

arc flash FAQ

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What is an Arc Flash?

An Arc Flash is an electrical explosion resulting from a low impedance connection to ground or another voltage phase in an electrical system. High temperatures cause rapid heating of surrounding air and extreme pressures, resulting in an arc blast. The arc blast (what results from the arc flash) will likely vaporize all solid copper conductors, which will expand up to 67,000 times its original volume when it is vaporized. The arc blast releases fire, intense light, and pressure waves in an explosion of flying shrapnel. An arc flash happens without warning. This typically results in the complete destruction of equipment involved and severe injury or death to people inside the arc flash boundary at the time of the incident. **The energy released by an arc flash is a function of system voltage, available fault current at the location, and duration of the arc.**

Should I be concerned about Arc Flash Hazards on Low Voltage Equipment?

The theory that Arc flash hazards are greater at higher voltages is a common misconception. It is far more common for low voltages, such as 480v, to have much more significant arc flash hazard levels because the fault currents are much higher. Most recorded arc flash accidents happen at lower voltages as a fault is created from a technician working on electrical equipment. It is not uncommon to have an arc flash hazard Category 3 or Category 4 on low voltage systems due to the long clearing time of the protective devices and high fault currents.

What causes an Arc Flash?

When significant fault currents are flowing through several conductors that are in close proximity of each other, the differences in potential, among other factors, will ionize the air, allowing a low resistance path between the conductors. Improper tools, improper electrical equipment, corrosion of electrical equipment, improper work techniques, lack of electrical safety training, and a lack of preventative maintenance are just some of the events that make an arc flash more likely.

What sort of injuries can happen from an Arc Flash?

It is estimated that 5 to 10 arc flash and blast explosions occur in electrical equipment every day in the United States with 2,000 people each year being admitted to burn centers for severe burns (CapSchell Inc.) The degree of injury is directly related to the power of the arc flash, the distance the person is at the time of the arc flash and the protective equipment (PPE) worn by an individual during an arc flash. Due to the force from the explosion of energy (the blast) and the intense heat, burns, concussions, collapsed lungs, hearing loss, shrapnel injuries, and broken bones are the common injuries.

What are the costs associated with an Arc Flash accident?

Total costs of arc flash accidents have been estimated to be between \$12 and \$15 million, and can include medical expenses, down time, equipment replacement, lawsuits, and insurance and litigation fees. OSHA has fined some facilities over \$500K for not being compliant with electrical safety regulations (www.osha.gov). The biggest costs are the probable lawsuits, because the employer did not properly identify the hazards, train employees and provide proper warnings, procedures and protective equipment (PPE). It is widely recommended to outsource arc flash analysis to trained experts, with the knowledge and experience needed to determine all hazards.

Does Proper PPE Protect me from Injury?

Protective equipment is designed to limit burns to second-degree burns. Those who experience an arc flash and are wearing the proper equipment can still be seriously injured or even killed from the force of the arc blast. An arc blast can knock people off of elevated platforms or blow doors or shrapnel across the room, to which the proper arc flash PPE provides little to no protection. In an ideal situation, the operator would utilize safety equipment, such a Remote Racking device, that would allow them to stand outside of the arc flash boundary.

How is the correct level of PPE determined?

In order to select the proper PPE (personal protective equipment), incident energy must be known at every point where workers may be required to perform work on electrically energized equipment. These calculations are determined in an arc flash study and need to be performed by a qualified person such as an electrical engineer. NFPA 70E offers a guide to proper protection. All parts of the body that may be exposed to the arc flash need to be covered by the appropriate type and quality of PPE. Proper PPE can include Arc Resistant clothing, hardhat, hood, face shield, safety glasses, gloves, shoes, etc. depending upon the magnitude of the incident energy present.

For more information, please download our “PPE Category Level Chart” at www.inolect.com.

Can an Arc Flash incident be prevented?

There is no way to completely prevent an arc flash from happening in electrical distribution systems. The best one can do is to mitigate or reduce the risk. Below is a prioritized list, based off of The Risk Control Hierarchy by NIOSH, which describes ways to systematically reduce risk to its lowest practicable level by mitigating a given risk. Higher priority and weight are given to methods that seek to control risk by proactive means as close as possible to the root cause. Meanwhile lower priority is placed on reactive methods of controlling damage after an incident has occurred.

