

Shenandoah Valley Wastewater Treatment Plant Network

PURE H₂O FORUM



Safeguarding Operations Personnel

Understanding Arc Flash &
Developing an Electrical Safety
Program

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OBJECTIVES

- Why is Electrical Safety important and what is my responsibility?
- What is arc flash?
- What happens during an arc flash event?
- What is an arc flash analysis and does our organization need one?

OBJECTIVES



- What should we require in the way of deliverables?
- How do we modify our behavior after the analysis?
- Why have an Electrical Safety Program and will it help prevent injuries?

IMPORTANCE OF ELECTRICAL SAFETY



- What should we require in the way of deliverables?
- How do we modify our behavior after the analysis?
- Why have an Electrical Safety Program and will it help prevent injuries?

ELECTRICAL SAFETY STATISTICS



- Electrocution is the 4th leading cause of death in the US industrial workplace
- 97% of electricians report having been shocked or injured on the job
 - Long term effects of shocks on human health unknown
- 80% of electrical injuries are related to arc flash incidents

ELECTRICAL SAFETY STATISTICS



- 5-10 arc explosions occur in the United States every day
- 2000 people are treated in burn trauma units every year resulting from arc flash incidents
- Someone dies from an electrical event in the United States every working day (and that includes significant improvement over the last decade)

COST OF AN ARC FLASH INCIDENT



- \$1.5M average cost of medical treatment
- 8-12 months away from work
(on average)
- \$10-12M average litigation cost for general industry incident
- Human tragedy

WHAT IS MY RESPONSIBILITY



- Position of Authority
- Set the tone for work practices
- Define the importance of safety

IMPORTANCE OF AN ELECTRICAL SAFETY PROGRAM

- The goal is to minimize risk
 - Eliminate the hazard
 - Substitute lower hazards for higher hazards
 - Implement engineering controls to limit risk
 - Raise awareness of risks and their consequences
 - Establish administrative controls to regulate work practices
 - Mandate the use of personal protective equipment (PPE) as a last resort

WHAT'S INCLUDED IN AN ELECTRICAL SAFETY PROGRAM



- Definition of the hazards that exist
- Acknowledgement of situational realities
- Tool to assess the work required
- Process to request electrical outage
- Process to request energized work permit
- Lock-out/Tag-out (LO/TO) procedures
- Description of available PPE

ARC FLASH

- Regulatory Compliance
 - OSHA – effective August 2007, regulations require that employers protect employees against arc flash hazards
 - Since 2002, NEC requires “field marking” of equipment requiring service while energized
 - NFPA 70E – industry standard for guidance on electrical safety in the workplace
 - IEEE 1584 defines a standard for calculating incident energy levels

ARC FLASH



- NFPA Definition
 - Electrical current that passes through air when insulation or isolation between electrified conductors is no longer sufficient to withstand the applied voltage

