



Arc Flash Hazards



Presented by:
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Equipment

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- Equipment capable of arc flash and blast are:
 - Panel boards
 - Switchboards
 - Motors
 - Transformers
 - Motor starters
 - Drive cabinets
 - Fused disconnects
- An arc flash happens when electric current flows through an air gap between conductors.



10 common causes of an arc flash



1. Carelessness



2. Worn or broken
conductor insulation



3. Exposed live parts



4. Loose wire
connections



5. Improperly maintained
switches and circuit breakers



6. Obstructed
disconnect panels



7. Water or liquid near electrical
equipment



8. High voltage cables



9. Static electricity



10. Damaged tools and
equipment

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Causes

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- Common causes of arc flash accidents:
 - Operator error
 - No matter how well trained a worker is, accidents happen and are often the result of operator error.
 - Distractions, weariness, pressure to get the job done quickly, or simply overconfidence can cause a worker to move too fast, fail to don protective equipment, or bypass other safety procedures.
 - It's estimated that two out of every three arc flash incidents occur as a result of human error and carelessness.
 - Additionally, failure to verify absence of voltage, utilizing incorrect testing equipment (i.e. voltage testers), overconfidence, complacency and poor co-worker communication and lack of lockout/tagout procedures have all been underlying root causes of arc flash incidents.
 - A dropped screw or bolt, a tool slipping when he or she applies torque, or a distraction during a critical moment could result in a mistake that leads to the flash.



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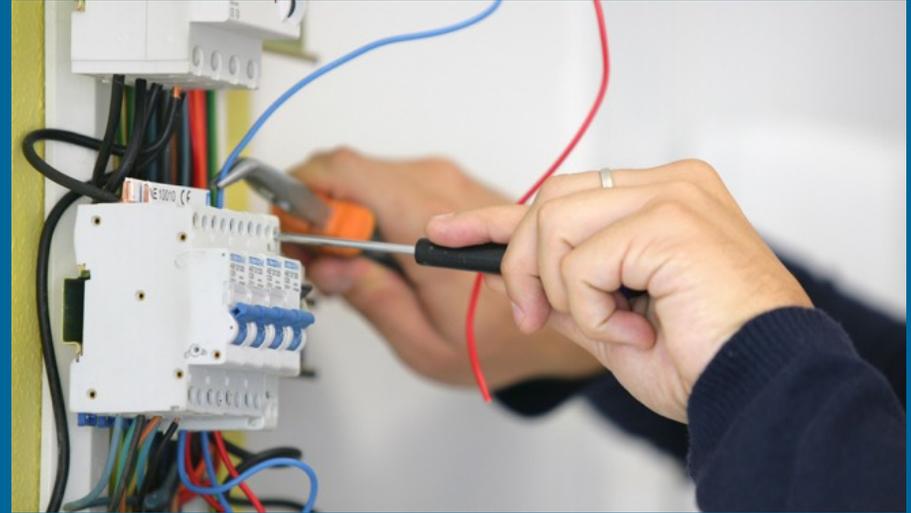
Causes

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– Failure to Use an Insulated Tool

- While this may fall into the carelessness category, many arc flash explosions occur when an employee uses a non-insulated tool that is not designed for the job.
- A tool slips or gets dropped and without the proper insulation it immediately becomes a conductor for electricity.



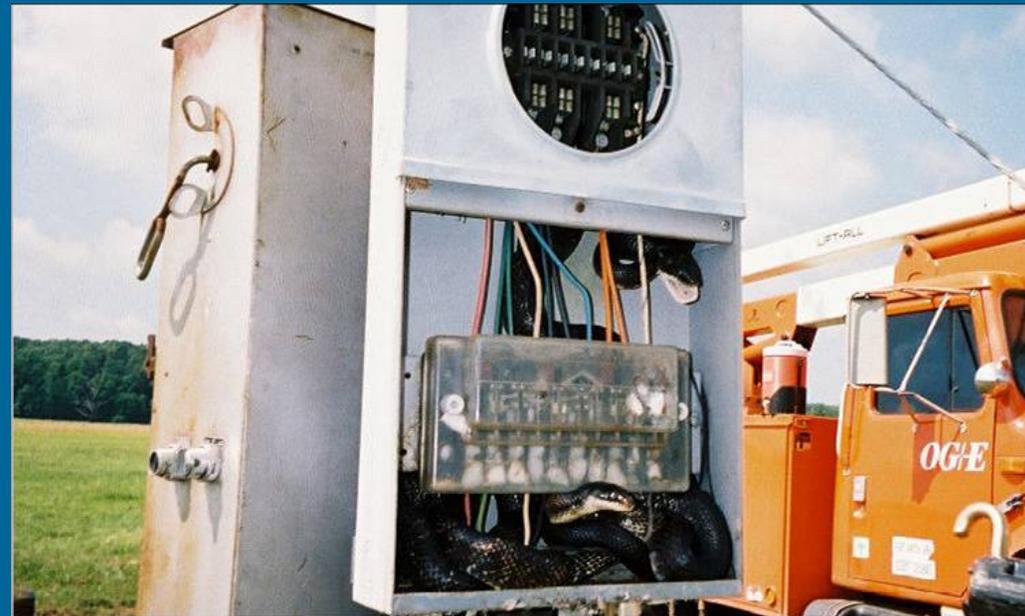
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Causes