1. Elimination -- remove the hazard
 1. Only work on energized electrical equipment, when absolutely necessary. De-energizing equipment removes the arc flash hazard, although there is some risk of arc flash and blast when testing to make sure that the equipment is de-energized, as well as when re-energizing.

2. Removing the personnel from the arc flash boundary eliminates the risk of human injury. Equipment such as Remote Racking devices allow users to stand outside of the arc flash boundary, while operating breakers.
2. Substitution -- replace higher risks with lower risks. This can be done with two methods:
 1. Arc Flash Study with short circuit study and protective device coordination study can identify how to reduce an arc flash hazard category for some equipment.
 2. Technologies can be implemented to reduce risks. This includes equipment such as arc limiting fuses and remote racking technologies.
3. Engineering Controls -- reinvent ways to limit/prevent the risk
 1. This can be done by replacing it with equipment that will lower the incident energy, including but not limited to: adjusting breaker settings and redesigning electrical distribution systems.
4. Awareness -- raise knowledge of risks and consequences thereof
 1. Train all workers on the hazards of arc flash Although this is #4 on the Risk Control Hierarchy, it should be the first thing done and is mandated by OSHA regulations. It is only through training that workers will understand how to eliminate, substitute or otherwise lower the risk.
 2. Conduct an arc flash study to properly identify the hazards, boundaries and required PPE.
5. Administrative Controls -- create regulations, work processes, etc.
 1. Make sure that you have a written electrical safety program AND that it is understood by everyone AND that it is enforced.
 2. Allow only Qualified Persons wearing the proper PPE and using the correct tools to work on or around electrically energized equipment.
 3. Implement a preventive maintenance plan for electrical systems based on NFPA 70B. A proper preventive maintenance program will help identify or fix electrical hazards before they become big problems.
6. PPE -- use Personal Protective Equipment as last defense.

Does Preventive Maintenance reduce the potential for an Arc Flash?

Preventive maintenance should be conducted on a routine basis to ensure safe operation. A preventive maintenance program not only ensures that the equipment is functioning properly, but it also identifies potential hazards before they cause an accident. As part of a preventive maintenance program, electrical equipment should be thoroughly cleaned and routine inspections should be conducted by qualified personnel who understand how to uncover loose connections, overheated terminals, discoloration of nearby insulation, and pitted contacts. NETA states, "The ideal maintenance program is reliability-based, unique to each plant and to each piece of equipment." NETA offers a frequency of maintenance tests matrix and table available here and is recognized as a guide only.

How can system design impact Arc Flash hazards?

System configuration plays a key role in arc flash calculations. Lowering available fault currents leads to either transformer replacement or reactor installations, which generally is a high long-term expense. Trip times can be improved more cost efficiently. The system configuration, system fault levels, and exposure time can affect the incident energy exposure caused by an arc flash. System fault levels can be reduced by changing the system configuration to reduce available fault current and limit trip time. Using faster acting relays and trip devices can reduce arcing time or exposure time. A protective device coordination study should also be conducted to ensure proper device settings. Fuse ratings and characteristics can also be evaluated to determine if a smaller and/or faster fuse could be used to help reduce the exposure time. All of these factors must be considered along with the reliability needs of the facility and a protective device coordination.

What regulations govern Arc Flash analysis?

OSHA mandates that employers identify electrical hazards, warn their workers about them and provide the proper protective equipment and training related to working around the hazards. OSHA provides the employer "what" to do, but does not define "how" to do it. The role of NFPA 70E, IEEE and NEC is to provide guidance on "how" to properly implement the OSHA regulations.

