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QUESTION #6

Original question with answer and explanation:

An interactive UL 1741 listed inverter is turning on and off on sunny days during what would be expected to be the time of day for peak performance. You are sent to the jobsite to troubleshoot the problem. Of the following, which would be the most likely scenario?

a. Voltage too low at the ac terminals of the inverter
b. Voltage too high at the ac terminals
c. Voltage too high at the dc terminals
d. Frequency too high at the terminals

Explanation:

Let us rule out the wrong answers first and then settle on the right answer.

a. In most places, the utility voltage does not sag significantly just during the parts of the day that the PV production would expect to peak. This is probably not a likely scenario.

c. During the peak part of the day for sunshine, usually around noon, we would not expect the dc voltage to get too high. If the dc voltage would get too high, we would expect that to be at the coldest time of the day and year on a system that was improperly designed. We would also not expect this problem to repeat itself on a regular basis and we could expect the inverter to break if the dc voltage was too high.

d. In most places where there are utility interactive inverters, it is uncommon for inverters to shut off due to the frequency being too high. In most of North America, for example, the frequency is so reliable on the grid that we set our clocks to it.

b. is the correct answer. When the conductors on the ac side of the inverter are undersized or there are other causes of resistance, we will get voltage drop. Voltage drop on the ac side of the inverter causes the voltage to rise at the inverter terminals, since the power is coming from the inverter, the voltage will be higher at the inverter and the voltage will drop as it approaches the interconnection. Many people in the industry call this phenomenon voltage rise.

EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES:

Explanation:

Let us rule out the wrong answers first and then settle upon the right answer.

a. In most places, the utility voltage does not sag significantly just during the parts of the day that the PV production would expect to peak. This is probably **not a likely scenario.**

b. is the correct answer. When the conductors on the ac side of the inverter are undersized or there are other causes of resistance, we will get voltage drop. **Voltage drop on the ac side of the inverter causes the voltage to rise at the inverter terminals,** since the power is coming from the inverter, the voltage will be higher at the inverter and the voltage will drop as it approaches the interconnection. **Many people in the industry call this phenomenon voltage rise.**

c. During the peak part of the day for sunshine, usually around noon, we would not expect the dc PV voltage to get too high. If the dc voltage would get too high, we would expect that to be at the coldest time of the day and year on a system that was improperly designed. This could void the warranty.

d. In most places where there are utility-interactive inverters it is uncommon for inverters to shut off due to the frequency being too high. In most of North America, for example, the frequency is so reliable on the grid that we set our clocks to it.

QUESTION #12

Original question:

For a large ground-mount system every eight modules will need two bal- last blocks. Each ballast block is made from concrete that weighs 140lbs per square foot. The dimensions of each block are 2 feet 3" north to south, 3 feet 2" east to west. If the ballasts for the section of eight modules have to weigh 3824lbs, to keep the array stable, then how deep must we pour the concrete into the forms?

A. 23"
B. 46"
C. 72"
D. 48"

EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES:

Explanation:

First, we will calculate how many cubic feet of concrete will weigh 3824 lbs.

3824 lbs / 140 lbs per cubic foot = 27.3 cubic ft

Now knowing that **length × width × depth = volume**, and we have length, width and volume, we just need to get the units correct and then solve for depth.

We can do the equations in inches or feet and since last time we worked with inches, this time we will work with feet (inches may be easier since there are 12 inches per foot, which does not do well with moving decimals).

Length = 2 ft 3 inches = 27 inches
27 inches / 12 inches per foot = 2.25 ft
Length = 2.25 ft

Width = 3 ft 2 inches = 38 inches
38 inches / 12 inches per foot = 3.17 ft

Depth is the unknown:

Volume = 27.3 cubic feet for two ballasts

Volume for one BALLAST is:

27.3 cubic ft / 2 = 13.7 cubic feet

$(L \times W) \times D = V$
$D = V/(L \times W)$

Depth = 13.7 cubic ft / (2.25 ft × 3.17 ft)
Depth = 1.92 ft

1.92 ft × 12 in per ft = 23 inches deep

Concrete note: Often concrete is reinforced with **rebar** (reinforcing bar). Rebar is sized the opposite of conductors in that the larger the number, the larger the diameter of the rebar. The imperial (USA) sizes are given in **increments of 1/8 of an inch**, so that a **#4 rebar is a half inch** in diameter and a **#8 rebar has a 1-inch diameter**.

QUESTION #13

Original question:

On a ballasted ground-mounted PV system, the width of the footing would be wider due to:

A. Soil load bearing
B. Frost line
C. Wind uplift
D. Insulation

Explanation:

There may be a few answers here that can be argued, but the best answer appears to be soil load bearing. If the ballast was narrow and the soil was soft, it would sink into the soil.

QUESTION 13 EXPLANATION REVISED: HGHLIGHTED ARE THE CHANGES

Explanation:

There may be a few answers here that can be argued, but the best answer appears to be soil load bearing. If the ballast was narrow and the soil was soft, it would sink into the soil. A soil engineering study is often done before a ground-mounted project.

QUESTION #20

Original question:

You are working on a jobsite and the wrong inverter was sent, because the old inverter was thought to be less safe and less efficient by the business owner. What must you do to make sure that the new ungrounded inverter is installed correctly when adapting the plan from the grounded inverter?

A. Switch to a larger grounding electrode conductor.
B. Not use 90°C rated USE-2 for your source circuits on the roof outside of conduit.
C. Tap the transformer on the ungrounded inverter.
D. Switch the white wire from the negative to the positive.

QUESTION 20 NEW QUESTION AND EXPLANATION:

When installing a non-isolated (formerly known as ungrounded) inverter, which of the following wiring methods can be used for PV source circuits?

a. USE-2 only
b. PV wire only
c. Neither USE-2 nor PV wire
d. USE-2 dual listed as RHW-2 or PV wire

Correct answer d

Explanation:

In the 2014 NEC we were still using the term ungrounded for our PV arrays that were used with a "non-isolated" inverter. This is the most common type of inverter and used on almost every PV system with inverters less than a MW these days. These formerly known as ungrounded inverters are more correctly known as the non-isolated type of functionally grounded inverters these days. In the 2014 NEC, we were required to use PV wire, however as of the 2017 NEC and later, we can use USE-2 or PV wire.

