ಬೆವಿಕಂ
BESCOM

ಕಾರ್ಮಿಕ ನೌಕರರ ಸುರಕ್ಷತಾ ಸೂತ್ರಗಳು

ಆತ್ಮೀಯ ನೌಕರ ಬಾಂಧವರಿಗೆ
ಈ ಮೂಲಕ ತಿಳಿಸುವುದೇನೆಂದರೆ ಕೆಳಕಂಡ ಸುರಕ್ಷತಾ ಸೂತ್ರಗಳನ್ನು
ತಮ್ಮ ಕರ್ತವ್ಯದಲ್ಲಿ ಅಳವಡಿಸಿಕೊಂಡು ಉಂಟಾಗಬಹುದಾದ ಅನಾಹುತಗಳನ್ನು ತಪ್ಪಿಸಿ,
ಸಂಸ್ಥೆಯ ಅಮೂಲ್ಯ ಆಸ್ತಿಯಾಗಿರುವ ನೀವು, ನಿಮ್ಮ ಕುಟುಂಬವನ್ನು ರಕ್ಷಿಸಿ

1. ಪ್ರತಿದಿನ ಸಮವಸ್ತ್ರ ಹಾಗೂ ಸುರಕ್ಷತಾ ಸೂತ್ರಗಳ ಕಾರ್ಡನ್ನು ಕೆಲಸಕ್ಕೆ ಹೋಗುವ ಮುನ್ನ ಕಡ್ಡಾಯವಾಗಿ ಧರಿಸಬೇಕು.
2. ಕೆಲಸಕ್ಕೆ ಹೋಗುವ ಮುನ್ನ ವಿದ್ಯುತ್ ಸರಬರಾಜಿನ ಮಾರ್ಗಗಳ ಬಗ್ಗೆ ಹಾಗೂ ಉಂಟಾಗಿರುವ ದೋಷವನ್ನು ಸರಿಪಡಿಸಲು ಎ.ಇ./ಜೆ.ಇ. ಗಳಿಂದ ಸೂಕ್ತ ಮಾರ್ಗದರ್ಶನ ಪಡೆದು ಎಲ್ಲಾ ಸುರಕ್ಷತಾ ಸಾಮಗ್ರಿಗಳನ್ನು ತಪ್ಪದೆ ಒಯ್ಯಬೇಕು.
3. ಕೆಲಸ ಪ್ರಾರಂಭಿಸುವುದಕ್ಕಿಂತ ಮೊದಲು ಕೆಲಸ ಮಾಡುವ ಸ್ಥಳಕ್ಕೆ ಯಾವ ಯಾವ ಮಾರ್ಗದಿಂದ ವಿದ್ಯುತ್ ಸರಬರಾಜು ಆಗುತ್ತದೆಂದು ಗಮನಿಸಿ, ಸಂಬಂಧಪಟ್ಟ ಮಾರ್ಗಗಳಲ್ಲಿ ಮಾರ್ಗಮುಕ್ತತೆ (ಲೈನ್‌ಕ್ಲಿಯರ್) ತೆಗೆದುಕೊಂಡಿರುವುದರ ಬಗ್ಗೆ ಖಚಿತ ಪಡಿಸಿಕೊಳ್ಳಬೇಕು.
4. ಲೈನ್‌ಕ್ಲಿಯರ್ ಪಡೆಯುವಾಗ, ಆರ್.ಎಂ.ಯು./ಸ್ಪೇಷನ್ ಬ್ರೇಕರನ್ನು ಕೆಳಗಿಳಿಸಿ ಮತ್ತು ಹೊರಗಡೆ ತೆಗೆದಿರುವುದನ್ನು ಹಾಗೂ ಜಿ.ಓ.ಎಸ್ ಓಪನ್ ಮಾಡಿರುವುದನ್ನು ಖಂಡ್ರಾಗಿ ಖಚಿತ ಪಡಿಸಿಕೊಳ್ಳಬೇಕು.
5. ಜಿ.ಓ.ಎಸ್. ಓಪನ್ ಮಾಡುವಾಗ ಹ್ಯಾಂಡ್ ಗ್ಲೌಸ್ ಮತ್ತು ಕಾಲಿಗೆ ಚಪ್ಪಲಿ/ಷೂ ತಪ್ಪದೇ ಧರಿಸಬೇಕು ಮತ್ತು 3 ಬ್ಲೇಡ್‌ಗಳು ಸರಿಯಾಗಿ ಓಪನ್ ಆಗಿರುವುದರ ಬಗ್ಗೆ ಖಂಡ್ರಾಗಿ ಖಚಿತ ಪಡಿಸಿಕೊಳ್ಳಬೇಕು.
6. ಲೈನ್ ಕ್ಲಿಯರ್ ವಿಧಾನಗಳನ್ನು ಅನುಸರಿಸಿದ ಮೇಲೆ ಕೆಲಸ ಮಾಡುವ ಸ್ಥಳಕ್ಕೆ ಯಾವ ಯಾವ ಮಾರ್ಗದಿಂದ ವಿದ್ಯುತ್ ಸರಬರಾಜು ಆಗುತ್ತದೆಂದು ಗಮನಿಸಿ, ಲೈನ್ ಕ್ಲಿಯರ್ ತೆಗೆದುಕೊಂಡ ಎಲ್ಲಾ ಮಾರ್ಗಗಳಿಗೆ ಗ್ರೌಂಡಿಂಗ್ ಮಾಡಿಕೊಂಡು ಸುರಕ್ಷತಾ ವಲಯವನ್ನು ನಿರ್ಮಿಸಿಕೊಳ್ಳಬೇಕು.
7. ಕಂಬದ ಮೇಲೆ ಕೆಲಸ ಮಾಡುವಾಗ ಸೇಫ್ಟಿಬೆಲ್ಟ್ ಮತ್ತು ಹೆಲ್ಮೆಟ್‌ನ್ನು ಕಡ್ಡಾಯವಾಗಿ ಧರಿಸಬೇಕು.
8. ಕೆಲಸ ಪ್ರಾರಂಭಿಸುವ ಮುನ್ನ ಸಂಬಂಧಪಟ್ಟ ಎ.ಇ./ಜೆ.ಇ./ಮೇಸ್ತ್ರಿ ರವರ ಸಲಹೆ ಪಡೆದ ನಂತರವೇ ಕೆಲಸ ಪ್ರಾರಂಭಿಸಬೇಕು.
9. ಕಂಬದ ಮೇಲೆ ಕೆಲಸ ಮಾಡುವಾಗ ಮೊಬೈಲ್ ಫೋನ್ ಬಳಕೆ ಮಾಡಬೇಡಿ.
10. ಈ ಮೇಲ್ಕಂಡ ಸುರಕ್ಷತಾ ಸೂತ್ರಗಳನ್ನು ಪಾಲಿಸಿ, ಅಪಘಾತ ರಹಿತ ಸಂಸ್ಥೆಯನ್ನಾಗಿ ಮಾಡಿ.

ಪ್ರಧಾನ ವ್ಯವಸ್ಥಾಪಕರು
ಗುಣಮಟ್ಟ ಪ್ರಮಾಣೀಕರಣ ಮತ್ತು ಸುರಕ್ಷತೆ ಶಾಖೆ
ನಿಗಮ ಕಾರ್ಯಾಲಯ, ಬೆ.ವಿ.ಕಂ, ಬೆಂಗಳೂರು

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Accident Never happens
but
Caused
Chain of failure of critical events leads to ACCIDENT

You observe something that could cause injury or damage

This is a hazard

You had to react quickly in a way to prevent injury or damage or something happened in that moment that almost caused an incident

This is a Near Miss

"What?"

Be on the lookout for safety hazards!

No Wonder
This obeys
Kirchhoff law

But Practice is
Efficient and judicious use of knowledge

Accident Prevention by

- ✓Safety policy
- ✓Hazop study
- ✓Risk analysis
- ✓Design
- ✓Awareness
- ✓standard work practices
- ✓Tool Box meeting
- ✓Work permit
- ✓***Monitoring TOR***
- ✓Maintenance of Electrical equipment / Condition assessment
- ✓Training

Safety

- Definitions
  - **Safety** : freedom from unacceptable risk of harm.
  - **Basic Safety** : Protection against direct physical hazards when electrical equipment is used under normal or other reasonably foreseeable conditions.
  - **Hazard** : A situation of potential harm to people or property.
  - **Risk** : The probable rate of occurrence of a hazard causing harm and the degree of severity of the harm.

Types of Hazards

- Electrical hazards
  - Electrical shocks (micro and macro) due to equipment failure, failure of power delivery systems, ground failures, Arc flash, burns, fire, etc.
- Mechanical hazards - Fall
- Fire
- Environmental hazards
  - Solid wastes, noise, Smoke, water contamination etc

10 of the most important factors that need to be considered regarding electrical safety.

The list below is by no means exhaustive,

- Arc Flash – calculation, risk assessment, protection and dangers
- Electrical Accidents – causes, courses and cable faults
- Electrical Isolation – what is lock-out tag-out?
- Electrical Accidents – prevention and risk assessment
- Arc Flash Protection – eliminating, reducing and quenching
- Standards – Rules and Laws
- Partial Discharge – high voltages and cable breakdown
- Electrical Equipment – correct use and selection
- Safe Working – steps towards electrical safety
- Dead or Live – energized or de-energized electrical working

No Easy Day

Define your goal
Planning and Preparation
Taking no chance
Final briefing (Tool Box meeting)
Coordinated effort
Review

Avoid

Unsafe Environment

Unsafe act

Over Confidence

Unacceptable

- Dress code
- Behavior (talk Action)
- Conduct (influence of alcohol, Smoking, Use of Mobile phone)

Safety in distribution line work

- Identify dead line
- Earthing
- Line cross over
- Guarding
- Use of PPE
- Safety belt Vs Full body harness
- Fall protection
- Lifting heavy materials
- Distribution Transformer

STATUTORY CLEARNCES

IE Rule – 87: Minimum Clearances (in meters) between Lines when crossing each other

System Voltage	11-66 kV	110-132 kV	220 kV	400 kV	800 kV
Low & medium	2.44	3.05	4.58	5.49	7.94
11-66 kV	2.44	3.05	4.58	5.49	7.94
110 – 132kV	3.05	3.05	4.58	5.49	7.94
220 kV	4.58	4.58	4.58	5.49	7.94
400 kV	5.49	5.49	5.49	5.49	7.94
800 kV	7.94	7.94	7.94		7.94

IE RULE – 80: Clearance From building from EHV Lines.

Vertical Clearance:
Voltage up to & including 33kV – 3.7m
For EHV line – 3.7 m plus 0.3 m for additional 33kV
Horizontal Clearance
For high voltage lines up to & including 11kV – 1.2m
For high voltage line above 11kV up to 33kV – 2.0m
For EHV line– 2.0 m plus 0.3 m for every additional 33 kV

IE RULE -77: Clearance above the ground of the lowest overhead conductor including service lines erected across road/street:

Low & medium voltage line	- 5.8 m
High voltage line	- 6.1 m
Clearance above ground of overhead line conductor erected elsewhere other than along or across street:	
For low, medium & high voltage up to 11kv (Bare)	- 4.6 m
For low, medium & high voltage up to 11kV (insulated)	- 4.6 m
For high voltage above 11 kV	– 5.2 m
For EHV lines	- 5.2 m plus 0.3 m for every 33kV

WORKING ON CABLES

1 IDENTIFICATION OF CABLES TO BE WORKED UPON

A cable shall be identified as that having been proved dead prior to cutting or carrying out any operation which may involve work on or movement of the cable, A neon-contact indicating rod, induction testing set

2 WORKING ON HIGH VOLTAGE CABLE

Work on high voltage cables shall be only permitted on receipt of the permit to work. In addition to the precautions taken under the person carrying out such work shall be personally instructed on the spot by an authorized person who shall first satisfy himself that the cable has been made dead isolated and earthed and if possible, the switch controlling the cable drawn from the cubicle and suitable danger boards installed in position

3 WORKING ON UNDER GROUND CABLES

1) For isolation of cables open at least one set of disconnecting switches or fuses in every source through which the cables can be made alive including leads to the cable of potential transformers and then discharge the cable to earth.

2) Cable route indicators should be provided and cable route records maintained. It would access the particulars of all underground cables correctly in the vicinity of the faulty cable.

3) Use of sharp edged crowbars or pick axes should be avoided during excavation while locating the faulty cable or laying new cable.

4) Employees shall not step on live cables even though those are insulated and enclosed in a lead sheath. Tools and materials shall not be rested against the sheath of the cable.

WORKING ON HIGH VOLTAGE APPARATUS AND OVERHEAD LINES

Before commencing any work of repairs, alterations, extensions, additions or cleaning of high voltage apparatus, the following operations shall be carried out in sequence.

1) The apparatus or cable or transmission line shall be switched out and isolated from all points of supply under the direction of the authorized person. The switches, isolators and control links shall be locked in position by the keys provided for the purpose. Safety Tags shall be placed at all points where apparatus can be made alive.