The regulations that govern arc flash are:

1. OSHA Standards 29-CFR, Part 1910. Occupational Safety and Health Standards. 1910 sub part S (electrical) Standard number 1910.333 specifically addresses Standards for Work Practices and references NFPA 70E. OSHA 29CFR 1910.335 (a) (1)(i) requires the use of protective equipment when working where a potential electrical hazard exists and 29CFR 1910.132(d)(1) which requires the employer assess the workplace for hazards and the need for personal protective equipment.
2. NFPA 70E provides guidance on implementing appropriate work practices that are required to safeguard workers from injury while working on or near exposed electrical conductors or circuit parts that could become energized. Part II 2-1.3.3 regarding Arc Flash Study / Analysis states that an " Arc Flash Hazard Analysis shall be done before a person approaches any exposed electrical conductor or circuit part that has not been placed in an electrical safe work condition". This Arc Flash Hazard Analysis must be done to determine the level of Personal Protection Equipment PPE that a worker must use, and the Arc Flash Boundary in inches along with the incident energy found at each location. Each electrical panel must be marked with an ANSI z535 approved Arc Flash Warning Label.
3. The National Fire Protection Association (NFPA) Standard 70 - "The National Electrical Code" (NEC) contains requirements for warning labels, including ANSI compliance.
4. The Institute of Electronics and Electrical Engineers (IEEE) 1584 – Provides the Guide to Performing Arc Flash Hazard Study Calculations.

What does OSHA look for in Arc Flash Compliance?

Compliance with OSHA involves adherence to a six-point plan:

A facility must provide, and be able to demonstrate, a safety program with defined responsibilities.

1. Calculations for the degree of arc flash hazard.
2. Correct personal protective equipment (PPE) for workers
3. Electrical Safety Training for workers on the hazards of arc flash.
4. Appropriate tools for safe working.
5. Warning labels on equipment. Note that labels are provided by the equipment owners, not the manufacturers.

What is NFPA 70E?

The National Fire Protection Association is a non-profit organization and is the world's leading advocate of fire prevention and an authoritative source on public safety. NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks.

NFPA 70E is a comprehensive standard that establishes best electrical safety practices standards on how to protect electricians from electric arc flash and arc blast exposure and resulting potential injury and death. OSHA has referenced this electrical safety standard in numerous cases. Many organizations have now designed an NFPA 70E Compliance Guide to help protect their electrical personnel from the hazards associated with arc flash.

OSHA adopted regulations on safe electrical work practices in 1990 based on NFPA 70E, and is proposing a revised standard that conforms to the most recent editions of NFPA 70E. Given that the NEC (National Electrical Code) and OSHA have both started referring to it in their documents, citations are now being written based on NFPA 70E.

NFPA 70E applies to employees who work on or near exposed energized electrical conductors or circuit parts. This includes electrical maintenance personnel, operators, troubleshooters, electricians, linemen, engineers, supervisors, site safety personnel or anyone exposed to energized equipment of 50 volts or more.

What is an Arc Flash Hazard study or Analysis?

An Arc Flash Study or Analysis is a calculation performed by Professional Engineers to determine the incident energy found at each location which determines the various arc flash boundaries and what personal protective equipment (PPE) must be used in approaching each boundary.

As part of the study, the engineer should also provide recommendations to reduce the incident energy & arc flash hazard category, which requires a short circuit study and a protective device

coordination study. The short circuit study determines if all equipment is within OSHA standard 1910.303 (b)(4).

An Arc Flash Study / Analysis should only be performed by experienced and qualified electrical engineers knowledgeable in power system engineering, IEEE 1584, NFPA 70E, short circuit, device coordination and arc flash studies.

What is the difference between Short Circuit Hazards and Arc Flash Hazards?

It is important to understand that the dangers presented by overduty equipment are not the same as the dangers presented by Arc Flash, although the effects are similar. Overduty equipment hazards occur whenever the fault current through a device exceeds the device interrupting rating. An Arc Flash hazard is calculated and is inherent to a particular location based upon many factors, such as clearing time (coordination), available energy (short circuit) and working distance. Per NFPA 70E - Based upon the calculation made, appropriate personal protective equipment (PPE) can be selected to allow for hot work, such as voltage testing. Areas where the calculated incident energy is over 40 cal/cm² (over Category 4) represent extreme danger for personnel and equipment, and therefore hot work should not allowed at these locations. An event of this magnitude is very likely to destroy the containing equipment, potentially damage the building structure, and potentially fatally wound personnel. In order to protect workers, electrical equipment, infrastructure, and ensure plant reliability, engineered solutions can be applied to lower the calculated incident energy and thereby minimize risk to personnel as well as production.