In the 2020 NEC and later, there is a requirement that the PV source circuits when using USE-2 wire, that the USE-2 wire also has to be dual listed as RHW-2 wire. Since USE-2 wire is almost always dual listed as RHW-2 wire, this is not a problem. If someone were to find USE-2 wire that was not dual listed as RHW-2, then it could not be used indoors inside of conduit, since USE-2 itself is not allowed indoors, however RHW-2 is allowed indoors, so when dual listed as USE-2 and RHW-2, it is allowed indoors.

QUESTION #27

Original question with answer and explanation:

There is a building that you would like to put different inverters on for different tenants. What would be required in this situation?

a. There must be six or fewer PV disconnects to turn off all of the PV systems and all of the systems must be in the same enclosure.
b. There must be 12 or fewer PV disconnects.
c. **There shall be a maximum of six disconnects to turn off all of the PV systems and the disconnects need to be in the same location.**
d. There may be an unlimited number of disconnects as long as they are the anti-islanding type.

Explanation:

Part III of Article 690 of the NEC is titled "Disconnecting means." If we look a little farther down the page, we see690.13(D): maximum number of dis-connects, where it says that we cannot have more than six disconnects in an enclosure or group of enclosures

This means that we need to be able to turn off the PV systems with no more than six different switches to turn off that are PV switches. Since it says that the switches can be in a group of enclosures, then it would be accept-able to have the switches in different enclosures as long as they are in the same area.

690.13(D) also says that a single disconnecting means can disconnect multiple interactive inverters. So, we can definitely have more than six inverters on a building, if you were wondering.

As a side note, in Article 230: service equipment, 230.71 (often called the six handle rule) states that there should be no more than six service disconnects per service. It is generally understood in the PV industry that PV is not a service and that you can have six service disconnects in addition to six PV disconnects, how-ever, there will be some inspectors that will disagree with this interpretation. It is a best practice to try to locate all of the PV disconnects and the service disconnects in the same location. If everything is not in the same location, you should have a sign at each location telling where everything else is located.

This is so that someone unfamiliar with the site will not miss something when they are trying to turn everything in the building off. This is especially helpful for the fire department.

QUESTION 27 NEW QUESTION AND EXPLANATION:

Which of the following is not acceptable on a house?

A. 7 300W microinverters on 7 20A breakers at the bottom of a long 100A main service panelboard
B. 7 3.8kW inverters on a 200A subpanel with no other breakers
C. 7 PV modules and 7 dc disconnects connecting to a dc bus that is connected to 7 charge controllers, then a dc bus.
D. 7 PV systems on a single building with 7 PV system disconnects

Answer: c

Explanation:

It used to be that we could have no more than 6 PV system disconnecting means on a building, but that is no longer the case. This is what 2020 NEC 690.13(C) says now (this is also the case with the 2017 NEC):

2020 NEC 690.13(C) Maximum Number of Disconnects. "Each PV system disconnecting means shall consist of not more than six switches or six sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure, or in a group of separate enclosures. A single PV system disconnecting means shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system.

Informational Note: This requirement does not limit the number of PV systems connected to a service as permitted in 690.4(D). This requirement allows up to six disconnecting means to disconnect a single PV system. For PV systems where all power is converted through interactive inverters, a dedicated circuit breaker, in 705.12(B)(1), is an example of a single PV system disconnecting means."

It is now difficult to think up a PV system that has 7 different PV system disconnecting means.

We will briefly go through the different answers:

Explanation why a is not the best answer:
a. 7 300W microinverters = 2100W and 2100W/240V = 8.75A, so 125% of inverter current as used in the 120% rule = 8.75A x 1.25 = 10.9A, which is less than 20A. The 120% rule is 705.12(B)(3)(2).

Explanation why b is not the best answer:
b. Here we can apply the "sum rule", which is 705.12(B)(3)(3) and we are good here at this subpanel, however if there was further information about the main service panel, we would also have to consider that.

Explanation why c is the best answer:
c. This appears to be 7 disconnects for a single PV system, or at least the closest to it for all the available answers here. This would violate the NEC.

Explanation why d is not the best answer
d. 7 PV systems with 7 different disconnects if fine according to recent versions of the NEC. This used to be different.

Note that it would be difficult to come up with a single "PV system" that had more than one PV system disconnect. Perhaps having a number of arrays with separate disconnects going to a charge controller. Otherwise you typically have an ac disconnect being the end of a PV system or a single dc disconnect. Remember that a PV system does not include energy storage or loads, so if you disconnect something that also turns off energy storage or loads, then it is not a PV system disconnect, it is more.

QUESTION #29

Original question with answer and explanation:

What are the rapid shutdown voltage limits for inside the array boundary and outside the array boundary?

a. 30V in 30 sec inside and outside the array
b. 30V inside array and 80V outside of the array
c. 80V inside the array and 30V outside of the array
d. 80V in 30 sec inside and outside of the array

Explanation:

690.12(B)(1): outside the array boundary calls for 30V within 30 seconds.

690.12(B)(2)(2): controlled conductors inside of the array boundary calls for 80V within 30 seconds

Regarding inside of the array boundary, there are other uncommon possibilities, such as 690.12(B)(2)(3), which was instituted for BIPV, where you get away from the 80V rule and go up to 600V on one and two family dwellings and 1000V on other buildings if there are no exposed connective metal parts or exposed wiring.

QUESTION 29 NEW QUESTION AND EXPLANATION:

The neighborhood association requires that the inverter must be inside the house and the utility requires that the ac and dc disconnects are outside the house by the meter. Which is the best solution?

a. Tell the neighborhood association that they cannot make you put the inverter inside the house, because the NEC does not require that the inverters be inside.
b. Have the inverters inside the house within 50 feet of the disconnects, which are mounted at the meter.
c. Have 2 sets of disconnects, one set inside by the inverter and the other at the meter.
d. Educate the utility that pulling the meter will disconnect the ac and the dc power.