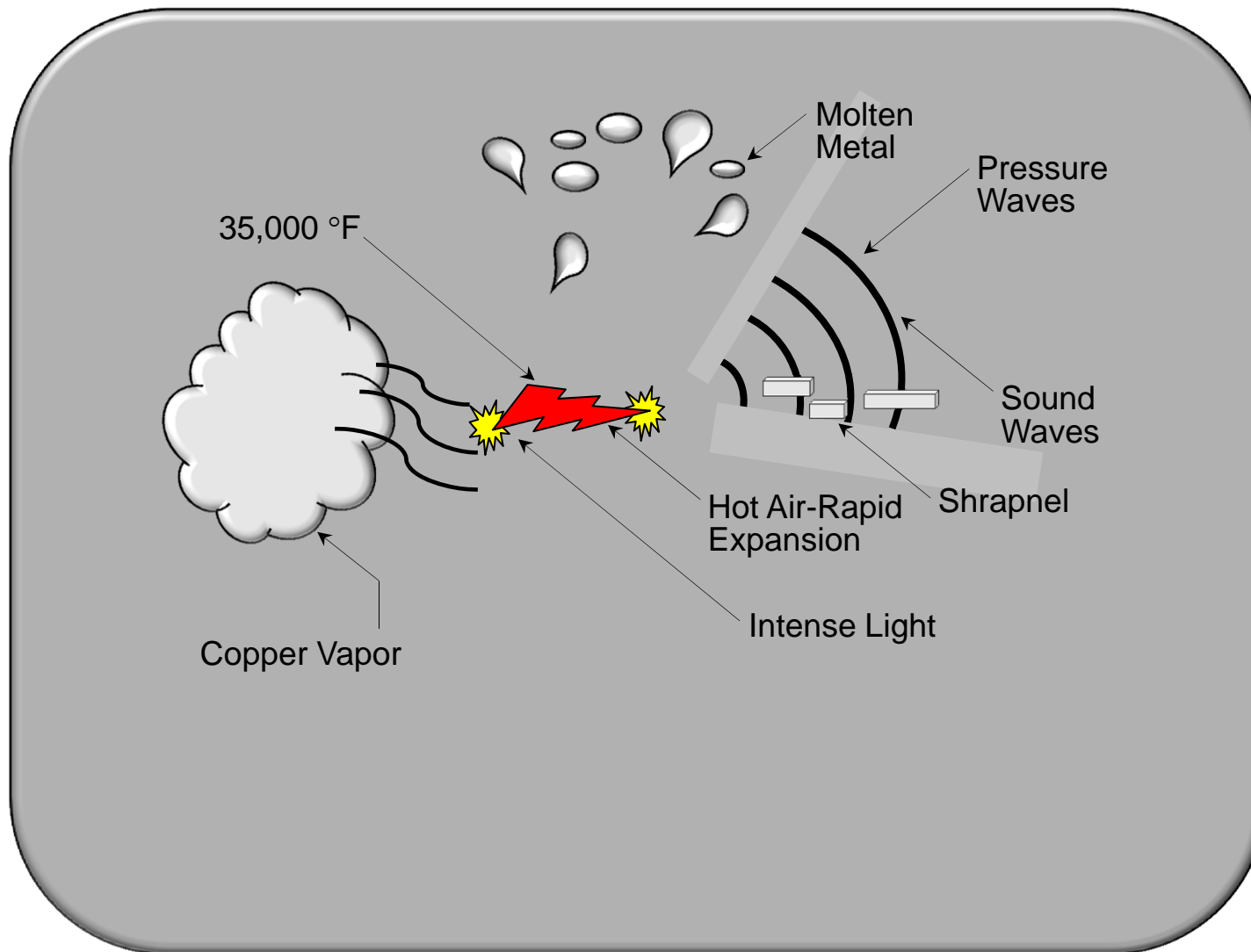
ARC FLASH

- Incident Energy
 - The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event
 - Often expressed in calories/cm², which aligns with ratings given to PPE
 - Function of short circuit current and the length of time that the current is permitted to flow

ARC FLASH



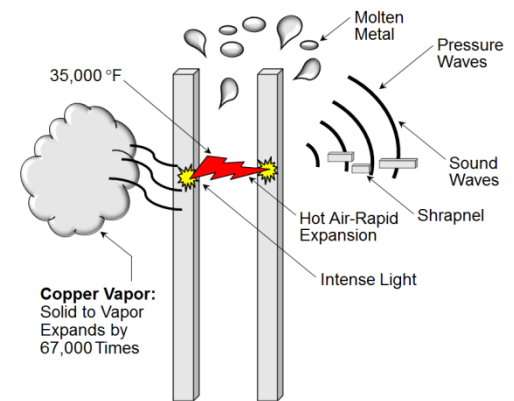
PHYSICAL IMPACTS OF ARC FLASH



NATURE OF A ELECTRICAL ARC

- Heat

- Temperature within the arc can be up to 35,000 °F (4x hotter than surface of the sun)
- Fatal burns can occur several feet from arc
- Cotton clothing can ignite several feet from arc
- Non-cotton clothing can melt into the skin several feet from arc



