2001 DOE ELECTRICAL SAFETY MEETING

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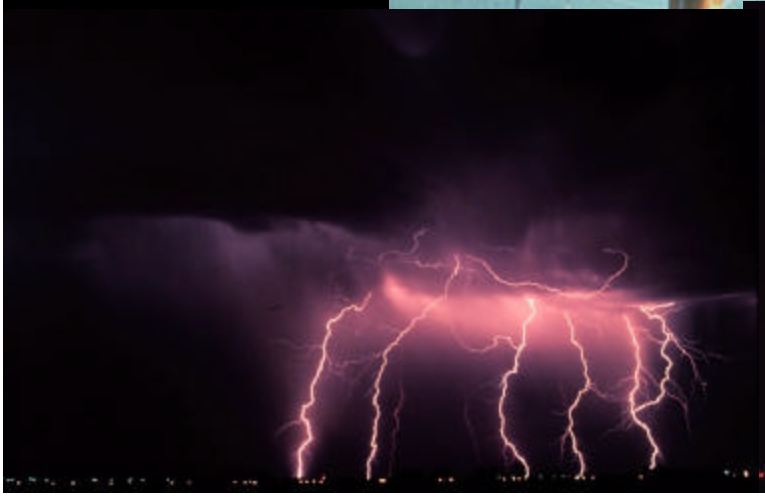


PPPL
PRINCETON PLASMA
PHYSICS LABORATORY
Welcomes
2001 DOE
Electrical Safety
Meeting
Aug. 1 & 2, 2001

Schedule for 2001 DOE Electrical Safety Meeting

Princeton Plasma Physics Lab
Lyman Spitzer Building
Mel Gotlieb Auditorium

Tuesday July 31

8 hours - NFPA 70-E Safe Work Practices (8:00 – 5:00) – Dave O'Neill

Wednesday Aug. 1

8:00 – 8:30 – Registration

8:30 – 8:45 – Welcome – DOE – Jerry Faul

8:45 – 9:00 – Welcome – PPPL Lab Director – Dr. Rob Goldston

9:00 – 10:00 – ASTM Electrical Standards Update – Allen Bingham

10:00 – 10:15 – Break

10:15 – 11:30 – The Electric Arc Hazard and NFPA 70E Protective Clothing Selection Guidelines – Dr. Thomas Neal

11:30 – 12:30 – Lunch

12:30 – 1:30 – ASTM Standards for Arc Flash - Ernie Jones

1:30 – 1:45 – Break

1:45 – 3:00 – The Burn Center at St. Barnabas – Sue D'Alessio

3:00 – 4:00 – Federal OSHA – Phil Peist

4:00 – 5:00 – Proposed Changes in the 2002 NEC – James Stallcup

Thursday Aug. 2

8:00 – 8:30 – Role of Current Limiting Fuses in Limiting Arc Energy – Vince Saporita

8:30 – 9:00 – Electrical D&D & Underground Detection –A Case History – Doug Lovette

9:00 - 10:00 – Underground Detection Update – Jerry Phillips

10:00 – 10:15 – Break

10:15 – 10:45 – Electrical Meter Update – Curt Geeting

10:45 – 11:45 – Electrical Safety in Industry – Steve Kovacs, Lanny Floyd, Bryan Drennan, Keith Gershon

11:45 – 12:45 – Lunch

12:45 – 1:15 – NFPA 70E Committee – Path Forward – Mark Earley

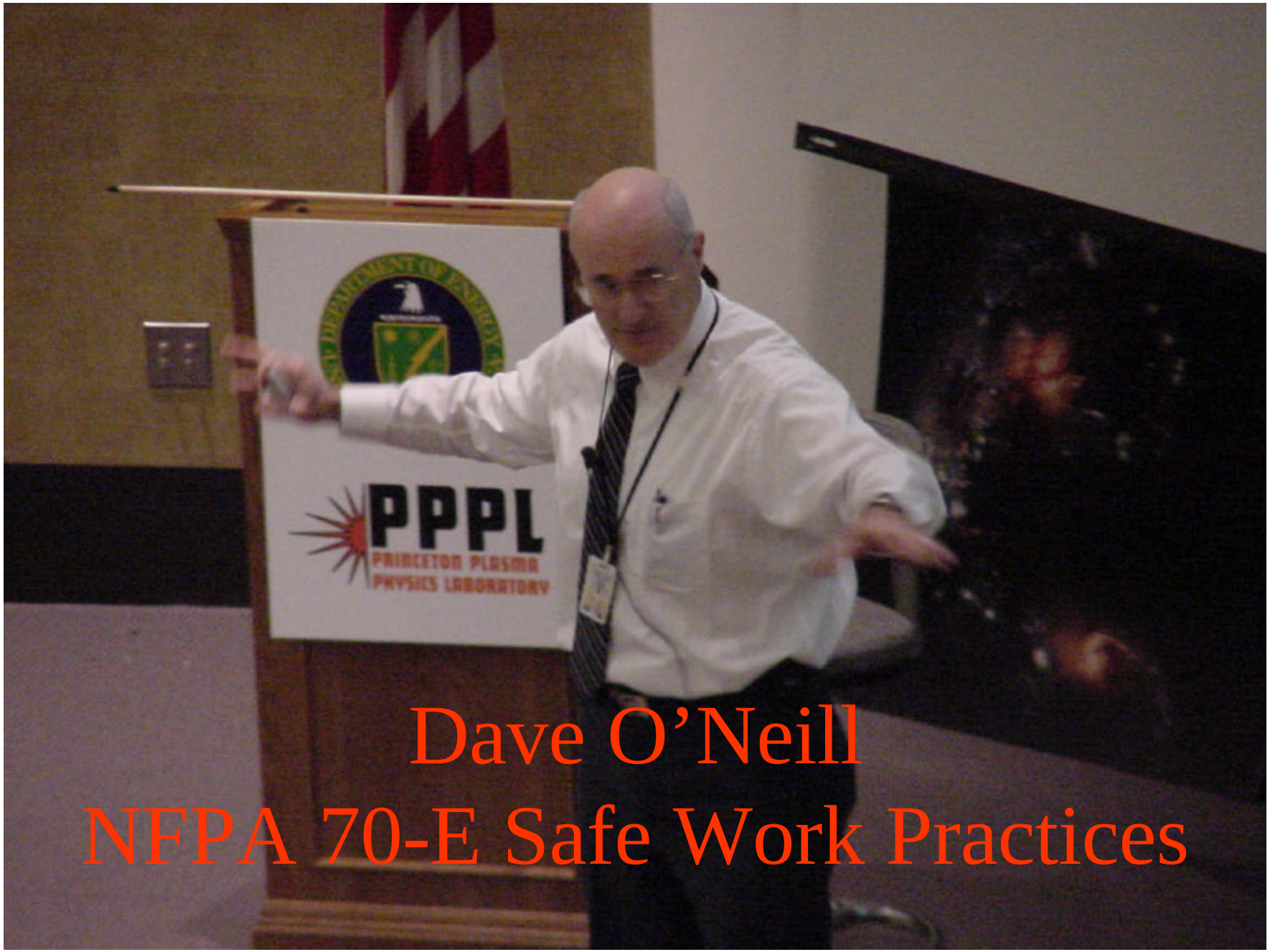
1:15 – 1:30 – Break

1:30 – 3:00 – Electrical Safety in Utilities – John Hughes, Doug Lovette

3:00 – 3:30 – Non-NRTL Equipment Inspection Training Program – Keith Gershon

3:30 - 4:30 – ISMS and Electrical Safety – Keith Schuh

4:30 – 5:00 – Closing



Dave O'Neill
NFPA 70-E Safe Work Practices

WELCOME
JERRY FAUL
DOE MANAGER
PRINCETON AREA
OFFICE

WELCOME
Dr. Rob Goldston
PPPL Laboratory
Director

John T. Conway, Chairman
A.J. Eggenberger, Vice Chairman
Joseph J. DiNunno
John E. Mansfield
Jessie Hill Roberson

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

625 Indiana Avenue, NW, Suite 700, Washington, D.C. 20004-2901
(202) 694-7000

June 21, 2001

The Honorable Spencer Abraham
Secretary of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Abraham:

In 1998, the Department of Energy (DOE) issued a handbook on *Electrical Safety* (DOE-HDBK-1092-98). The Defense Nuclear Facilities Safety Board (Board) reviewed this document before it was issued, provided constructive comments, and encouraged its use complex-wide. The Board's staff has used the guidance in this handbook as a reference for performing electrical safety reviews at several DOE nuclear sites. The handbook's Appendix A *DOE Model Electrical Safety Program* provides guidance for developing and maintaining an effective electrical safety program, and was used by the Board's staff as the template for an acceptable electrical safety program.

The staff reviews at several DOE nuclear sites noted that DOE and its contractors are not giving appropriate consideration to the guidance in DOE's *Electrical Safety* handbook. The Board urges DOE to take a proactive stance to ensure that adequate electrical safety programs are in place at every defense nuclear facility. The electrical safety programs at all DOE sites could be enhanced by evaluating each program against the guidance in DOE's *Electrical Safety* handbook and implementing appropriate upgrades. The Board also encourages DOE to continue with its planned updates to the handbook, addressing such topics as electrical safety during excavation, decontamination, and decommissioning activities.

Enclosed for your information is a report prepared by members of the Board's staff providing illustrative examples of areas where electrical safety programs are not meeting the guidance in the *Electrical Safety* handbook. The Board was particularly concerned that many sites do not have a structured program for identifying existing noncompliant and nonlisted electrical equipment. Defective or improperly installed electrical equipment not only poses an electrical safety risk to workers, but also can initiate facility fires and disable important safety equipment.

The Board wishes to be informed of DOE's progress in addressing the issues noted above.

Sincerely,

John T. Conway
Chairman

c: The Honorable Carolyn L. Huntoon
Brigadier General Thomas F. Gioconda
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

April 16, 2001

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: A. K. Gwal

SUBJECT: Department of Energy's Electrical Safety Program

This report documents a series of reviews of the electrical safety programs at the Pantex Plant, Lawrence Livermore National Laboratory (LLNL), the Y-12 National Security Complex (Y-12), and the Savannah River Site (SRS) performed by members of the staff of the Defense Nuclear Facilities Safety Board (Board) during the year 2000. The staff also monitored occurrence reports and activities related to electrical safety, including three occurrences involving electrical lines cut during excavation activities in January, February, and April 2001 (at Oak Ridge National Laboratory, Los Alamos National Laboratory, and SRS). Staff members A. Gwal, T. Davis, W. White, and C. Graham met with personnel from the Department of Energy (DOE) and the respective contractors to conduct these reviews.

Background. The DOE Handbook, *Electrical Safety* (DOE-HDBK-1092-98) presents the electrical safety standards for all DOE facilities. It provides uniform electrical safety guidance and information to help DOE facilities reduce or eliminate risks associated with the use of electrical energy. DOE also requires, through authorization bases and contractual documents that existing and new facilities comply with the provisions of Occupational Safety and Health Administration (OSHA) standards 29 Code of Federal Regulations (CFR) 1910 and 29 CFR 1926, the National Electrical Code (National Fire Protection Association [NFPA] 70), the National Electrical Safety Code (American National Standards Institute [ANSI] C2), and Electrical Safety Requirements for Employee Workplaces (NFPA 70E). These codes and standards also form the basis of the requirements for the handbook. The implementation of the guidance in the *Electrical Safety* handbook is not contractually required by DOE at the defense nuclear facilities. However, the Board's staff observed that the above facilities have utilized the handbook to some degree in developing their electrical safety procedures.

Issues. The Board's staff identified the following issues during its review of the electrical safety program at the Pantex Plant, LLNL, Y-12, and SRS.

Electrical Safety During Excavation—The staff has observed numerous examples of electrical cables/conduits being struck or cut during excavation activities at DOE sites. A search of DOE occurrence reports revealed multiple such occurrences at sites in the defense nuclear complex, including SRS, the Hanford Site, the Pantex Plant, Oak Ridge National Laboratory,

Los Alamos National Laboratory, the Rocky Flats Environmental Technology Site, and Idaho National Engineering and Environmental Laboratory.

The Board's staff believes such accidents could be minimized or avoided by the detection of underground utilities immediately before excavations are performed and by the conduct of thorough work planning. Locations of underground utilities need to be adequately identified using as-built drawings, subsurface radar, and a magnetometer. Currently, DOE Safety Notice 96-06, *Underground Utilities Detection and Excavation*, addresses electrical safety during excavation, but there are no contractual requirements for compliance. There is a need to revise the *Electrical Safety* handbook to add guidance for excavation safety and the detection of underground utilities. Indeed, DOE committed to adding a chapter on excavation safety more than 3 years ago when the handbook was issued.

At Pantex, in particular, existing detection equipment is not capable of adequately detecting the location of underground utilities. The Board's staff encouraged Pantex to evaluate alternate detection equipment (such as subsurface radar detection systems) and to adhere strictly to the recommendations of DOE Safety Notice 96-06. The staff also observed that excavation activities at Oak Ridge Y-12 require only the review of as-built drawings to determine possible interference with underground utilities prior to excavation, with optional use of detection devices before digging. The contractor at Y-12 has been encouraged by the Board's staff to require the use of appropriate detection devices as a means of reducing the incidence of accidents and power interruptions resulting from excavation activities. Existing detection equipment at SRS is capable of adequately detecting the location of underground utilities. However, because survey markers are easily moved, there is a need to establish a time limit between the survey and the initiation of work. In addition, electrical personnel should be trained to understand the limitations of detection equipment.

Authority Having Jurisdiction (AHJ)—According to the *Electrical Safety* handbook, the official designated as the electrical AHJ should have thorough knowledge of standard materials and work practices used in the installation, operation, construction, and maintenance of electrical equipment. The AHJ should, through experience or education, be knowledgeable about the requirements contained in the OSHA standards; the National Electrical Code; the National Electrical Safety Code; DOE requirements; and other appropriate local, state, and national standards. The AHJ is responsible for interpreting codes as well as regulations and standards, and for approving electrical equipment, site assembled electrical equipment, and materials.

At Pantex, the program for the contractor's electrical AHJ has not been fully implemented. Issues associated with this program include the lack of appropriate resources to fulfill AHJ responsibilities and a multiyear delay in addressing DOE's findings related to the program. The staff is concerned that the lack of an adequate AHJ function has impacted Pantex's ability to address existing electrical equipment that is nonlisted or not in compliance with NFPA 70. A preliminary review of approximately 20 facilities by Pantex personnel revealed more than 506 instances of noncompliant or nonlisted equipment. Included are such items as emergency lights, transformers, switches, heater elements, and power supplies.

In addition to increasing the electrical safety risk to workers, the failure of nonlisted equipment or equipment that has not been properly installed per NFPA 70 could have a significant impact on facility safety. The use of noncompliant or nonlisted equipment increases the risk of fire and other equipment failures. A search of DOE occurrence reports revealed more than 100 occurrences at DOE facilities since 1991, related to defective or improperly installed electrical equipment. In particular, there have been several occurrences at DOE defense nuclear facilities in which a facility fire resulted from the use of defective or improperly installed electrical equipment:

- In 1991, defective electrical equipment led to a fire at the K Reactor at SRS.
- In 1997, an electrical equipment failure led to a fire in the emergency power switchgear at Building 707 at the Rocky Flats Environmental Technology Site.
- In 1999, use of an inappropriately rated solenoid led to a fire in Zone 12 at Pantex.