2) All apparatus shall be discharged to earth and efficiently connected to earth near all points from which supply could be connected to it or between such points and the place of the work. All earthing shall be done by the approved methods. The earthing leads used for earthing shall be of adequate cross section according to voltage levels to enable passage of the fault current without fusing. Safety Tags shall be removed by an authorized person.

3) Earthing shall also be carried out at the point of work by means of temporary earths on each phase and in no case shall the temporary earths be removed from two phases simultaneously while the work is being carried out.

WORKING ON DEAD LINES AND EQUIPMENTS

(1) Before doing any work on dead lines or equipment where there is a possibility of their becoming energized from any source, such line or equipment should be short circuited and grounded between the location of work and all possible sources of energy.

(2) Conductors to be grounded should be checked for potential by an approved method before the ground is installed.

(3) Temporary grounding cables shall be flexible stranded copper and shall be equipped with approved clamps at each end. Grounding cables should be inspected before each use.

(4) When grounding lines or equipment, the connection to the ground shall be made first and that to the circuit or equipment last. In removing grounds, first remove the connection to the circuit or apparatus and then remove the ground connection. Insulated hot-sticks should be used in making the ground connection to the circuit or apparatus.

(5) Grounds shall be placed on all phases even if work is to be carried out on one phase only.

(6) Where two or more crews are working independently on the same line or equipment, each crew shall properly protect themselves by placing their own temporary grounds.

SWITCHING OPERATIONS

1) Every message relating to the switching operations on the high voltage system shall, wherever practicable, be written down. Every such message shall be repeated in full to the sender to ensure that the message has been accurately received

2) A record of high voltage switching will be entered in station log.

3) All breakers and isolators should bear lettering or sign boards to indicate the circuit they control.

4) When releasing the electric circuits, breakers or equipment for work on them, the associated breaker and disconnecting switches shall be opened in the following order:
4.1 The breaker will be opened first.
4.2 The isolator will be opened, but before operating the isolator, it shall be made sure that the breaker is open.

5) After opening isolators and air break switches, check carefully to see that all blades are in full open position.

SWITCHING OPERATIONS continued

6) When lines and circuits are taken out of service, the breaker control circuit should be opened either by operating the opening device or by removing the control circuit fuses.

7) If the circuit is controlled by automatic re-closing breaker, the re-closing mechanism shall be made inoperative.

8) Isolators shall be closed in firm positive manner, using sufficient force to make full contact of blades.

9) Before removing fuses, switches should be opened if provided. Removing fuses from inductive circuit carrying current without opening the switch is hazardous.

10) CAUTION: INCASE OF INCOMMER, ISOLATE SUPPLY END FIRST

CAPACITORS

1) Every capacitor shall be treated as hot / LIVE until proved otherwise. Capacitors stores energy and are not necessarily dead when disconnected from the line. Once charged, a capacitor may retain its charge for several hours after it has been disconnected.

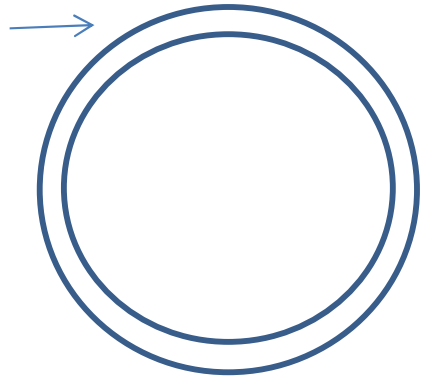
2) When a capacitor is to be worked on, first open all cutouts or disconnecting devices to the capacitor, then wait for at-least five minutes for the internal resistors to reduce the voltage. Next, using the hot stick (discharge rod), short circuit and ground all terminals of the capacitors. These terminals should remain short circuited and grounded while work is being done on the capacitor.

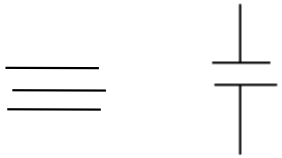
3) To bring the capacitor banks back into service, first remove the jumpers with hot sticks, and then close
the cutouts.

Electrical shock

- Electrical shock may cause an unwanted or unnecessary cellular depolarization and its associated muscular contraction, or it may cause cell vaporization and tissue injury.
- A cell is depolarized when the membrane is changed by approximately 20%
- To conveniently estimate the stimulus current in a cell the cell membrane is modeled as a dielectric with dielectric constant ε.

Cell membrane





Capacitor

$$\epsilon = \epsilon_0 \epsilon_r$$

$$C = \frac{\epsilon \times Area}{t}$$

Capacitance

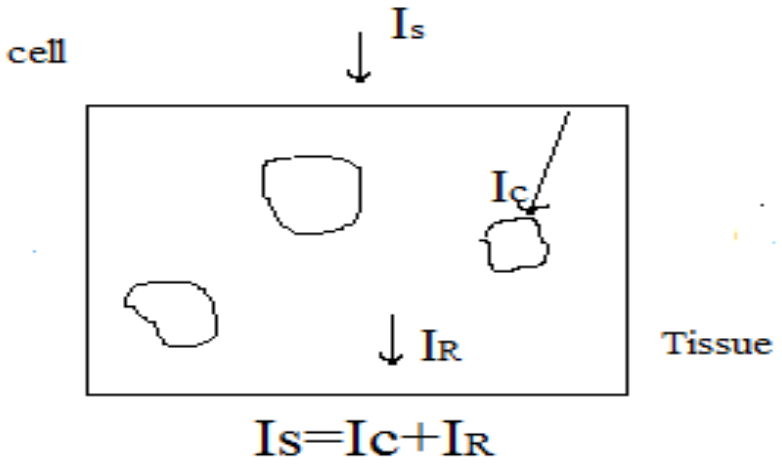
Where t:the membrane thickness, r: the radius of the cell

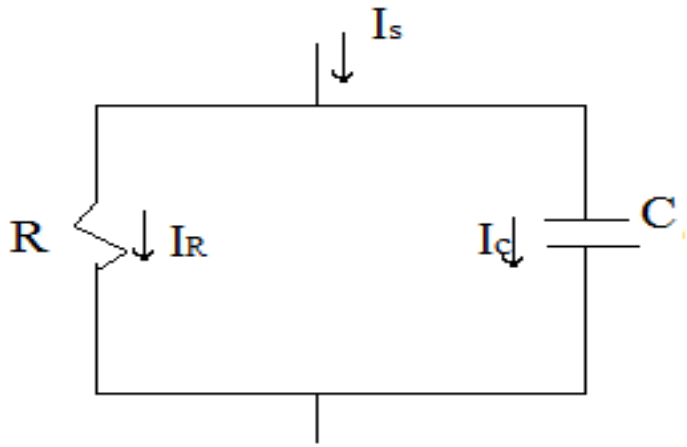
- The stimulus current I_c entering the cell:

$$I_c = \frac{V_{mt}}{Z} = V_{mt}\,(j2\pi f c)$$

Where V_{mt} : The threshold potential required to depolarize the cell

A model of tissue :





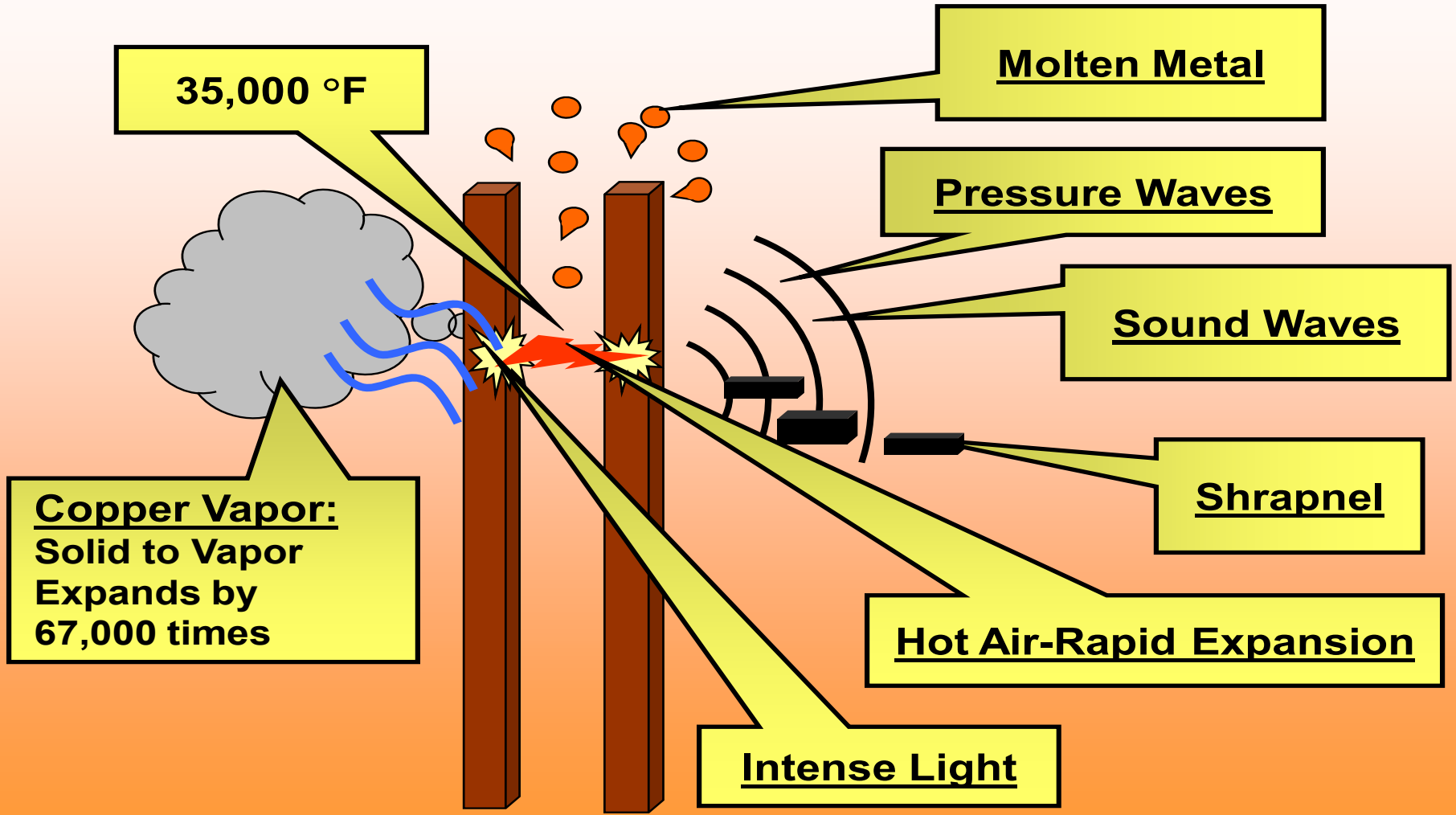
Safety tips

Types of Current	Current range (mA)	Physiological effect
Threshold	1-5	Tingling sensation
Pain	5-8	Intense or painful sensation
Let-go	8-20	Threshold of involuntary muscle contraction
Paralysis	>20-80	Respiratory paralysis and pain
Fibrillation	80-1000	Ventricular and heart fibrillation
Defibrillation	1000-10,000	Sustained myocardial contraction and possible tissue burns

Physiological Effects of Electricity

- **Threshold of perception:** The minimal current that an individual can detect. For AC (with wet hands) can be as small as 0.5 1 mA at 60 Hz. For DC, 2 ~10 mA
- **Let-go current:** The maximal current at which the subject can voluntarily withdraw. 6 ~ 10 mA, at which involuntary muscle contractions, reflex withdrawals, secondary physical effects (falling, hitting head) may also occur
- **Respiratory Paralysis / Pain / Fatigue** At as low as 20 mA, involuntary contractions of respiratory muscles can cause asphyxiation / respiratory arrest, if the current is not interrupted. Strong involuntary contraction of other muscles can cause pain and fatigue
- **Ventricular fibrillation** 75 ~ 100 mA can cause heart muscles to contract uncontrollably, altering the normal propagation of the electrical activity of the heart. HR can raise up to 300 bpm, rapid, disorganized and too high to pump any meaningful amount of blood ➔ ventricular fibrillation. Normal rhythm can only return using a defibrillator
- **Sustained myocardial contraction / Burns and physical injury** At 1 ~6 A, the entire heart muscle contracts and heart stops beating. This will not cause irreversible tissue damage, however, as normal rhythm will return once the current is removed. At or after 10A, however, burns can occur, particularly at points of entry and exit.

Electrical Arc



Arc-flash is an electric current that passes through air when insulation or isolation between electrified conductors is no longer sufficient to withstand the applied voltage.

The flash is immediate, but the result of these incidents can cause severe injury including burns.

Note that these are burn injuries, not electrical shocks. It is not necessary to touch live components to sustain an arc flash injury.

A calorie is the energy required to raise one gram of water one degree Celsius at one atmosphere.
Second degree burns occur at 1.2 calories per centimeter square per second.

