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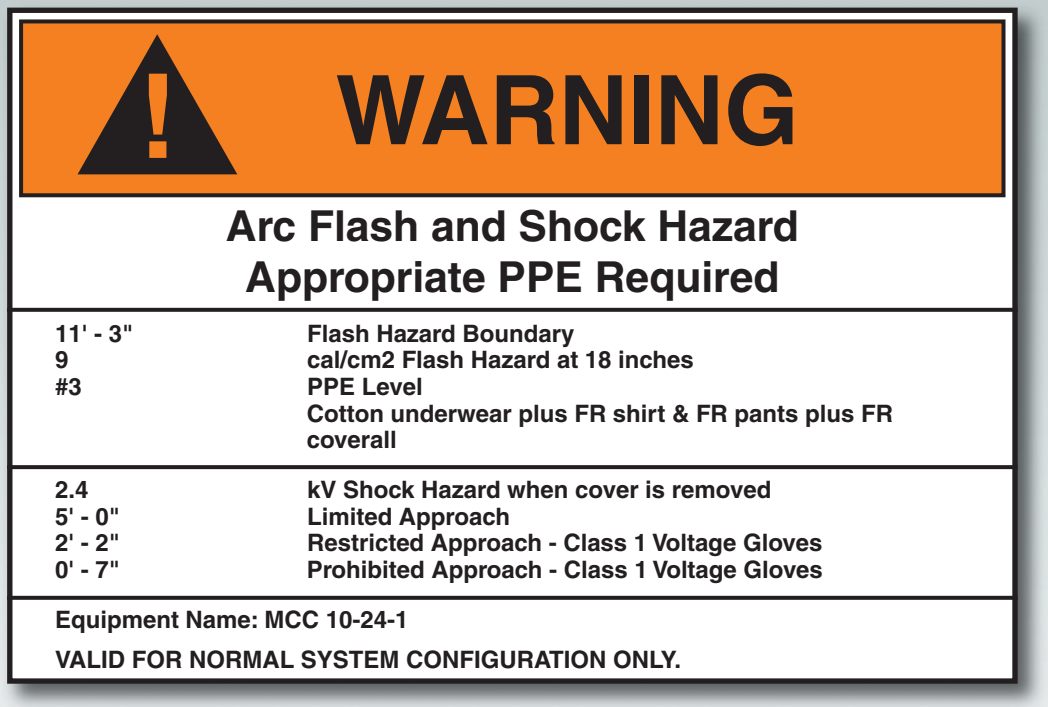
Arc Flash Hazard Labeling
Do's and Don'ts



WARNING

Arc Flash and Shock Hazard
Appropriate PPE Required

11' - 3"	Flash Hazard Boundary
9	cal/cm2 Flash Hazard at 18 inches
#3	PPE Level
	Cotton underwear plus FR shirt & FR pants plus FR coverall

2.4	kV Shock Hazard when cover is removed
5' - 0"	Limited Approach
2' - 2"	Restricted Approach - Class 1 Voltage Gloves
0' - 7"	Prohibited Approach - Class 1 Voltage Gloves

Equipment Name: MCC 10-24-1

VALID FOR NORMAL SYSTEM CONFIGURATION ONLY.

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Overview

With industry adopting NFPA 70E, and Canada's Z462 as the consensus electrical safety standard, North American facilities and many of their counterparts worldwide are performing arc flash hazard studies to label their electrical equipment for safety. The requirement for arc flash hazard labeling is found in the National Electrical Code, Article 110.16 for new equipment, NFPA 70E-2009 Article 130.3(C) for existing equipment, and OSHA 1910.335(b)(1) for general safety hazards.

There are as many different ways to label equipment as there are engineers and electricians in industry. Unfortunately, many of the methods being used are incorrect and may actually decrease worker safety, while increasing your company's liability should an accident occur. This article supplies a safe-approach reference developed through years of experience working with engineers and electricians on their arc flash hazard projects. The viewpoints expressed in this paper are provided as a guide to industry, recognizing that the NEC, NFPA, and OSHA set the standards but do not cover the myriad of questions associated with labeling the different types of electrical equipment in industry.