Following a review by the Board's staff in March 2000, the Pantex contractor conducted a self-assessment of its electrical AHJ program. This assessment, completed in July 2000, led to several findings. These findings were addressed through corrective actions identified to DOE in August 2000. One of these corrective actions, a rewrite of the AHJ standard to focus only on the identification and acceptance of unlisted electrical equipment, was completed in January 2001. The other major corrective action, a new site standard to establish an electrical AHJ program that would follow the guidance in DOE's handbook, was issued in April 2001. The staff will review the implementation of this new site standard during the next few years. In the interim, however, there has been little progress in addressing the backlog of non-listed equipment.

During its review of the electrical safety programs at LLNL, Y-12, and SRS, the Board's staff observed that although the contractors had established an AHJ program, no structured effort had been made to identify nonlisted and noncompliant electrical equipment that failed to meet the acceptance criteria set forth in the *Electrical Safety* handbook.

Electrical Safety Committee—The *Electrical Safety* handbook recommends that each site establish an Electrical Safety Committee (ESC), as well as an AHJ interpretation of the electrical requirements of OSHA, the National Electrical Code, and other standards applicable to the site or its facilities. The ESC also interfaces with DOE, all organizations and sites, and other DOE contractors. In addition, the ESC performs the following functions:

- Presents management with the requirements and training needed to implement the electrical safety program.
- Advises management of the need to fund and support these requirements.
- Maintains and assists in the implementation of the electrical safety program.
- Develops and maintains the electrical safety manual.

- Assists the departments by interpreting the electrical requirements of DOE Orders, criteria, and guides, as well as other codes, standards, and practices.

- Maintains a copy of each interpretation given.

- Publishes electrical safety bulletins.

The Board's staff has observed that the ESCs at Pantex, Y-12, LLNL, and SRS are involved primarily in the development of procedures and portions of the safety manual and are not performing all the duties and responsibilities set forth in Appendix A of the *Electrical Safety* handbook. Weaknesses in electrical safety can potentially impact any activity or facility function, as virtually everyone is exposed to electrical hazards. The staff believes the role of the ESC at DOE sites needs to be strengthened.

Allen Bingham

ASTM Electrical Standards Update

CURRENT ASTM STANDARDS
for Personal Protective Equipment

DOE CONFERENCE - PRINCETON
AUGUST 1 & 2, 2001

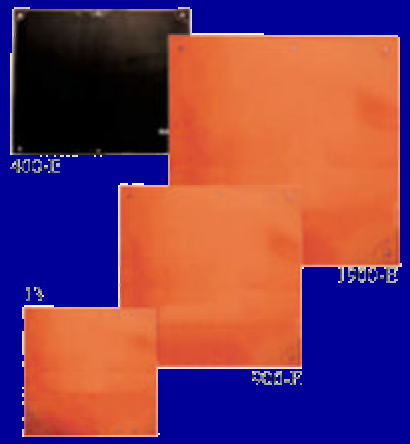
Oberon Company
abingham@mediaone.net

Presentation Goals

- What is an ASTM Standard
- Committee F18 on Electrical Protective Equipment for Workers
- Specification, In-Service Care, Test Method, and Guides

Standards for Rubber Molded Products

Rubber Insulating Blankets



D1048 Specification

This specification covers acceptance testing of rubber insulating blankets for protection of workers from accidental contact with live electrical conductors, apparatus, or circuits.

F479 In Service Care & Maintenance

This specification covers the in-service care, inspection, testing and use voltage of insulating blankets for protection from electrical shock.

Rubber Insulating Gloves

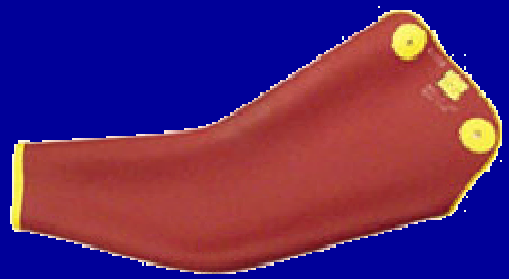
D120 Specification

This specification covers acceptance testing of rubber insulating gloves for protection of workers from electrical shock.

F496 In Service Care & Maintenance

This specification covers the in-service care, inspection, testing and use voltage of insulating gloves and sleeves for protection from electrical shock.

Rubber Insulating Sleeves



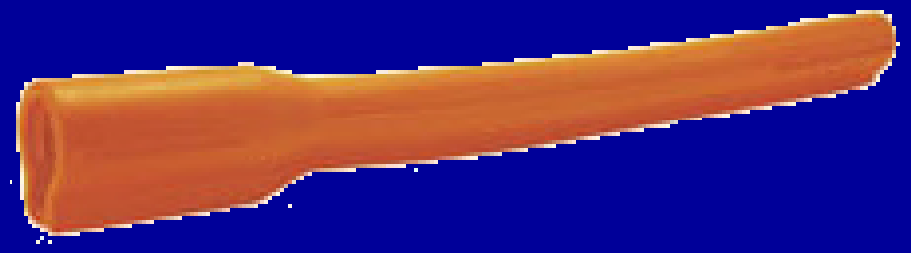
D1051 Specification

This specification covers acceptance testing of rubber insulating sleeves for protection of workers from electrical shock.

F496 In Service Care & Maintenance

This specification covers the in-service care, inspection, testing and use voltage of insulating gloves and sleeves for protection from electrical shock.

Rubber Line Hose



D1050 Specification

This specification covers acceptance testing of rubber insulating line hose for use as a portable protection device for protection of workers from accidental contact with electrical conductors.

F478 In Service Care & Maintenance

This specification covers the in-service care, inspection, testing and use voltage of insulating line hose and covers for protection from electrical shock.

Insulating Covers

D1049 Specification

This specification covers acceptance testing of rubber insulating covers for use as a portable protection device for protection of workers from accidental contact with electrical conductors, apparatus or circuits.

F478 In Service Care & Maintenance

This specification covers the in-service care, inspection, testing and use voltage of insulating line hose and covers for protection from electrical shock.

Rubber Insulating Matting

D178 Specification

This specification covers acceptance testing of rubber insulating matting for use as floor covering for protection of workers.

Dielectric Overshoe Footwear

F1117 Specification

This specification covers acceptance testing of overshoe footwear designed to provide additional isolation or insulation of workers if in accidental contact with energized electrical conductors, apparatus or circuits.

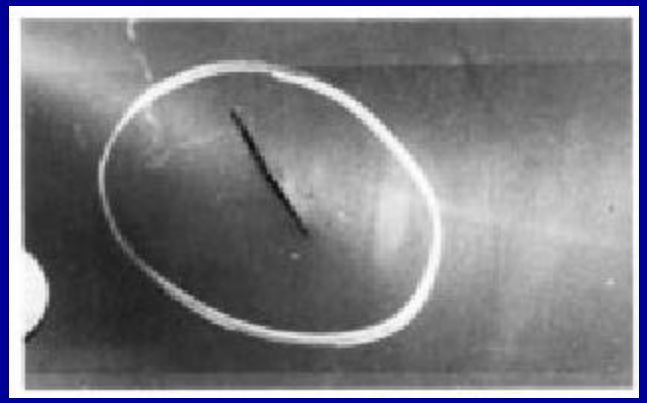
F1116 Test Method

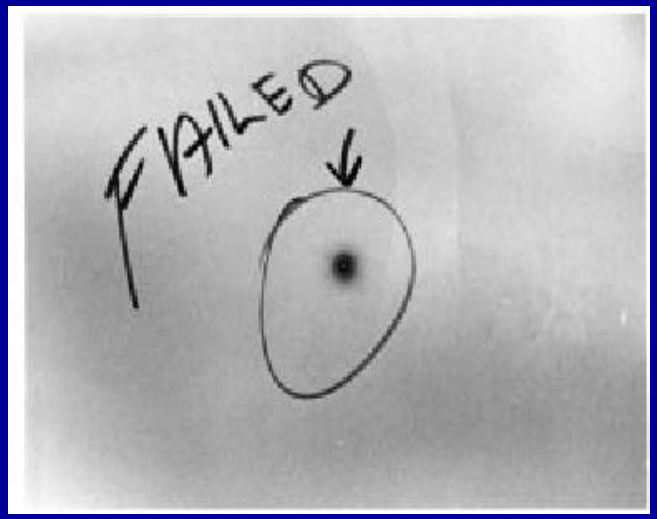
This test method covers the determination of the dielectric strength of overshoe footwear. Three procedures are provided, the use of which depends upon the portion of the footwear that is desired to test.

Guide for Visual Inspection of Rubber Molded Products

F1236 Specification

The purpose of this guide is to present methods and techniques for the visual inspection of electrical protective rubber products.





Nail Laboratories for Personal Protective Equipment Testing

SMUD	Sacramento	CA	1-916-732-5861	Mr. Doug Barns	
San Diego Gas & Electric Compan	San Diego	CA	1-619-491-5941	Doug Schliekelman	
Burlington Safety Laboratory of CA,	San Ramon	CA	1-888-817-1412	Bob Senin	
Burlington Safety Laboratory of CA,	Westminster	CA	1-800-296-2803	Rex Smith	
Utility Equipment and Testing (VET	Tampa	FL	1-800-805-9679	Mr. Ray Morrison	
Southeastern Testing Laboratory	Bishop	GA	706-769-6645	Toby Hardigree	
Skarshaug Testing Laboratory, Inc	Ames	IO	1-800-367-0480	John Miller	
Consumers Power Company	Jackson	MI	1-517-788-0668	Mr. Daniel Sitko	
Reed City Power Line Supply Com	Reed City	MI	1-616-832-2297	Brad Hilliard	
Burmeister Electric Company	Minneapolis	MN	1-612-588-0545	Mr. Dennis Gaffney	
Mid States Development, HVTL (O	Morehead	MN	1-800-742-8054	Mr. Don Schatz	
Association of Missouri Electric Co	Jefferson City	MO	573-659-3417	Mr. Rob Land	
CAR-VIR Corporation	Goldsboro	NC	1-800-672-5874	Mr. John Beachem	
American Safety Utility Corporatior	Shelby	NC	1-704-482-0601	Buddy or Andy Price	
Safety Test & Equipment Company	Shelby	NC	704-482-7346	Ms. Penny Mauney	
NPPD Protective Equipment Lab.	York	NE	1-402-362-7273	Sale Schoening	
Burlington Safety Laboratory, Inc	Burlington	NJ	1-800-220-2120	Mike Senin	
AEP Meter Laboratory	Canton	OH	1-330-580-5128	Don Franz	
Cotton Electric Services, Inc.	Walters	OK	1-580-875-3351	Mr. David Glenn	
K-TEK	Scarborough	Ontario	416-723-6433	Dace Lawrence	
Arnett Testing Laboratory	Portland	OR	1-503-684-9844	Mr. Randy Shipley	
PP&L	Hazleton	PA	1-570-3845179	Mr. John Hinkle	
Lower Colorado River Authority	Austin	TX	1-800-776-5272	Mr. Mike Cleveland	
City Public Service of San Antonio	San Antonio	TX	1-210-978-2580	Dennis Catera	

Standards for Insulating Products

Leather Protectors for Rubber Insulating Gloves and Mittens

F696 Specification

This specification covers leather protector gloves and leather protector mittens to be worn over electrical workers' rubber gloves and rubber mittens. It is intended that the gloves specified herein shall fit snugly and without undue wrinkles over rubber gloves and rubber mittens specified in Specification D 120.

Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live Line Tools

F711 Specification

This specification covers insulating rods and foam-filled tubes made from fiberglass-reinforced plastic (FRP) that are intended for use in live line tools.

Fixed Length Clampstick Type Live Line Tools

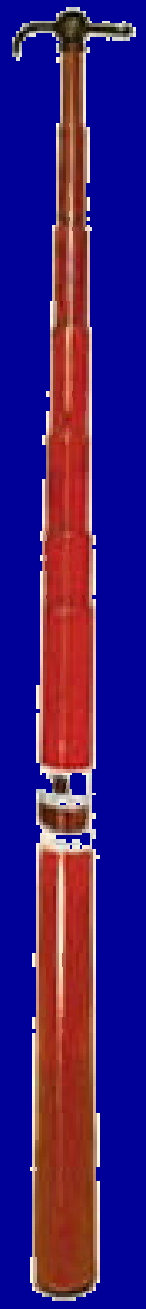
F1825 Specification

This specification applies to the Clampstick type live line tools to ensure manufacturing processes and materials are compatible and no deterioration of components occur during the assembly process.

Live Line and Measuring Telescoping Tools

F1826 Specification

This specification covers mechanical and electrical testing and acceptance criteria for telescoping live line tools.

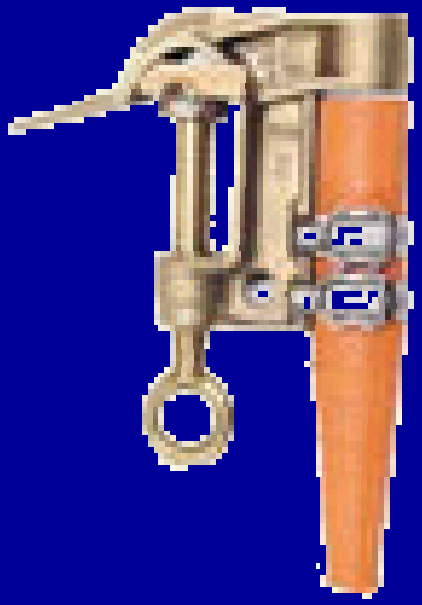


Insulated and Insulating Hand Tools

F1505 Specification

This specification covers the acceptance testing of insulated and insulating hand held tools used for working on, or in close proximity to, energized electrical apparatus or conductors operating at maximum voltage of 1000-V ac or 1500-V dc.

Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment



F855 Specification

These specifications cover the equipment making up the temporary grounding system used on de-energized electric power lines, electric supply stations, and equipment.

Personal Climbing Equipment

F887 Specification

These specifications cover acceptance testing of climbers and climber straps, body belts and positioning straps, and harnesses used by workers in the climbing of poles, trees, towers, and other structures.

Electrically Insulating Plastic Guard Equipment

F968 Specification

This specification covers plastic guard equipment and guard systems used by workers for temporary insulation on electric power circuits.

F712 Test Method

These test methods cover three electrical tests on plastic guards and assembled guard systems. They are:

- *Method A*--Withstand voltage proof test,
- *Method B*--Flashover voltage, and
- *Method C*--Leakage current.

Unused Polypropylene Rope with Special Electrical Properties

F1701 Specification

This specification covers the requirements, sizes, construction, tests, and procedures for unused polypropylene ropes for use by electrical utilities and related industries on energized lines operating at voltages higher than 1 kV.

PVC Insulating Sheeting

F1742 Specification

This specification covers acceptance testing of Poly Vinyl Chloride insulating sheeting for use as a covering for protection of workers.