One calorie per centimeter square per second can be equal to holding your finger over the tip of the flame of a cigarette lighter for one second

Electrical arcs produce some of the highest temperatures known to occur on earth, up to 19,400 °C. or 35,000°F

This is 4 times the temperature of the surface of the sun which is about 5000°C.or 9000°F

Causes of arc flashes

- An arc flash may be caused by a tool, rodent or other element in a breaker or service area, that could compromise the distance between energized components. Incidents often occur when personnel fails to ensure that the equipment has been properly de-energized.

- The intense heat from arc causes a sudden expansion of air. This results in a blast with very high air pressure (lightning are natural arcs).

- When materials vaporize, they expand in volume (Copper-67,000 times, water 1670 times).

Dangers of arc flashes

- An arc flash can cause minor injuries, third degree burns and potential death as well as other injuries including blindness, hearing loss, nerve damage and cardiac arrest.

- Fatal burns can occur when the victim is several feet from the arc. Serious burns are common at a distance of 3m.

- Staged tests have shown temperatures greater than 225°C or 437°F on the neck and hands of a person standing close to an arc blast.

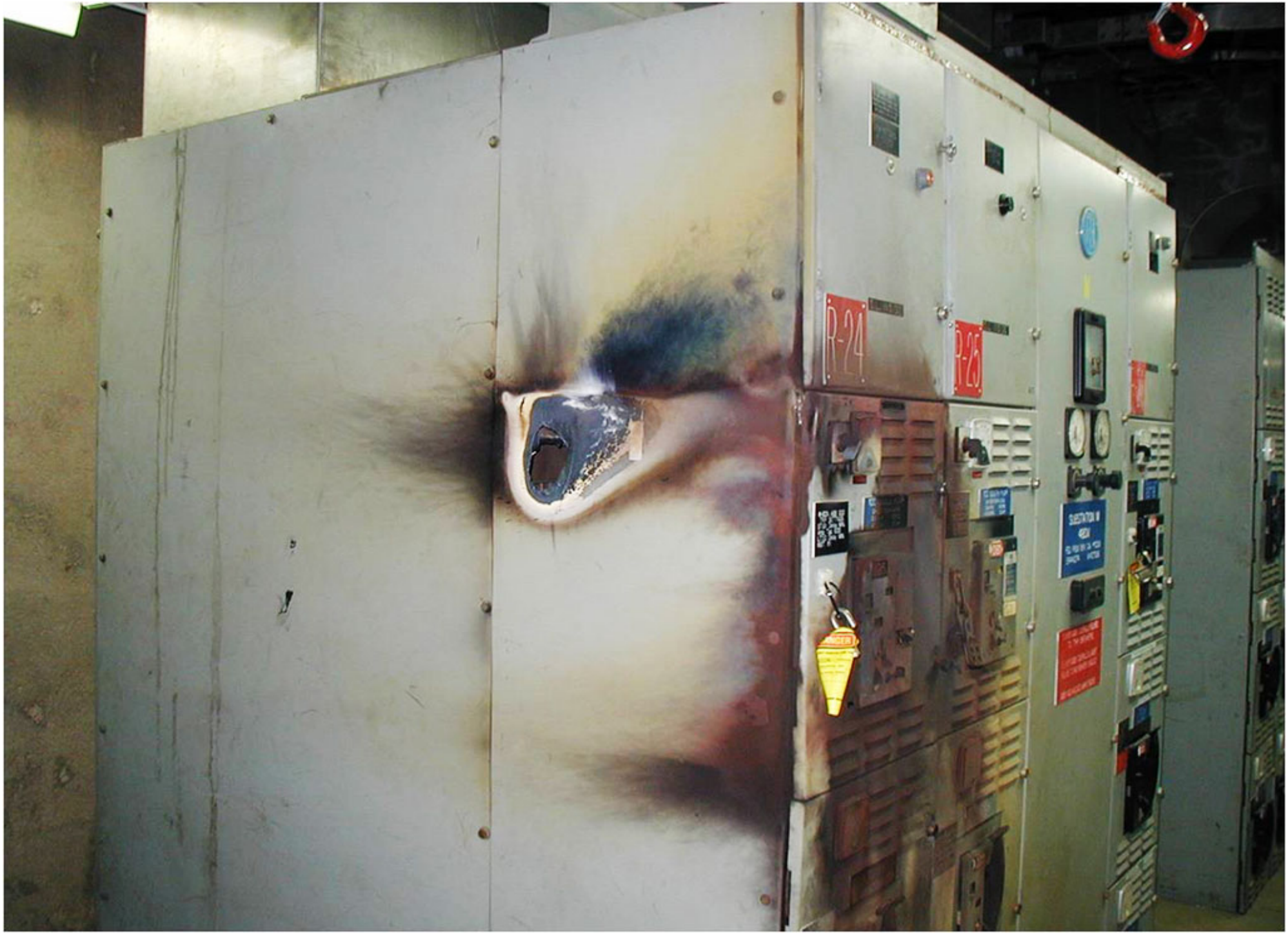
Dangers of arc flashes -- Continued

- Arcs spray droplets of molten metal at a high speed.

- Molten metal from an arc can be propelled for distances up to 10 feet. Blast shrapnel can penetrate the body.

- Blast pressure waves have thrown workers across rooms and knocked them off ladders. Pressure on the chest can be higher then 14 Mpa or 140 Bar

- Clothing can be ignited several feet away. Clothed areas can be burned more severely than exposed skin.


R-24
R-25
DANGER

Standards

NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces (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)

IEEE Standard 1584-2002, Guide for Performing Arc Flash Hazard Calculations

The NFPA 70E standard is a comprehensive standard that contains detailed information on how to protect workers from the heat of electric arc exposures. Preventative maintenance, worker training, and an effective safety program can significantly reduce arc flash exposure.

Costs

- Arc flashes can destroy equipment causing extensive downtime and requiring costly replacement and repair.

- Treatment for the injured worker can be very costly. This does not include significant litigation fees, insurance increases, fines, accident investigation, etc.

Arc Flash Safety and Prevention

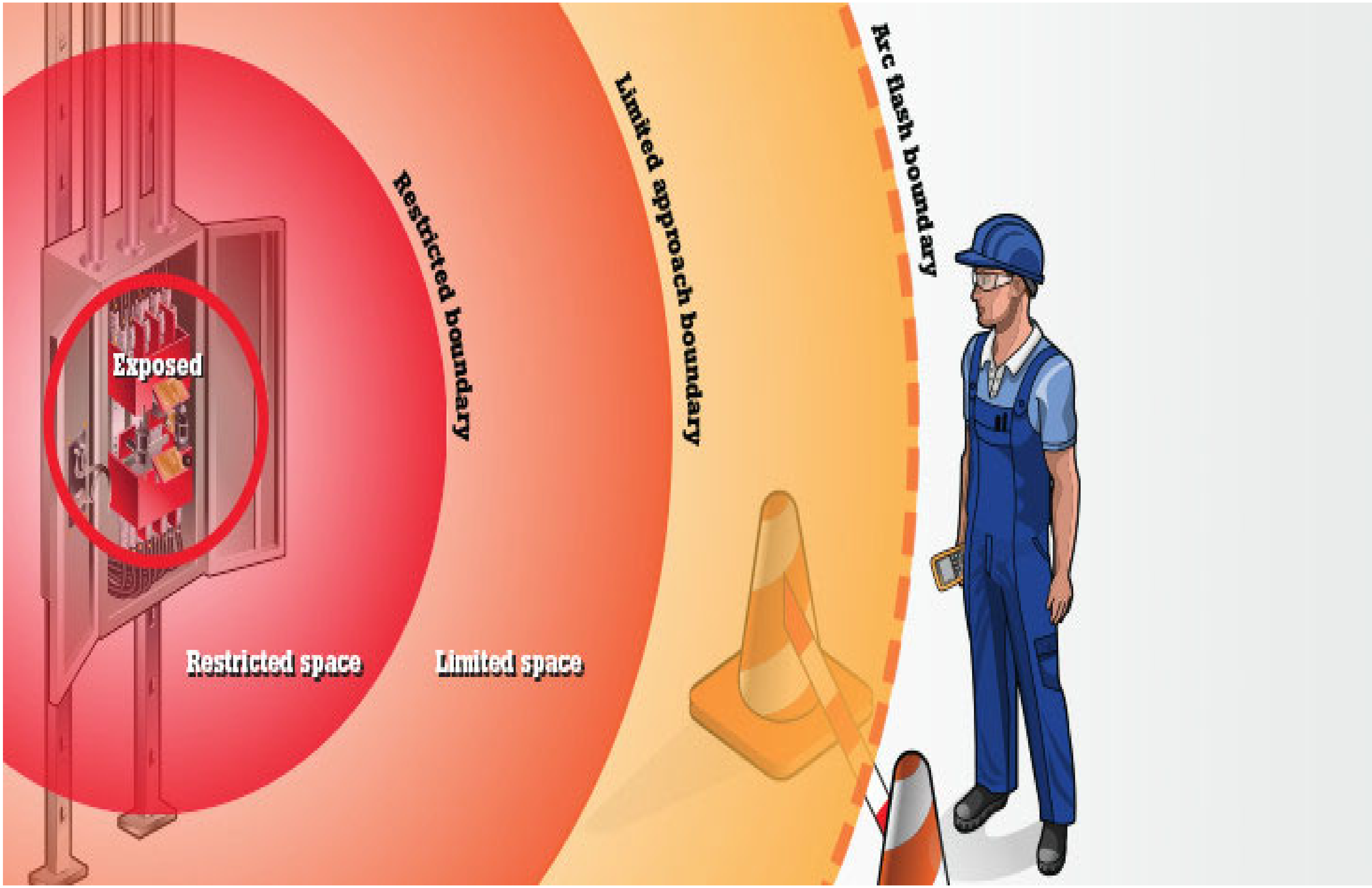
- Arc flash analysis must be performed prior to allowing personnel to work on energized equipment. The analysis defines the flash protection boundary distance and the type of Personal Protection Equipment (PPE) required.

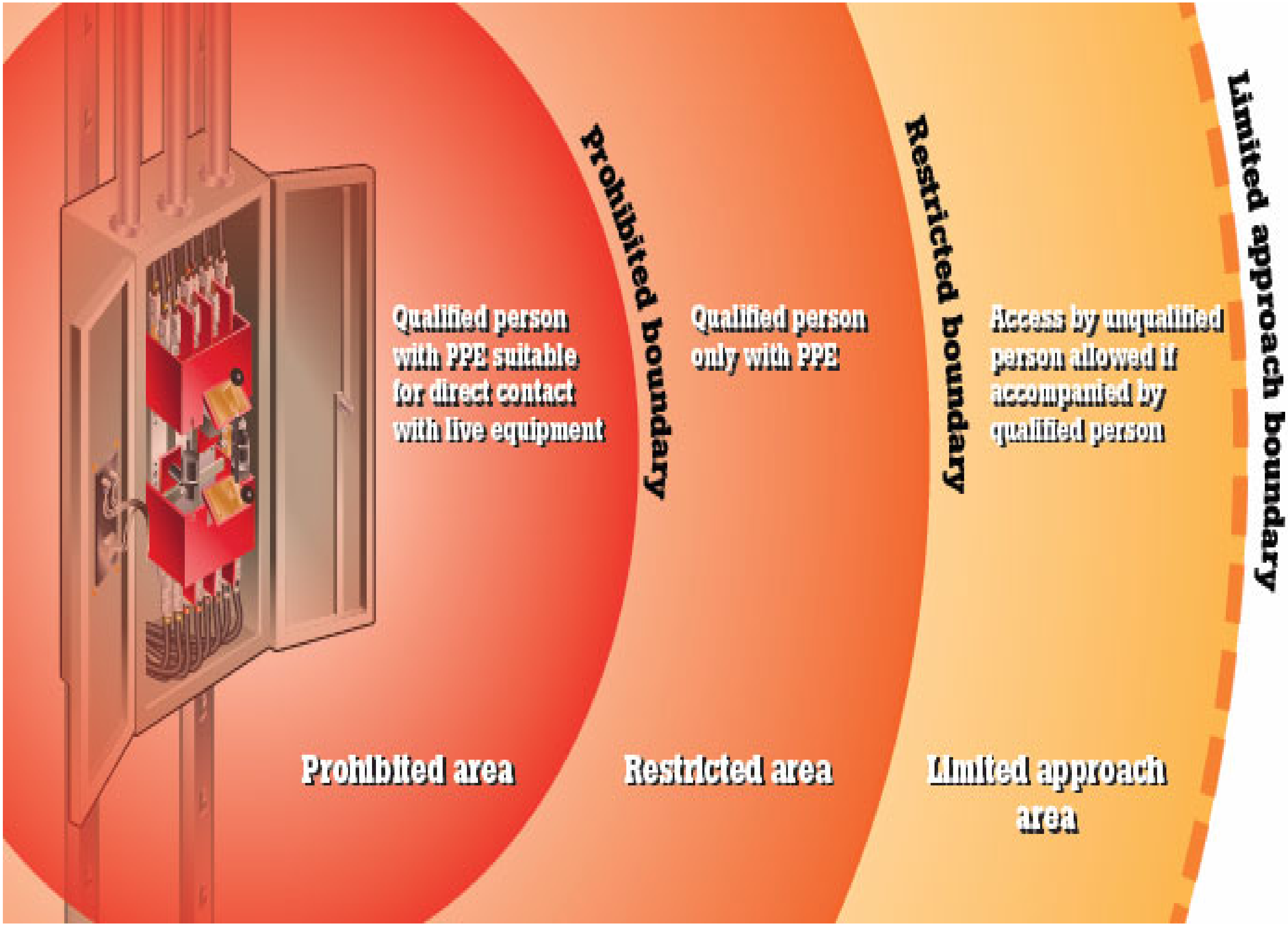
- The most common and industry accepted Personal Protective Equipment is flame resistant (FR) clothing.