PPE PERFORMANCE TEST



PERSONAL PROTECTIVE EQUIPMENT

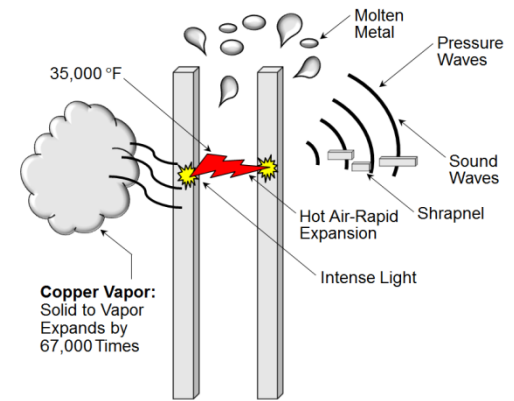
- NFPA 70E, Table H.3(b) provides guidance
 - Less than or equal to 1.2 calories/cm²
 - Greater than 1.2 to 12 calories/cm²
 - Greater than 12 calories/cm²

NATURE OF A ELECTRICAL ARC

- Light

- Intense light can cause immediate and permanent eye damage

- Intense light can cause early development of cataracts



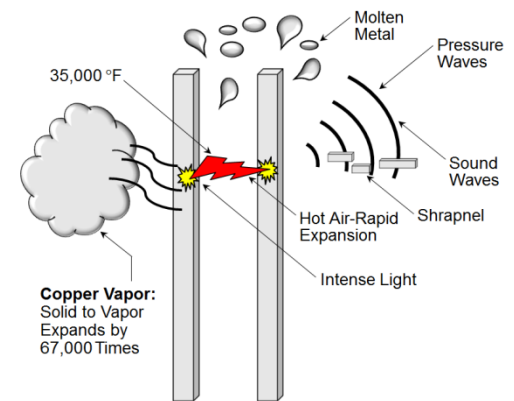
NATURE OF A ELECTRICAL ARC

- Hot Vapor Expansion

- Solid copper to copper vapor expands at a rate of 67,000/1

- Water to vapor expands at a rate of 1670/1

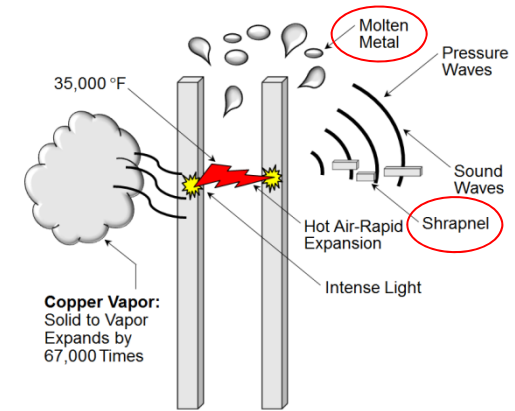
- Lung damage can readily occur



NATURE OF A ELECTRICAL ARC

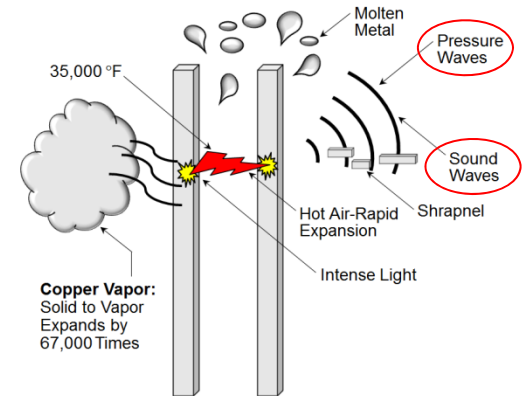
- Molten Debris

- Droplets of molten metal may be propelled several feet and lodge in clothing or skin and then solidify again
- Blast shrapnel can penetrate the body with speeds in excess of 700 mph