High Voltage Detectors - Part 1 Capacitive Type to be Used for Voltages Exceeding 600 Volts AC

F1796 Specification

This specification covers portable, live-line tool-supported, direct-contact type capacitive voltage detectors to be used on electrical systems both indoors and outdoors for ac voltages from 600 V to 800kV with frequency of 60 Hz. The function of the voltage detector is limited to the detection of the presence or absence of nominal operating voltage.

Acoustic Emission (AE) Testing of Aerial Devices

F914 Standard Test Method for Insulated Aerial Personnel Devices

F1430 Standard Test Method for Insulated Aerial Personnel Devices with Supplemental Load Handling Attachments

F1797 Standard Test Method for Insulated Digger Derricks

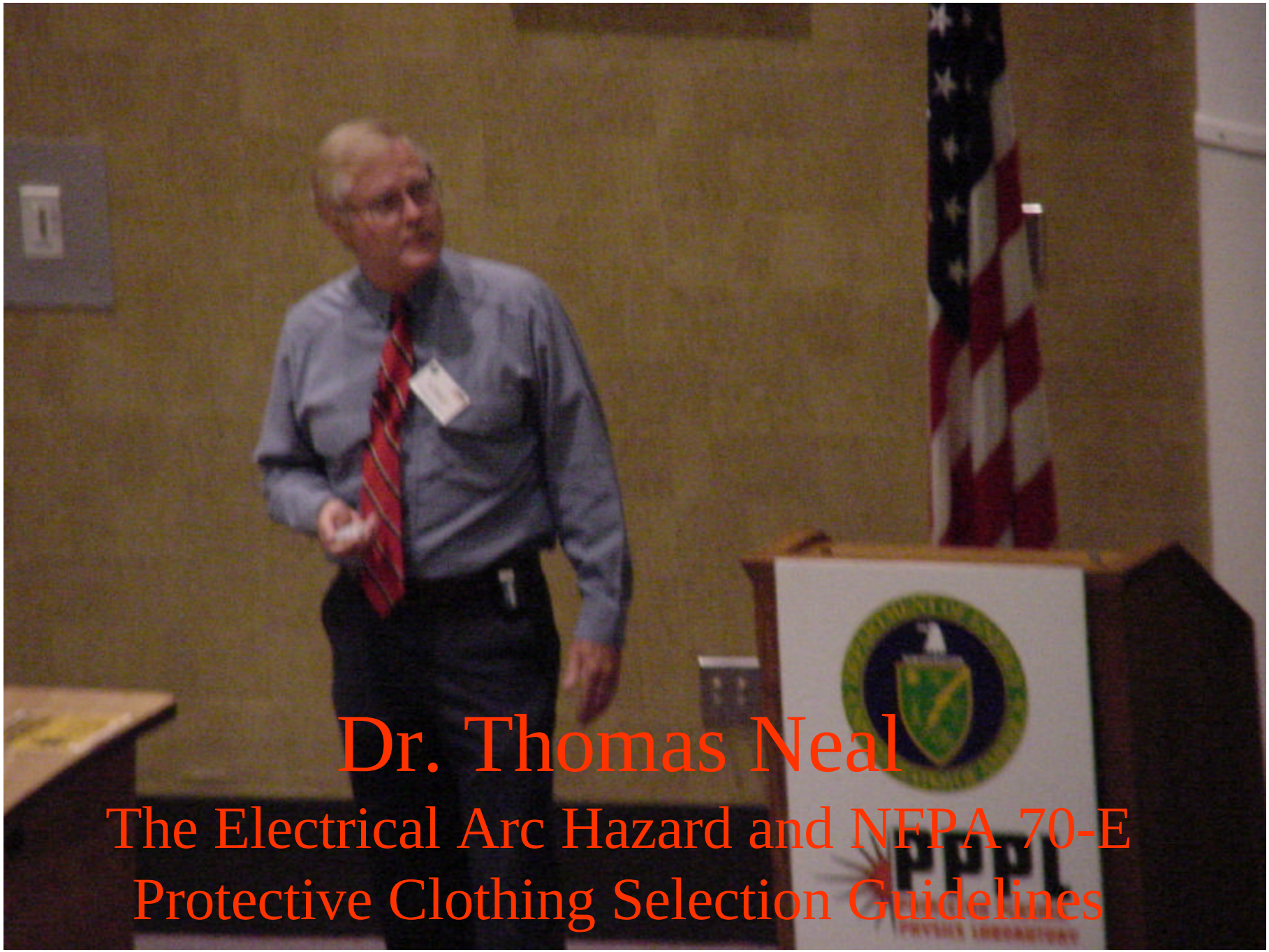
Standards Under Development

- ASTM – Specification for Jumpers
- The negatives and comments were addressed at the March meeting and a revised document will be balloted and the results discussed at the September meeting.

Additional Information

Allen H. Bingham
Oberon Company
2585 Brushy Nob Lane
Stockbridge, Georgia 30281

Phone/Fax: 770-474-4098
Toll Free: 877-623-7661
Email: abingham@mediaone.net



Dr. Thomas Neal

The Electrical Arc Hazard and NFPA 70-E Protective Clothing Selection Guidelines

THE ELECTRIC ARC HAZARD AND NFPA 70E PROTECTIVE CLOTHING SELECTION GUIDELINES

2001 DOE Electrical Safety Meeting

August 1, 2001 PPPL

Thomas E. Neal, PhD

203-458-2208 nealassociates@earthlink.net

AGENDA FOR TODAY

- WHY IS BURN INJURY A MAJOR CONCERN
- ELECTRIC ARC HAZARD FUNDAMENTALS
- USING NFPA 70E TO SELECT PROTECTIVE CLOTHING

WHY IS BURN INJURY A MAJOR CONCERN IN THE WORK PLACE?

- IN NORTH AMERICA, THERE ARE MORE THAN 7,000 BURN INJURIES IN THE WORK PLACE EACH YEAR
- THE MOST SEVERE BURNS ARE CAUSED BY IGNITED CLOTHING, NOT BY THE ORIGINAL FLASH FIRE OR ELECTRIC ARC EXPOSURE.
- *CLOTHED AREAS CAN BE BURNED MORE SEVERELY THAN EXPOSED SKIN.*

WHEN CLOTHING IGNITES

CLOTHED AREAS CAN BE BURNED MORE SEVERELY THAN EXPOSED SKIN

BURN INJURY PRINCIPLES

- BURN DEPTH IS A MEASURE OF SEVERITY
  - FIRST-DEGREE: SKIN BECOMES RED, NO BLISTER
  - SECOND-DEGREE: SKIN BLISTERS, EPIDERMIS MUST REGENERATE (~100 MICRON DEPTH)
  - THIRD-DEGREE: FULL THICKNESS DESTROYED, SKIN CANNOT REGENERATE, SCAR TISSUE FORMS (~1,000 MICRON DEPTH)

BURN INJURY PRINCIPLES

- *EXPOSURE TO AN ELECTRIC ARC CAN RAPIDLY EXCEED HUMAN TISSUE HEAT TOLERANCE AND CAUSE SECOND- OR THIRD-DEGREE BURNS*

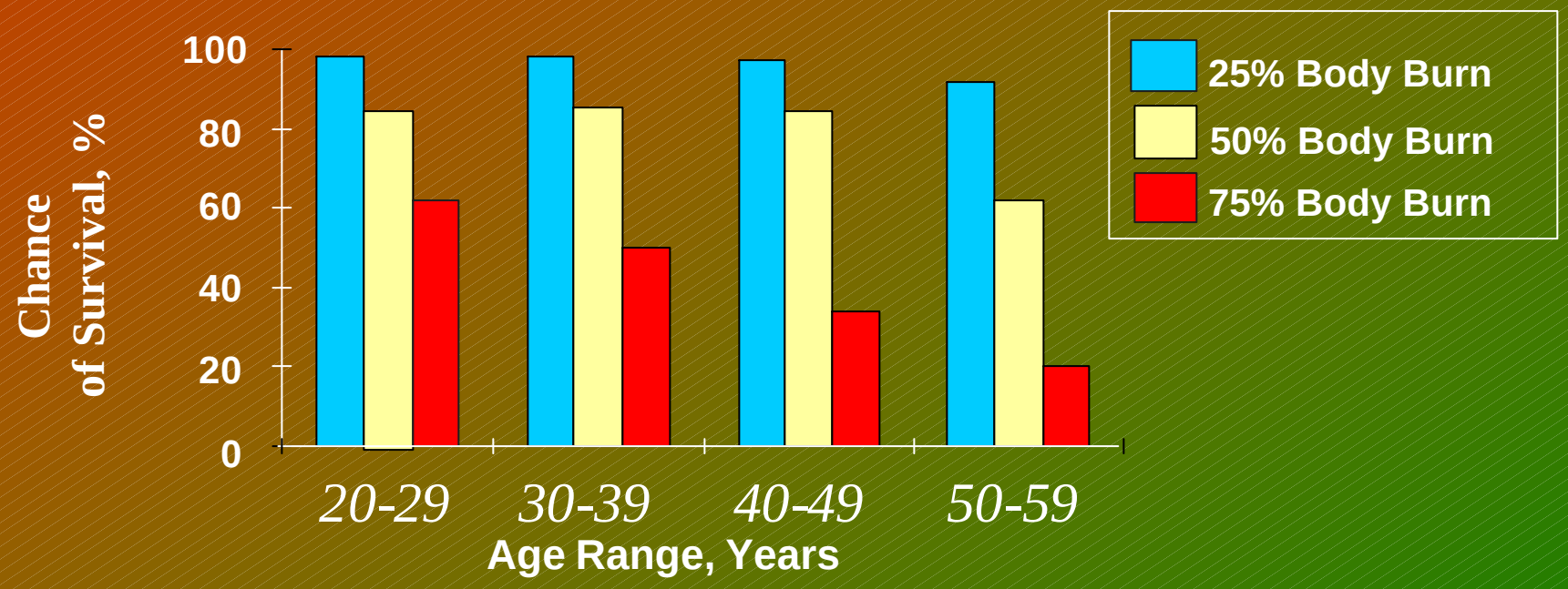
- *IGNITED CLOTHING CAN CAUSE EXTENSIVE 3RD DEGREE BURNS*
- *TREATMENT OF 2ND DEGREE BURNS REQUIRES WEEKS*
- *FOR EXTENSIVE 3RD DEGREE BURNS SKIN GRAFTING AND REHAB CAN REQUIRE YEARS*

WHY IS BURN INJURY A MAJOR CONCERN?

- ***BURN INJURIES CAN BE FATAL***
- ***SURVIVAL FROM A BURN INJURY ACCIDENT DEPENDS ON AGE, HEALTH, EXPOSURE INTENSITY AND TIME, TOTAL AREA OF THE BODY BURNED***

MOST OF THIS CAN BE KNOWN BEFORE THE ACCIDENT HAPPENS

CHANCE OF SURVIVAL FROM BURN INJURY



Source: American Burn Association (1991-1993 Study)

WHY IS BURN INJURY A MAJOR CONCERN?

- ***TREATING BURN INJURY IS VERY EXPENSIVE***
- **THE COST OF TREATMENT CAN EXCEED $1,000,000 FOR A SINGLE BURN CASE**
- **TREATMENT CAN REQUIRE YEARS OF SKIN GRAFTING AND REHAB**
- **THE BURN VICTIM MAY NEVER BE ABLE TO RETURN TO WORK**

COST OF BURN INJURY TREATMENT

DATE OF ACCIDENT	EXPENSE ITEM		TOTAL PAID	RESERVE AMOUNT
07/29/93		$	618,301.81	$ 978,928.00
FLAMMABLE	Medical	=	562,677.78	250,000.00
CLOTHINIG	Indemnity	=	52,182.14	721,437.00
	Vocational	=	2,510.36	7,438.00
	Expenses	=	931.53	0.00
07/12/94		$	217,128.98	$ 124,999.00
FLAMMABLE	Medical	=	184,572.12	124,999.00
CLOTHING	Indemnity	=	30,143.43	19,226.00
	Vocational	=	2,393.43	7,606.00
	Expenses	=	20.00	0.00
06/01/95		$	40,682.21	$ 4,564.00
FR	Medical	=	32,707.38	4,564.00
CLOTHING	Indemnity	=	6,035.28	0.00
	Vocational	=	1,903.55	0.00

WHY IS BURN INJURY A MAJOR CONCERN?

- ***FOR THE BURN VICTIM, THE PERSONAL COST IS DEVASTATING***
- **DUE TO DISFIGUREMENT AND INTENSE PAIN THE VICTIM WILL OFTEN NOT WANT TO LIVE, DEPRESSION IS COMMON**
- **CHILDREN WILL OFTEN NOT BE ABLE TO RECOGNIZE THEIR SERIOUSLY BURNED PARENT WHEN THEY VISIT IN THE HOSPITAL**
- **THE VICTIM'S SPOUSE WILL BE TRAUMATIZED, DIVORCE IS COMMON**

BUT—IT DOESN'T HAVE TO BE THIS WAY

HOW DOES FLAME RESISTANT CLOTHING PROVIDE PROTECTION ?

- DOES NOT IGNITE & BURN, MELT OR DRIP
- RESISTS BREAKOPEN
- MAINTAINS A BARRIER TO ISOLATE THE WORKER FROM THE THERMAL EXPOSURE
- TRAPS AIR BETWEEN THE WORKER AND THE BARRIER TO PROVIDE ADDITIONAL INSULATION FROM THE EXPOSURE
- *REDUCES BURN INJURY*
- *INCREASES SURVIVABILITY*
- *HELPS PRESERVE THE QUALITY OF LIFE*

ARC EXPOSURE ENERGY BASICS

- **Exposure Energy is Expressed in cal/cm^2**
- **Copper Calorimeters or Other Types of Thermal Sensors Are Used to Measure Exposure Energy**
- **1 cal/cm^2 Equals the Exposure on the tip of a finger by a Cigarette Lighter in One Second**
- ***An Exposure Energy of One or Two cal/cm^2 Will Cause a 2nd Degree Burn on Human Skin***

EXPOSURE ENERGY BASICS

- Heat Flux Is the "Flow Rate" of Energy Onto a Surface
- Exposure Energy = Heat Flux X Exposure Time
- Typical Values

	Flash Fire	Electric Arc
Heat Flux cal/cm^{2}sec	1 to 3	1 to 200
Exposure Time seconds	1 to 5	0.1 to 1
Exposure Energy cal/cm^2	2 to 10	2 to 60