Answer: c

Explanation:

Unfortunately, in most places an HOA (Homeowners Association) and the utility can make you do extra work that is beyond the scope of the NEC. It would probably be easiest to have everything by the meter, with only one set of ac and dc disconnects, however in this case we have to comply with the local rules.

Note that some states have solar rights rules, where they can prohibit HOAs from making your PV system unaffordable or completely restricting PV systems. You can find this information about a specific state and much more at www.dsireusa.org . For example in California entities are allowed to impose reasonable restrictions on a solar energy system that do not add more than $1,000 to the cost, or limit the efficiency of the system by 10%.
https://programs.dsireusa.org/system/program/detail/1253/california-solar-rights-act

Here is from 690.15 Disconnecting means and 690.15(A) Location:

2017 NEC:

690.15 Disconnection of Photovoltaic Equipment.
Isolating devices shall be provided to isolate PV modules, ac PV modules, fuses, dc-to-dc converters, inverters, and charge controllers from all conductors that are not solidly grounded. An equipment disconnecting means or a PV system disconnecting means shall be permitted in place of an isolating device. Where the maximum circuit current is greater than 30 amperes for the output circuit of a dc combiner or the input circuit of a charge controller or inverter, an equipment disconnecting means shall be provided for isolation. Where a charge controller or inverter has multiple input circuits, a single equipment disconnecting means shall be permitted to isolate the equipment from the input circuits.
Informational Note:
The purpose of these isolating devices are for the safe and convenient replacement or service of specific PV system equipment without exposure to energized conductors.
(A) Location.
Isolating devices or equipment disconnecting means shall be installed in circuits connected to equipment at a location within the equipment, or within sight and within 3 m (10 ft) of the equipment. An equipment disconnecting means shall be permitted to be remote from the equipment where the equipment disconnecting means can be remotely operated from within 3 m (10 ft) of the equipment.

2020 NEC:

690.15 Disconnecting Means for Isolating Photovoltaic Equipment.
Disconnecting means of the type required in **690.15(D)** shall be provided to disconnect ac PV modules, fuses, dc-to-dc converters, inverters, and charge controllers from all conductors that are not solidly grounded.
(A) Location.
Isolating devices or equipment disconnecting means shall be installed in circuits connected to equipment at a location within the equipment, or within sight and within 3 m (10 ft) of the equipment. An equipment disconnecting means shall be permitted to be remote from the equipment where the equipment disconnecting means can be remotely operated from within 3 m (10 ft) of the equipment. Where disconnecting means of equipment operating above 30 volts are

readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open.

So, what this means is you pretty much need a disconnecting means within 10 feet of and within sight of your equipment, so you can work on the equipment knowing that you will not get shocked.

QUESTION #47

Original question with answer and explanation:

In a grid-tied system with battery backup, which of the following would be the most important attribute?

a. Having a charge controller that will power diversion loads when the system is in interactive mode.
b. Having a system that will equalize sealed lead–acid batteries.
c. Using a multimodal charge controller with an automatic transfer switch.
d. Having an inverter that will power all of the backed up loads.

Explanation:

The backed up loads with a grid-tied battery backup system are the loads that will operate when the grid is down. It would be important to have an inverter that will power all of the backed up loads. Typical backed up loads are a refrigerator, lighting, outlets and communication devices. Typically, people do not backup air-conditioning or heating, because those loads would very quickly drain the batteries.

To rule out some of the other wrong answers:

a. When the system is in interactive mode, it will typically be feeding the extra power back to the grid, rather than a diversion load.
b. You do not equalize sealed batteries. If the batteries are sealed, then you cannot add electrolyte to them. When you equalize batteries, the electrolyte will turn into hydrogen gas and oxygen, which needs to be replaced by distilled water.
c. We do not see multimode charge controllers in the NEC. A multimode inverter is what can operate in interactive and standalone mode.
d. The correct answer.

QUESTION 47 NEW QUESTION AND EXPLANATION:

In a non-hybrid grid-tied system with battery backup, which of the following would be the most important attribute?

a. Having a charge controller that will power diversion loads when the system is in interactive mode
b. Having a system that will equalize sealed lead–acid batteries

c. Using a multimodal charge controller with an automatic transfer switch
d. Having an inverter that will power at least the largest backed up load

Answer: d

Explanation:

Here is 710.15(A)
Supply Output.
Power supply to premises wiring systems fed by stand-alone or isolated microgrid power sources shall be permitted to have less capacity than the calculated load. The capacity of the sum of all sources of the stand-alone supply shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load.

A non-hybrid system, means there are no other sources besides the grid, batteries and the PV system (see hybrid in 690.2 Definitions). The backed-up loads with a grid-tied battery backup system are the loads that will operate when the grid is down. It is the requirement of 690.15(A) that the sources must be able to power at least the largest load. Typical backed up loads are a refrigerator, lighting, outlets and communication devices. Typically, people do not back-up air-conditioning or heating because those loads would very quickly drain the batteries.

It used to be that the NEC required the inverter to be able to power at least the largest stand-alone load, but now you can sum up the power sources, so if you have a generator, you can add that to the inverter for this calculation. I modified this question to say non-hybrid for that reason, so we are saying there are no other power sources besides the inverter.

According to the NEC hybrid does not include batteries, however a common industry term, which contradicts the NEC for hybrid is a "hybrid inverter" (not hybrid system), which is an inverter that is connected to batteries and PV. The SolarEdge StorEdge inverter and the SolArc inverter are two common examples of what people are calling a "hybrid inverter".

To rule out some of the other wrong answers:

- **a.** When the system is in interactive mode, it will typically be feeding the extra power back to the grid, rather than a diversion load.
- **b.** You typically do not equalize sealed batteries. If the batteries are sealed, then you cannot add water to them. When you equalize batteries, the electrolyte will turn into hydrogen gas and oxygen, which needs to be replaced by distilled water. I ran into an exception to this rule in Pakistan.
- **c.** We do not see multimode charge controllers in the NEC. A multimode inverter is what can operate in interactive and stand-alone mode.
- **d.** The correct answer.

QUESTION #48

Original Question:

Which of the following would be the most important feature to have with a supply-side connection?

a. Have a service-rated fusible disconnect**.**
b. Do not exceed the rating of the main breaker.
c. Do not exceed 120% of the ampacity of the service conductors.
d. Do not exceed the rating of the busbar.