Can we do an Arc Flash Analysis ourselves?

Yes, you may conduct your own arc flash study, however, there are many IMPORTANT issues to consider.

Conducting an arc flash study / analysis is a complex process and requires engineers familiar with conducting power analysis studies and arc flash analysis in particular. Properly collecting all the data is the first phase of the project, which is difficult for anyone to do if they are not first familiar with all the potential outcomes and pitfalls of conducting an arc flash analysis. The engineer that conducts the study needs to be proficient in conducting short circuit studies, protective device coordination studies and have a strong understanding of NFPA 70E and IEEE 1584.

Beyond technical qualifications, in-house assessments are something that plant managers or engineers have little time for, often resulting in the project not getting completed or conditions of the electrical equipment changing before completion, making the results void.

The biggest reason not to do the study internally is the cost of getting it wrong. If someone is injured or killed due to an arc flash and the analysis was incorrect and done by someone who is not considered qualified to conduct the study, the liability will rest with the person or group that performed the study.

For some larger organizations that have multiple and large facilities and are willing to invest in developing a team to perform the analysis and are comfortable with the liability, conducting the studies internally can help save money. For all other organizations, conducting an arc flash analysis internally typically has little or no upside compared to any cost savings.

Can't we just use NFPA Table 130.7 (C) (9)

NFPA Table 130.7 (C) (9) identifies arc flash hazard risk categories based on tasks being performed and the equipment which its being performed on. On the surface, this table appears to be an easy and low-cost solution, however, it has many conditions and potential problems.

Using the NFPA Table 130.7 is acceptable **if you know your short circuit current and fault clearing time AND these results fall within the parameters of using the table**. If you do not know your short circuit current and fault clearing time of each piece of the equipment or the short circuit current or clearing times exceed the parameters of using the table, then the table can not be used and an arc flash study / analysis must be conducted.

The problem here is that very few facilities have up-to-date electrical one-line drawings, let alone any knowledge as to what their short circuit current or fault clearing times are. In order to determine the short circuit current and the fault clearing times, an electrical engineering analysis must be completed, which is comprised primarily of the same work process and costs in doing an arc flash analysis, so unless this information is already known and accurate, an engineering analysis will need to be done anyway.

Independent of having the right information to use the charts, the recommendations of the table have some gaps and are, in general, widely contested. In particular, the table has the following deficiencies:

1. The NFPA 70E Table does not address or have any ratings for the highest arc flash hazard category; Greater than Category 4.
2. The NFPA 70E Table does not address all tasks. If the task one is performing is not listed on the table, the table can not be used.
3. Actual engineering studies have found that the NFPA 70E table can suggest using far more protective equipment than is actually necessary. Working in Cat 3 or Cat 4 PPE can be hot, difficult and result in loss of dexterity and vision. If the work does not require this for safety purposes, the worker should not be exposed to this. Further, those experienced in working on electrical equipment may realize that the table recommendations are over-protective and therefore, the table gets devalued or ignored because of lack of accuracy.
4. Labeling: Labels are still required to warn workers of the hazards and must include specific information. Using the table alone does not satisfy the label requirements. Further, providing just the information from the charts requires a worker to read and self-determine the hazard category, adding room for error.
5. No ability to mitigate hazards. Without doing an arc flash study, there is no ability to identify and mitigate the hazards down to a lower level.

Can all employees just dress in category 4 PPE when working on energized equipment?

Working in Category 3 or Category 4 PPE can be hot, difficult and result in loss of dexterity and vision. Some workers argue that while working in Category 4 PPE provides them more protection in the event of an accident, they are more likely to make a mistake and cause an accident when wearing Category 4 PPE. If the work does not require this for safety purposes, the worker should not be exposed to this. Also, sometimes a situation exists where hazard levels are greater than 40 cal/cm², aka over Category 4.

What is incident energy and incident energy exposure?