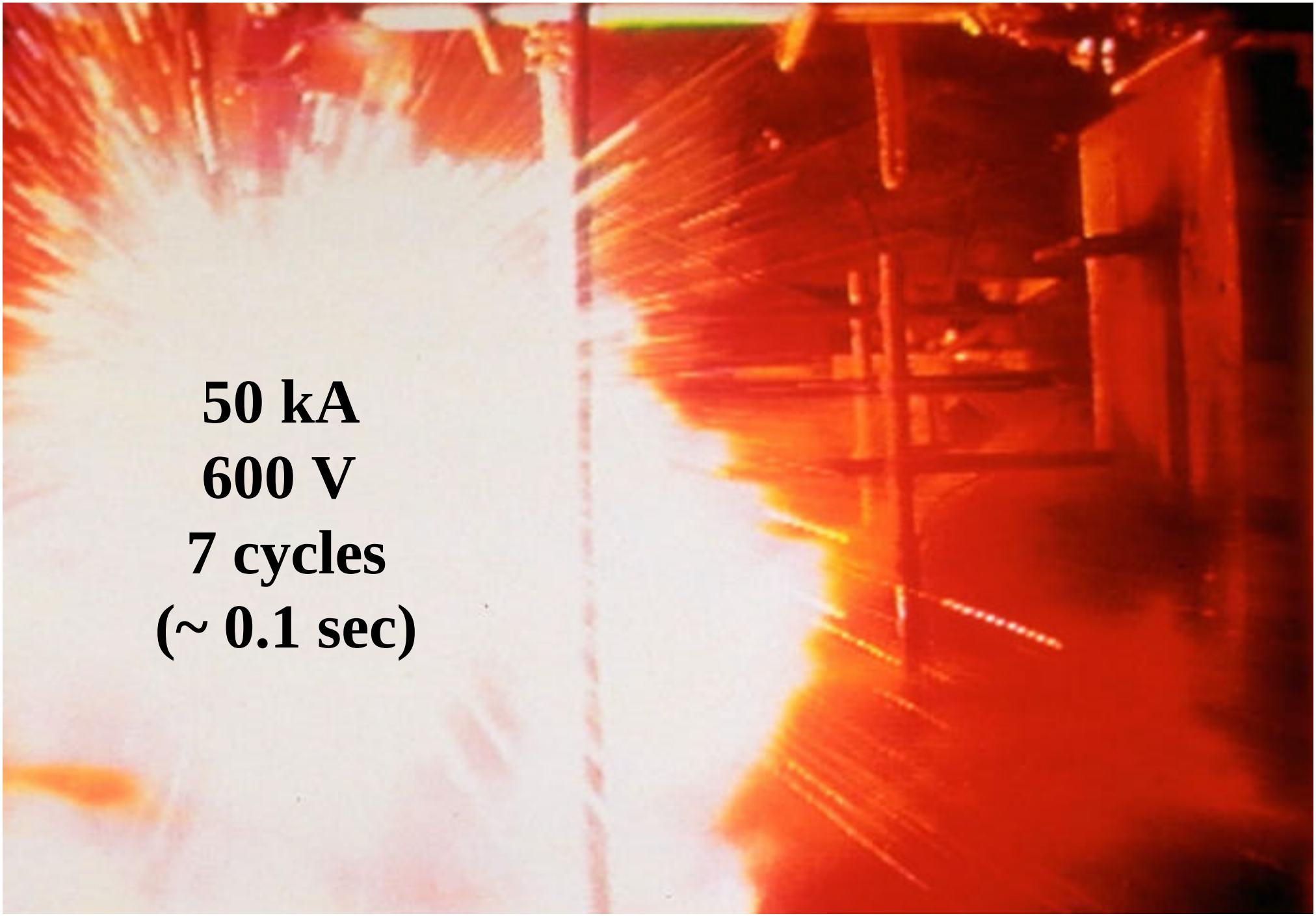
MOST EXPOSURES ARE MORE THAN SUFFICIENT TO IGNITE FLAMMABLE CLOTHING OR CAUSE BURN INJURY TO EXPOSED SKIN

EXAMPLES OF ESTIMATED TOTAL INCIDENT ENERGY OF VARIOUS HAZARD

EXPOSURE DESCRIPTION	GARMENTS OF NOMEX®IIIA	ESTIMATED EXPOSURE ENERGY, CAL/CM^2
OIL WELL-FLASH FIRE	COVERALLS	4
BRUSH FIRE	SHIRT	12
FLASHOVER IN PAINT SHOP	TURNOUT COAT	16
ARC IN VAULT	COVERALL + PANTS	35
3-PHASE 100 kA ARC IN A BOX	TWO FR COVERALLS	>60

WHAT IS AN ELECTRIC ARC?

- AN ELECTRIC ARC IS THE PASSAGE OF SUBSTANTIAL ELECTRICAL CURRENT THROUGH IONIZED AIR


50 kA
600 V
7 cycles
(~ 0.1 sec)

ELECTRIC ARC FACTS

- TYPICALLY LASTS LESS THAN A SECOND
- EXTREMELY HIGH RADIANT ENERGY
- EXPLOSIVE IN NATURE

- ***CAN IGNITE AND/OR MELT CONVENTIONAL WORK CLOTHING***

UNDERSTANDING ELECTRICAL HAZARDS

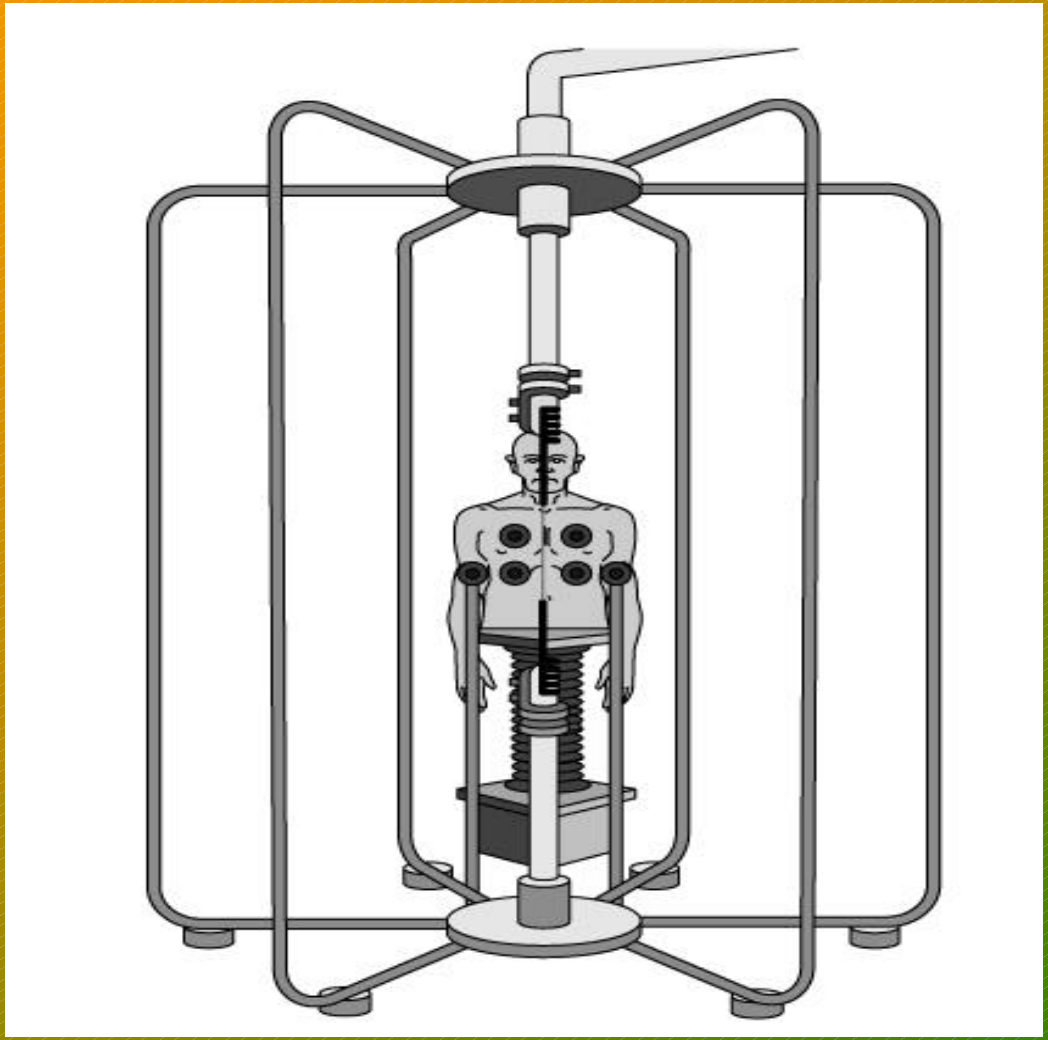
- ELECTRIC SHOCK
  - WIDELY RECOGNIZED HAZARD
  - INVOLVES CURRENT FLOW THROUGH OR ON THE BODY
  - *ELECTRIC SHOCK IS VERY IMPORTANT—BUT NOT THE SUBJECT OF THIS PRESENTATION*
- NON-CONTACT BURN INJURY FROM AN ELECTRIC ARC RADIANT HEAT ENERGY EXPOSURE
  - MORE COMMON BUT NOT AS WELL RECOGNIZED
  - *BURNS CAN BE SEVERE IF CLOTHING IGNITES*

BAD THINGS CAN HAPPEN DURING AN ELECTRIC ARC EXPOSURE

- NON-CONTACT BURN INJURY FROM ARC EXPOSURES
  - INTENSE RADIANT ENERGY
  - MOLTEN METAL SPLATTER
  - SECONDARY FIRES, E.G., TRANSFORMER OILS
- BURN INJURY DUE TO CLOTHING IGNITION AND MELTING
  - CAN INCREASE THE BODY AREA WITH 3RD DEGREE BURN INJURY
- PHYSICAL INJURIES DUE TO EXPLOSIVE FORCES
- HEARING LOSS DUE TO HIGH NOISE LEVEL

Mannequin Electric Arc Test Set-Up at the Kinectrics High Current Lab in Toronto

ASTM F 1958 Ignition Test Method



ASTM F 1958
Arc Test Method

Cotton Shirt
- **6 oz/yd²**

12 inch arc gap

Exposed surface
- **12 inches from the arc center line**

ASTM F 1958
Arc Test Method

15 kA
3 kV
10 cycles
12 inch arc gap

ASTM F 1958
Arc Test Method

Cotton Shirt Ignites

Consequences:
3rd degree burns on most of the upper torso and face

IN AN ARC EXPOSURE

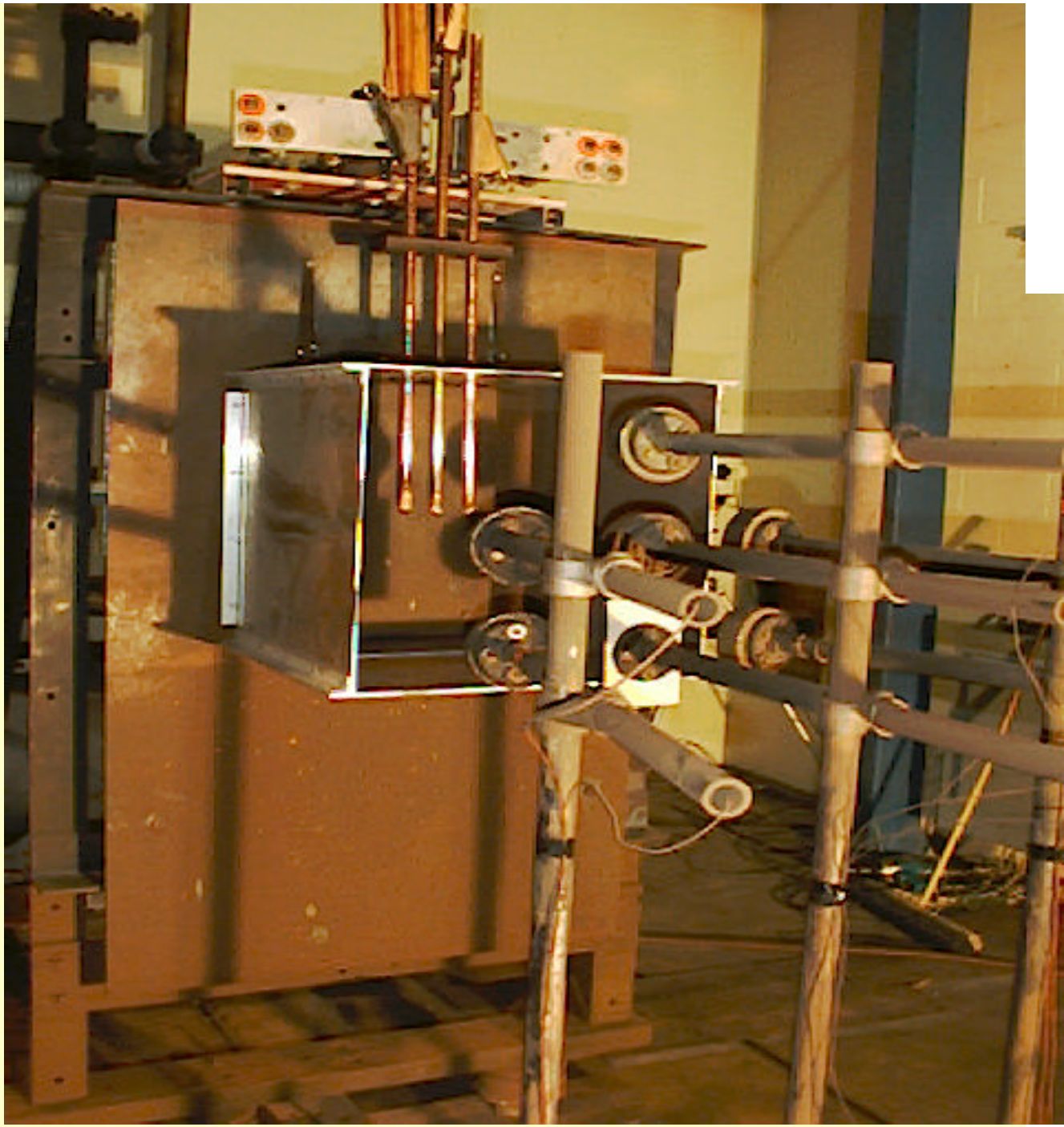
NO CLOTHING CAN BE BETTER THAN FLAMMABLE CLOTHING THAT IGNITES

WHAT ARE THE KEY VARIABLES THAT DETERMINE THE INTENSITY OF AN ELECTRIC ARC EXPOSURE?