QUESTION 48 CHOICES REVISED: HIGHLIGHTED ARE THE CHANGES

Which of the following would be the most important feature to have with a supply side connection?

a. Have a service rated fusible disconnect
b. Do not exceed the rating of the main breaker
c. Do not exceed 120% of the ampacity of the service conductors
d. Do not exceed the rating of the busbar in the main service panel

QUESTION #49

Original question with answer and explanation:

On a low slope roof ballasted PV system, there are rooftop combiners that can take up to 20 strings each. If the PV Isc is 8.25A and the Imp is 7.9A and the PV source circuits each have 12 modules in series, then how many strings can each combiner have if there is a fused disconnect on the PV output circuit that is 200A?

a. 15
b. 24
c. 20
d. 17

Explanation:

To size a fuse on a PV source or output circuit, we multiply Isc × 1.56 and round- up to the next common fuse size. If the fuse size was 200A, then to determine the amount of current that the fuse can protect, we will have to first determine what the current of 1 PV source circuit multiplied by 1.56 is:

$$8.25A \times 1.56 = 12.9A$$

Then we take that current and divide it into 200A:

200A/12.9A = 15.5

Since we cannot have half of a circuit, we will have to round-down, so the maximum number of PV source circuits is 15.

156% is a number that is commonly known by those in the PV industry. We have this number to account for extra currents when PV modules can operate beyond STC. Sometimes irradiance in the natural world is above 1000W per square meter, which means that current will be above what is written on the label. This 1.56 correction factor is only on PV source and output circuits and not inverter output circuits, most dc-to-dc converter circuits, or standalone battery to inverter circuits.

It is also interesting to note that the dimensions of the typical solar cell are 156mm × 156mm.

In Section 690.9: overcurrent protection, we find that 690.9(B) says that the OCPD shall not be less than 125% of the currents from 690.8(A); when we are talking about PV source and output circuits, the current will be found in **690.8(A)(1), where it defines maximum current as 125% of Isc**. When we have 125% twice we have 1.25 × 1.25 = 1.56.

QUESTION 49 QUESTION AND EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES

On a ground mounted PV system, there are combiners that can take up to 20 PV source circuits each. If the PV Isc is 8.25A and the Imp is 7.9A and the PV source circuits each have 12 modules in series, then how many strings can each combiner have if there is a fused disconnect on the PV output circuit that is 200A?

a. 15
b. 24
c. 20
d. 17

Answer: a

Explanation:

To size a fuse on a PV source or output circuit, we multiply Isc × 1.56 and roundup to the next common fuse size. If the fuse size was 200A, then to determine the amount of current the fuse can protect we will have to first determine the current of one PV source circuit multiplied by 1.56:

8.25A × 1.56 = 12.9A

Then we take that current and divide it into 200A:

200A / 12.9A = 15.5

Since we cannot have half of a circuit, we will have to round-down, so the **maximum number of PV source circuits is 15**.

> 156% is a number that is commonly known by those in the PV industry. We have this number to account for extra currents when PV modules can operate beyond STC. Sometimes irradiance in the natural world is above 1000 W per square meter, which means that current will be above what is written on the label. This 1.56 correction factor is only on PV source and output circuits and not inverter output circuits or stand-alone battery to inverter circuits.
>
> It is also interesting to note that the dimensions of the typical solar cell are 156 mm × 156 mm.
>
> 156% is less common for rooftop PV professionals, due to rapid shutdown and electronics under PV modules that can control currents. If the current can be limited by electronics, then we do not use this factor, since we are protected by the electronics in most cases. There are exceptions, so be sure to read instructions for the product you are using. For example SolarEdge and Enphase systems do not require using 156% in any calculations, since the PV currents are limited and controlled by the module level power electronics (MLPE).

In **Section 690.9 Overcurrent Protection** we find that **690.9(B) says that the OCPD shall not be less than 125%** of the currents from 690.8(A); when we are talking about PV source and output circuits, the current will be found in **690.8(A)(1), where it defines maximum current as 125% of Isc**. When we have 125% twice we have 1.25 × 1.25 = 1.56.

QUESTION #52

Original question:

There are 15 PV source circuits and an equipment grounding conductor on a rooftop in sunlight in a circular raceway, which is elevated 3" above the roof going from the array to a combiner 22 feet away in a location with a constant breeze keeping the conduit cool. The ASHRAE 2% average high design temperature is 35C. The PV source circuits are 12 AWG THWN-2 and the ground wire is 12 AWG THWN-2. The terminals in the combiner box are rated for 75C. What is the maximum Isc for modules used in this system?

a. 10.35A
b. 7A
c. 16A
d. 24A

<u>**QUESTION 52 EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES**</u>

Explanation: There are a few steps that we have to do here and first and easiest is to follow 690.8(A)(1) and 690.8(B)(1) by taking the 12AWG copper terminal temperature ampacity in the 75°C column of Table 310.16 (2017 NEC 310.15(B)(16)), which is 25A as seen in the table below:

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

	Temperature Rating of Conductor [See Table 310.4(A)]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
Size AWG or kcmil	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			Size AWG or kcmil
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8

Next, we can divide 25A by 1.56, which equals: 16.0A, so for this branch of the wire sizing family tree, we could have a PV module with an ampacity of up to 16.0A.

The next thing we are going to do is to reverse engineer the conditions of use (adjustment and correction factors) method we see in 690.8(B)(2). Here we are going to use the 90°C column of Table 310.16 for 12 AWG (not the terminals this time) and we are also not going to have the extra 125% for "required ampacity for continuous current" this time.

Big change here when going from the 2014 to the 2017 NEC and beyond, is that we no longer have to derate for conduit over a rooftop in sunlight (unless the conduit is ⅞ of an inch or less, which is not recommended). So, now **we get to ignore the raceway being 3" over the roof. This was formerly known as table 310.15(B)(3)(c) Raceways and Cables Exposed to Sunlight on Rooftops and we no longer use it.**

Since we have 15 PV source circuits (positives and negatives) in conduit, then we have 30 current carrying conductors in a raceway that we have to derate for using Table 310.15(C)(1), which is formerly known as Table 310.15(B)(3)(a) in the 2017 NEC, which was just a name change.

