety requirements are important to understand and implement for components that support the rapid shutdown function. Our firefighters are an essential part of our first responder community so keeping them safe is paramount to the safety of our communities.

For additional information on functional safety in renewable energy applications, see the UL white paper, “Why Functional Safety Matters in Renewable Energy Applications,” on UL.com.

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