- Use arc resistant equipment such as the Arc Shield for a higher level of employee protection.

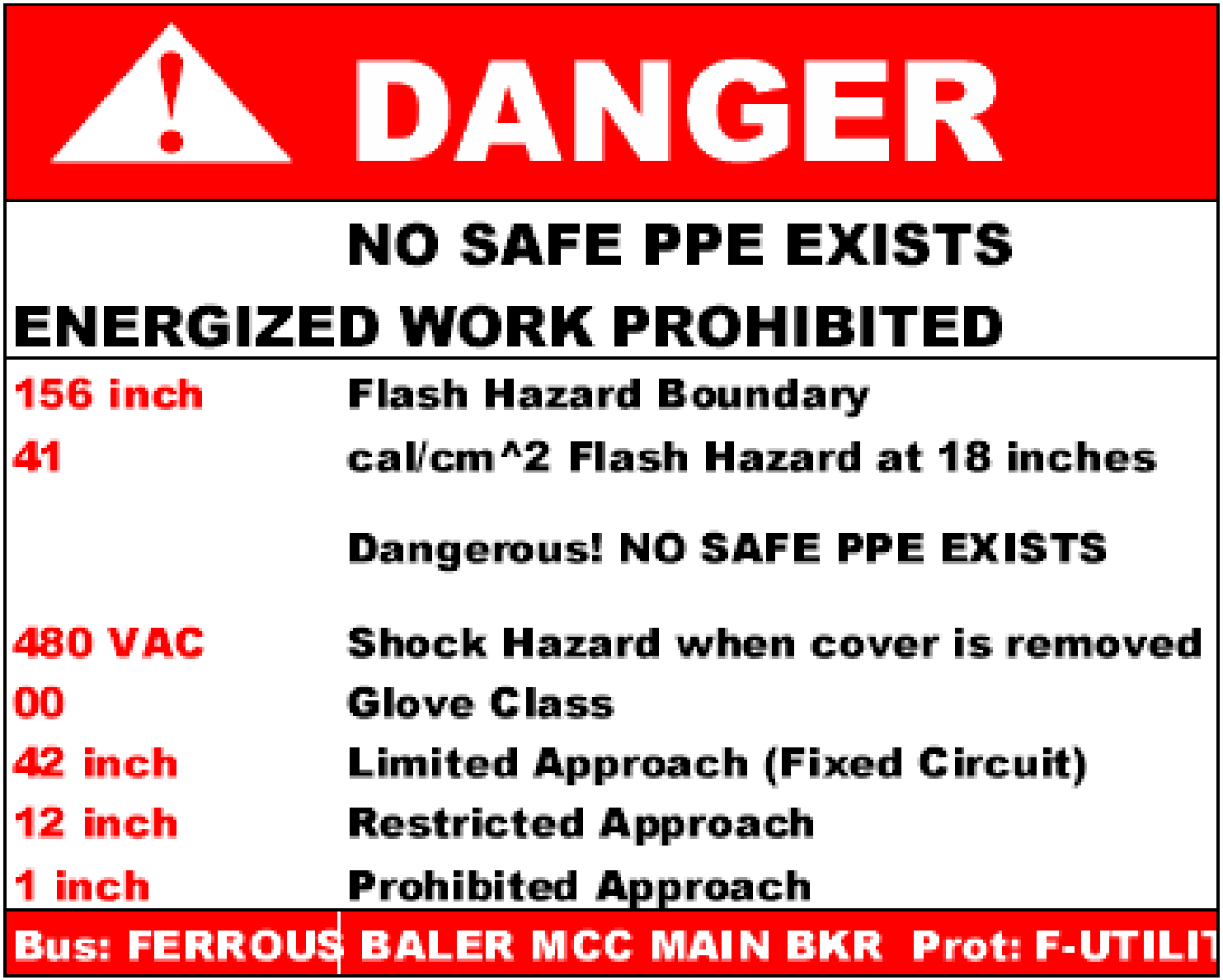
The flash protection boundary is an imaginary sphere that surrounds the potential arc point “within which a person could receive a second degree burn if an electrical arc flash were to occur,” according to NFPA 70E.

This standard also defines the incident energy level as “the amount of energy impressed on a surface,
a certain distance from the source, generated during an electrical arc event.”


Arc flash boundary
Limited approach boundary
Restricted boundary
Exposed
Restricted space
Limited space


Prohibited boundary
Restricted boundary
Limited approach boundary
Qualified person with PPE suitable for direct contact with live equipment
Qualified person only with PPE
Access by unqualified person allowed if accompanied by qualified person
Prohibited area
Restricted area
Limited approach area

Arc Flash Label



DANGER

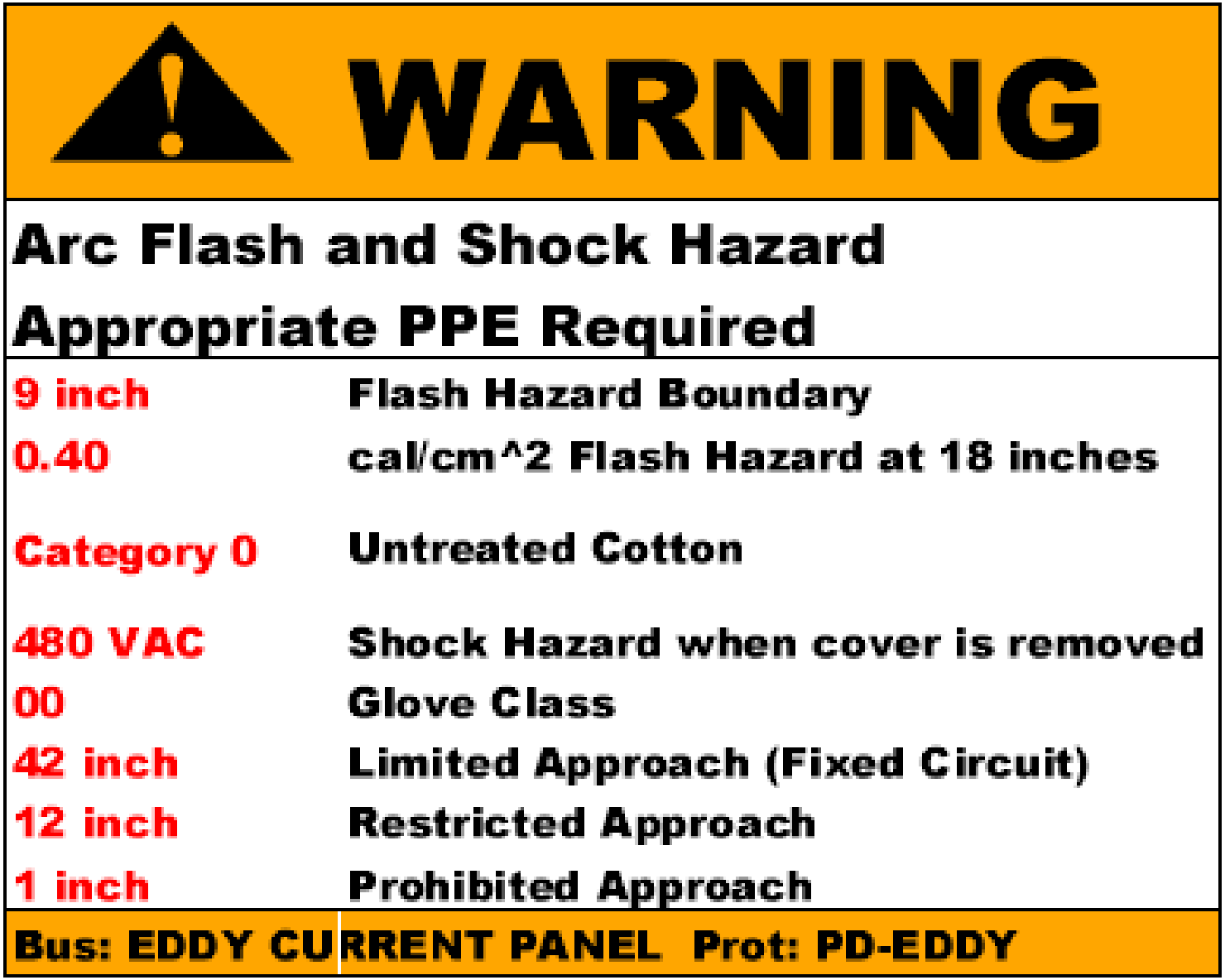
NO SAFE PPE EXISTS

ENERGIZED WORK PROHIBITED

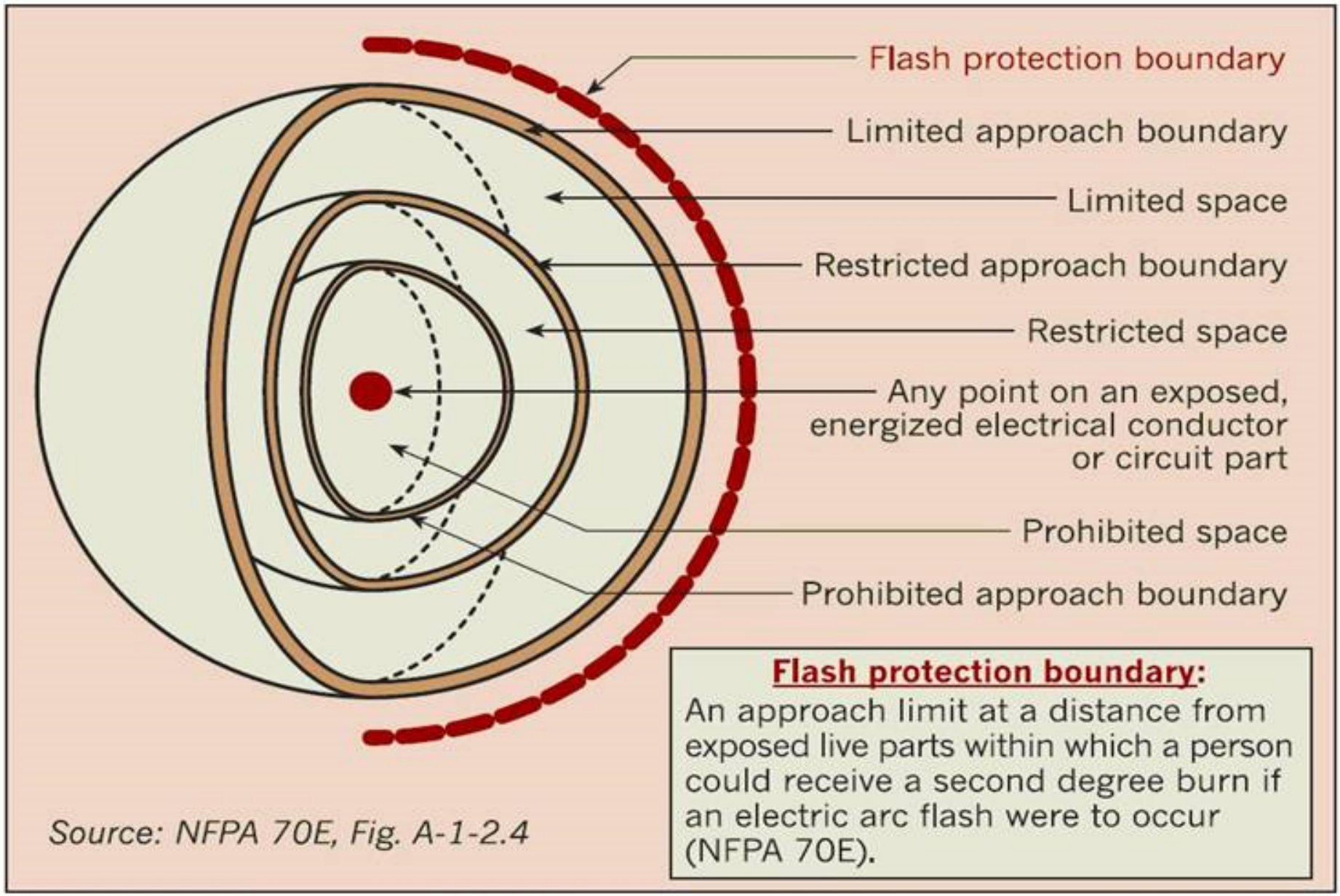
156 inch	Flash Hazard Boundary
41	cal/cm^2 Flash Hazard at 18 inches
	Dangerous! NO SAFE PPE EXISTS
480 VAC	Shock Hazard when cover is removed
00	Glove Class
42 inch	Limited Approach (Fixed Circuit)
12 inch	Restricted Approach
1 inch	Prohibited Approach