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- Excessive Dust or debris or animals
 - The result of negligence over the course of months or years, dust buildup can result in a faulted path in the electrical current.
 - This faulted path causes the current to be drawn to another conductor, creating an environment in which arc flash incidents occur.



Hazards

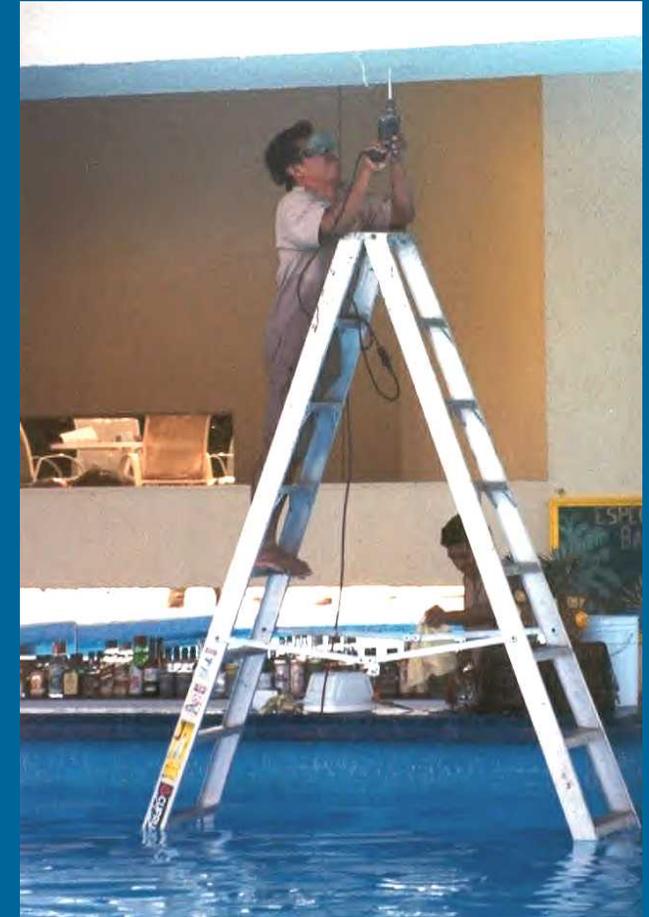
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- There are three general categories of electrical hazards:
 - Electrical shock,
 - Arc flash, and
 - Arc blast.
- Cost for serious electrical injury \$13 million
 - 2% of injuries but 30% of costs
- According to NFPA approximately 2,000 are treated in the US for severe arc flash injuries each year.