Common Terms: AFH (arc flash hazard), NFPA 70E (National Fire Protection Association – Standard for Electrical Safety in the Workplace), OSHA (Occupational Safety and Health Administration), CSA Z462 (Canadian Standards Association - Standard for Electrical Safety in the Workplace), PPE (Personal Protective Equipment), NEC (National Electrical Code), ANSI (American National Standards Institute).

Don't label for Energized Work — Do label to warn of hazards

In the majority of facilities hoping to obtain NFPA 70E compliance, the most prevalent mistake we see is performing an AFH study for the sole purpose of labeling equipment. Following the study, the plant continues the same day–to-day operations, only now the electricians wear PPE as labeled on the equipment.

Two myths need to be dispelled: 1) Arc flash hazard labeling alone does not provide 70E or OSHA compliance and 2) Labeling does not eliminate the requirement for work permits, safety programs, or training and planning when working on energized equipment. What this means in simplified terms is that a facility cannot perform energized work based solely on the fact that the equipment is labeled and the worker is wearing the appropriate PPE as designated on the label.

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Arc Flash Hazard labels should be applied to warn personnel of a potential hazard. Labels should not be used to "assess" a hazard, select PPE levels, or perform energized work based on the information provided on the label. These tasks are part of the planning, documentation and work permit process required by NFPA 70E 130.1. Arc Flash hazard information such as PPE level, incident energy, and boundary information shown on many labels should only be used as a cross-check with the information provided in the work permit process.

Label Worst Case

NFPA 70E, 2009 Article 130.3(C) requires AFH labels to show the incident energy or the required PPE level for that equipment. Most labels being applied today list both, along with a host of other items such as AFH boundaries, approach boundaries, glove requirements, etc. Whatever options you select, the listed incident energy or PPE should be the "worst" case for that equipment.

Many companies choose to label switchgear, for instance, with a working distance of 24-36 inches. They do this based on the assumption that the only work being done on the equipment is racking out the breaker. However, that is not a realistic assumption. What happens if the breaker racking mechanism sticks and the electrician positions himself/herself closer to fix the mechanism? What if there are other work tasks that crop up requiring a closer working distance?

Other factors contribute to "worst" case results such as generators being turned on/off, motors being turned off or on during a shutdown condition, etcetera. These variables must be considered in a "worst" case calculation.

AFH labeling with values less than "worst" case requirements will increase your company's liability, should there be an arc flash accident.

AFH labeling with values less than "worst" case requirements will increase your company's liability, should there be an arc flash accident. The attorneys working for the injured parties will easily prove that a higher incident energy existed at a standard working distance of 18 inches or with a different mode of operation, and show the equipment label did not warn the party of potential increased danger, concluding pure and simple negligence. This is not to say that you cannot rack a breaker out using the calculated incident energy at a longer distance, say 36 inches. The important point to note is that each work permit and planning procedure documents a specific work task and its associated requirements. If that task or working distance changes, a new work permit is required along with the possible need for new safety procedures. The employee will be properly briefed and protected if this procedure is followed.

Label with only one working distance and one PPE requirement

When equipment has multiple AFH labels with different working distances, and different PPE levels, it is a recipe for disaster in the making. With multiple options, workers now have the opportunity to select the label/PPE of their choice without management oversight. It is human nature for all of us to assume there will not be an incident. It usually goes something like this.

The worker looks at the front side label and reads an incident energy of 12.4 cal/cm2 and a PPE level of #3. The backside label (breaker terminals) is labeled 3.6 cal/cm2, PPE level #1, due to the feeder breaker instantaneous trip units. The employee thinks: 1) "Man it's really hot today. I bet the humidity is 95%." 2) "I've done this same task for the past 26 years without an incident." 3) "It's almost time to go home. I really don't want to go back and get in that stupid tank suit."

When given the choice, most people are going to take what they perceive as the easy way out. If this worker initiates an arc flash incident wearing PPE level #1 and ends up with third degree burns over half his body, who will be blamed and found liable? The objective reader may easily point the blame at the worker for being lazy or lacking intelligence. However, his attorney is going to claim: 1) The labeling process was confusing. My client could not tell which label applied to which area of the equipment. 2) The labels did not denote specific work tasks for the equipment, and they did not segregate boundaries on the equipment for their application. 3) My client was not properly trained by the company to distinguish how different labels apply to Manufacturer XYZ's equipment. In any arc flash hazard lawsuit, if there is any doubt regarding whether or not the corporation followed the industry mandates, the court jury or judge will rarely side with the corporation. In spite of the fact that the worker was lazy or broke company policy, the jury will see a traumatized man with multiple skin grafts, scarred for life and unable to ever work again.