Bus: FERROUS BALER MCC MAIN BKR Prot: F-UTILI

Arc Flash Label

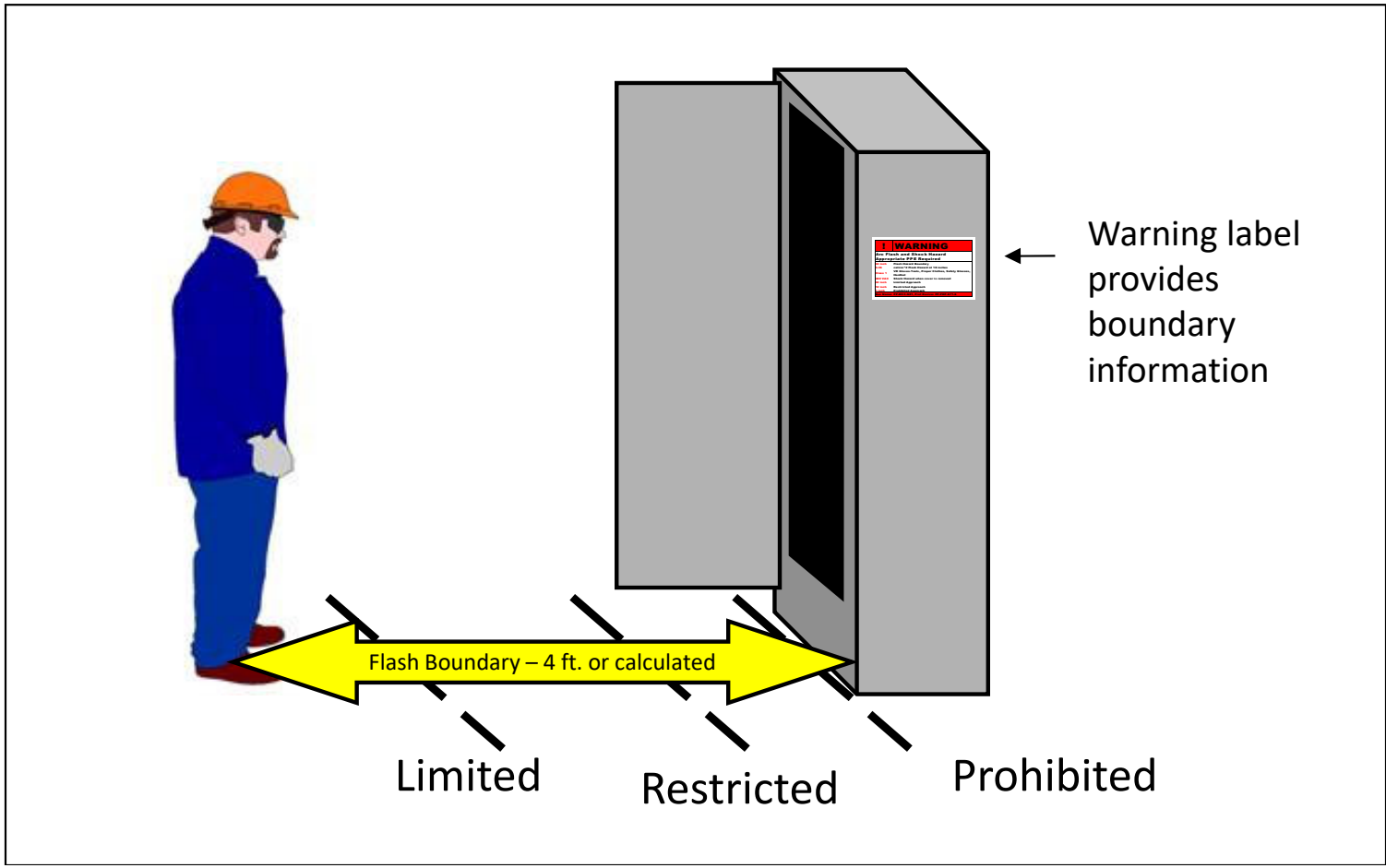


NFPA 70E Approach Boundaries



NFPA 70E Approach Boundaries (cont.)

- The qualified worker is responsible for ensuring physical barriers are in place and all approach boundaries are enforced during work.



NFPA 70E Table - Approach Boundaries to Live Parts for Shock Protection

(All dimensions are distance from live parts to employee)

(1)	(2)	(3)	(4)	(5)
Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
0 to 50	Not Specified	Not Specified	Not Specified	Not Specified
51 to 300	10 ft 0 in.	3 ft 6 in.	Avoid contact	Avoid contact
301 to 750	10 ft 0 in.	3 ft 6 in.	1 ft 0 in.	0 ft 1 in.
751 to 15 kV	10 ft 0 in.	5 ft 0 in.	2 ft 2 in.	0 ft 7 in.
15.1kV to 36kV	10 ft 0 in.	6 ft 0 in.	2 ft 7 in.	0 ft 10 in.
36.1kV to 46 kV	10 ft 0 in.	8 ft 0 in.	2 ft 9 in.	1 ft 5 in.
46.1kV to 72.5kV	10 ft 0 in.	8 ft 0 in.	3 ft 3 in.	2 ft 1 in.
72.6kV to 121kV	10 ft 8 in.	8 ft 0 in.	3 ft 5 in.	2 ft 8 in.
138kV to 145kV	11 ft 0 in.	10 ft 0 in.	3 ft 7 in.	3 ft 1 in.
161kV to 169kV	11 ft 8 in.	11 ft 8 in.	4 ft 0 in.	3 ft 6 in.
230kV to 242kV	13 ft 0 in.	13 ft 0 in.	5 ft 3 in.	4 ft 9 in.
345kV to 362kV	15 ft 4 in.	15 ft 4 in.	8 ft 6 in.	8 ft 0 in.
500kV to 550kV	19 ft 0 in.	19 ft 0 in.	11 ft 3 in.	10 ft 9 in.
765kV to 800kV	23 ft 9 in.	23 ft 9 in.	14 ft 11 in.	14 ft 5 in

Arc Ratings

Hazard/Risk Category	Incident Energy (cal/cm^2)
0	0 - 1.2
1	1.2 - 4
2	4 - 8
3	8 - 25
4	25 - 40
Dangerous	Over 40

NFPA 70E Table 130.7(C)(11)

Safe Work Practices

- De-energize-Lockout Policy
- Don’t wear conductive apparel
- Work area must be illuminated
- Never reach into blind spots
- Don’t allow conductive liquids near electrical work or equipment
- Buddy system (over 1,000 volts, work in pairs)
- Do not defeat electrical interlocks
- Use nonconductive ladders

Steps to Compliance

1. Have an arc hazard survey completed.
2. Implement any recommendations to reduce the hazards.
3. Develop and implement a labeling system.
4. Determine what tasks will be performed and at what hazard category.
5. Train (qualify) employees and provide PPE.

Arc Hazard Survey

- Conducted by an engineering firm
- Survey includes:
  - Single line diagram of electrical system
  - Incident energy levels
  - Current limiting device coordination
  - Calculates a hazard risk category and approach boundaries
  - Develops recommendations to reduce high hazard risk categories

Reduce the hazards!

- Some examples:
  - Change fuses
  - Develop a maintenance program
  - Adjust circuit breakers
  - Install additional disconnects

Specific Tasks

- Troubleshooting only! NO “WORK!”
  - Checking / replacing fuses
  - Checking motor starters
  - Checking amp draw
  - Checking relays

Voltage-rated Gloves

- First line of defense
- Choose the right size
- Leather protectors must be worn over the rubber gloves
- Gloves must be tested
  - Before first issue and every 6 months
  - If tested, but not issued for service, glove may not be put into service unless tested within previous 12 months.
- Checked before use
  - Roll-up test
  - Inflator test

Arc-Rated FR Clothing & PPE

- Layering
  - Outer layers must be flame resistant
  - Under layers must be non-melting
- Fit – Clothing shall fit properly (loose), w/ least interference
- Coverage – Clothing must cover potentially exposed areas (wrist, neck)
- Care & Maintenance
  - Inspect before use
  - Launder according to mfg's instructions

*Photo courtesy of Salisbury

PPE - Hazard Risk Category 0

0-1.2 cal/cm^2

- 100% cotton long sleeve shirt
- Long pants
- Safety glasses
- Hearing protection
- Leather and insulated gloves (as required)
- Leather work boots

PPE - Hazard Risk Category 1

1.2 - 4 cal/cm^2

- 4+ cal long sleeve shirt & long pants (or) coveralls
- Hardhat
- Safety glasses
- Arc rated faceshield
- Hearing protection (inserts)
- VR gloves
- Leather gloves
- Leather work boots

PPE - Hazard Risk Category 2

4 - 8 cal/cm^2

- 8+ cal long sleeve shirt & long pants (or) coveralls
- Hardhat
- Safety glasses
- Arc rated faceshield
- Hearing protection (inserts)
- VR gloves
- Leather gloves
- Leather work boots

PPE - Hazard Risk Category 3

8 - 25 cal/cm

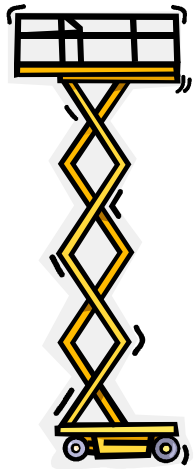
- 25+ flashsuit w/ hood over long sleeve shirt and long pants
- Safety glasses
- Arc rated faceshield
- Hearing protection (inserts)
- VR gloves
- Leather gloves
- Leather work boots

PPE - Hazard Risk Category 4

25 - 40 cal/cm^2

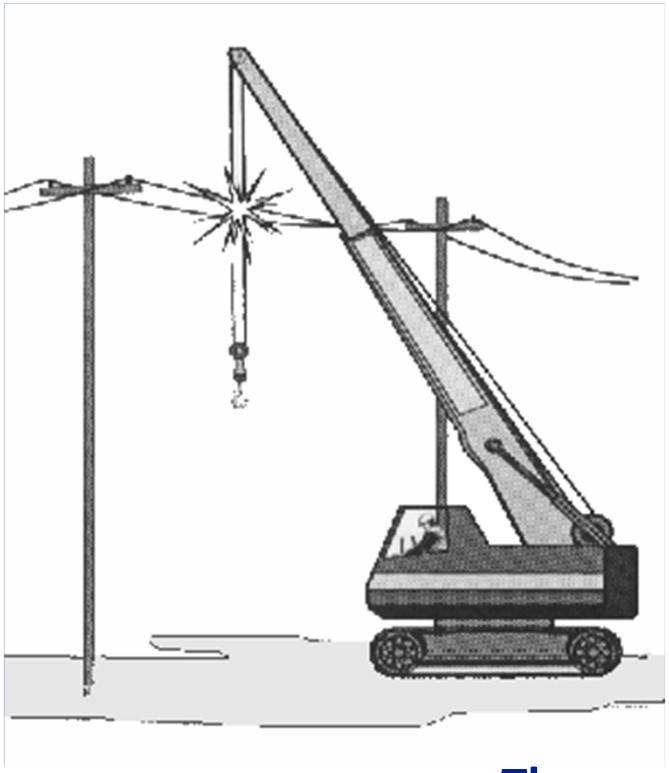
- 40+ flashsuit w/ hood over FR long sleeve shirt and long pants
- Safety glasses
- Arc rated faceshield
- Hearing protection (inserts)
- VR gloves
- Leather gloves
- Leather work boots

Ladders used around electrical hazards must have non-conductive side rails.
Ladders with non-conductive side rails that are contaminated with paint, greases or other coatings may no longer be non-conductive. Check them out.

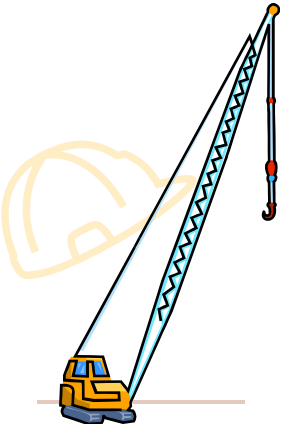


Stay away from exposed energized equipment.

Always look up before you lift or climb up.



Be aware of overhead exposed energized equipment such as overhead lines, cords, or overhead crane rails.
Minimum approach distance to overhead lines below 72,500 volts is 10 feet. (Limited Approach Boundary - 70E)



There may be other requirements that apply to approach distances to overhead lines. Make sure you inquire about these requirements.