Table 310.15(C)(1) Adjustment Factors for More Than Three Current-Carrying Conductors	
Number of Conductors*	**Percent of Values in Table 310.16 Through Table 310.19 as Adjusted for Ambient Temperature if Necessary**
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

* Number of conductors is the total number of conductors in the raceway or cable, including spare conductors. The count shall be adjusted in accordance with 310.15(E) and (F). The count shall not include conductors that are connected to electrical components that cannot be simultaneously energized.

As we can see in the table above, with 30 current carrying conductors (equipment grounding conductor does not carry current), we can carry 45% of the current we could have carried if there were 3 or less conductors in conduit, so the derating factor for 45% is **0.45**, which is significant!

The other derating factor we have is for the ambient temperature being over 30°C and we look to table 310.15(B)(1), which was 310.15(B)(2)(a) in previous to 2020 versions of the NEC, which was just a name change.

We go by a 35°C design temperature from the question.

Table 310.15(B)(1) Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor			Ambient Temperature (°F)
	60°C	75°C	90°C	
10 or less	1.29	1.20	1.15	50 or less
11–15	1.22	1.15	1.12	51–59
16–20	1.15	1.11	1.08	60–68
21–25	1.08	1.05	1.04	69–77
26–30	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	132–140
61–65	—	0.47	0.65	141–149
66–70	—	0.33	0.58	150–158

So our derating factor here is only 0.96, but then we can multiply 0.96 by 0.45 to get our total derating factor of 0.432.

To get our rated current, we need to take our 12 AWG ampacity of 30A in the 90°C column of 310.16.

Derated ampacity of the conductor here is then 30A x 0.432 = 12.96A

Since we also have to multiply Isc by 1.25 to get our rated current then, we can calculate backwards this equation:

Isc x 1.25 = derated ampacity = 12.96A

Now to solve for Isc, divide both sides by 1.25 (same as multiplying by 0.8)

Isc = 12.96 / 1.25 = 10.4A

Discussion: This is a complex and difficult question to answer and may be more difficult than anything you see on the NABCEP Certification exams, however something like this was once on a certification exam. The answer here would have been different if based on the 2014 NEC, but will be the same for subsequent versions due to the removal of Table 310.15(B)(3)(c). Remember that you only need to use the terminal temperature check for the first check where you use the extra 125% for required ampacity for continuous current. You can see the huge derating taking place for so many conductors in conduit, so in that case, you could just skip the 156% step, since it is obvious that with 30 current carrying conductors in conduit, you are going to have a lot of derating. If I were taking a NABCEP exam, I would skip this question, take an educated guess, flag it (which the platform allows you to do) and save it for the end, so I do not run out of time for the faster to answer questions. Or if I was well practiced up, I would just do a bunch of shortcuts in my head and look up 90C ampacity of 12 AWG wire, which is 30A, in 310.16 and divide it by (0.96 x 0.45 x 0.8).

Changes in wire sizing table names from 2017 NEC and earlier to 2020 NEC and later:

310.15(B)(16) = 310.16
310.15(B)(17) = 310.17
310.15(B)(2)(a) = 310.(B)(1)
310.15(B)(3)(c) = 310.15(C)(1)

QUESTION #54

Original question:

What is the smallest copper equipment grounding conductor that can be used when running 10 source circuits in conduit with 10AWG THWN-2 wire 100 feet to a dc combiner? The fuses in the dc combiner are 15A and the dc combiner terminals are rated for 75C.

A. 14AWG
B. 10AWG
C. 12AWG
D. 6AWG

Explanation:

Equipment grounding conductor sizes are found in Table 250.122 and are based on fuse size.

Table 11.12 From Table 250.122 Minimum size of equipment grounding con- ductor (EGC)

Overcurrent device size	Copper EGC minimum size
15A	**14**
20A	12
60A	10
100A	8

From the table, we can see that the minimum size EGC would be a 14 AWG copper conductor.

It is acceptable to use a larger conductor and if the conductor is not inside of conduit, the AHJ may require it to be larger. In some locations the AHJ requires a 6 AWG when running bare copper in free air under arrays and in other locations the AHJ will require 10AWG bare copper in free air.

According to 690.45, if there were no fuses on a PV source circuit, we would use Isc x 1.56 in place of the OCPD in Table 250.122. The reason we can have no fuses on a PV source or output circuit is when there are one or two strings combined and not enough current for the fuse to open the circuit with one string backfeeding down another in a short circuit scenario.

QUESTION 54 EXPLANATION REVISED:

Equipment grounding conductor sizes are found in Table 250.122 and are based on fuse size.

Table 9.13 From Table 250.122, Minimum size of equipment grounding conductor (EGC).

Overcurrent device size	Copper EGC minimum size
15A	14
20A	12
60A	10
100A	8

From the table, we can see that the minimum size EGC would be a 14AWG copper conductor.

An interesting fact about sizing EGCs is that according to Section 250.122(B), when an ungrounded conductor is oversized, then the EGC should be oversized proportionally.

This is contradicted by **Section 690.45 Size of Equipment Grounding Conductors**, where the NEC says you do not need to oversize the EGC for PV source and output circuits.

According to 90.3 Code Arrangement, Chapters 5, 6 and 7 supplement or modify Chapters 1 through 4. 690 is in Chapter 6, so it is modifying 250.122(B). Therefore, **we do not need to upsize the EGC for PV source and output circuits**. Often, PV systems conductors are oversized for voltage drop considerations.

It used to say in 690.3 that 690 will supersede Chapters 1-4, however that was removed, since we do not need to say this, because it is essentially repeating 90.3.

According to 690.45, which directs us to 690.8(A), if there were no fuses on a PV source circuit, we would use 125% of maximum circuit current, which is 125% of 125% of Isc, (which means 156% of Isc) in place of the OCPD in Table 250.122. We can have no fuses on a PV source or output circuit when there are one or two strings combined and not enough current for the fuse to open the circuit.