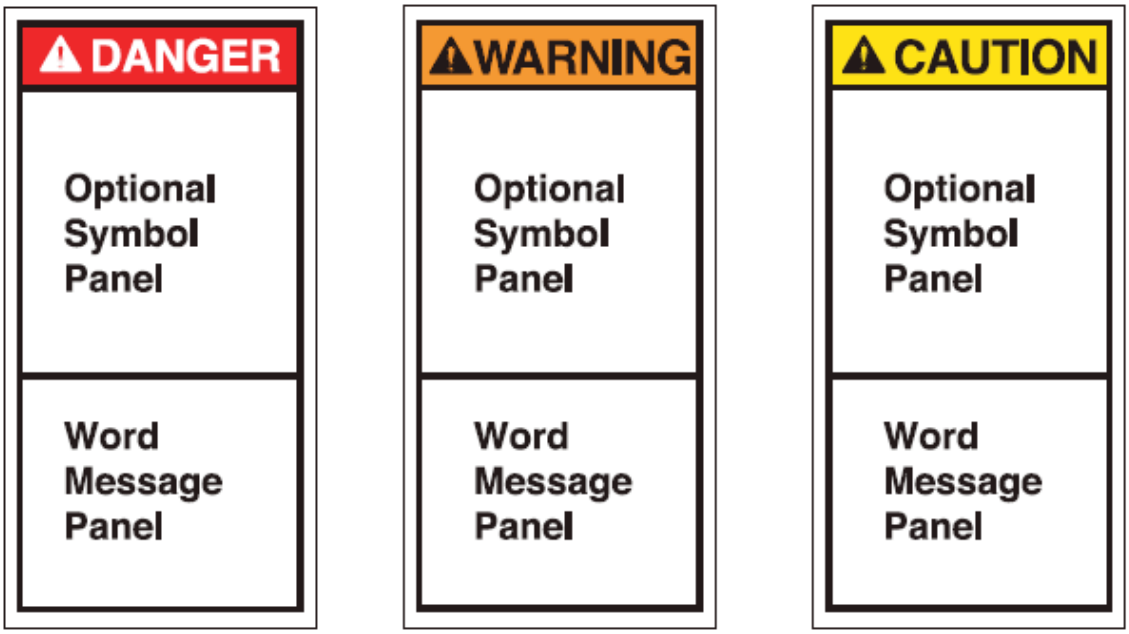
It is critical to label the equipment using only one (worst case) energy PPE level and one working distance per equipment. Following this procedure will minimize training requirements, confusion, and liability. Additionally, we strongly recommend standardizing on an 18 inch working distance for all equipment. Considering every enclosed equipment type from 120V through 34.5 kV, there will always be some work task that will put a worker in the 18 inch range. Labeling some equipment for 24 or 36 inches, and others for 18 inches adds confusion to your safety program. If workers want to manage down the PPE level for a "specific task" by working from an increased distance, this is properly done by an Article 110.7(F) Hazard /Risk assessment and a detailed Article 130.1 work permit combined with proper work procedures and training.

The only exception to this rule might be for isolated and barrier protected main breakers in a switchgear lineup. Many facilities prefer to label the incoming switchgear breaker separately from the bus and feeder breakers. This allows work on the feeder breakers to be conducted under the lower PPE level provided by the main breaker. The problems with this approach are threefold. 1) Workers could follow the ratings on the lower rated bus label beginning their work in the appropriate area and either accidentally, or intentionally, transition to the main breaker compartment where the AFH energy will typically be "extreme danger". 2) This method promotes work on the bus and feeder breakers using only a label, potentially bypassing the necessary Article 130.1 work permit requirements. 3) This method can only be done on isolated and barrier protected main devices. In most facilities this applies only to a minor portion of equipment; therefore, additional training will be required to ensure all workers understand the specific restrictions for this particular labeling method.