Possible examples may include:

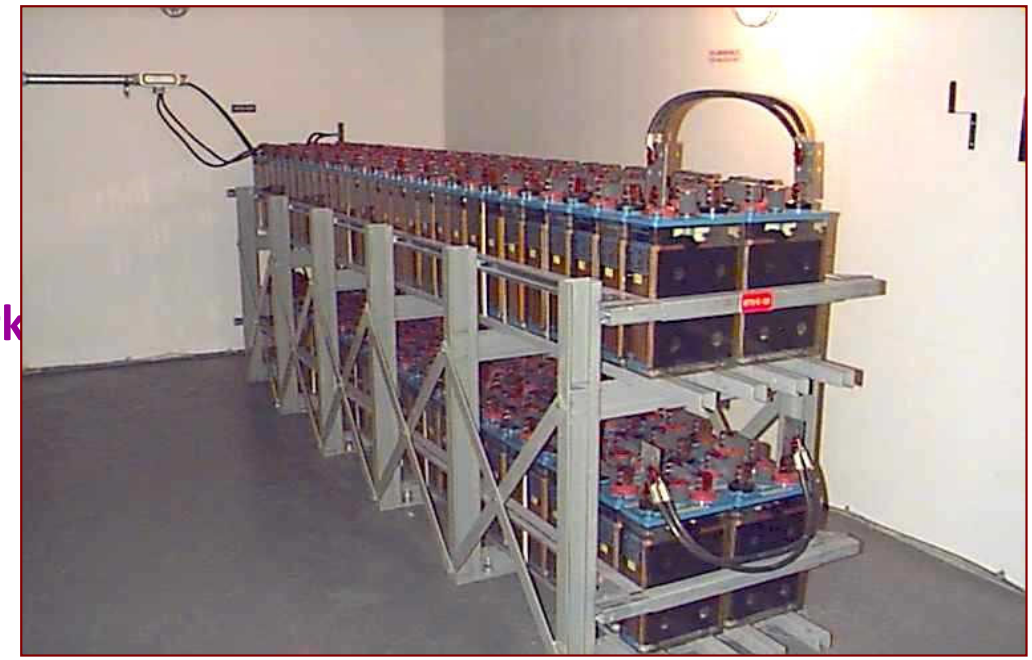
- **The use of a designated spotter.**
- **Approach distances may be different than 70E requirements.**
- **Overhead utilities may be under separate management.**

The IE Rules 56 has specific clearance requirements around electrical equipment to maintain safe working clearances for electrical workers. These are dedicated spaces and include width, height, and depth requirements. The clearance distances are based on configuration and voltage level.

You must keep these spaces clear. Check with a qualified electrical worker to ensure you do not store or install materials and equipment in theses dedicated spaces.

Batteries present special hazards in the work place. They may contain an acid or an alkaline substance in the electrolyte. If you get electrolyte on you, rinse with water for 15 minutes then get medical help. Failure to do this may lead to severe burns or blindness.

Most batteries give off explosive gasses when charged. Make sure adequate ventilation is available. Don't cause spark or flames in the vicinity of batteries. A catastrophic explosion may occur.



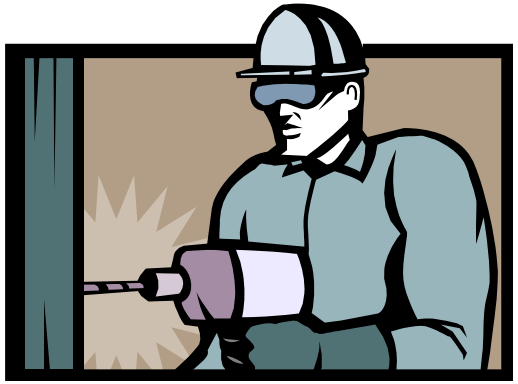
Batteries can store significant amounts of electrical energy. Do not use conductive equipment/tools around batteries. If you cause an ARC, you can be severely injured. Remember, there is no off switch on a battery!

If you must perform work around batteries or battery racks, eye wash/drench stations are required.

Spill kits for the electrolyte are to be available. Use non-sparking/non-conductive tools.

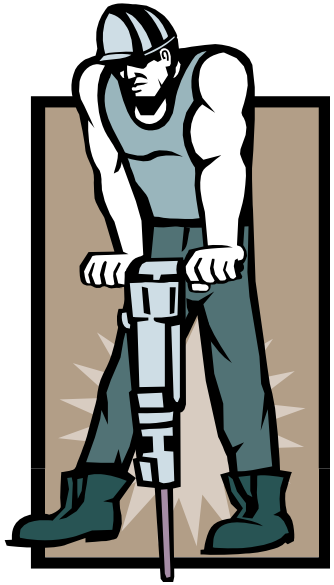
Electrical System Intrusions

- One of the most common occurrences with electrical systems is excavating, cutting or drilling into electrical systems.
- There are many methods of trying to identify buried or concealed electrical conduits and cables. None of them are fool proof.

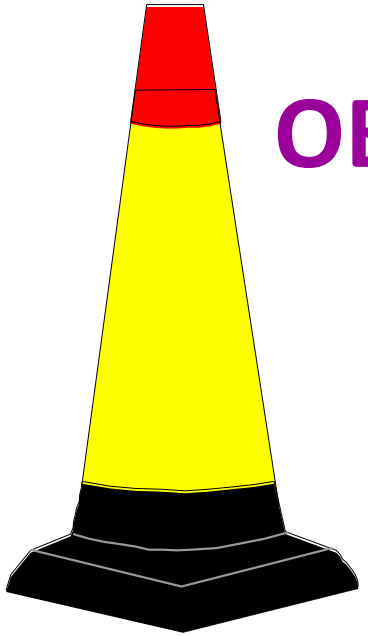


- Facilities have developed methods and procedures to help prevent these occurrences.
- If you are involved in this type of activity, it is your responsibility to comply with facility requirements.

If location or condition of energized electrical systems is uncertain, utilize electrically rated PPE and other protective measures such as drill stops, hand digging, vacuum excavators, etc.



Conduit cut – Location was right, depth was wrong.



OBEY ALL SIGNS AND BARRIERS!

Signs, Symbols, Tags, and Barricades are used to warn personnel of potential electrical hazards.

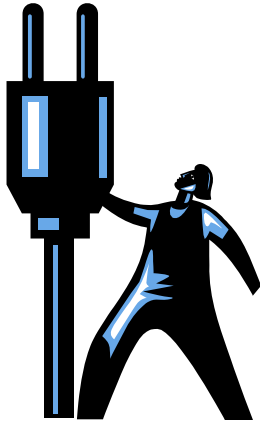
CAUTION

AREA IN FRONT OF THIS ELECTRICAL PANEL MUST BE KEPT CLEAR FOR 36 INCHES OSHA - NEC REGULATIONS

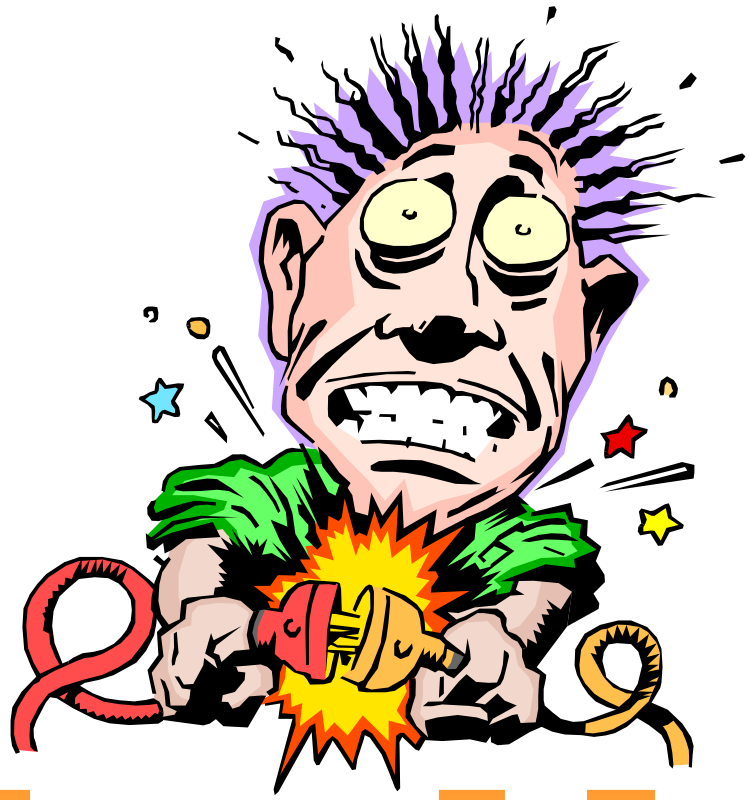
REMEMBER!

- The results of a mistake with electrical energy occur at the speed of light. There is not time to react after the error is made. You must think ahead.
- Pre-job briefs, planned work instructions, and facility requirements are not optional. Pay attention and obey all the rules, not just the ones that are convenient. They provide the edge you need to be safe with electrical energy.

- Post-job reviews help keep us from repeating errors – participate in them.
- You are responsible for your safety.

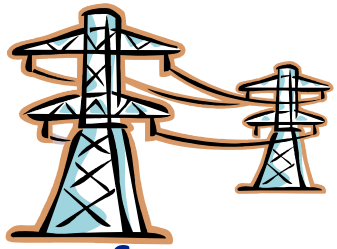


Work Shouldn't be...



Shocking!

Summary



- Many items concerning electrical safety have been presented. It isn't possible to cover all the hazards electrical energy can present.
- If you identify a hazard, make sure you and others are safe and then report it immediately to the proper authority for your work location.
- electrical workers to be ALERT.
- You are also required to be **ALERT** and **AWARE** of potential electrical hazards. If you are not, you can be severely injured or killed

- **Above all, BE SAFE.**


Final Advice
Treat electricity with
the respect it demands,
and
it will serve you
efficiently and effectively

My Safety is my prime duty

There is no compromise in Safety and security

Make Safety a Habit

Some CEA guide lines for safety

Electrical Safety Officer

All suppliers of electricity including generating companies, transmission companies and distribution companies shall designate an Electrical Safety Officer for ensuring observance of safety measures specified under these regulations in their organization, for construction, operation and maintenance of power stations, sub-stations, transmission and distribution lines.

Chartered Electrical Safety Engineer

The Appropriate Government shall authorize Chartered Electrical Safety Engineer, having the qualification and experience as specified by the Authority under sub-regulation (3) to assist the owner or supplier or consumer of electrical installations for the purpose of self-certification.

Safety measures for Operation and, Maintenance of Electric Plants and Transmission, Distribution Systems

1 Engineers and supervisors appointed to operate or' undertake maintenance of any part or whole of a power generating station.
2 The Technicians to assist engineers or supervisors shall possess a certificate in appropriate trade, preferably with a two years course from a Industrial Training Institute recognized by the Central Government or the State Government.

Deposit of Maps

When a license has been granted, two sets of maps showing, as regards such licensee, the particulars specified in application for license shall be signed and elated to correspond with the date of notification of the grant of the license by an officer designated by the Appropriate Commission in this behalf.

Plan for Area of Supply to be made and kept Open for Inspection

The licensee shall, after commencing to supply electricity, forthwith cause a plan, to be made in electronic form, of the area of supply, and shall cause to be marked thereon the alignment and in the case of underground works, the approximate depth below the surface of all the existing electric supply lines, street distributing boxes and other works, and shall once in every year cause that plan to be duly corrected so as to show the electric supply lines, street distributing boxes and other works for the time being in position and shall also, if so required by an Electrical Inspector, cause to be made sections showing the approximate level of all his existing underground works other than service lines.

General Safety Requirements

All electric supply lines and apparatus shall be of sufficient rating for power, insulation and estimated fault current and of sufficient mechanical strength, for the duty cycle which they may be required to perform under the environmental conditions of installation, and shall be constructed, installed, protected, worked and maintained in such a manner as to ensure safety of human beings, animals and property.

Identification of Earthed and Earthed Neutral Conductors

1 An indication of a permanent nature shall be provided by the owner of the earthed or earthed neutral conductor, or the conductor which is to be connected thereto, to enable such conductor to be distinguished from any live conductor and such indication shall be provided-

(a) where the earthed or earthed neutral conductor is the property of the supplier, at or near the point of commencement of supply;

(b) where a conductor forming part of a consumer's system is to be connected to the supplier's earthed or earthed neutral conductor, at the point where such connection is to be made;

(c) in all other cases, at a point corresponding to the point of commencement of supply or at such other points as may be approved by an Electrical Inspector.

2 no cut-out, link or switch other than a linked-switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductors shall be inserted or remain inserted in any earthed or earthed neutral conductor of a two wire-system or in any earthed or earthed neutral conductor of a multi-wire system or in any conductor connected thereto.

Inter-locks and Protection for use of Electricity at Voltage Exceeding 650 Volts

1 Gas pressure type and winding and oil temperature protection to give alarm and tripping shall be provided on all transformers of ratings 1000 KVA and above.
2 Transformers of capacity 10 MVA and above shall be protected against incipient faults by differential protection.
3 All generators with rating of 100 KVA and above shall be protected against earth fault or leakage.
4 In respect of existing 132 kV sub-stations and switching stations having more than one incoming feeders, the high speed bus bar differential protection along with local breaker back up protection, shall be commissioned and shall always be available.
5 Distance protection and carrier communication protection shall be provided for all lines connecting to 400/220 kV substation.

Testing, Operation and Maintenance

1 No new apparatus, cable or supply line of voltage exceeding 650 Volts shall be commissioned unless such apparatus, cable or supply line are subjected to site tests as per relevant code of practice of the Bureau of Indian Standards.