It is acceptable to use a larger equipment grounding conductor (EGC) and if the conductor is not inside conduit, the AHJ may require it to be larger. In some locations the AHJ requires a 6AWG when running bare copper in free air under arrays and in other locations the AHJ will require 10AWG bare copper in free air (not an NEC requirement).

We used to have to use a minimum of an 8AWG for microinverter EGCs, since we considered the EGC to also be a dc grounding electrode conductor (GEC), which is no longer the case, since we have re-defined typical PV inverter grounding to be functionally grounded.

This is where it tells us that we do not need a dc GEC for a functionally grounded inverter:

690.47(A)(1) For PV systems that are not solidly grounded, the equipment grounding conductor for the output of the PV system, where connected to associated distribution equipment connected to a grounding electrode system, shall be permitted to be the only connection to ground for the system.

QUESTION #62

Original question with answer and explanation:

If the dc disconnect is not near the main service disconnect at the service entrance, what should be done according to the NEC?

A. Install another dc disconnect at the service entrance. Under no cir- cumstances can the dc disconnect not be at the main service discon- nect at the service entrance.
B. Include the location of all disconnects in the as-built plans that you will submit tothe building department.
C. **Have a sign at the disconnects in different locations that indi- cates where the other disconnects are located**.
D. At the utility's discretion, you should put a sign at the main service entrance indicating where the dc disconnect is located.

Explanation:

There are many references to plaques and directories spread out through the NEC for PV:

- **690.4(D): multiple PV systems.** Multiple PV systems shall be permitted to be installed ona single building or structure. Where the PV systems are remotely located from each other, a directory in accordance with 705.10 shall be provided at each PV system disconnecting means.
- **705.10: directory.** A permanent plaque or directory denoting the location of all electric power source disconnecting means on or in the premises shall be installed at each service equipment location and at the location(s) of system disconnect(s) for all electric power production sources capable of being interconnected.

To sum this up and simplify: If all of the PV disconnects and the main service disconnect are all **at the same location, you do not need a plaque or direc- tory**. If they are in **different locations, then at each of those locations, you do need a plaque** or directory showing where the other disconnects are located.

If we think about this, you would never have one plaque or directory, because if everything was not located in the same location, you would need at least two signs showing where the other disconnects are at two or more different places.

Therefore the correct answer to the question is "to have a sign at the discon- nects at different locations that shows where the other disconnects are located."

This is one of those cases where it would be nice if the NEC had it all in the same location to avoid paper cuts.

QUESTION 62 QUESTION AND EXPLANATION REVISED: HIGHLIGHTS ARE THE CHANGES

If the PV system disconnect is not near the main service disconnect at the service entrance, what should be done according to the NEC?

A. Install another dc disconnect at the service entrance. Under no circumstances can the dc disconnect not be at the main service disconnect at the service entrance
B. Include the location of all disconnects in the as-built plans that you will submit to the building department
C. Have a sign at the disconnects in different locations that indicates where the other disconnects are located
D. At the utility's discretion, you should put a sign at the main service entrance indicating where the dc disconnect is located

Answer: c

Explanation:

There are many references to plaques and directories spread out through the NEC for PV.

690.4(D) Multiple PV Systems:
Multiple PV systems shall be permitted to be installed in or on a single building or structure. Where the PV systems are remotely located from each other, a directory in accordance with 705.10 shall be provided at each PV system disconnecting means.

690.56(B) Facilities with utility services and PV Systems (in Article 690 Part VI Marking and in Section 690.56 Identification of Power Sources):
Plaques or directories shall be installed in accordance with 705.10 and 712.10, as required.

705.10 Identification of Power Sources
A permanent plaque or directory shall be installed at each service equipment location, or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means for the building or structure and be grouped with other plaques or directories for other on-site sources. The plaque or directory shall be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER." Any posted diagrams shall be correctly oriented with respect to the diagram's location. The marking shall comply with 110.21(B).
Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually.

To sum this up and simplify: If all of the PV disconnects and the main service disconnect are all **at the same location, you do not need a plaque or directory**. If they are in **different locations, then at each of those locations you do need a plaque** or directory showing where the other disconnects are located.

If we think about this, you would never have one plaque or directory, because if everything was not located in the same location, you would need at least two signs showing where the other disconnects are at two or more different places.

Therefore, the correct answer to the question is "to have a sign at the disconnects at different locations that shows where the other disconnects are located."

This is one of those cases where it would be nice if the NEC had it all in the same location to avoid paper cuts.

Many inspectors require a plaque or directory if everything is co-located, which is not an NEC requirement. You can try politely telling them about the 705.10 exception if you do not want to have an extra plaque.

QUESTION #63

Original Question:

You are connecting 3 different 5kW inverters to a subpanel on a residential service. Each inverter is connected to a 30A breaker on the subpanel. What is the smallest breaker that you could use for the breaker at the main service panel that is feeding the MLO (main lug only) subpanel?

A. 80A
B. 90A
C.100A
D.75A

Explanation:

First, we will determine the current that is coming out of the inverter and since it is a residential service, we are dealing with 240Vac:

Watts = volts × amps
Watts/volts = amps
5000W inverter/240Vac = 20.8A inverter output

Then we will multiply by 1.25 for continuous current and to size the circuit breaker:

20.8A × 1.25 = 26A

We have to round-up to the next common size of circuit breaker, so the test is right in using a 30A circuit breaker for the individual inverters.

To determine the smallest allowable breaker for the feeder, we will multiply 26A by three inverters. (Note: we did not use the 30A breaker size for this calculation.)

26A × three inverters = 78A

Rounding-up the next common size breaker gives **us 80A, which is the correct answer.**

QUESTION 63 EXPLANATION REVISED: HIGHLIGHTS ARE THE CHANGES

Explanation:

First, we will determine the current that is coming out of the inverter. Since it is a residential service we are dealing with 240V ac.

Watts = Volts × Amps
Watts / Volts = Amps
5000W inverter / 240V ac = 20.8A inverter output

We will multiply by 1.25 for continuous current and to size the circuit breaker:

20.8A × 1.25 = 26A

We have to round-up to the next common size of circuit breaker, so the test is right in using a 30A circuit breaker for the individual inverters.