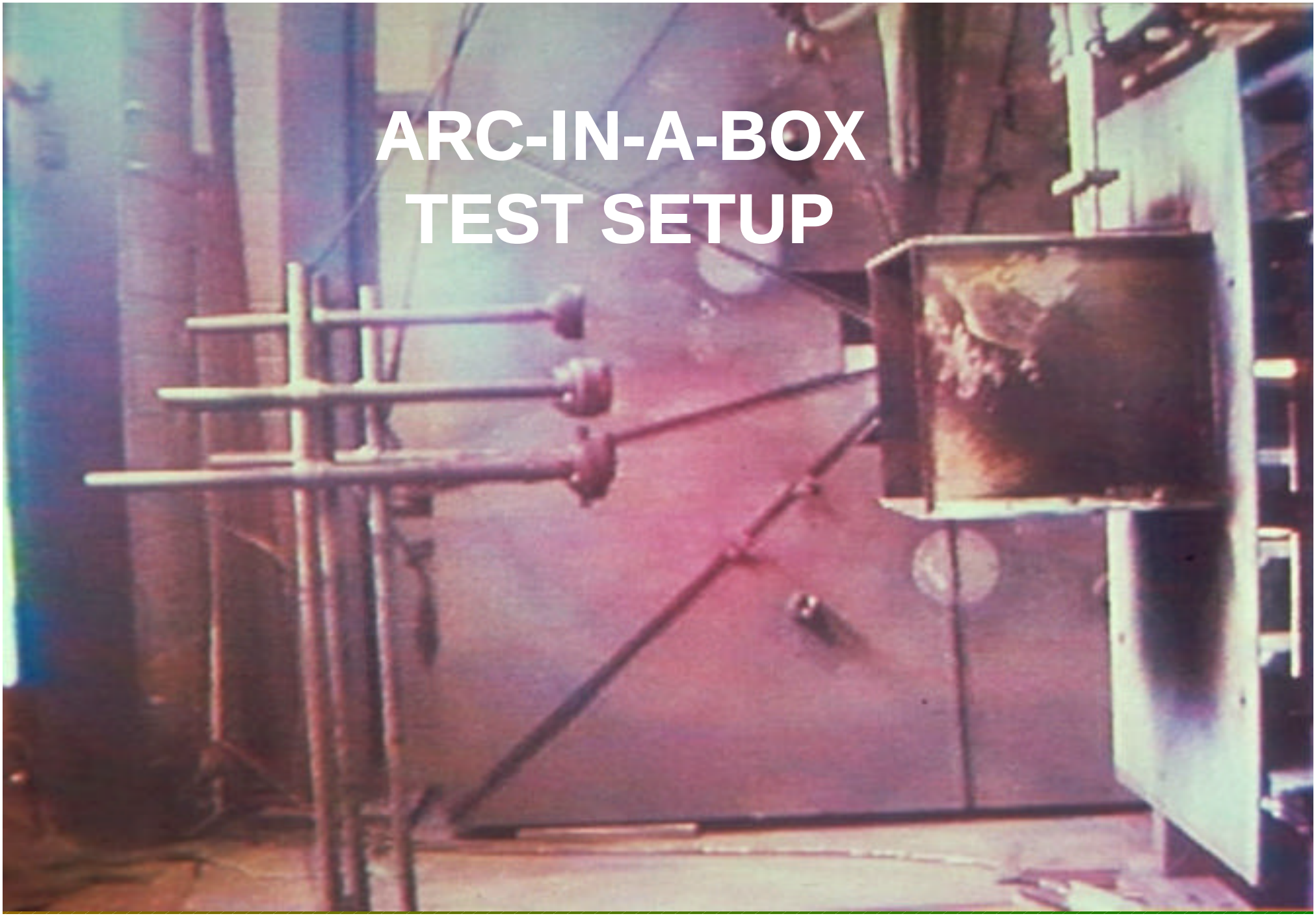
- ELECTRIC ARC FAULT CURRENT
- ELECTRODE GAP/AVAILABLE SYSTEM VOLTAGE
- ELECTRIC ARC DURATION
- NUMBER OF PHASES INVOLVED
- OPEN ARC CONFIGURATION OR ARC ENCLOSURE, E.G. ARC-IN-A-BOX
- DISTANCE FROM THE ELECTRIC ARC

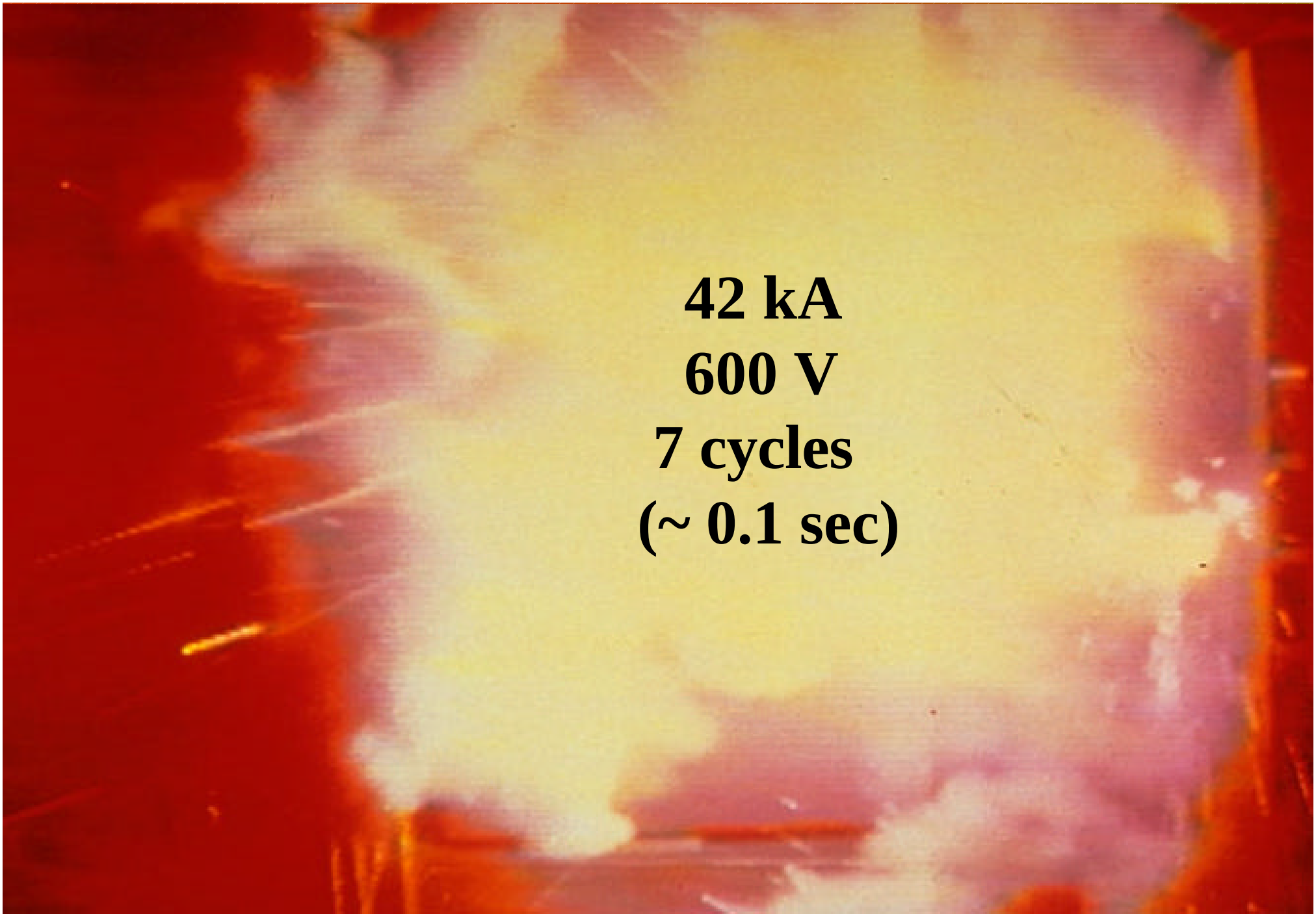
.

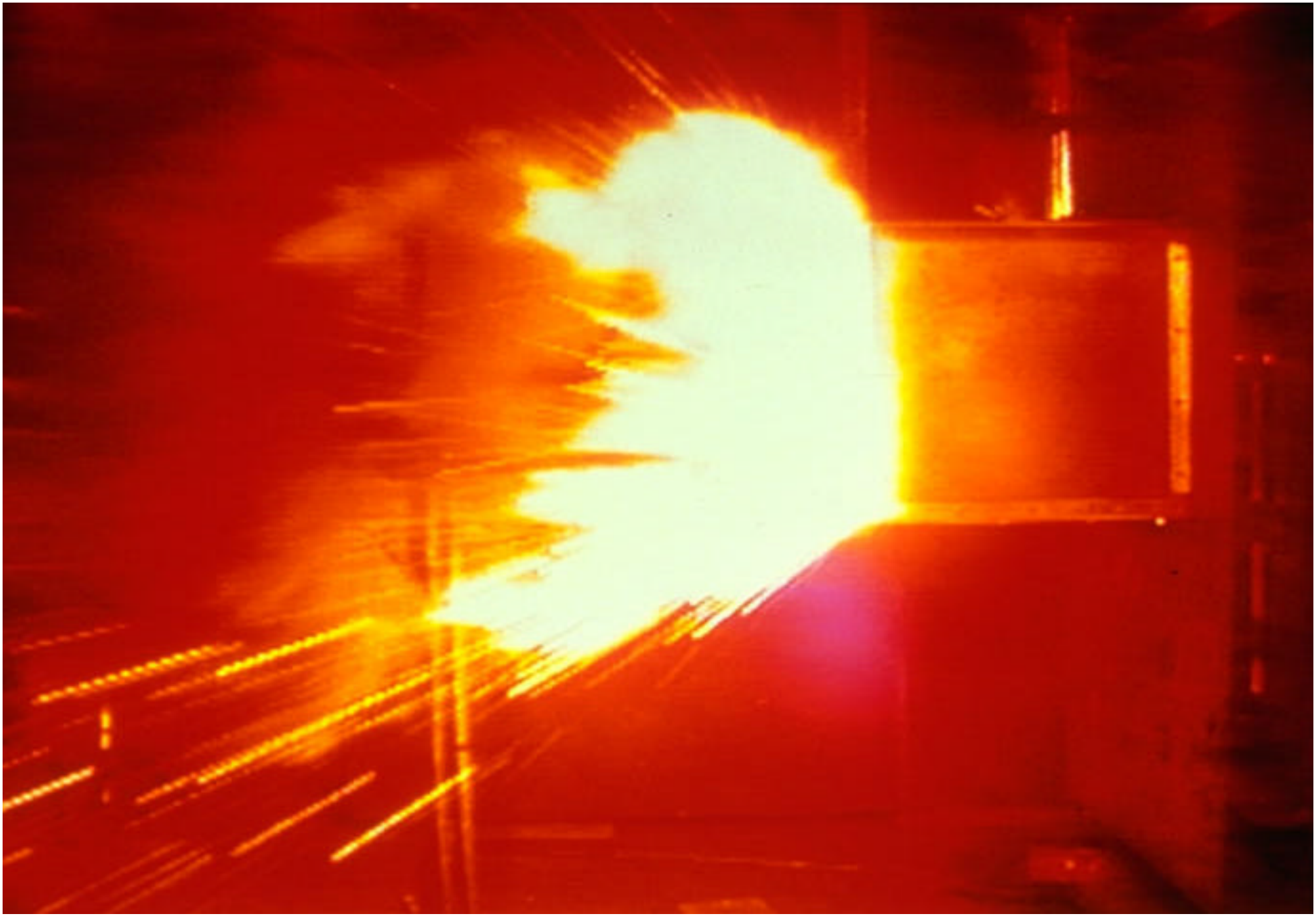
3-PHASE ARC-IN-A-BOX TEST SET UP



ARC-IN-A-BOX TEST SETUP

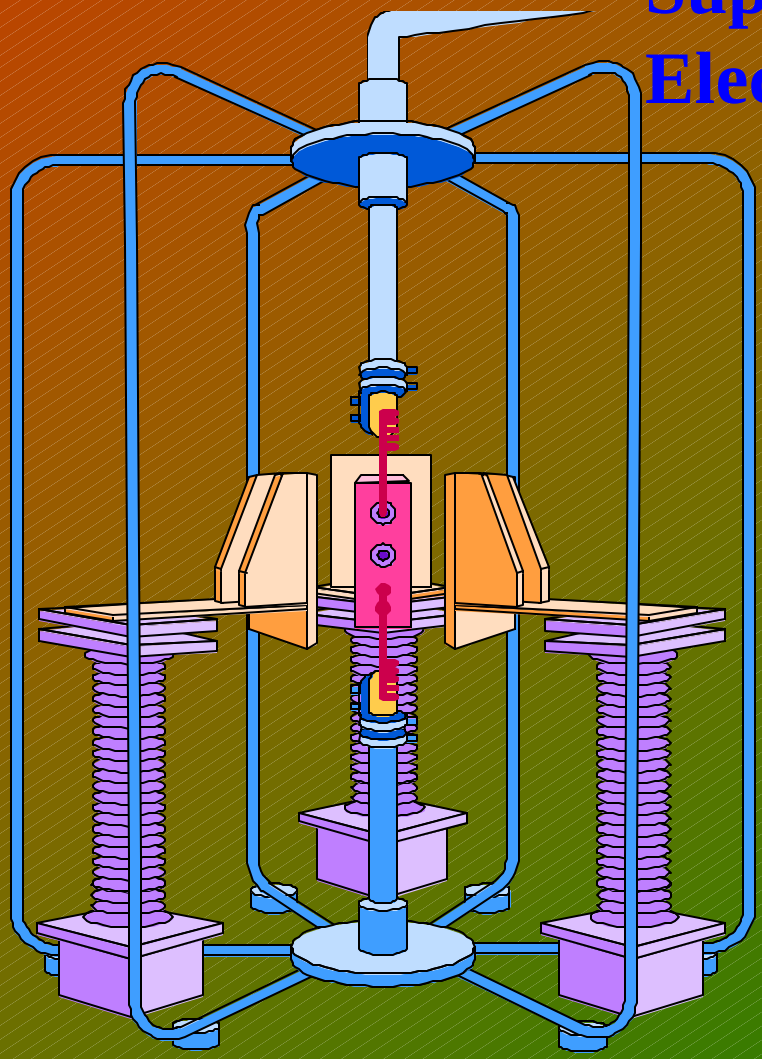



42 kA
600 V
7 cycles
(~ 0.1 sec)