2 Failures of transformers and reactors of 20 MVA or MVAR and higher capacity shall be reported by the consumer and the suppliers of electricity, within forty eight hours of the occurrence of the failure, to the Central Electricity Authority and the reasons for failure and measures to be taken to avoid recurrence of failure shall be sent to the Central Electricity Authority within one month of the occurrence.

Safety requirements for overhead lines, underground cables and generating stations

Material and Strength

1 All conductors of overhead lines shall have a breaking strength of not less than 350 kg.

2 Where the voltage, does not exceed 250 V and the span is of less than fifteen metres, and is drawn through the owner's or consumer's premises, a conductor having an actual breaking strength of not less than 150 kg may be used.

Maximum Stresses and Factors of Safety

1 The following minimum factors of safety, namely:
(a) for metal supports 1.5
(b) for mechanically processed concrete supports 2.0
(c) for hand-moulded concrete supports 2.5
(d) for wood supports 3.0
2 The minimum factor of safety for stay-wires, guard-wires or bearer-wires shall be 2.5 based on the ultimate tensile strength of the wire.
3 The minimum factor of safety for conductors shall be two, based on their ultimate tensile strength, in addition, the conductor's tension at 32° C, without external load, shall not exceed the following percentages of the ultimate tensile strength of the conductor.
(a) Initial unloaded tension 35 percent
(b) Final unloaded tension 25 percent

General Clearances

1 No blasting for any purpose shall be done within 300 metres from the boundary of a sub-station or from the electric supply lines of voltage exceeding 650 V or tower structure thereof without the written permission of the owner of such sub-station or electric supply lines or tower structures; and in case of mining lease hold area, without the written permission of the Electrical Inspector of Mines.

2 No person shall construct brick kiln or other polluting units near the installations or transmission lines of 220 kV and above within a distance of 500 metres.

Guarding

Every guard-wire shall have an actual breaking strength of not less than 635 kg and if made of iron or steel, shall be galvanized.

Service lines from Overhead Lines

The number of tappings per conductor shall not be more than four in case of connections at voltage not exceeding 650 V.

Earthing

1 Metallic bearer wire used for supporting-insulated wire of overhead service lines of voltage not exceeding 650 V shall be efficiently earthed or insulated.

2 Each stay-wire shall be similarly earthed unless insulator has been placed in it at a height not less than 3.0 metres from the ground.

Laying of Cables

1 No underground power cable of voltage exceeding 33 kV shall be laid without a minimum underground depth of 1.2 meters.

2 No underground telecommunication cable shall be laid without a minimum separation distance of 0:6 meters to the underground power cable of Voltage exceeding 33 kV.

Voltage of Supply to Vehicle

No person shall supply electricity to any trolley wire or other conductor at voltage exceeding 650 V used in direct electrical and mechanical connection with any vehicle, except with the written approval of the Central Government or the State Government, as the case may be, and subject to such conditions as the State Government may think reasonable to impose.

Switchyard
Fire prevention
And
Fire protection

Topics

- Switchyard Design Consideration
- Active and Passive Systems
- HSE Issues
- Electrical Fire Hazards
- Fire Protection
- Housekeeping Issues

Design Considerations

- Layout, Outdoor and Indoor
- Selection of Equipments
- HAZOP study and design review

HAZOP Study includes

Risk Assessment
Life Safety Assessment
Fire Protection Assessment
Hazard Assessment
Radiation Exposure Assessment
Fire Spread Assessment

Risk Assessment

- Review the criticality of the control room and building fire loss to the substation operation and asset base.
- Review the historical frequency of fire in control buildings.

Life Safety Assessment.

- Review the control room layout to ensure that the room has a minimum of two outward swinging exit doors.
- Ensure that the travel distance from any area within the control building to an exit does not exceed 100 ft.
- Ensure that exit signs are installed at each exit door.
- Review that emergency lighting is provided that will provide a minimum lighting level of 10 lux at the floor, along the exit paths.
- Review the size and number of stories of the building to ensure proper exits are provided to ensure that maximum travel distances to the exits do not exceed 100 ft.
- Determine if there are any building or fire code requirements for the installation of a fire detection system.

Fire Protection Assessment

. Review the availability of a fire department response to the site.

. Review the availability of fire fighting water supply at or adjacent to the site.

. Review the adequacy of any existing control building fire protection.

. Review criticality of control building equipment, hazards involved, and response time of station personnel and the fire department.

. Determine the type of detection that will provide an acceptable very early detection (air sampling detection) to detect a fire at a very early stage (small electronic component failure—arcing) or at an early stage with smoke detection (photoelectric detection) to detect a fire at a smoldering or small flame stage.

. Fire Protection Assessment (continued)

- Determine the type of fire-suppression system that will provide an acceptable equipment losses and outages (i.e., gaseous suppression systems to suppress a fire at an early stage [component loss], or sprinkler protection to suppress a fire at the stage where the loss would be restricted to a single control cabinet).

- Review the occupied hours of the building and ability of site personnel to safely extinguish a fire with portable fire equipment. Determine the levels of portable fire equipment required by the local fire code and that is suitable for safe staff operation

Hazard Assessment

➢. Review the other uses (shops, offices, storage, etc.) within the control building and their exposure to the critical substation equipment.
➢. Review the use of combustible construction in the control building (i.e., exterior surfaces and roofs).
➢. Review the use of combustible interior surface finishes in the control room and ensure that the surface finishes have a flame spread rating of less than 25.
➢. Review the combustibility of any exposed cable.
➢. Review the control room separation walls to other occupancies to ensure that the walls have a fire resistance rating of a minimum of 1 h.

Switchyard Fire Protection Assessment

Determine the initial electric equipment layout and equipment types Risk Assessment

- . Review the criticality of the various pieces of equipment
- . Review types of insulating fluid used and their flammability
- . Review the historical frequency of fire for the various types of equipment
- . Review the availability of a fire department response to the site
- . Review the availability of a fire fighting water supply at or adjacent to the site
- . Review the adequacy of any existing substation fire protection

Radiant Exposure Assessment

- Review the spacing between individual single-phase transformers and breakers
- Review the spacing between large three phase transformers, banks of single-phase transformers or groups of breakers.
- Review the spacing of oil-filled equipment with respect to substation buildings.
- Review the distances between oil-filled equipment and the property line. Note: combustible vegetation and building structures beyond the property line of the substation may be exposed to high enough heat fluxes to ignite combustible surfaces.
- Review the use of the various methods of fire protection that will address the hazard determined in the radiant exposure assessment

such as changing the type of equipment and insulating fluid used, increased spacing, provision of gravel ground cover, oil containment, fire barriers,and automatic water deluge fire protection.

Fire Spread Assessment

- Is the surface around oil-filled equipment pervious (gravel) or impervious? Use of 12-in. thick gravel ground covers will suppress the flames from a burning oil spill fire. Impervious surfaces can allow the burning oil to form a large pool fire, which will increase the heat flux to adjacent equipment and structures.

- Is there any oil containment in place around the oil-filled equipment? Oil containment can contain pool fires and prevent their spread.

- Does the grade surrounding the oil-filled equipment slope toward the equipment or away from the oil-filled equipment toward adjacent oil-filled equipment, cable trenches, drainage facilities or buildings? The burning oil released from ruptured oil-filled equipment can spread for significant distances if the ground surrounding the equipment has a slope greater than 1%.

Fire Spread Assessment (Continued

Review the use of the various methods of fire protection discussed in IEEE 979 that will address the hazard determined in the fire spread assessment. These methods include the following:

- Changing the type of equipment and insulating fluid used
- Increasing the spacing, use of gravel ground cover
- Provision of oil containment
- Changing the grade surrounding the equipment
- Use of liquid tight noncombustible cable trench cover adjacent to oil-filled equipment
- Fire stopping of cable trenches entries into Control buildings
- Use of automatic water deluge fire protection

Active and Passive Systems

Active

Describes a system that has moving parts or relies on mechanical, chemical or electrical controls in order to function. Examples of a*ctive systems include fire protection systems such as sprinklers and smoke detection systems.*

Passive

Describes a system that relates to fire protection that has no moving parts or does not rely on other external controls in order to function as intended. Examples of *passive systems include fire rated building elements such as fire barrier walls and fire doors in the closed position etc.*

Compartmentalisation

The division of a building into discrete compartments thereby confining any potential fire to the compartment of origin with the aim to prevent the spread of the fire into adjacent compartments for a designated
fire resistance period.

Convection

The transfer of heat by the circulation or buoyant motions of air flow. This mode of heat transfer becomes less significant for larger lateral distances from a fire or other heat source.

Dedicated compartment

A compartment that only has the nominated equipment contained within and only the cabling required for its operation. There is no other equipment and associated cables in the compartment.

Fire barrier	**A wall, floor, ceiling bounding a *fire rated compartment.***
Fire Hazard	**A hazard that occurs when a fire risk zone extends to include other buildings, parts of the same building that house the high voltage installation, fire escape routes, or other fire sensitive locations and facilities.**
Fire Intensity	**The rate of release of calorific energy from a fire.**
Fire rated *(FRL).*	**An item or a compartment that has a *Fire Resistance Level***

Fire Refuge Area

A refuge area is a safe place providing refuge to personnel from a substation fire. It can be a temporary “haven” to protect people while evacuating during a fire. Refuge areas can be either inside or outside a building and must provide personnel with protection from a fire until safe escape is possible to open space.

Fire Resistance: The ability of an element of construction, component or structure to maintain its structural adequacy, integrity and thermal insulation during exposure to a fire.

Fire Resistance Level (FRL): The ability of an element of construction, component or structure to maintain its structural adequacy, integrity and thermal insulation during exposure to a fire for a specific *fire resistance period.*

Fire Resistance Period (FRP):

The ability of an element of construction, component or structure to maintain a specific expected duty during exposure to a fire for a specified period of time. *Fire Resistance Period is generally specified in minutes*

Fire Risk Zone

A zone that extends in every direction from the perimeter of a high voltage installation based on a risk assessment.

Fire Separation Wall

A wall with an appropriate level of resistance to the spread of fire that divides a building (or a storey within a building) or switchyard into *segregated zones.*

Fire Source

Any electrical apparatus (generally of high voltage) that comprises of mineral oil, or a similar combustible fluid as an insulating medium. This includes oil filled *transformers and oil filled switchgear. Other fuel sources can be combustible construction materials, cables etc.*

Passive Fire Protection

Passive fire systems are required to minimise the risk of damage from the spread of fire from one segregation zone to another.

Except where exceptional circumstances apply, *active fire protection systems shall be used only as additional protection to passive systems and not as a substitute to passive fire protection systems.*

Examples of *passive fire protection systems include:*

- Fire separation walls and fire barriers.
- Fire stopping and fire dampers to penetrations within fire barriers.
- Self Closing Fire Doors to openings in fire separation walls and fire barriers.
- Minimum fire separation distances from fire sources.
- Oil containment/bunding.

Active fire extinguishing systems such as sprinklers and deluge systems aim at reducing the damage to burning equipment by reducing or eliminating any fire or smoke damage to the substation and equipment. Active systems assist in reducing the overall damage:

- by providing early warning for Fire Brigade intervention.
- by reducing the duration of a fire and providing a safe means of extinguishing the fire without isolating and earthing.
- by overcoming access problems for fire fighting.
- by limiting the spread of fire within a compartment.
- by reducing smoke.
- by providing, in some cases, cooling to adjoining areas.
- by providing a secondary system in the event the primary *passive system is compromised prior or during a fire event.*
- where linear compartmentalisation is not possible, such as cable basements.

Limitations of Active Systems

Designers shall make allowances for all the conceivable limitations of *active systems including any OH&S and environmental impacts*

Emergency Egress External to Buildings

Fire emergency egress within yards must consider the effects of radiant heat exposure from burning oil-filled *transformers or other oil-filled electrical equipment with a similar fire hazard.*

Radiant heat and Personnel Safety

Apart from preventing fire spreading to buildings, it is essential to have provisions for personnel safety and emergency egress.

Consideration shall be given to providing other means of protection if adequate separation distances cannot be provided, such as refuge areas. Apply a factor of safety of 1.5 to calculated separation distances to allow for prevailing wind effects.

Minimum Egress Provisions

Egress points in gates shall be positioned such that exposure for personnel shall be limited to 2.5 kW/m2 for egress where a single action handle is on the escape door/gate. Where there is no single action door/gate 1.7 kW/m2 for indefinite exposure shall be adopted for egress.

Design of substation egress paths shall consider locations of safe egress points from site, radiant heat levels of egress paths, all possible oil and other significant fire source locations and exposure limits on personnel. Personnel shall not be exposed to a radiant heat flux of level greater than 2.5kW/m2 along designated egress paths during evacuation. This shall be reduced where exposure times greater than 30 seconds is possible.

Fire detection

Manual call points

The fire may be detected by personnel manning or working on the substation site at the time of the fire. The alarm may therefore be raised by the breaking of glass at a manual call point.

Sensors

Two types of detector or sensor are found in substation applications:

1. Heat detectors

Bimetallic strips and thermistors are commonly used devices in such sensors. Maximum mounting heights depend upon the grade of the detector but lie in the range 6–13.5 m.