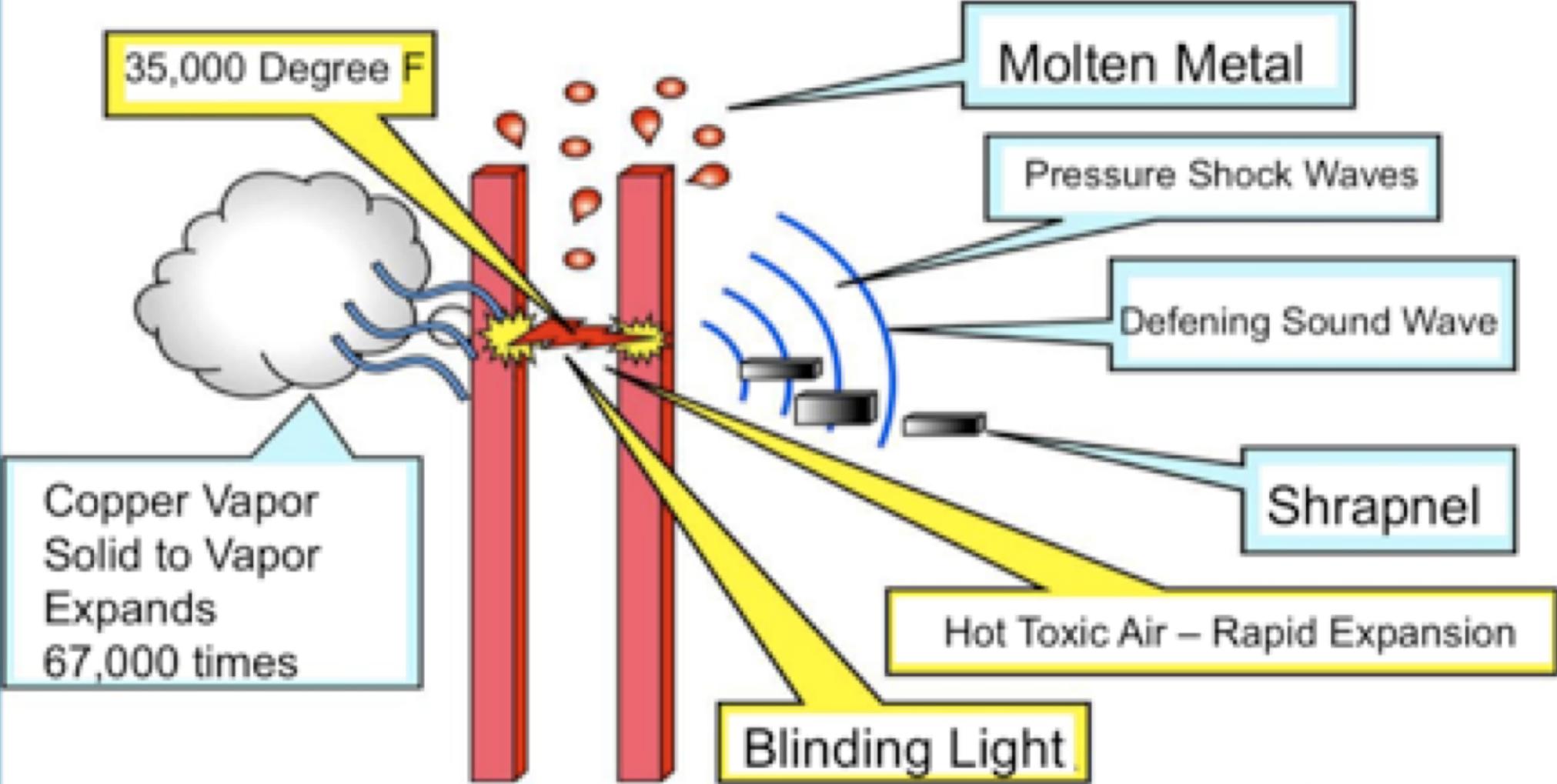
mA	Effect on Human Body
0.5 - 3	Tingling sensations
3 - 10	Muscle contractions and pain
10 - 40	"Let-go" threshold
30 - 75	Respiratory paralysis
100 - 200	Ventricular fibrillation
200 - 500	Heart clamps tight
1500 +	Tissue and Organs start to burn

Shown at (60 hz AC) – Effect will vary with frequency and duration of exposure



Electrical Arc

Electrical Arc



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- When an electric current passes through air between ungrounded conductors or between ungrounded conductors and grounded conductors, the temperatures can reach up to 35,000° F.
 - Producing some of the highest temperatures on earth (four times the temperature of the sun's surface), creating a pressure wave that can throw a worker across a room, and emitting vaporized metal.
 - Exposure to these extreme temperatures both burns the skin directly and causes ignition of clothing, which adds to the burn injury.
- If a heat source can impose 1.2 cal/cm² on human skin, a second-degree burn will result.
 - A second-degree burn is characterized by blistering of the skin and will normally heal without advanced medical intervention.
 - This is referred to as a curable burn because the skin can normally heal itself.



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- Studies have shown that incident energy exposures of as little as 10.7 cal/cm^2 can cause third-degree or incurable burns meaning that skin grafting becomes necessary and burn area will never function as it did before the burn.
- The majority of hospital admissions due to electrical accidents are from arc flash burns, not from shocks.
 - Arc flashes can and do kill at distances of 10 ft.



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- The energy released by the arc is a function of:
 - System voltage
 - Magnitude of the current
 - Duration of the arc
- It is important to note that the clearing time (or duration of the arc) can significantly affect the intensity of an arc flash whereby lower amperage systems can become more dangerous than a higher amperage systems.



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- An arc flash is extremely bright and can cause eye injuries.
- 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 Personal 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.
 - Death can and does occur from these injuries, but is mostly associated with blast.



Arc Blast

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- The arc blast presents three principle dangers to humans (similar to a grenade):
 - Concussive force
 - Projectiles
 - Hot gases
- When the air within an electrical equipment room is superheated to more than 10,000 °F in less than 1 second, the air rapidly expands, generating a pressure wave that pushes outward from the arc source.
 - This pressure wave is experienced as an explosion and is recognized in electrical vernacular as an arc blast.
 - For example, copper expands by a factor of 67,000 times when it turns from a solid to a vapor.