Label per ANSI Z535.4

ANSI Z535.4 provides the consensus standard used in North America for safety labels. Deviation from this standard is allowed, but courts will rule that Z535 is the minimum acceptable standard. This means that deviation from this standard requires that you prove increased effectiveness is provided by your equipment labeling program.

Examples of the Z535 standard are shown below.



The Z535 format includes a triangle with an exclamation mark which is the safety alert symbol. This symbol appears to the left of the signal word DANGER, WARNING or CAUTION and signifies that there is a personal injury hazard potential. The ANSI Z535.4-2002 revision makes this symbol a universal element on all U.S. personal injury-related safety signs and labels.

The Z535 standard requires that a product safety label communicate the following:

- the type of hazard
- the seriousness of the hazard
- the consequence of interaction with the hazard, and
- how to avoid the hazard

We recommend labels that use the orange “Warning” label rather than the red “Danger” label. The reason for this is that “Danger” often denotes an immediate problem such as open or exposed wiring or moving equipment and indicates the need to stay away. “Warning” alerts the individual to a potential problem dependent on user interaction. This reasoning is subjective and the user should select a color based on their safety program objectives.

We have seen more than one facility color code labels based on PPE levels. Red=Extreme danger (> 40 calories), Orange =PPE Level 4 (> 25 calories), Yellow = PPE Level 2 (> 8 calories), and Green= PPE Level 0 (< 2 calories or <1.2 calories). Because ANSI has selected three colors to denote specific levels of hazard, we do not recommend color coding AFH labels based on PPE level. Company defined color coding confuses the basic ANSI color coding and subjectively encourages levels of danger in the facility. In reality, an arc flash of 8 calories can have the same life changing impact as that of a 15 calorie event. Additionally, color coding any AFH label with green, conveys the message that there are no potential hazards in this equipment, since green is the universal color for “go” or “safety”. A PPE level of 0 does not mean that there are no potential hazards in this equipment.

The following label is an example of a thorough ANSI Z535 AFH label.

WARNING

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Appropriate PPE Required

11' - 3"	Flash Hazard Boundary
9	cal/cm2 Flash Hazard at 18 inches
#3	PPE Level
	Cotton underwear plus FR shirt & FR pants plus FR coverall
2.4	kV Shock Hazard when cover is removed
5' - 0"	Limited Approach
2' - 2"	Restricted Approach - Class 1 Voltage Gloves
0' - 7"	Prohibited Approach - Class 1 Voltage Gloves

Equipment Name: MCC 10-24-1

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ANSI Z535 labels are the most recognized safety label in North America. Using standardized labels minimizes safety training requirements for both employees and contractors, thereby reducing liability on the part of the facility. Custom labels will require specialized training not only for your company employees, but also for every contractor coming onsite. Note: Labels that display company logos, flashy colors, or vendor advertising should be avoided, as they distract from the warning!

How Many Labels per equipment?

A frequently asked question is how many labels are enough? Obviously if one is good, more is better – right? This philosophy has both positive and negative aspects that must be considered. The more labels used the higher the visibility factor. However, too many labels clutter the objective and cause workers to ignore the warning.

For the MCC above, a simple one-word “warning” label was used without providing specific PPE, boundary information, or hazard levels. This minimizes clutter, however, if you take a step back and see 50-75 of these labels the clutter becomes obvious. The clutter is even more prevalent and confusing if the standard AFH information is included on the labels. The worker looking at the MCC must then determine 1) Which label is important? 2) If the labels are different, what information applies to this task? 3) How do I react to these circumstances?

When deciding quantity, another factor to consider is the cost of replacing the labels when system changes take place or when the IEEE-1584 calculation changes are released in 2010-2011? Relabeling an entire facility is time consuming and expensive.

A common sense approach to labeling seems to make the most sense for general applications. Labeling with one high profile 4x6 inch or 6x8 inch label front-side and back-side should be sufficient for most switchgear, switchboard, and panelboard applications. For larger equipment such as long switchboards, two labels should be sufficient. Labels should be placed where clearly visible; the top is preferable when equipment type allows. See examples below.

For feeder bus duct, labeling every 15-25 feet with the bus duct "worst case" label, provides sufficient warning of the potential hazard. It is not necessary or recommended to label each plug-in for the reasons already stated.