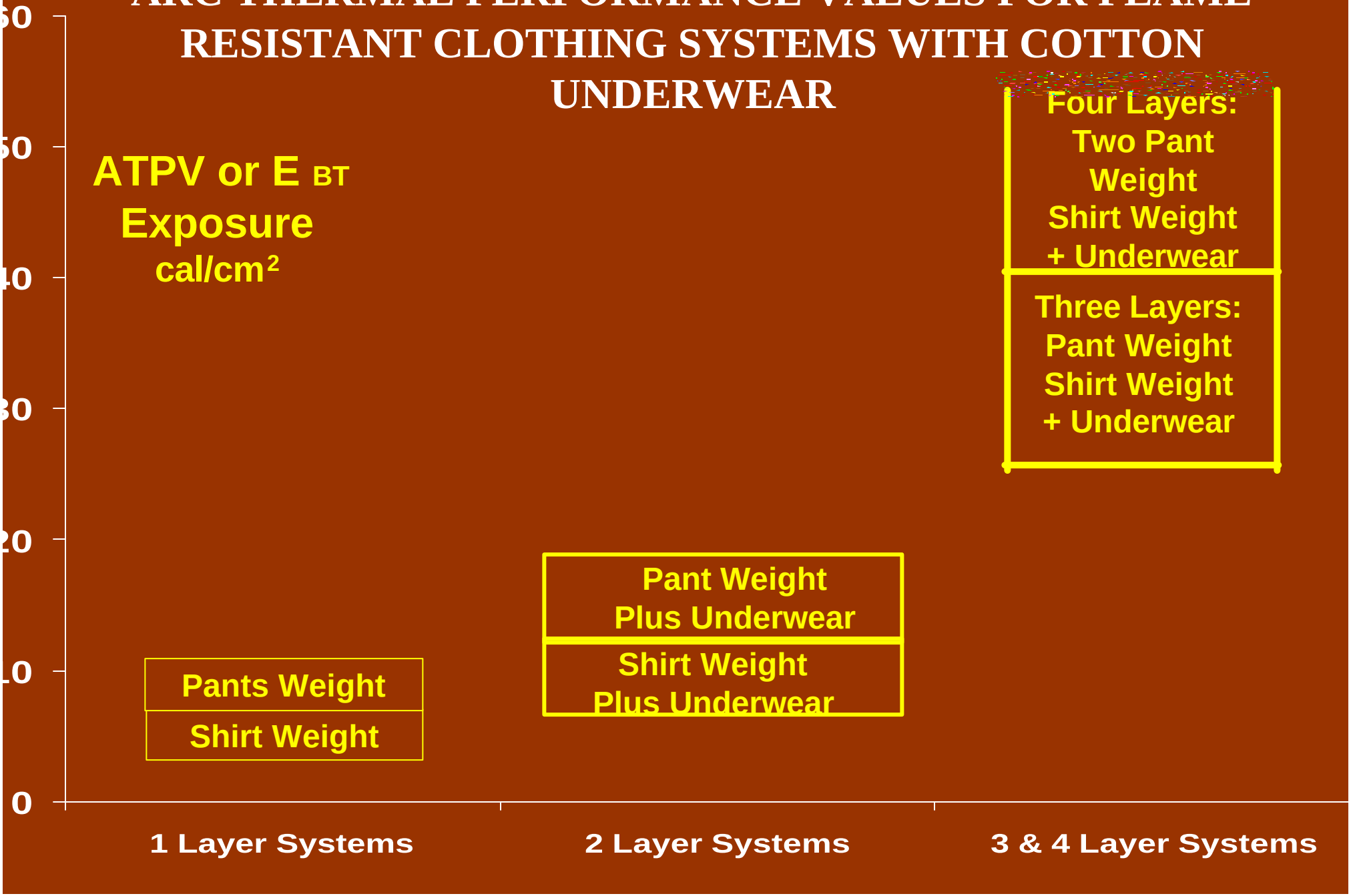


Panel Electric Arc Test at the Kinetrics High Current Lab in Toronto

ASTM F 1959
ARC TEST
METHOD
FOR
ARC THERMAL
PERFORMANCE
OF FLAME
RESISTANT
FABRICS



ARC THERMAL PERFORMANCE VALUES FOR FLAME RESISTANT CLOTHING SYSTEMS WITH COTTON UNDERWEAR



RAINWEAR FUNDAMENTALS

- TWO FUNCTIONAL COMPONENTS
  - SUPPORTING FABRIC
  - WATERPROOF PERMEABLE MEMBRANE OR COATING

- EITHER COMPONENT CAN REDUCE FLAME OR ARC RESISTANCE
  - SUPPORTING FABRIC CAN SHRINK, MELT, DRIP, IGNITE, AND/OR BREAKOPEN
  - COATING CAN MELT, DRIP OR IGNITE
  - ALL PVC, NEOPRENE OR POLYURETHANE COATINGS ARE <u>NOT</u> CREATED EQUAL

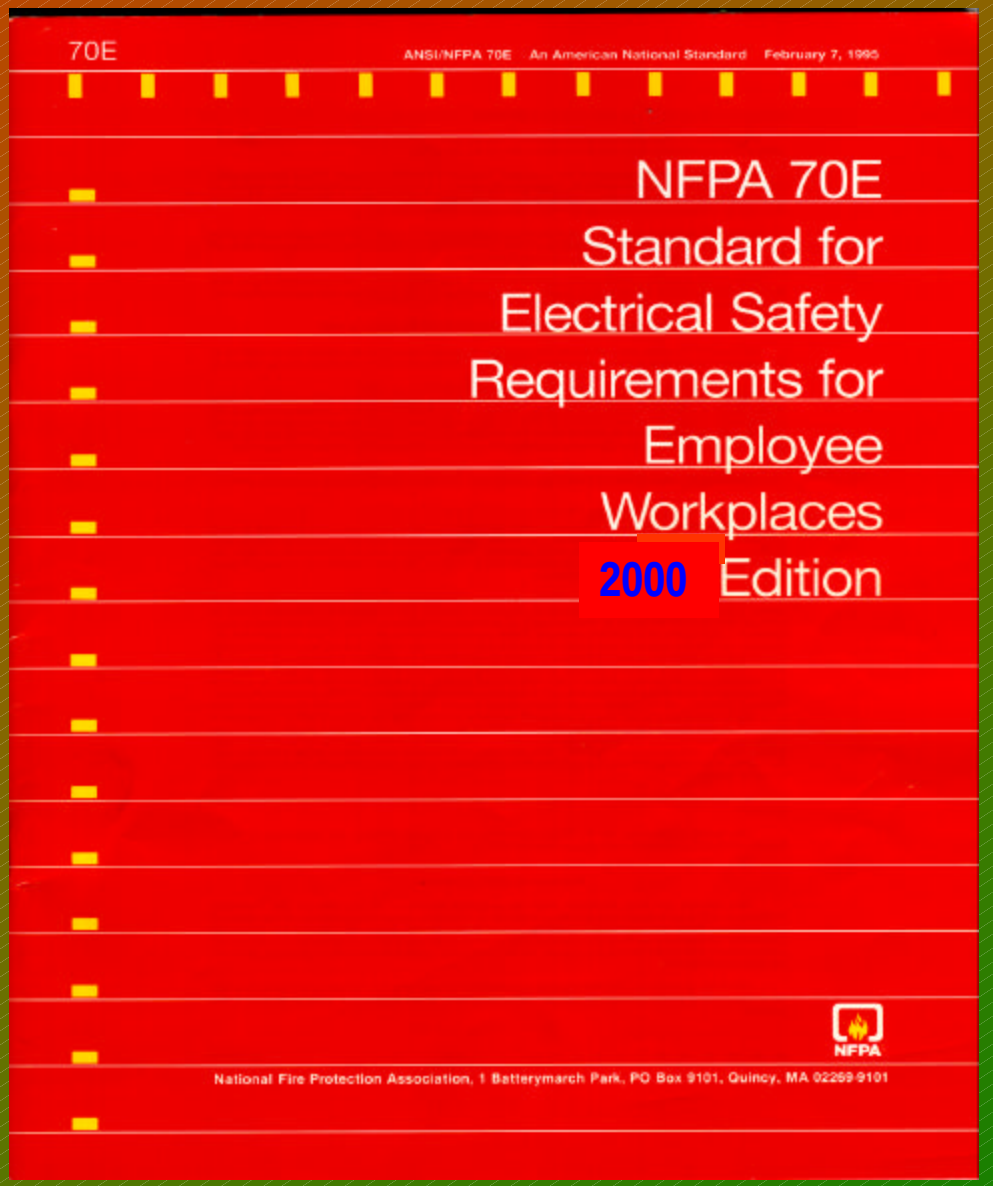
Non-Melting Substrates in FR Rainwear
Melting Substrates Can Increase Worker Injury
Melting Substrates in FR Rainwear
ASTM F1958
Arc Test Method

FR RAINWEAR STANDARDS

- ASTM F1891 STANDARD FOR FLAME RESISTANT RAINWEAR PROVIDES MINIMUM PERFORMANCE REQUIREMENTS
- ASTM F1891 WILL BE ADDED TO NFPA 70E IN THE NEXT EDITION

NFPA 70E 2000 Edition

WHAT DOES IT MEAN FOR YOU?



WHY ARE ELECTRICAL SAFETY STANDARDS LIKE NFPA 70E IMPORTANT?

DuPont Electrical Injury History

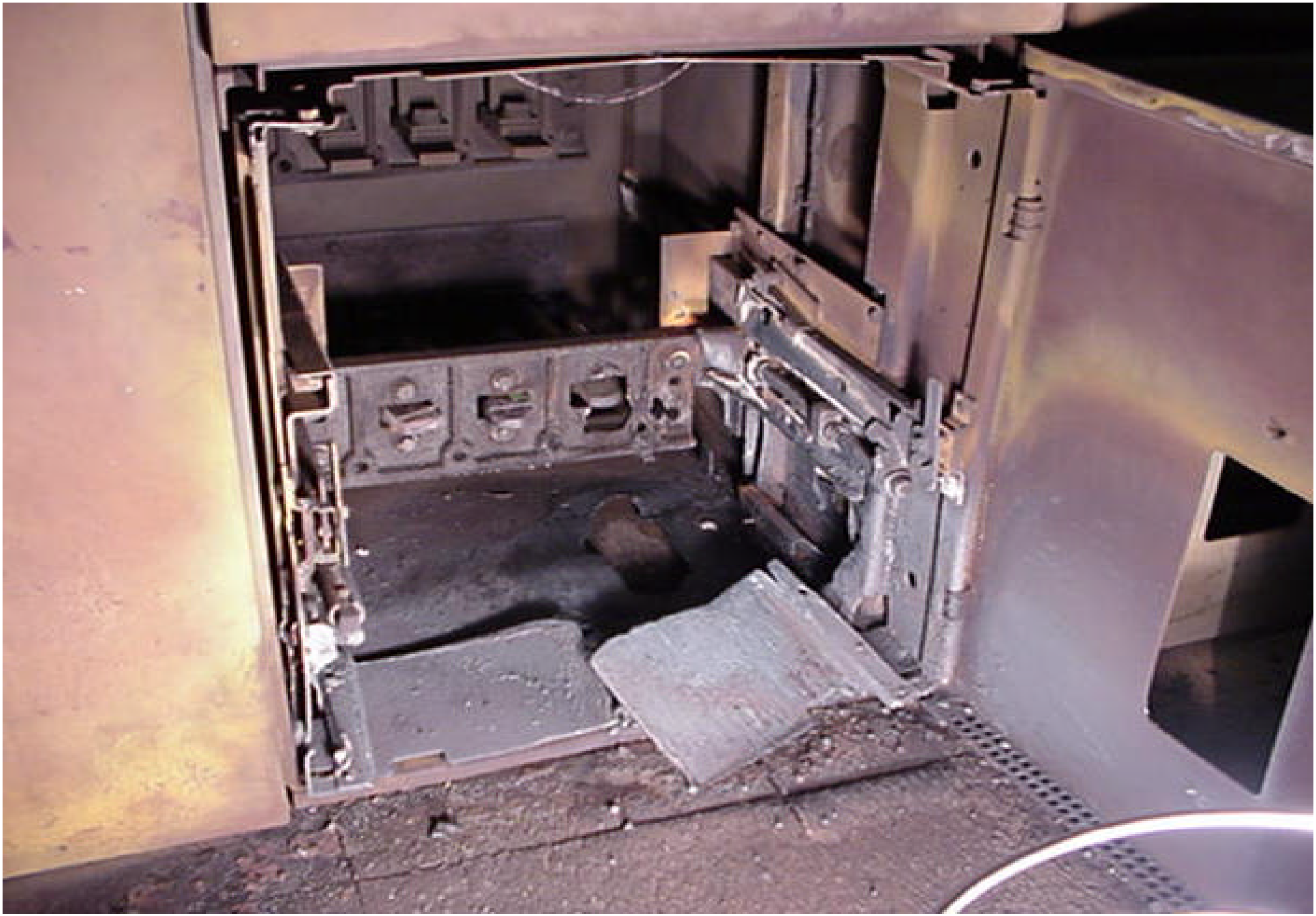
	1980s	1990s	2000s
Injuries	29	36	??
Fatalities	3	2	??

80% of the Injuries Involved No Electrical Contact

NFPA 70E BASICS

- TITLE: Standard for Electrical Safety Requirements for Employee Workplaces 2000 Edition
- Most Comprehensive Electrical Safety Std Available
- Developed Primarily by Electrical Engineers, not Electrical Workers or FR Clothing Specialist
- >100 Pages of Detailed Requirements and Information on All Aspects of Electrical Safety in the Workplace
- 23 Pages Deal with Protective Clothing
- Protective Clothing Selection is Based on Arc Hazard Analysis, i.e. Clothing is MATCHED to the Exposure Level

Bad things can happen.
An electric arc flash is a bad thing.



WHAT IS NEW IN THE NFPA 70E - 2000 EDITION WITH REGARD TO PROTECTION?

- HAZARD ANALYSIS—ESTIMATING THE EXPOSURE ENERGY THAT A WORKER WOULD RECEIVE IF THERE WERE AN ARC FLASH ACCIDENT DURING A SPECIFIC ELECTRICAL TASK
- MATCHING THE PROTECTIVE CLOTHING AND EQUIPMENT THAT A WORKER UTILIZES TO THIS ESTIMATED EXPOSURE ENERGY
- NOTE: THIS DOESN'T MEAN THAT ALL INJURIES WILL BE PREVENTED IN AN ARC FLASH ACCIDENT, BUT THIS APPROACH CAN MINIMIZE INJURIES

.

HOW DO WE NAVIGATE NFPA 70E TO SELECT THE REQUIRED PROTECTIVE CLOTHING?

- First, Identify the "Electrical Resource" for the Site—Remember, 70E Was Developed by Electrical Engineers
- Work with the Electrical Resource on Digesting Pages 48 to 62 & 67 to 75 Which Deal with Protective Clothing
- Focus on Electrical Tasks and Other Types of Work Where there May be an Electric Arc Hazard
- Select One of the Three Approaches Provided by 70E for Electric Arc Hazard Analysis and Protective Clothing Selection
- Group the Tasks by the Electric Arc Hazards Levels
- Match the Arc Hazard Level for Each Group of Tasks to the Appropriate Protective Clothing and Equipment

THE NFPA 70E FLASH PROTECTION BOUNDARY WHERE WORKERS NEED PROTECTIVE CLOTHING

- The "Flash Protection Boundary is a zone surrounding an exposed, energized part, i.e. a place where an electric arc accident could occur. Inside this zone, unprotected skin would be expected to receive at least a 2nd degree burn, and outside this zone unprotected skin would NOT be expected to receive a 2nd degree burn.
- The electrical resource can calculate the "Flash Protection Boundary" for each type of task
- Workers Who Need to be Inside the "Flash Protection Boundary", Will Need 70E Compliant Protective Clothing. (Pt II Section 2-1.3.3.2 of NFPA 70E, Pg 50)
- Workers NOT wearing 70E Compliant Protective Clothing Need to Stay Outside of the "Flash Protection Boundary"
.

EXAMPLES OF THE 70E FLASH PROTECTION BOUNDARY

- For a Hazard Involving 600 Volts or Less Where the Fault Current does not exceed 50kA and the Clearing Time does not Exceed 6 cycles, i.e. not more than a 300 "kA x cycle" product, the "Flash Protection Boundary" is 4 feet from any exposed, energized part (2-1.3.3.1)
- Above 600 Volts, the "Flash Protection Boundary" is set by Determining Where Unprotected Skin would Receive a 2nd Degree Burn. The electrical resource will use the electrical parameters for each specific hazard to do this calculation. Generally this would be a greater distance than four feet

.

EXAMPLES OF THE 70E FLASH PROTECTION BOUNDARY

- For a Hazard Involving 600 Volts or Less Where the Fault Current does not exceed 50kA and the Clearing Time does not Exceed 6 cycles, i.e. not more than a 300 "kA x cycle" product, the "Flash Protection Boundary" is 4 feet from any exposed, energized part (2-1.3.3.1)

- At 600 Volts or less, the flash protection boundary can also be calculated, e.g. for 480 Volts, 25kA and 8 cycles:

$$DC = [\ 2.65 \times MVABF \times t\ ]^{0.5}$$

Dc = Distance for burn on unprotected skin, 1.5 cal/cm²

MVABF = Bolted Fault MVA at Point of Hazard

$$Dc = [\ 2.65 \times 20.78 \times 0.133\ ]^{0.5} = 2.71 \text{ feet}$$

.