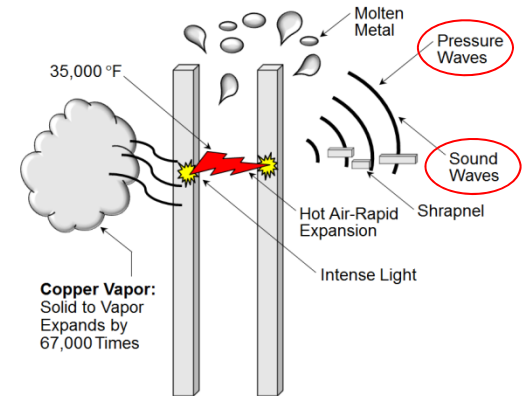
NATURE OF A ELECTRICAL ARC

- Pressure and Sound Waves
 - Blast pressure of up to 2000 lbs/ft² on a body
 - Deafening explosion



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Case Study
Will Tyree,
Lynchburg Electrician



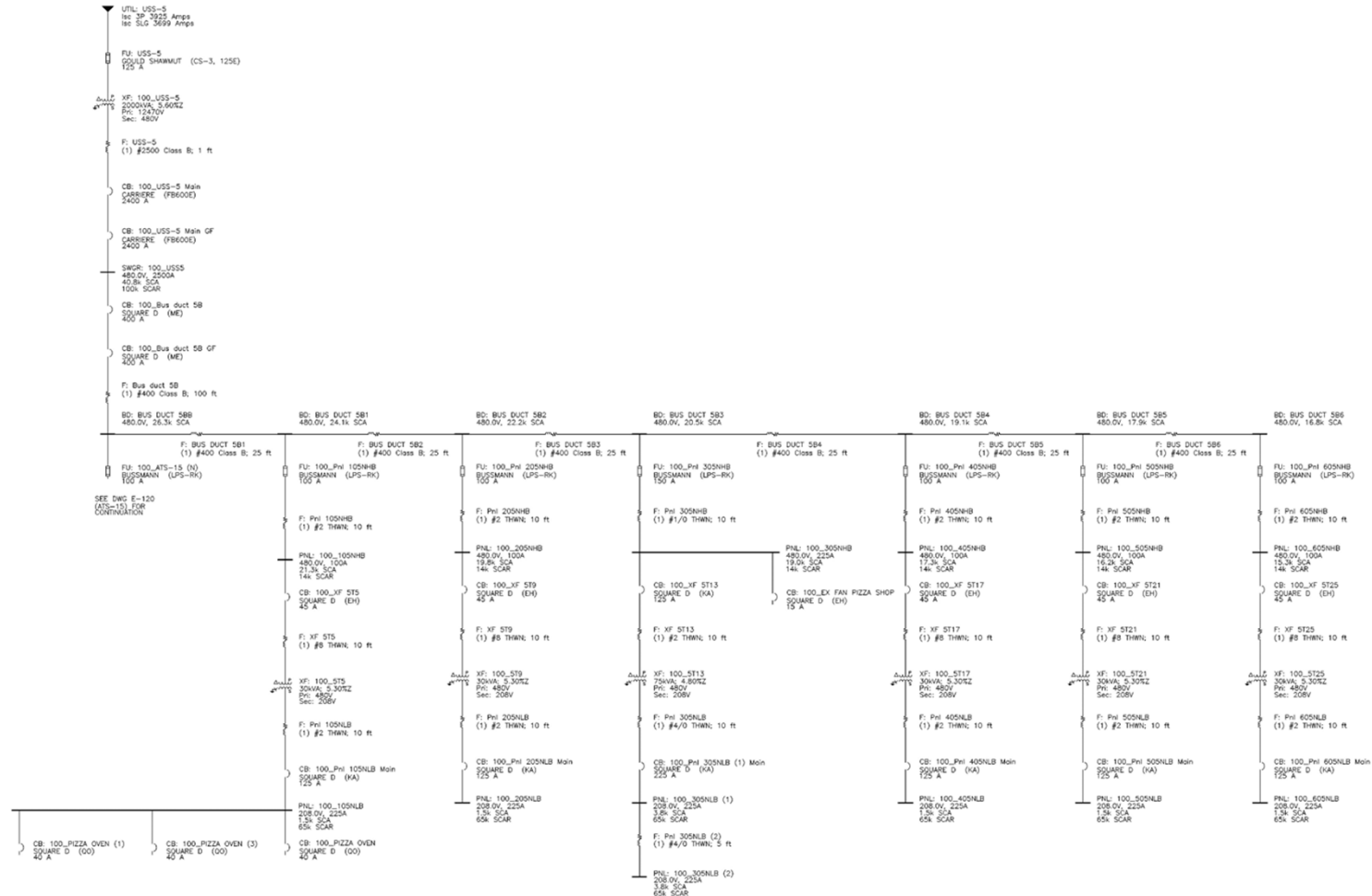
WHAT IS ARC FLASH ANALYSIS?