To determine the smallest allowable breaker for the feeder, we will multiply 26A by three inverters. (Note: we did not use the 30A breaker size for this calculation.)

26A × 3 inverters = 78A

Rounding up, the next common size breaker is **80A, which is the answer**.

We base this calculation on 125% of inverter current and not the inverter breaker size.

QUESTION #64

Original question with answer and explanation:

Using the information for Question 63 above, what would be the main breaker and busbar combination of the panelboard that would work best for a load-side connection?

A. 200A main breaker, 225A busbar
B. 400A center-fed main breaker, 450A busbar
C. 400A main breaker, 400A busbar
D. 175A main breaker, 200A busbar

Explanation:

Let's see what the different options will let us connect on a load-side connection:

A. 200A main breaker, 225A busbar

120% rule applies
busbar × 1.2 = 240A
240A - 200A main = 40A
40A/1.25 = 32A
Largest inverters here could only equal 32A
32A × 240V = 7680W inverter
definitely cannot connect three 5kW inverters here

B. 400A center-fed main breaker, 450A busbar

Busbar is center fed here, so 120% rule does not apply.

The rule here is that the inverter current × 1.25 + main breaker cannot exceed the busbar rating according to 705.12(D)(2)(3)(a). This way you can put the solar breaker any place on the busbar, not just the opposite end from the main breaker, like with the 120% rule:

450A busbar - 400A main = 50A
50A/1.25 = 40A inverter(s)
40A × 240Vac = 9600W max. inverter(s)

Three 5kW inverters is more than 9600W or 9.6kW, so this will not work either.

C. 400A main breaker, 400A busbar

400A busbar × 1.2 = 480A
480A - 400A main = 80A
80A/1.25 = 64A inverter(s)

64A inverter(s) × 240Vac = 15,360W of inverters
15.36kW > 3 × 5kW inverters

In this scenario, we can have three 5kW inverters! (**c**. is the correct answer.)

Let's solve this again another way with a formula that can let you keep all of the numbers on your calculator and do the calculation quickly!

We have spent a lot of time explaining these calculations, but once you practice the method, you can answer this problem very quickly.

(((Busbar × 1.2) - main)/1.25) × grid voltage
= max. inverter power

Since the inverse of 1.25 is 0.8 we can also write:

(((Busbar × 1.2) - main) × 0.8) × grid voltage
= max. inverter power
(((400A × 1.2) - 400A) × 0.8) × 240Vac = 15.36kW

The calculator buttons we push are:

400 × 1.2 = - 400 = × .8 = × 240 =
and we get 15,360W

Practice this and you can get an answer in 30 seconds or under.

D. 175A main breaker, 200A busbar

(((Busbar × 1.2) - main) × 0.8) × grid voltage
= max. inverter power
(((200A × 1.2) - 175A) × 0.8) × 240V = 12.48kW

This is less than 15kW, but we would expect that, since we have already found the right answer. Thinking like a test taker can score extra points!

QUESTION 64 NEW QUESTION AND EXPLANATION:

You are connecting three different 5kW inverters to a subpanel on a US residential service. The subpanel is then connected to a feeder breaker at the main service panel on the opposite end of the busbar from the main breaker. What would be the main breaker and busbar combination of the main panelboard that would work best for a load side connection?

A. 200A main breaker, 225A busbar
B. 500A center-fed main breaker, 450A busbar
C. 400A main breaker, 400A busbar
D. 175A main breaker, 200A busbar

Answer: c

Explanation:

This is screaming 120% rule, especially since we read about the opposite end of the busbar, so we will use 705.12(B)(3)(2):

Where two sources, one a primary power source and the other another power source, are located at opposite ends of a busbar that contains loads, the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120 percent of the ampacity of the busbar. The busbar shall be sized for the loads connected in accordance with Article 220. A permanent warning label shall be applied to the distribution equipment adjacent to the back-fed breaker from the power source that displays the following or equivalent wording:

WARNING:
POWER SOURCE OUTPUT CONNECTION – DO NOT RELOCATE
THIS OVERCURRENT DEVICE.

First let's calculate 125% of inverter current:

Total inverter power = 5kW x 3 inverters = 15kW

Residential voltage = 240V

Inverter current = 15,000W / 240V = 62.5A

125% of inverter current = 78A

120% rule calculations:

(Busbar x 1.2) – Main >= 78A

a. (225A x 1.2)-200A = 70A
b. This is already a Code violation since you cannot protect a 450A busbar with a 500A breaker. You can use the 120% rule with center-fed, busbar, which was not always the case, such as with the 2014 NEC and earlier. The 2014 NEC was amended with a TIA, so you can apply the 120% rule with the 2014 NEC. Some places are still on earlier versions of the NEC.
c. (400A x 1.2)-400A = 80A is the right answer
d. (200A x 1.2)-200A = 40A

If you are in a hurry, you may be able to answer this question correctly, knowing that the 120% rule gives you 20A with a 100A breaker, 100A busbar combination and to multiply everything by 4 for the 400A breaker, 400A busbar combination, to get you 80A.

QUESTION #65

Original question with answer and explanation:

You are converting a grid-tied PV system to an ac coupled grid-tied battery backup PV system. Which of the following must you do?

A. Use 50Vdc or higher rated disconnects for 48V battery circuits.
B. Make provisions to equalize batteries if using sealed valve regulated lead–acid batteries. There shall be a schedule for equalization kept at
the site of the battery bank.
C. **Have a sign that indicates grounded conductor, polarity, max short circuit current, and date calculations were performed**.
D. You must backup all of the circuits in the building. Selective loads
are not allowed due to firefighters not knowing which loads are backed up.

Explanation:

Article 690, Part VI: marking is a good place to start looking for labeling requirements, also be aware that there are many places that we can look for PV and batteries in the NEC, such as **Article 480: Storage batteries** or **690.55: PV systems connected to energy storage systems**.