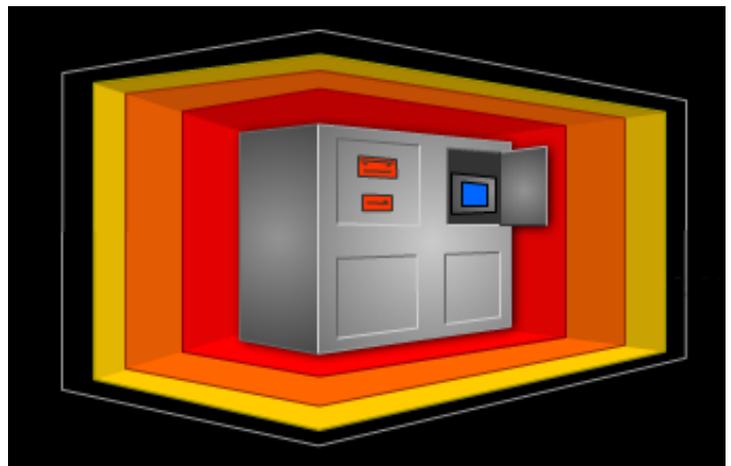
This is the amount of thermal incident energy to which the worker's face and chest could be exposed at working distance during an electrical arc event. Incident energy is measured in joules per centimeter squared (J/cm²) or calories per centimeter squared (cal/cm²). Holding your hand over the hottest part of the lighter flame for one second is equivalent to one calorie.

What is an Arc Flash boundary?

NFPA 70E defines an arc flash boundary as a “boundary within which a person could receive a second-degree burn if an electrical arc flash were to occur”. It also defines incident energy as “the amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.” NFPA 70E requires the calculation and creation of an “arc flash boundary”. This imaginary boundary, which surrounds the potential arc point, specifies what level of personal protective clothing and equipment must be used by qualified workers within that boundary.

-  Arc Flash Boundary
-  Limited Approach Boundary
-  Restricted Approach Boundary
-  Prohibited Approach Boundary

For more information, please download our “Arc Flash Approach Boundaries” eBook.



What is a Short Circuit study and must this be performed in conjunction with an Arc Flash study?

The short-circuit study is based on a review of one-line drawings by a professional engineer. Maximum available fault current is calculated at each significant point in system. Each interrupting protective device is then analyzed to determine whether it is appropriately designed and sized to interrupt the circuit in the event of a bolted type of short circuit. Next, the associated equipment must be reviewed to insure that the bus bar is adequately braced to handle the available fault current. Finally, the bolted fault currents are converted into arc fault currents for additional analysis.

This is a critical step in developing an electrical safety program because devices and buses that are not adequately rated will cause an extreme danger that is not the same as the associated arc flash hazard. A short circuit study is not required to complete an arc flash study, however, short circuit information is required in order to analyze an electrical distribution system to determine if changes can be made to mitigate arc flash hazards. A minor change in an adjustable breaker may make the difference in the result of an arc flash hazard category "4" or a "2". Only doing the arc flash analysis may result in designating a piece of equipment as Category 0, which would cause minimal PPE to be used on a potentially dangerous piece of equipment. The availability of the short circuit information is a standard output of an arc flash study calculation, however, there is a big difference between having the information available and doing a report. A study is value added information to help a plant run more efficiently. Most companies that complete an arc flash study / analysis also choose to get the short circuit study as well in order to take advantage of the information at a significantly reduced cost compared to doing just an short circuit study.

What is a Protective Device Coordination study / analysis and must this be performed in conjunction with an Arc Flash study?

A coordination analysis is the examination of the electrical system and available documentation with the goal of ensuring that over-current protection devices are properly designed and coordinated. Over-current protective devices are rated, selected and adjusted so only the fault current carrying device nearest the fault opens to isolate a faulted circuit from the system. This permits the rest of the system to remain in operation, providing maximum service continuity. The study consists of time-current coordination curves that illustrate coordination among the devices shown on the one-line diagram. Note that protective devices are set or adjusted so that pickup currents and operating times are short but sufficient to override system transient overloads such as inrush currents experienced when energizing transformers or starting motors.