- Thorough and accurate data collection and system modeling
- Incident energy calculations
- Protective device coordination study
- Scope of the study should be limited only if administrative procedures are in place to restrict energized work
- Licensed professional engineer

PROTECTIVE DEVICE COORDINATION

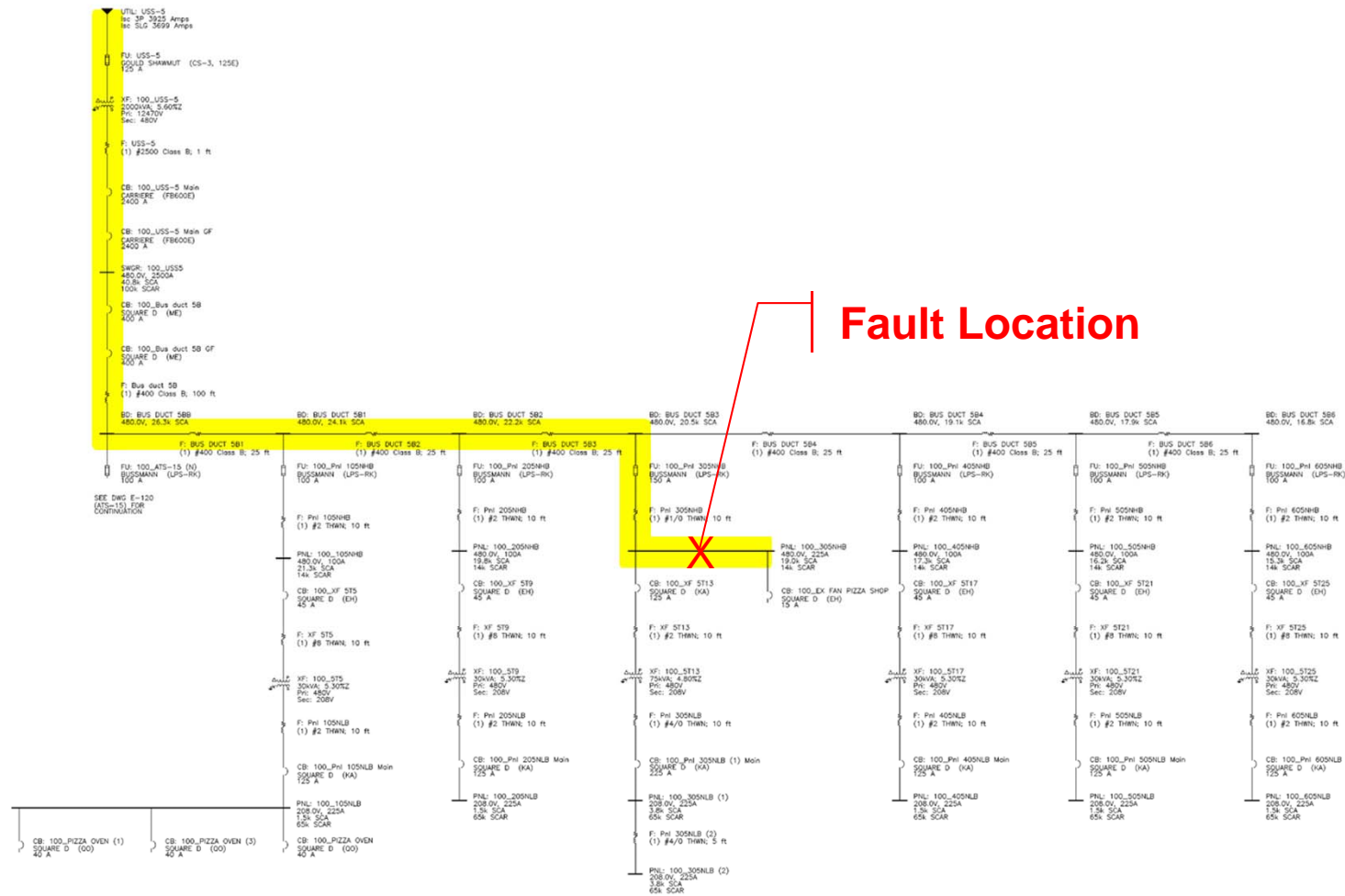
- NEC Definition
 - Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings

ONE-LINE DIAGRAM



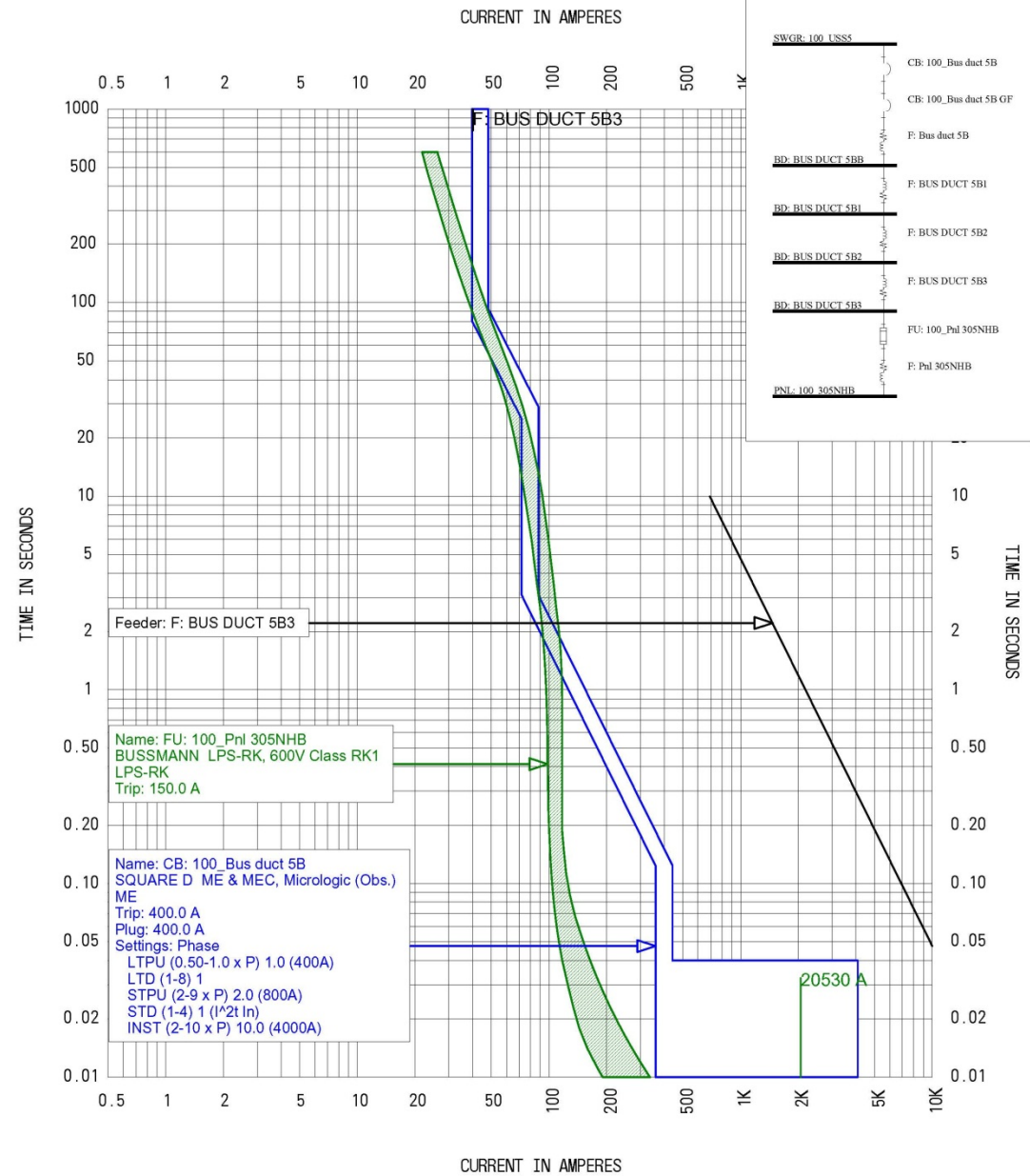
AREA F — USS-5 BUSDUCT B — ONE-LINE DIAGRAM
NO SCALE

ONE-LINE DIAGRAM



Fault Location

EXISTING CONDITIONS



TCC Name: USS5B_31_CB 100_BD 5B_FU 100_Pnl 305NHB
 July 10, 2010 1:06 PM

Reference Voltage: 480
 Current Scale x 10
 VAMC Houston (Existing)
 SKM Systems Analysis, Inc.

100



SKM Systems Analysis, Inc.

OVERCURRENT PROTECTIVE DEVICE COORDINATION

- Required by the NEC for Emergency Systems (Life Safety and Critical Branches) and for Legally Required Standby Systems (Equipment Branch)

Case Study