For some equipment, additional labels should be considered at potential entry or work points. Examples might include open bus vaults or large junction boxes where access can be obtained from several sides.

Examples

This section provides multiple labeling examples for different types of electrical equipment, which can be modified or extrapolated to fit your system. For some equipment types, multiple options will be provided.

Panels

Panels are typically of box construction with a fixed backing plate attached to a beam, or wall mounted. The front of the panel, which provides opening access, is bolted in place. The front cover typically has a hinged opening, which allows viewing and operation of the breakers. For standard 42 circuit lighting panels, the typical labeling procedure is one label on the main cover, top center. See Figure-1.

Figure 1

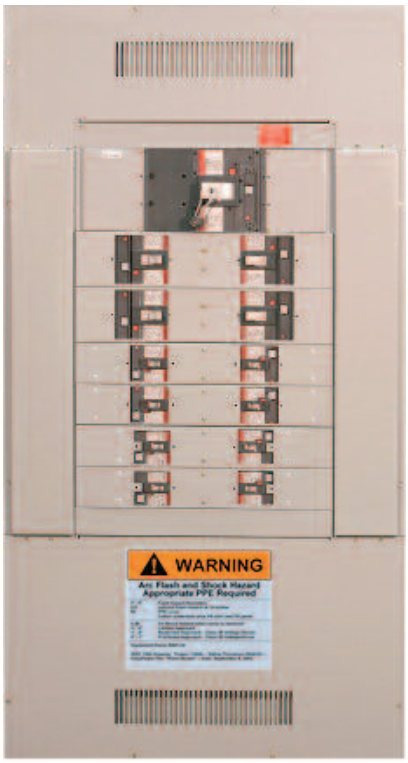

Figure 2

Panelboards

Panelboards, sometimes called distribution panel boards (DPB), or distribution boards are larger than a standard panel and may range from 400-1200A. They are typically standalone, but smaller units may be wall or beam mounted. Larger units may be accessible front and back side via bolted covers. For standard DPB's, typical labeling procedures is one label on the main cover, top center. For the example shown in Figure-2, the label was moved to the bottom to prevent covering the cooling vents. Panelboards, do not have isolated and barrier protected main breakers unless specially ordered and should always have only one label.

Dry Type Transformers

Dry type transformers typically have a bolted on face plate section with exposed terminals behind the face plate. Since this is the main access point, it is usually not necessary to label the other sides.

Figure 3

Figure 4

Larger units may have two or more cubicles and can be labeled with one or multiple labels.

Variable Frequency Drives, and Control Cabinets

Variable frequency drives and control cabinets are typically hinged front opening units with an open, exposed incoming main breaker. The incoming breaker or fuse is typically not isolated or barrier protected from the other sections and therefore cannot be used for AFH protection. Like other cabinets, one “worst case” label is typically sufficient. See Figure-5.

Figure 5

In the example of Figure-6 the incoming line section (upper left section) is not isolated from the main SCR/reactor compartments. Therefore, any arc initiation will propagate instantly to the incoming protection and prevent its operation.

Figure 6

In the drive example shown in Figure-7 below, the incoming main breakers shown in the right side cubicle appear to be properly isolated by a section divider. Once this has been verified by the facility, the lower value incident energy/PPE level can be labeled on the other sections. Facilities employing this approach assume the three liabilities listed in the previous section entitled, “Label with only one working distance and one PPE requirement”. We recommend that only the “worst case” label for the complete equipment be used. If they are not working in the main incoming section, we recommend that users manage down the required PPE level via work permit and strict safety procedures.