Arc Blast

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- The concussive force of the blast can directly cause physical trauma similar to that caused by any type of explosion.
 - Studies have shown that pressure can build to more than 15,000 times atmospheric pressure within the first 5 ms of arc initiation.
 - Pressure of this magnitude can easily exceed the structural strength limits of metal enclosures and cause injury to anyone in the vicinity of the arc blast.
 - The high pressures can easily exceed hundreds or even thousands of pounds per square foot, knocking workers off ladders, rupturing eardrums, and collapsing lungs.
 - The sounds associated with these pressures can exceed 160 decibels.



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Arc Blast

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- The blast provides the propellant for projectiles (e.g., partially melted metal parts, broken insulators) that present a serious hazard to anyone in the vicinity.
 - Material and molten metal is expelled away from the arc at speeds exceeding 700 mph, fast enough for shrapnel to completely penetrate the human body.
- The blast can blow the enclosure doors open, releasing hot gases and molten metal into the area near the electrical equipment.
 - These hot gases and molten metal present significant burn hazards to those in the vicinity.



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Arc Blast

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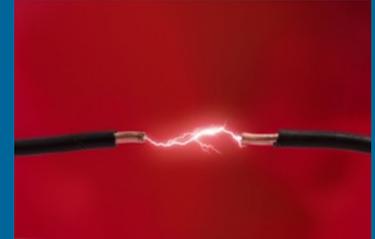
- The risk of arc flash/blast depends on the following:
 - Number of times the workers perform a task involving exposed live electrical equipment
 - Complexity of the task performed, need to use force, available space, safety margins, reach, etc.
 - Training, skills, mental and physical agility
 - Tools used
 - Condition of electrical equipment
 - The available short circuit current and the condition and rating of the overcurrent protective equipment.

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- A life threatening electrical arc event can happen when a powered-on piece of electrical equipment is opened for maintenance or repair.
 - Insulation properties of air are reduced over time as moisture and conductive particles in the air accumulate.
 - When the resistance of air is reduced to a level when it can no longer resist current to flow in an electrical system, an arc flash can occur.
- The oxygen (O₂) component of the air is actually a very good insulator with respect to conducting electrical current.
 - The insulating property of oxygen is what allows energized electrical terminals to be located within only a few inches of each other in electrical equipment without flashing-over to each other.



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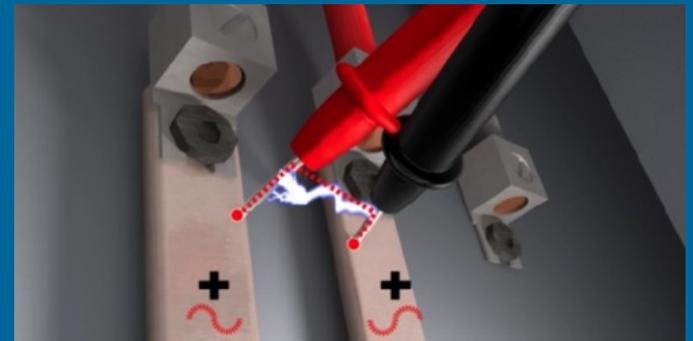
- However, when an arc occurs near electrical conductors, the energy of the arc converts the oxygen to ozone, which creates a very conductive atmosphere within the electrical equipment.
- Studies conducted by Lee (1982) reveal that the heat released in an electrical arc can rise to values of more than 35,000 °F.
 - This is approximately four times hotter than the surface of the sun.
 - The metal in electrical panels will melt when heated to approximately 2,500 °F (1,984 °F for copper) (Kross, 2007).
 - This means that electrical panels can withstand electrical arcs for only a few seconds before panel components begin to disintegrate; the enclosure (usually made of sheet steel) will then melt open (i.e., breach the panel), and the arc heat and the blast will be released into the surrounding area, endangering anyone nearby.

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- There are a variety of reasons why an Arc Flash can occur, but most of them are human error and preventable.
 - Many arc flashes occur when maintenance workers are manipulating live electrical equipment for testing or repair and accidentally cause a fault or short circuit.
 - Improper tools, improper electrical equipment, corrosion of electrical equipment, improper work techniques and lack of electrical safety training are just some of the causes of arc flash/blast.
 - The cause can be as simple as a rodent or leaving a tool or forgetting to tighten a connection.



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- An arc flash hazard may exist when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc.
 - Under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard.



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- MISCONCEPTION among electrical workers is that PPE is not necessary when working on equipment that is enclosed inside a metal cabinet (metal-clad).
 - Scientific studies have demonstrated that metal enclosures can only contain electrical arc blasts of limited intensity and duration (Gammon & Matthews, 2003).
 - Several common work practices and equipment failures can precipitate arc blasts that can exceed the structural limits of metal-clad enclosures and still cause injury to nearby workers.

Hazardous Task

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Hazardous Task

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