Smoke detectors

These sense small particles of matter or smoke in the air which are the result of a fire. Ionization detectors work on the principle that the current flowing through an ionization chamber reduces when smoke particles enter the chamber. Electronic alarm circuitry detects this change and initiates the alarm.

- Optical detectors note the scattering or absorption of light due to the smoke particles in a light beam. Maximum mounting heights are typically 10.5–15 m.

- It is considered that optical types are best suited to detect slow smouldering fires where large smoke particles are formed and that ionization types are best suited for fast burning fires where small smoke particles are formed.

- Smoke detectors tend to give a faster response than heat detectors but may also be liable to give more false alarms.

- Because of this and since prediction of the fire type may not be possible both types of smoke detector are often found in a single installation together with heat detectors.

Radiation (flame) detectors.

- These detect ultraviolet or infrared radiation and are mainly suitable for supplementing heat and smoke detectors or as a general surveillance of a large switchyard area


6 16:22

Adjacent Cable Trenches

Marshalling Box

Fire Fighting Equipments

Carbon dioxide fire extinguishers
Carbon tetrachloride fire extinguishers
Inergen gas system
Dry chemical powder fire extinguishers
Foam fire extinguishers
Fire buckets , sand and water
Mulsifier system
Deluge System
Gas(nitrogen)purging system

Personal Protective gears

Housekeeping

- Good housekeeping habits are an important part of a safe workplace.
- Why is good housekeeping important?
  - To reduce amounts of flammable and combustible materials.
  - To reduce ignition hazards.
  - To ensure safe emergency evacuation of occupants.
  - To allow for quick emergency response.

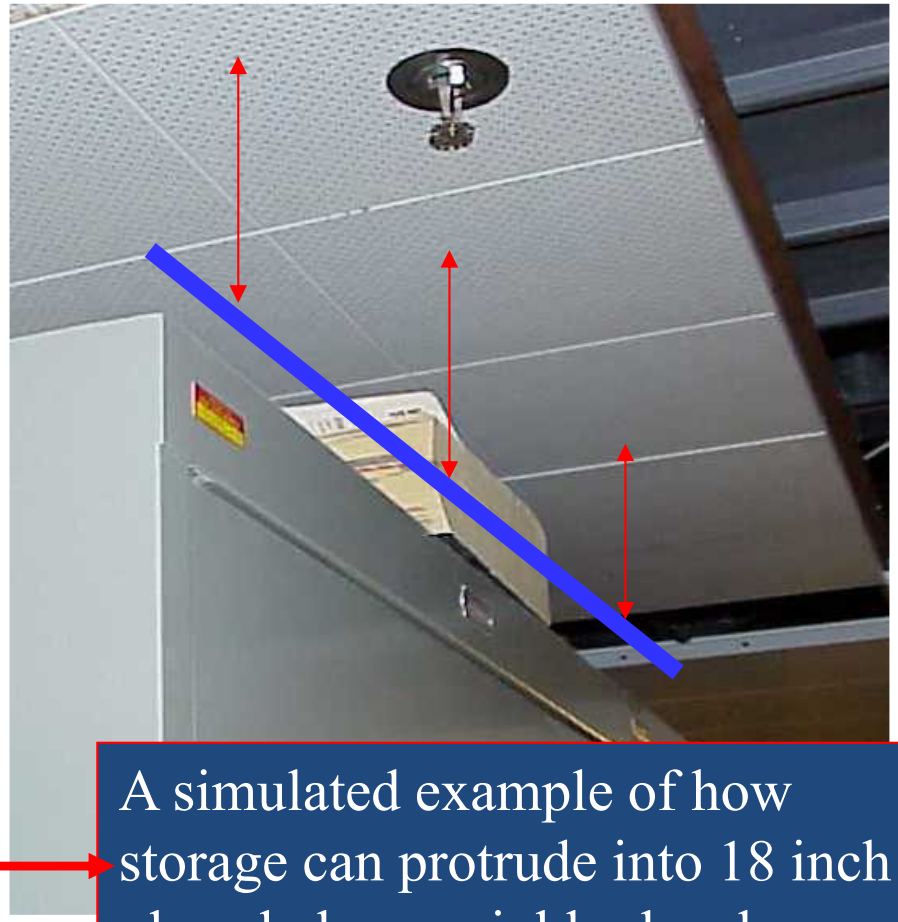
General Housekeeping Guidelines

- Work areas, aisles, walkways, stairways, and equipment should be kept clear of loose materials, trash, scraps, etc.
- Never block aisles, fire exits, emergency equipment, or alarm pull stations with equipment or materials.
- Avoid build up of combustible trash and waste such as paper, wood, cardboard, etc.
- Keep use and storage of flammables and combustibles to a minimum.
- Clean up all spills such as grease, oil, or water immediately. A delay could result in accidents.

Storage Guidelines

- No storage is allowed in corridors and stairwells. A cluttered hallway could slow down emergency evacuation.

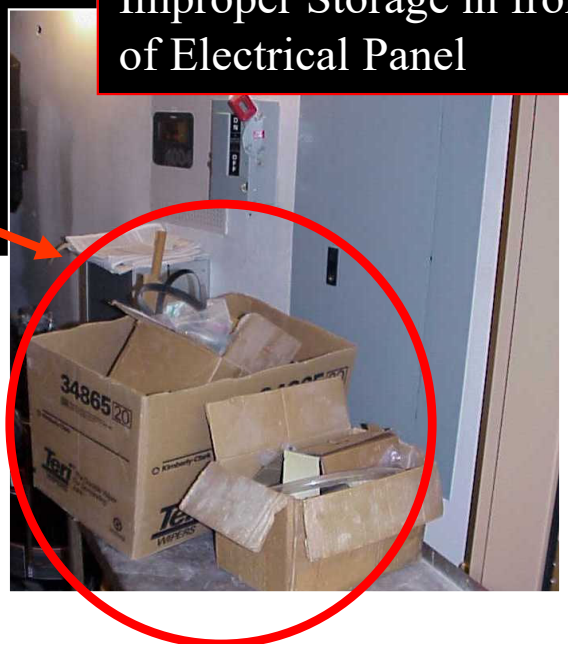
- Storage must not exceed a plane of 18 inches below sprinkler heads or smoke detectors. Storage that breaks this plane may prevent sprinkler heads from fully covering room during a fire.



A simulated example of how storage can protrude into 18 inch plane below sprinkler heads.

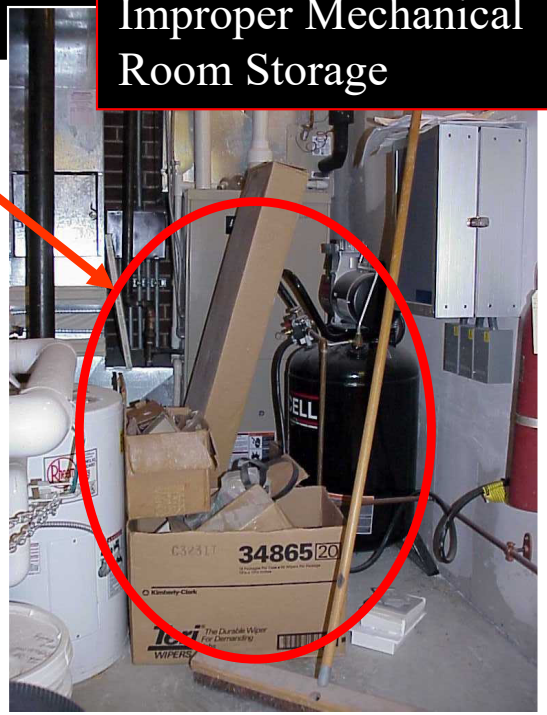
Storage Guidelines

- All storage must be at least 3 ft from electrical panels. In some emergency situations it will be necessary to access these panels quickly.



Improper Storage in front of Electrical Panel

- Maintain at least a 3ft clearance from heating surfaces, air ducts, heaters, and lighting fixtures.
- Storage of combustible materials in mechanical rooms is prohibited.



Improper Mechanical Room Storage

Flammable and Combustible Liquids

- Flammable and combustible liquids are potential fuel sources for fires and are present in almost every workplace.
- It is actually the vapor created by flammable and combustible liquids that ignites and burns.
- It is important to understand what materials in your work area are flammable and combustible so that you may properly store and isolate them from ignition sources.

Storing Flammable and Combustible Liquids

- Flammable liquids must be stored away from ignition sources in cool, well ventilated areas away from incompatible materials
- Limit the amount of flammable and combustible liquids to the minimum amount necessary.
- As a general rule, No more than 50 litres of flammable materials should be outside of approved flammable liquid storage cabinets or approved storage rooms.
- Room storage limits of flammable and combustible materials depend on various factors such as sprinklers, and storage cabinets. Refer to the table on the following slide for storage guidelines.

-Electrical Issues

- Electrical hazards are the cause of numerous workplace fires each year. Faulty electrical equipment or misuse of equipment produces heat and sparks that serve as ignition sources in the presence of flammable and combustible materials.
- Examples of common ignition hazards:
  - overloading circuits
  - use of unapproved electrical devices
  - damaged or worn wiring

Compartmentalization

- Buildings are designed to prevent fire, heat, and smoke from spreading beyond locations of origination. Building elements such as fire walls, fire dampers, and fire doors, are designed to seal off one location from the next. This system is called compartmentalization.
- Compartmentalization increases the safety of evacuating building occupants because smoke and fire are not able to escape into exit passageways.
- Containment of fire and smoke reduces property damage and prevents small fires from growing into large fires.
- In order for compartmentalization efforts to be effective fire barriers must be maintained.

What's A Fire Door?

- Fire doors are designed to withstand fire, heat and smoke for a period of 20-minutes to 3 hours.
- Did you know that corridor office doors are fire doors and should have a 20 minute rating?
- Corridor laboratory doors should have a 60 minute rating.
- Fire Doors are required to:
  - Be Self Closing: fire doors should have a door closure that pulls doors completely shut after the door has been opened
  - Have Positive latching: a positive latch locks a door in place so can open swing open freely.

Maintaining Fire Barriers

- Fire doors need occasional maintenance and repairs to function properly and should be periodically checked. To test a fire door:
  - Open the door fully and allow it to swing shut.
  - The door should close and latch completely by itself. Give the door a push after it closes to ensure that the latch has engaged.
  - If the door is not operating properly contact FP&M for repairs.
- Ceiling, Floor, Wall Penetrations
  - All areas should be properly sealed to prevent the escape of fire, heat and smoke.
  - Common penetrations include holes in walls, around ducts, pipes, etc. These types of penetrations should be sealed with appropriate fire-stopping material.

Conclusion

- The Fire Prevention and Fire Protection shall be an integral part of substation design
- Prototype fire protection is not recommended, but should be case specific
- The substation personnel shall be aware of fire fighting techniques, and regular drill is a must
- All fire fighting equipments shall be properly maintained

Some reference:

IEEE 979 Guide for Substation fire protection

NFPA 10 to 17 for various fire extinguishers

NFPA 30 Flammable and combustible liquid code

NFPA Fire Protection Handbook

CBIP Manual on Transformers

Novel fire extinguishing agent, INERGEN.

INERGEN is a breathable gaseous extinguishing agent based on mixtures of various inert type gases.

It is the subject of US patent 4,807,706, dated February 28, 1989 (1).

The composition of INERGEN consists of mixtures of Nitrogen, Carbon Dioxide, and any one of the Inert Gases including Helium, Neon, Argon, Krypton and Xexnon. The most common composition is derived from a mixture of Nitrogen (52%), Argon (40%), and Carbon Dioxide (8%).

A normal atmosphere contains 21% oxygen. Most combustibles will bum until the oxygen concentration has been reduced to less than 15% (4).

INERGEN, when discharged into a hazard enclosure, will reduce the oxygen concentration to about 12.5% which is well below that required to support combustion or fire. A normal atmosphere will also contain 0.03% Co2.

When INERGEN is discharged into a hazard enclosure, the concentration is increased to about 4%. The increased concentration results in increased respiration rates.

This means that a person who is in that atmosphere will breath deeper and more frequently (5). This is the basic process by which a material such as INERGEN causes extinguishment of a fire while allowing persons to breath as they egress the hazard area. Thus INERGEN functions as both an extinguishing and inerting agent.

Since INERGEN does not contain any halogen component, such as chlorine, fluorine, bromine or iodine, it has no ozone depletion potential like the existing halons.

Because of its composition, INERGEN cannot be considered a chemical toxin like the existing halons

It does not have an effect on the central nervous system nor does it sensitize the heart as do the existing halons .

INERGEN is a high pressure gas mixture and, therefore, only suitable for total flooding pre-engineered and engineered systems applications.
It is not suitable for local application either from a portable extinguisher or from an extinguishing system.

The pressure of the INERGEN gas mixture at normal temperatures is dependent only on the volume of the storage container.

If the pressure were doubled, the cylinder size could be cut in half.
INERGEN, like a, requires the use of heavy duty pipe and fittings.
At higher pressures heavier duty pipe and fittings are required.

Thank you