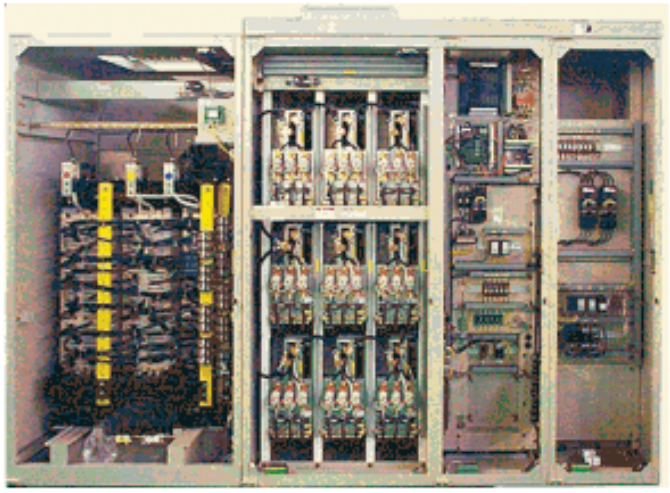

Figure 7

Figure 8

Switchboards and Switchgear

Switchboards and Switchgear are the standard for low voltage distribution equipment. Switchgear by definition has isolated and barrier protected cubicles, rack-in air frame breakers/switches, and isolated bus. Switchboards may have similar attributes but will most likely be equipped with molded case or insulated case breakers, or fuses in non-isolated cubicles with non-isolated bus work. By special order, the main breaker/switch can be isolated, enhancing arc flash protection.

For a typical 4 section or less switchgear lineup, only one label (worst case) on the front side is necessary. See Figure-3 below. For longer sections additional labels can be applied every 5-10 feet. Since both front and back-side switchgear covers are hinged, the back-side covers should also be labeled.

For switchboards, the back-sides are typically open exposed bus with bolted covers, which should prevent access. Labeling should be optional since access is not easily obtained.

If the user prefers to label the main breaker section separately, thereby providing a lower PPE level label for the bus and feeder breakers, the main incoming section should be sectioned off to clearly demark the switchgear. The main section will most likely be labeled “Extreme Danger” unless specialized relaying has been implemented, and the feeder breaker/bus section will typically have a lower PPE level rating. See Figure-9 below. One label on each side of the demarcation is typically sufficient, although the back-side should also be labeled if it is hinged and easily opened.

Note: ESA recommends “worst case” labeling for all switchgear and does not advocate demarcation lines to sectionalize equipment with different labels. The procedure shown here is presented only to show the proper method for demarcation. ESA recommends NFPA 70E Article 130.1 Work Permits, safety procedures, and proper planning for reduced PPE level work on different sections.

Figure 9

Some switchgear line-ups come in combination units with a connected transformer and high voltage primary switch. These should be sectionalized with a clear demarcation line for section labeling. The preferred method is shown in Figure-10, where the “worst case” low voltage arc flash results extend from the transformer section through the low voltage switchgear. This method can be applied to all switchgear, switchboard, and panelboard combination units, with or without main breakers. Note that the transformer HV terminals would actually be labeled with the higher incident energy value LV label, since the HV terminals are in the same cabinet as the LV terminals. The HV fused switch terminals should be labeled separately.

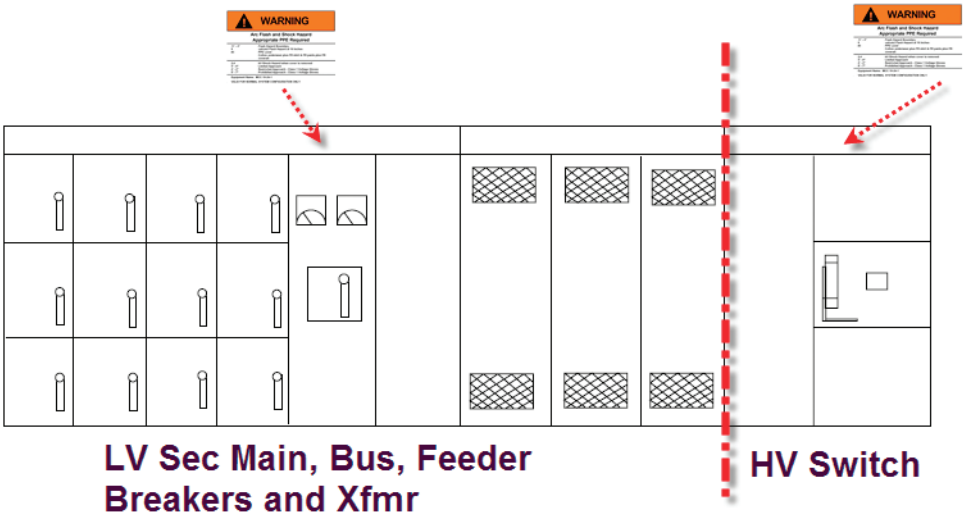

Figure 10

For switchgear with an isolated and barrier protected main breaker, the bus and feeder breaker section can typically be sectionalized with a lower incident energy label. Once again, clear demarcation and additional training is required. See Figure-11. This same labeling method can be applied to enclosed High Voltage Switchgear and fused disconnects also.