Here are the two places where we find the answer to this question:

690.55: photovoltaic power systems employing energy storage systems (which is in Part VI: marking) says that PV connected to energy storage sys- tem should be marked with:

• Polarity

480.6: disconnecting means, 480.6(D): notification. Disconnect shall be labeled with:

- Nominal battery voltage
- Max. short circuit current
- Date calculation was performed

QUESTION 65 QUESTION AND EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES

You are converting a grid-tied PV system to an ac coupled grid-tied battery backup PV system with lead-acid batteries. Which of the following must you do?

A. 50Vdc or higher rated disconnects for 48V battery circuits
B. Make provisions to equalize batteries if using sealed valve regulated lead–acid batteries. There shall be a schedule for equalization kept at the site of the battery bank
C. Have a sign at a battery bank that indicates grounded conductor, polarity of grounded conductor, voltage, max short circuit current and date calculations were performed
D. You must backup all of the circuits in the building. Selective loads are not allowed due to firefighters not knowing which loads are backed up.

Answer: c

Explanation:

Article 690 Part VI Marking is a good place to start looking for labeling requirements. Also be aware that there are many places that we can look for PV and batteries in the NEC, such as **Article 480 Storage Batteries** or **690 Part III Storage Batteries** or **690.10 Stand-Alone Systems.**

Here are the two places where we find the answer to this question:

690.55 Photovoltaic Power Systems Employing Energy Storage (which is in Part VI Marking) says that the battery system should be marked with:

- maximum operating voltage, including equalization voltage
- polarity of the grounded conductor.

480.6 Disconnecting Means, 480.6(F) Notification Disconnect shall be labeled with:

- nominal battery voltage
- available fault current
- arc flash label
- date calculation was performed.

Remember that NABCEP exams are written by people that have been around for a while and are very familiar with the old-style lead-acid battery systems that are covered in Article 480. There are arguments that since lead-acid batteries are not used in any UL 9540 listed energy storage systems, that you cannot even install lead-acid batteries in a house according to the 2018 International Residential Code (IRC). I have never heard of this being enforced. Perhaps we can consider that this PV system with batteries is not in a 1 or 2 family dwelling and not covered by the IRC. If it were on a 1 or 2 family dwelling, then there is a 480.6 exception, where we are only required to have the nominal battery voltage.

QUESTION #66

Original question with answer and explanation:

If a battery temperature sensor is not connected in New Jersey, what could be the problem with the batteries?

A. Undercharge in the summer and overcharge in the winter
B. Too much current in the winter
C. Undercharge in the winter and overcharge in the summer
D. Excessive current when it is hot

Explanation:

Batteries require more voltage to charge when it is cold. It is convenient that when it gets colder that PV makes more voltage and batteries require more voltage. If we did not have temperature compensation and were not increasing the voltage when it was cold, then the voltage would be low in the winter causing an undercharge and it would be high in the summer causing an overcharge. Another way to look at this is heat will speed up chemical reactions that happen in a battery, so the battery will require less voltage when it is hot.

If a battery overcharges in the summer, a symptom would be increased loss of electrolyte and a need to add distilled water. Another thing that can cause heat on a single cell is a bad connection at a battery terminal. The associated cell would require increased amounts of water when compared to the other battery cells. The installation manual for the Rolls AGM battery recommends temperature compensation to be –4mV/C/cell. In a 48-volt system, which is 24 cells, our temperature coefficient would be – 96mV/C.

QUESTION 66 QUESTION AND EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES

If a lead-acid battery temperature sensor is not connected in New Jersey, what could be the problem with the batteries?

A. Undercharge in the summer and overcharge in the winter
B. Too much current in the winter
C. Undercharge in the winter and overcharge in the summer

D. Excessive current when it is hot

Answer: c

Explanation:

Batteries require more voltage to charge when it is cold. It is convenient that when it gets colder PV makes more voltage and batteries require more voltage. If we did not have temperature compensation and were not increasing the voltage when it was cold, then the voltage would be low in the winter, causing an undercharge, and it would be high in the summer, causing an overcharge. Another way to look at this is that heat will speed up chemical reactions that happen in a battery, so the battery will require less voltage when it is hot.

If a battery overcharges in the summer, a symptom would be increased loss of electrolyte and a need to add distilled water. Another thing that can cause heat on a single cell is a bad connection at a battery terminal. The associated cell would require increased amounts of water when compared to the other battery cells.

The installation manual for the Rolls AGM battery recommends temperature compensation to be –4 mV/C/cell. In a 48-volt system, which is 24 cells, our temperature coefficient would be –96 mV/C.

Note: UL 9540 listed lithium-ion energy storage systems (ESSs) will have a temperature sensor built into them as part of their battery management system.

QUESTION #69

Original question with answer and explanation:

Which of the following is the wrong way to do a supply-side connection?

A. Split bolt onto service entrance conductors.
B. Splicing into the conductors between the main breaker and the meter with a three-port lug.
C. **Bolting conductors onto busbar on opposite side of main breaker from the meter**.
D. Pull the meter before making the connection.

Explanation:

A supply-side connection is between the main service disconnect (main breaker) and the meter. **The wrong way to do a supply-side connection is any- thing that is not on the supply-side of the main breaker.** In the case of this question, bolting conductors onto the busbar on the opposite side of the main breaker from the main disconnect is the wrong way to make a supply-side connection.

Oftentimes, there is a main disconnect by the meter and a panelboard inside the house. Many people try and connect the solar system in between the main disconnect and the panelboard inside the house, which is also not a supply-side connection.

QUESTION 69 CHOICES AND EXPLANATION REVISED: HIGHLIGHTED ARE THE CHANGES

Which of the following is the wrong way to do a supply side connection?

A. Split bolt onto service entrance conductors
B. Splicing into the conductors between the main breaker and the meter with a 3-port lug.
C. Connecting to a very large conductor between an outside main breaker and a subpanel that is inside the house
D. Pull the meter before making the connection

Answer: c

Explanation:

A supply side connection is between the main service disconnect (main breaker) and the meter. **The wrong way to do a supply side connection is anything that is not on the supply side of the main breaker.**

Oftentimes there is a main disconnect by the meter and a panelboard inside the house. Many people try to connect the solar system in between the main disconnect and the panelboard inside the house, which is not a supply side connection.

Connecting to a large conductor between a main breaker outside and a panelboard inside the house would be a feeder connection and is covered in section 705.12.