Fault in motor windings at hospital resulted in disruption of the critical branch for five hours



CORRELATION BETWEEN ARC FLASH HAZARD AND PROTECTIVE DEVICE COORDINATION

- System adjustments to improve coordination will sometimes have an adverse effect on incident energy

MITIGATION TECHNIQUES TO REDUCE INCIDENT ENERGY

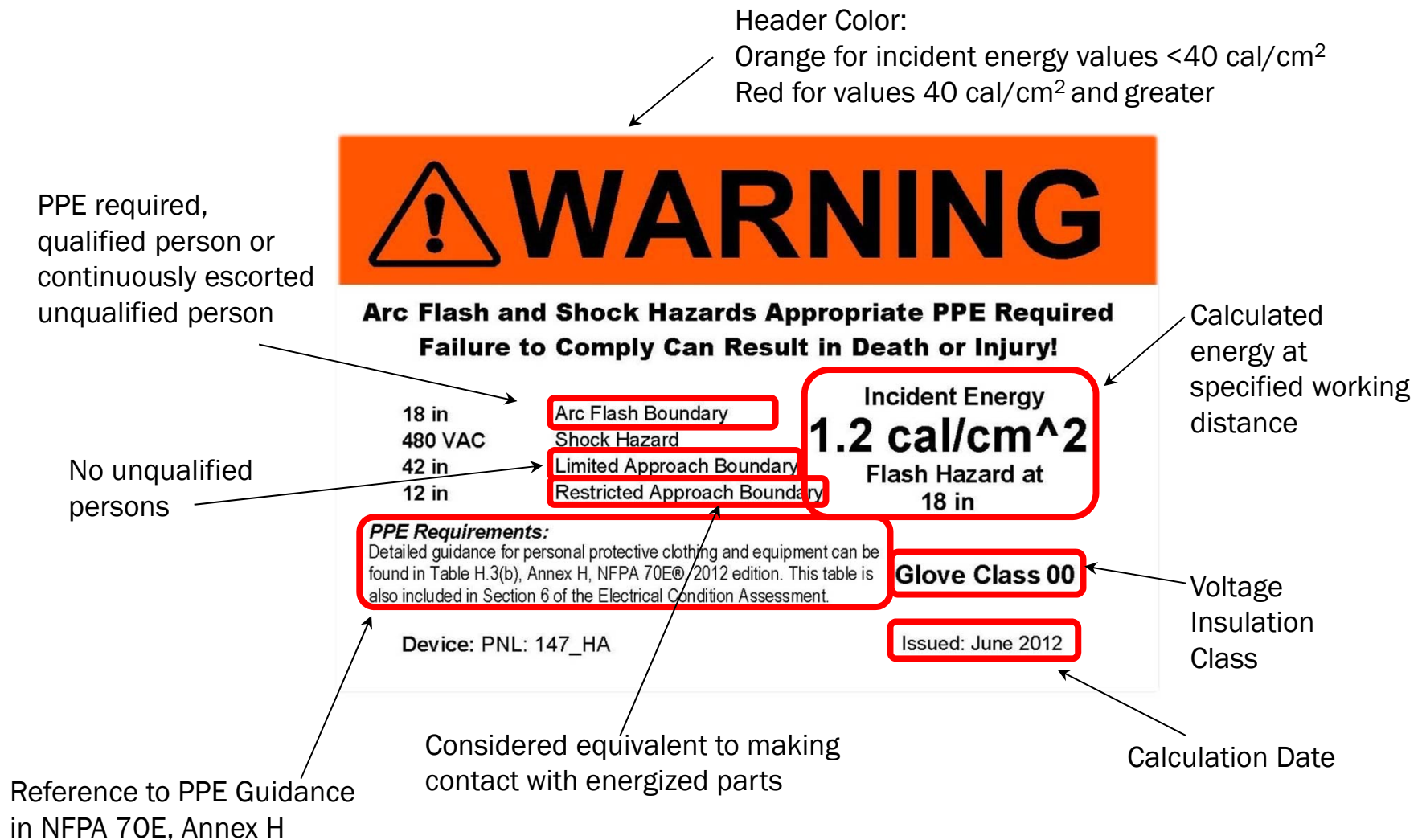
- Make use of OCPD adjustments
- Replace basic OCPDs with more adjustable types
- Reconfigure the system
 - More branches, smaller transformers
 - Remove main devices to exterior of cabinets
- Maintenance mode on OCPDs
- Zone selective interlocking
- Optical sensors