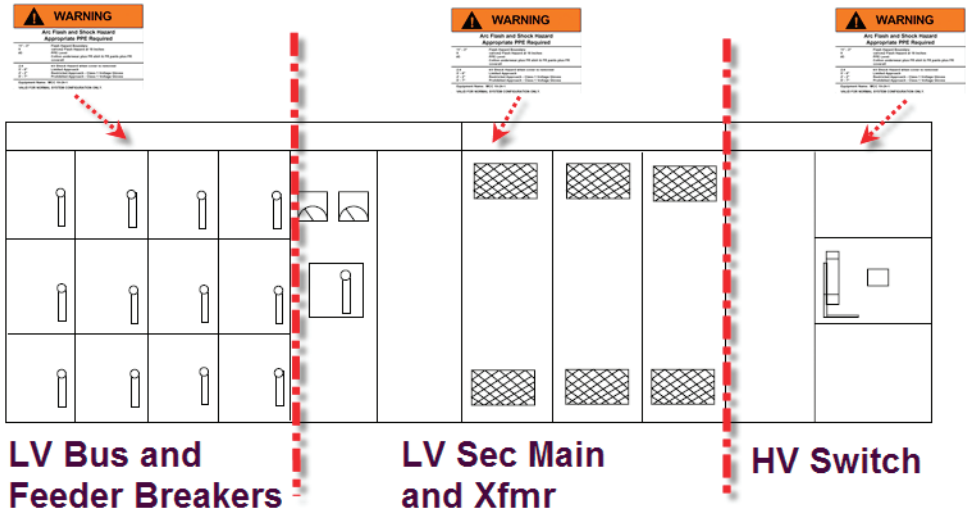

Figure 11

Feeder Bus Duct

Low Voltage feeder bus duct has become the standard for many manufacturing facilities where production requirements require frequent machine tool change out, updating assembly lines, etc. The ease of simply plugging in a new feed for a different machine tool has many advantages. The disadvantages of feeder bus duct are that the phase conductors are typically not insulated, the bus structure can flex and become misaligned creating a hazard when plugging in or removing plug-ins, and the long lengths of some runs create short circuit disparities between the beginning and end sections, which create protection difficulties. All three of these issues relate directly to the best method for labeling a feeder bus duct. It is beyond the scope of this paper to explain the proper procedure for calculating the worst case PPE level for a feeder bus duct. However, it should be sufficient to recognize that there can typically be several different PPE levels along a feeder bus duct length, due to the changing impedance and varying short circuit levels.