NFPA 70E
PROTECTIVE CLOTHING AND EQUIPMENT BASICS

- Protective Clothing, e.g. Flame Resistant Shirts, Pants, Coveralls, Outerwear, Switching Suits, Rainwear, is One of the Key Protective Equipment Elements of 70E
- 70E also includes Protection Requirements for the Head, Face, Neck, Chin (3-3.3) Eyes (3-3.4), Hands and Arms (3-3.6), Feet and Legs (3-3.7)

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PROTECTIVE CLOTHING BASICS
CLOTHING THAT IS PROHIBITED BY NFPA 70E

- Synthetic Materials with a Melting Hazard, e.g. Polyester, Nylon, or cotton blends with these. This rules out conventional polyester cotton blend work apparel and nylon cotton blends (3-3.9.7.1)
- Synthetic material, e.g. acetate, nylon, polyester, rayon either alone or in blends with cotton (3-3.9.8)–Meltable Fibers can Stick to the Skin During Heat Exposure Causing More Severe Burn Injury
- Clothing that does not meet the requirements of ASTM F1506 (3-3.8)

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THREE APPROACHES TO HAZARD ANALYSIS AND CLOTHING SELECTION—APPROACH A

- The electrical resource conducts a hazard analysis for each task with an identified arc flash hazard.
- The hazard analysis is based on the electrical parameters, equipment configuration and work rules for each task involving an arc hazard inside a "Flash Protection Boundary".
- Equations in 70E are used to determine the predicted incident energy (in cal/cm^2) in the event of an arc flash.
- The protective clothing system Arc Rating in cal/cm^2 (ATPV in or E_{BT}) is then Matched to Equal or Exceed the Estimated Incident Energy of the hazard.
- There is no minimum fabric Arc Rating (ATPV in or E_{BT}) for Approach A

EXAMPLES OF 70E HAZARD ANALYSIS

- For an open (No Box) Arc Hazard Involving 600 Volt, Bolted Fault Current of 50kA, Clearing Time of 6 cycles, and the worker's chest and face are at a distance of 18 inches from an energized part which could be the site of an arc, the following formula can be used to calculate the arc exposure:

$$E_{MA} = 5271\ D_A^{-1.9593}\ t\ [\ 0.0016F^2 - 0.0076F + 0.8938\ ]$$

D_A = Distance From Electrodes, inches ($D_A \geq 18$) = 18

F = Bolted Fault Current, kA (16-50 kA Range) = 50

t = Arc Duration in seconds = 0.1

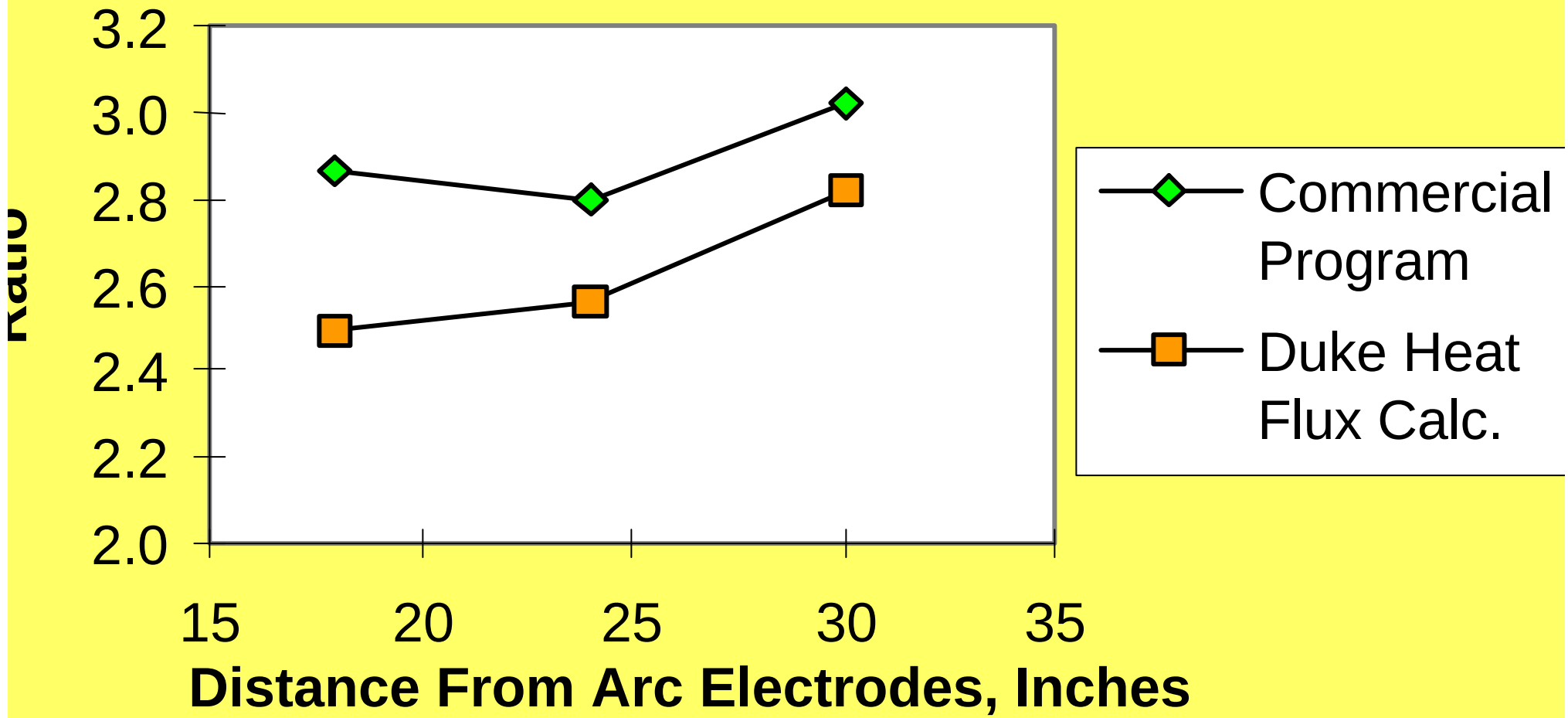
E_{MA} = Max. Open Arc Incident Energy, cal/cm²

$$E_{MA} = 5271\ (18)^{-1.9593} \times 0.1\ [\ 4.00 - 0.38 + 0.89\ ]$$

E_{MA} = 8.3 cal/cm² E_i (Duke Heat Flux Calc)* = 7.3 cal/cm²

*Assumptions: 1.25 inch gap, 3-phase factor of 2.5x

Ratio Of Max. 3 Ph. Open Arc Test Results With Calc. 1 Ph. Incid. Energy



Data from "Electric Arc Hazard Assessment and Personnel Protection," 2000 IEEE IAS Rome Conference Record

EXAMPLES OF 70E HAZARD ANALYSIS

- For an Arc-in-a-Box Hazard Involving 600 Volt, Bolted Fault Current of 50kA, Clearing Time of 6 cycles, and the worker's chest and face are at a distance of 18 inches from an energized part which could be the site o an arc, the following formula can be used to calculate the arc exposure:

$$E_{MB} = 1038.7\ D_B^{-1.4738}\ t\ [\ 0.0093F^2 - 0.3453F + 5.9675\ ]$$

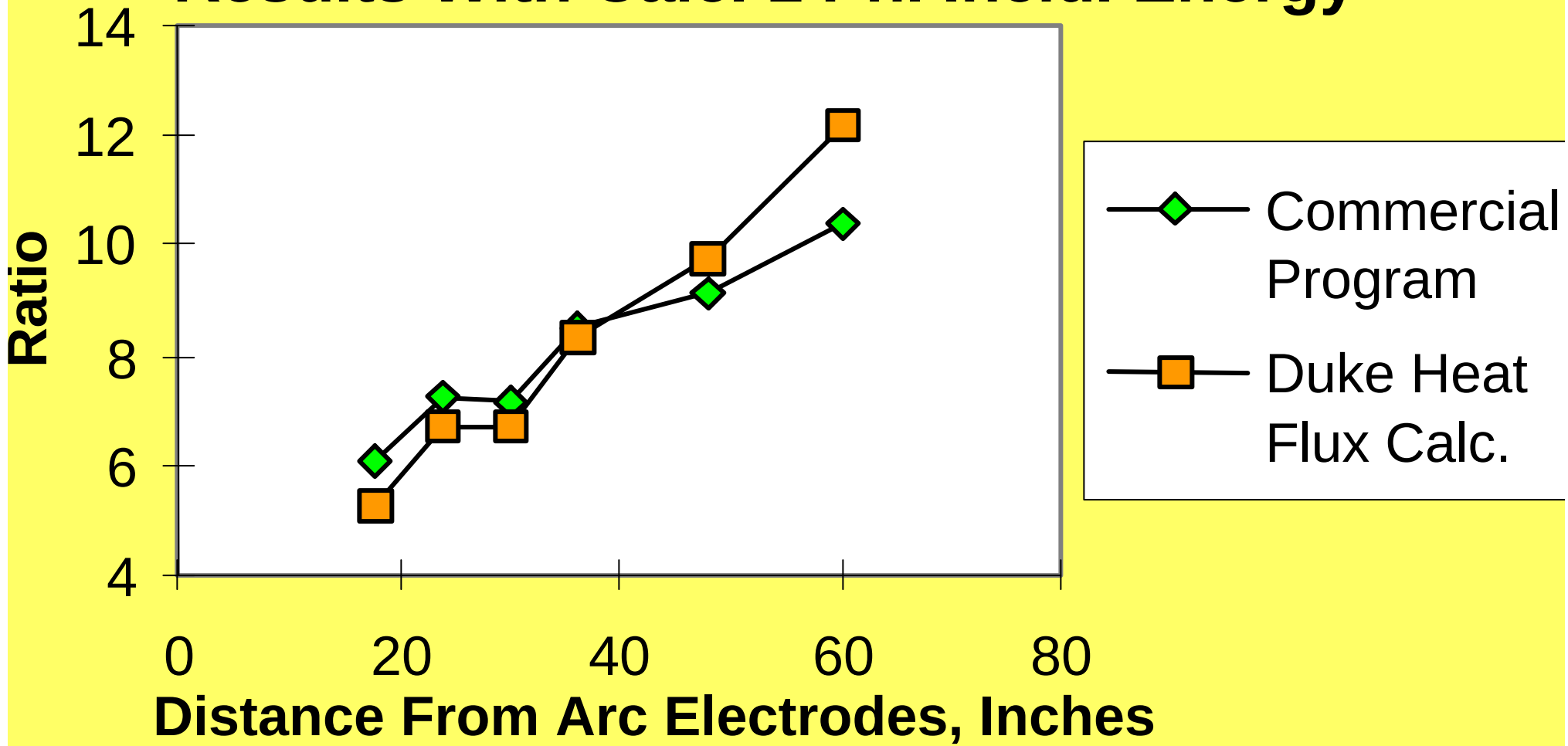
D_A = Distance From Electrodes, inches ($D_A \geq 18$) = 18
F = Bolted Fault Current, kA (16-50 kA Range) = 50
t = Arc Duration in seconds = 0.1
E_{MB} = Max. Open Arc Incident Energy, cal/cm²

$$E_{MB} = 1038.7\ (18)^{-1.4738}\ \times 0.1\ [\ 23.35 - 17.27 + 5.97\ ]$$

E_{MB} = 17.7 cal/cm² E_i (Duke Heat Flux Calc)* = 14.5 cal/cm²

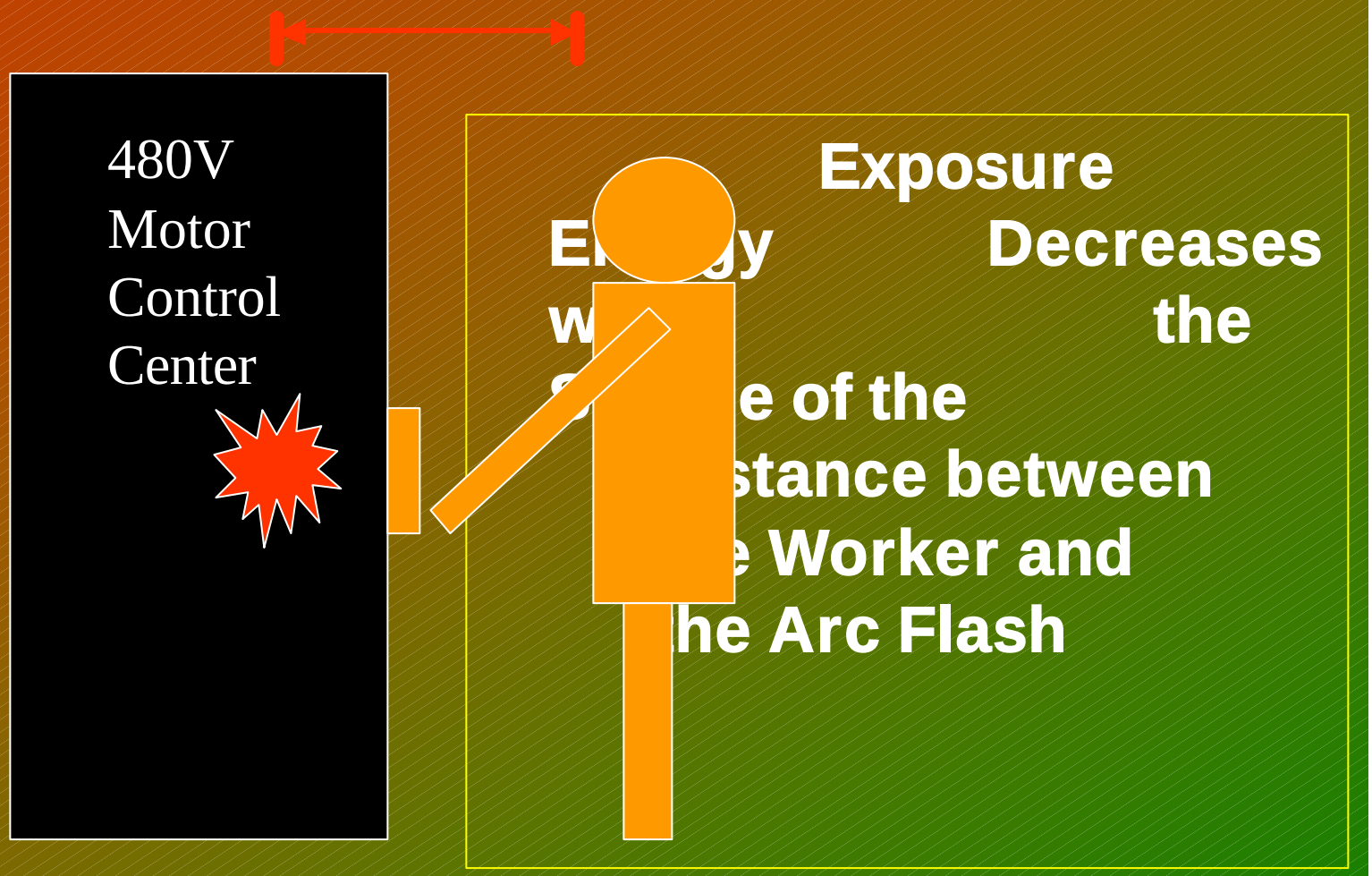
*Assumptions: 1.25 inch gap, 3-phase/box factor of 5x