ANALYSIS DELIVERABLES



- One-line diagrams for systems studied
 - Medium-voltage distribution system
 - Low-voltage building systems
- TCC coordination sheets
- Recommendations for coordination improvement
- Arc flash incident energy calculations
- Arc flash mitigation recommendations
- Arc flash hazard labels

ARC FLASH HAZARD LABELS



FOLLOW-UP STEPS

- There is a cost of ownership associated with an Arc Flash Analysis
 - NFPA 70E requires refreshing the study when a major modification or renovation takes place, not to exceed five years
 - Requires engineer to update the study and provide new labels with each significant alteration

FOLLOW-UP STEPS

- How do we change behavior after an analysis?
- Development or Enhancement of Electrical Safety Program
 - Energized Work
 - If? When? Who has authority?
- PPE for energized work

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HOW CAN I PROTECT MYSELF,
CO-WORKERS, EMPLOYEES?



DO NOT
Work on Energized
Equipment!!!

JUSTIFICATION FOR ENERGIZED WORK

- Work on energized electrical equipment is permitted when:
 - Employer can demonstrate that deenergizing will create additional or *greater hazards*, or
 - Employer can demonstrate that the task to be performed is *infeasible* in a de-energized state due to equipment design or operational limitations, or
 - Energized conductors and parts operate at *less than 50 volts*, and there will be no increased exposure to electrical burns or arcs

INFEASIBLE VS. INCONVENIENT

- Infeasible
 - Not practical; not capable of being done or carried out
- Inconvenient
 - Inopportune; untimely; not suiting one's needs or purposes

IF ENERGIZED WORK IS NECESSARY...



- Know and abide by the requirements set forth in the NFPA 70E, including:
 - Obtain hot work permit (including justification)
 - Be a “qualified person”
 - Train, train, train!
 - Use lock-out/tag-out procedures
 - Follow your electrical safety program/procedures
 - Know the hazard and the risks
 - Wear your PPE!

QUALIFIED PERSON

- **NFPA Definition**

One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved

- **OSHA Definition**

Expands on the NFPA definition by expanding to say “demonstrated skills”

TRAINING



- Safety training
- Training on construction and operation on specific equipment
- First Responder / First Aid / CPR training
- Training must be documented

QUESTIONS

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