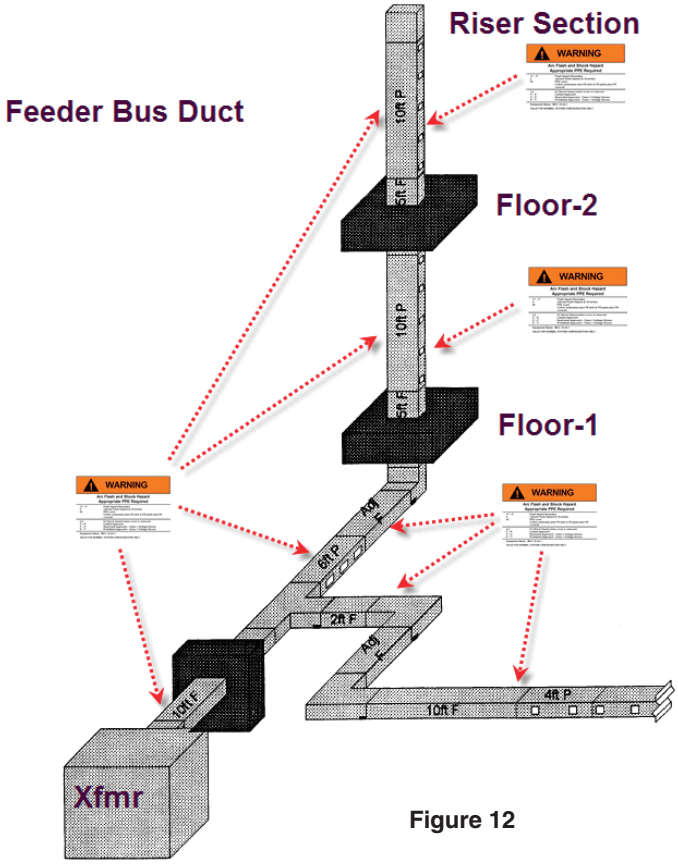

Figure 12

We recommend that the worst case PPE level of the entire bus duct length be used to label the entire bus duct. We do not recommend different labels for different plug-ins, or the need to label each plug-in. A 4”x6” or 6”x8” label every 10-20 feet should be sufficient. See Figure-12.

Often, bus duct can have multiple bends which can hide a label from view. Consideration should be given to labeling these sections if there is potential for plug-ins. For vertical riser sections, it is probably only necessary to label at each floor level where plug-ins occur. Labeling should include both front and back sides of all runs.

Motor Control Centers

Motor control centers raise more labeling questions than almost any other type of equipment. The reason for this is the number of individual buckets or units in the equipment. Does each bucket require a label, or can the equipment be labeled using the same procedures as described for other equipment?

Figure 13

The key factor in labeling MCC’s is understanding that the breaker/fuse in the individual motor starter bucket will not protect the worker if they initiate an arc flash in that bucket. The initial arc caused by the worker will instantly ionize the air in the bucket. This will propagate the arc to the breaker/fuse primary terminals, which will sustain the arc and prevent device operation. Therefore, the arc energy for each individual bucket is controlled by the remote tripping of the breaker/fuse that feeds the MCC. This is the same issue found in panelboards, switchboards, etc. Since there is only one arc energy for the entire MCC, we recommend labeling in the same manner as the other equipment – one “worst case” label as shown in Figure-13.

If the MCC extends more than 3-4 sections, additional labeling can be applied as necessary. MCC’s are manufactured with bolted on side and back sections, preventing inadvertent exposure of the main and vertical buses. Additionally, most MCC’s are located either back-to-back in the center of the room or against the wall preventing opening of the MCC back panels. Therefore, labeling the side and back sections of an MCC is typically not required.

Junction Boxes and Miscellaneous Equipment

Junction boxes come in many forms, from standard conduit interconnections, to motor terminal connections. In a typical facility, there could be hundreds-of-thousands of boxes with accessible electrical wires. NFPA 70E 130.1 indicates it is imperative to train all workers that every electrical equipment is a potential AFH that requires a work permit before any equipment is opened, including junction boxes.

The key factor in deciding labeling protocol for junction boxes may come down to how frequently are they opened? If they are never opened, the need for labeling would follow the guidelines as provided for the back of an MCC or switchboard lineup. However, if they are opened on a routine basis, labeling is appropriate and necessary. According to Article 130.1, either option still requires a work permit.

Summary – Do's and Don'ts of AFH labeling

This paper provides guidelines and examples for proper AFH labeling to increase worker safety and minimize corporate liability. A series of equipment examples have been provided to guide users in labeling decisions. As in any type of safety procedure, common sense is the key.

Do's

Do label "WORST" case energy or PPE level. Consider all possible modes of operation.

Do label per ANSI Z535.4

Do label using only one color, Orange for Warning or Red for Danger.

Do standardize on only one working distance – preferably 18 inches for all labels in a facility.

Manage down PPE levels using work permits stating increased distances based on work task and proper safety procedures.

Label to warn of potential danger, not for the purpose of working on the equipment.

Do use common sense in your hazard labeling.

Do implement NFPA 70E Article 130.1 work permit requirements for all energized work even if a label is present.

Don'ts

Do not label each MCC bucket, breaker/fuse cubicle, or plug-in (busway).

Do not label using colors for PPE level.

Don't label with multiple distances or PPE levels on the same equipment.

Don't make it complicated.

Don't substitute labeling for NFPA 70E Article 130.1 work permit requirements.