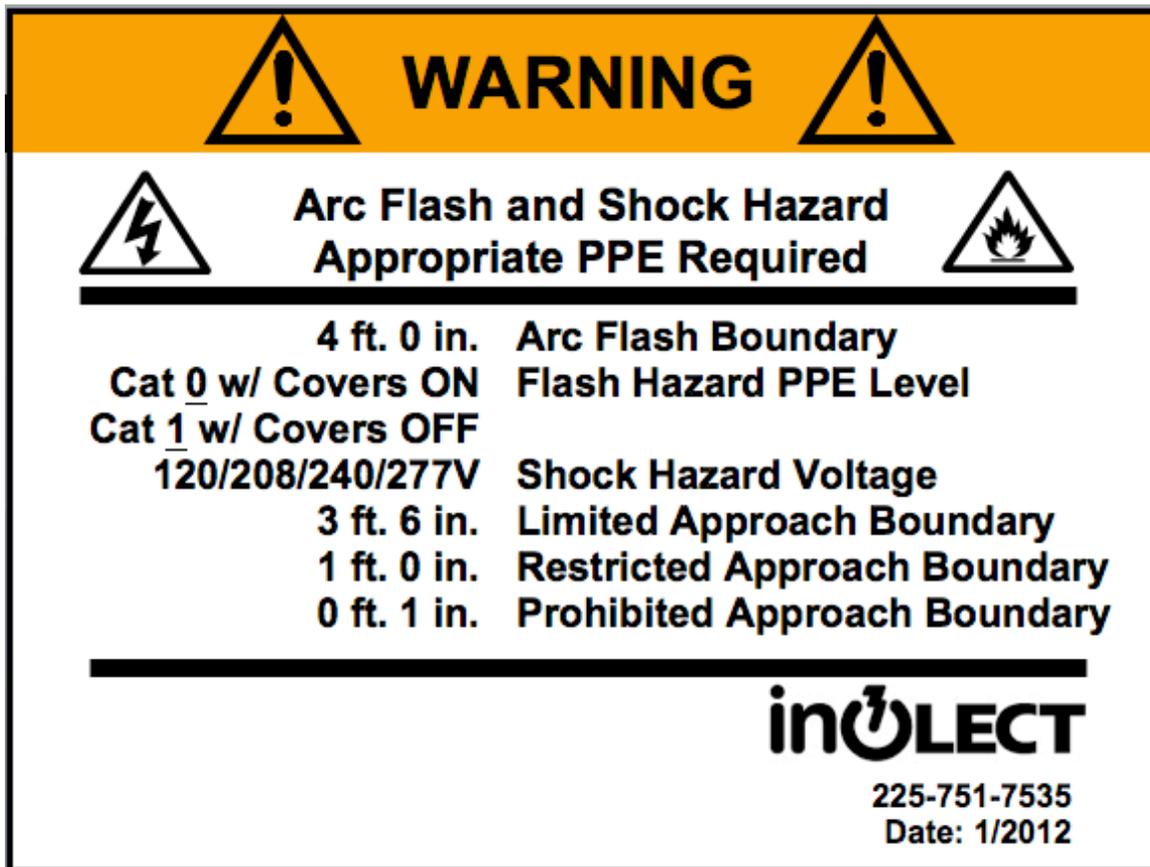
A protective device coordination study is not required as part of an arc flash study, however, doing this analysis one can determine if minor revisions in breaker settings or equipment can lead to major reductions of arc flash hazards. No arc flash analysis should be completed without first doing a protective device coordination analysis in order to save money and to remove potential hazards.

What are Arc Flash Hazard categories?

The hazard / risk Category is specified as a number representing the level of danger, which depends upon the incident energy. The Category ratings range from 0 to 4 where Category 0 represents little or no risk, and Category 4 signifies high risk. Above Category 4 (>40 calories/cm², per NFPA 70E) all equipment should be considered too dangerous to work on energized because of the tremendous pressure blast.

What is an Arc Flash Label?

The NEC® and NFPA 70E require labeling of equipment to warn of potential arc flash hazards. Each panel must be marked with an ANSI approved Arc Flash Warning Label to warn and instruct workers of the arc flash hazard, voltage, arc flash boundary and required PPE (Personal Protective Equipment). Subject to the requirements of the facility and arc flash analysis, labels are attached for each analyzed point of concern.



What is considered “Overduty”?

Equipment is considered “Overduty” when it has a higher available short circuit current than it has been rated for. When a piece of equipment or a protective device is considered “overduty”, it is an OSHA violation.

OSHA Code 1910.303(b)(4) Interrupting Rating: Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment. Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

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