Ratio Of Max. 3 Ph. Arc-In-Box Test Results With Calc. 1 Ph. Incid. Energy



Data from "Electric Arc Hazard Assessment and Personnel Protection," 2000 IEEE IAS Rome Conference Record

Working Distance is a Very Important Factor in Hazard Analysis



ASTM F1959 ARC TESTING—Single and Double Layers

FABRIC WT. oz/yd^2	FABRIC DESCRIPTION	ATPV cal/cm^2 (±95% CI)	E_{BT} w/T-shirt cal/cm^2 (±95% CI)
4.5	**Nomex®IIIA** plain weave	**4.5** (4.3 – 4.8)	**8.7** (7.8 – 9.5)
4.5	**Nomex® ComfortWear** plain weave	**4.4** (4.2 – 4.6)	**8.1** (7.0 – 9.2)
5.5	**Nomex® ComfortWear** plain weave	**4.8** (4.2 – 5.4)	**10.9** (TBD)
6.5	**Nomex® ComfortWear** twill	**5.9** (5.4 – 6.2)	**12.4** (TBD)
6.0	**Nomex®IIIA** plain weave	**5.6** (5.4 – 5.8)	**13.7** (12.0 – 15.4)
7.5	**Nomex®IIIA** twill	**7.0** (6.5 – 7.7)	**15.6** (15.0 – 16.1)
8.5	**Nomex®IIIA** Denim	**9.7** (9.1 – 10.2)	**TBD**

Source: Arc Test Results from DuPont

ASTM F1959 ARC TESTING—Single and Double Layers

FABRIC WT. oz/yd^2	FABRIC DESCRIPTION	ATPV cal/cm^2
7.5	**S/30 Indura®** twill weave	6.0
9.3	**S/45 Indura®** twill weave	7.9
12.5	**S/306 Indura®** denim weave	13.8
12.2	**Nomex®IIIA** 2 layers 6.1 oz/yd^2	22.6
16.8	**S/45 + S/30 Indura®** 2 layers 9.3 and 7.5 oz/yd^2	29.4

Source: Arc Test Results from Westex

ASTM F1959 ARC TESTING—Three and Four Layers

DESCRIPTION OF LAYERS	NO. OF LAYERS	SYSTEM WEIGHT	E_{BT} cal/cm^2
4.5 oz/yd^2 cotton T-shirt knit 6 oz/yd^2 Nomex®IIIA 9 oz/yd^2 Insulated Batt &Liner	3	19.5 oz/yd^2	>50
4.5 oz/yd^2 cotton T-shirt knit 2 layers 7.5 oz/yd^2 Nomex®IIIA	3	19.5 oz/yd^2	39.9
4.5 oz/yd^2 cotton T-shirt knit 2 layers 6 oz/yd^2 Nomex®IIIA 4.5 oz/yd^2 Nomex®IIIA	4	21 oz/yd^2	>50
4.5 oz/yd^2 cotton T-shirt knit 2 layers 7.5 oz/yd^2 Nomex®IIIA 4.5 oz/yd^2 Nomex®IIIA	4	24 oz/yd^2	>50

Source: Arc Test Results from DuPont

FR Rainwear
Typical Arc Tests Results

- 10 oz/yd² PVC/Nomex® E-88

  ATPV= 5-17 E_{BTAS} = 30
- 8 oz/yd² PVC/Nomex®/Kevlar® E-89®

  ATPV= 7-16 E_{BTAS} = 33-36
- 9 oz/yd² Low Smoke Neoprene coated Nomex®/Kevlar® E-89

  ATPV= 7 E_{BTAS} = 38

Data from "Electric Arc Hazard Assessment and Personnel Protection," 2000 IEEE IAS Rome Conference Record

FR Rainwear Layered Systems
Arc Test Typical Results

- 8 oz/yd² PVC/Nomex®/Kevlar® E-89® Yellow Over 4.5 oz/yd² Nomex®IIIA ATPV= 40
- 9 oz/yd² PVC/Nomex®/Kevlar® E-89® Fluorescent Orange Over 4.5 oz/yd² Nomex®IIIA ATPV= 29
- 9 oz/yd² PVC/Nomex®/Kevlar® E-89® Yellow Over 4.3 oz/yd² cotton knit T-shirt E_{BT}=34

Data from "Electric Arc Hazard Assessment and Personnel Protection," 2000 IEEE IAS Rome Conference Record

THREE APPROACHES TO HAZARD ANALYSIS AND CLOTHING SELECTION—APPROACH B

- If the "Electrical Resource" elects not to Conduct a Hazard Analysis, 70E Tables on pages 55 – 61 can be used by the to select 70E compliant protective clothing.
- The electrical task and the associated "Hazard Risk Category" from 0 through 4 is identified in Table 3-3.9.1.
- Tables 3-3.9.2 and 3-3.9.3 indicate the clothing and equipment required for each Risk Hazard Category and typical protective clothing systems for each Category.
- Approach B sets a minimum of 5 cal/cm² for fabric in some clothing items.
- Generally, "Approach B" will lead to some degree of over protection compared to "Approach A" where the protection can be more closely matched to the hazard

APPROACH B NFPA 70E Typical Protective Clothing Systems

Hazard Risk Category	Clothing System Description (No. of Layers)	Total Weight oz/yd^2	Minimum Arc Rating Arc Thermal Performance Value (ATPV) or Breakopen Threshold Energy cal/cm^2
0	Untreated Cotton (1)	4.5-7	N/A
1	FR Shirt and FR Pants (1)	4.5-8	5
2	Long Cotton Underwear plus FR Shirt & Pants (2)	9-12	8
3	Cotton Underwear plus FR Shirt & Pants plus FR Coverall (3)	16-20	25
4	Cotton Underwear plus FR Shirt & Pants plus Double Layer Switching Coat (4)	24-30	40

Hazard Risk Category Examples

Category 1

Category 4

THREE APPROACHES TO HAZARD ANALYSIS AND CLOTHING SELECTION—APPROACH C

- If the “Electrical Resource” elects not to Conduct a Hazard Analysis as in Approach A, and not to use Table 3- 3.9.1 as in Approach B, the Simplified Two-Category system in Table F-1, Appendix F (Part II) can be used to select 70E Compliant Protective Clothing.
- Table C shows the Two Categories and the Protective Clothing for each Category which meets NFPA 70E requirements.
- Approach C sets a minimum of 5 cal/cm² for fabric in some clothing items.
- Generally “Approach C” will lead to more over protection situations than “Approach A” or “Approach B”.

.

THREE APPROACHES TO HAZARD ANALYSIS AND CLOTHING SELECTION—APPROACH C

Clothing Category	Minimum ATPV or E_{BT} cal/cm²	Protective Clothing Systems Which Mee NFPA 70E Requirements
Everyday Work Clothing	No Minimum Similar to Hazard Risk Category 2	FR Shirt (min. ATPV of 5), e.g. 6 oz/yd² Nomex®IIIA with a cotton T-shirt and FR Pants (min. ATPV 8), e.g. 9 oz/yd² Nomex®IIIA Denim Or FR Coverall (min. ATPV of 5), e.g. 6 oz/yd² Nomex®IIIA over a cotton T-shirt or cotton long sleeve shirt and cotton work pants
Electrical Switching Clothing	No Minimum Similar to Hazard Risk Category 4	Double-layer FR flash jacket and FR bib overalls over FR coverall (min. ATPV of 5) over long sleeve cotton shirt and cotton T-shirt and cotton work pants Or—Insulated FR coverall (min ATPV of 25) over long slv. cotton shirt, T-shirt, & jeans

FLAME-RESISTANT CLOTHING SYSTEM COMMON SENSE GUIDELINES

- Protective Clothing Selection Must Be Based on the Probable Worst Case Exposure
- A Good Functional Fit is Important for Protection and Comfort. Loose Fitting Clothing Provides Additional Thermal Protection Due to Increased Air Spaces.
- Sleeves, Shirt, and Outerwear Should Be Fully Buttoned
- Appropriate Protective Neck, Face, Head, Hand and Foot Coverings Should Be Worn.

FLAME-RESISTANT CLOTHING SYSTEM COMMON SENSE GUIDELINES

- Outerwear Needs to be Flame Resistant– Flammable Outerwear Can Ignite and Continue to Burn Essentially Eliminating the Protection of Flame Resistant Clothing Worn Underneath
- Underwear Worn Against the Skin Needs be Non-Melting, i.e. Cotton, Wool, Silk, Rayon.
- Meltable Undergarments Can Increase Burn Injury Severity Due to Melt Adhesion to the Skin and Treatment Exacerbation

WHAT IS NEEDED IN THE FUTURE TO PROVIDE BETTER PROTECTION FOR WORKERS?

- WORK WITH THE INDUSTRY TO ADOPT NFPA 70E FOR WORKERS WHO FACE ELECTRIC ARC HAZARDS
- BUILD HAZARD ASSESSMENT INTO WORK PRACTICES
- CONTINUE TO DEVELOP FR CLOTHING OPTIONS THAT LOOK AND FEEL MORE LIKE CONVENTIONAL WORK CLOTHING

Ernie Jones
ASTM Standards for Arc Flash

CURRENT STANDARDS for CLOTHING for ELECTRIC ARC HAZARDS

DOE CONFERENCE - PRINCETON

AUGUST 1 & 2, 2001

ERNEST A. JONES ASSOCIATES LTD.

ejonesc@aol.com

What is an Electric Arc?

- The IEEE Dictionary of Electrical and Electronic Terms defines an arc as a discharge of electricity through a gas, normally characterized by a voltage drop approximately equal to the ionization potential of the gas.
- An electric arc is the passage of substantial electrical current through ionized air

Electric Arc Facts

- Typically Lasts Less Than One Second
- Extremely High Radiant Energy
- Explosive in Nature
- Can Ignite and/or Melt Non-FR Clothing

Electric Arc Hazards

- Electrocution
- Clothing Igniting or Melting
- Clothing Breaking Open
- Heat from the Electric Arc
- Secondary Fire or Explosion

The Purpose of Flame-Resistant Clothing

- Minimize or Reduce Burn Injury
- Provide Escape Time

CURRENT STANDARDS for CLOTHING for the ELECTRIC ARC HAZARD

- INDUSTRY STANDARDS

ASTM F18 Standard Protective Clothing Specification, ASTM F1506-01

- *Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards*
- Uses vertical flame test for flammability evaluation
- Uses F1959/F1959M-99 for determining the arc rating of materials (ATPV or EBT)

What Fabrics Meet ASTM F1506-01?

- Flame-Resistant Fabrics Pass This Standard
- All Weights of Everyday Cotton and Polyester/Cotton Commonly Used for Work Clothes, Including Those Heavier Than 11oz/yd^2 , Do **NOT** PASS This Standard
- Any Weight of 100% Cotton Will Ignite and Continue to Burn!!

ASTM Standard Rainwear Specification,ASTM F1891-00

- *Standard Specification for Arc and Flame Resistant Rainwear*

- *NOTE: Revisions to F1891 are presently out for ballot and the results will be discussed at the ASTM F18 meeting in September, 2001*

What is "FR" Rainwear for the Electric Arc Hazard?

- Rainwear that meets the Thermal Performance Requirements (Section 9) of F1891.
- F1891 Requires the Rainwear to be Tested According to F1959
- Rainwear that does NOT ignite, melt, drip when exposed to the thermal effects of an electric arc

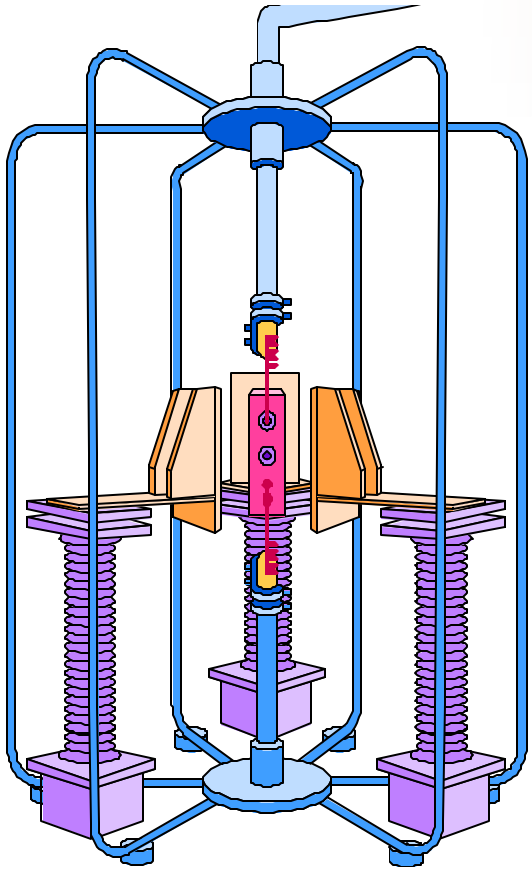
ASTM F18 Standard Test Method, ASTM F1959/1959M-99

- *Standard Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing*

ASTM F18 Standard Test Method, ASTM F1959/1959M-99

- The standard uses material samples mounted on instrumented panels placed 12 inches from an arc 12 inches long, at 120 degree spacing.

Panel Electric Arc Test at the Kinectrics High Current Lab in Toronto



ASTM F18 Standard Test Method, ASTM F1959/1959M-99

- ASTM Sub-committee F18.65 has recently reviewed the standard and conducted tests to verify the test method.
- The results were positive.
- A report of the results was sent to the sponsors and a further series of tests is being proposed.

VIDEO CLIP

ASTM F18 Standard Test Method, ASTM F1958/1958M-99

- *Standard Test Method for Determining the Ignitability of Non-flame-Resistant Materials for Clothing by Electric Arc Exposure Method Using Mannequins*

ASTM F18 Standard Test Method, ASTM F1958/1958M-99

- Requires the material to be made into shirts.
- A minimum of 50 shirts of each material type and weight must be tested on the mannequins to determine the probability of ignition.
- The test method does NOT determine the onset of second degree burn.

ASTM F18 Standard Test Method, ASTM F1958/1958M-99

- Heavier weights ignite at higher levels of energy.
- Second degree burns may occur before the material ignites.

VIDEO CLIP

Protective Clothing for Electrical Workers - Current Standards

- IEEE 1067 - IEEE Guide for In-Service Inspection, Use, Care, Maintenance and Testing of Conductive Clothing Worn During Live Line Work on Voltages up to 800kV AC and +/- 750 kV DC (Under Revision)
- IEC 60895 - Ed.2 - Conductive Clothing for Live Working at Nominal Voltage up to 800 kV AC-Committee document for comments

Standards Under Development

- ASTM - Standard Test Method for Determining the Arc Thermal Performance Value of Eye, Face and Head Protective Products: Sub-committee Ballot-Mar. 2001
- The negatives and comments were addressed at the March meeting and a revised document will be balloted and the results discussed at the September meeting.

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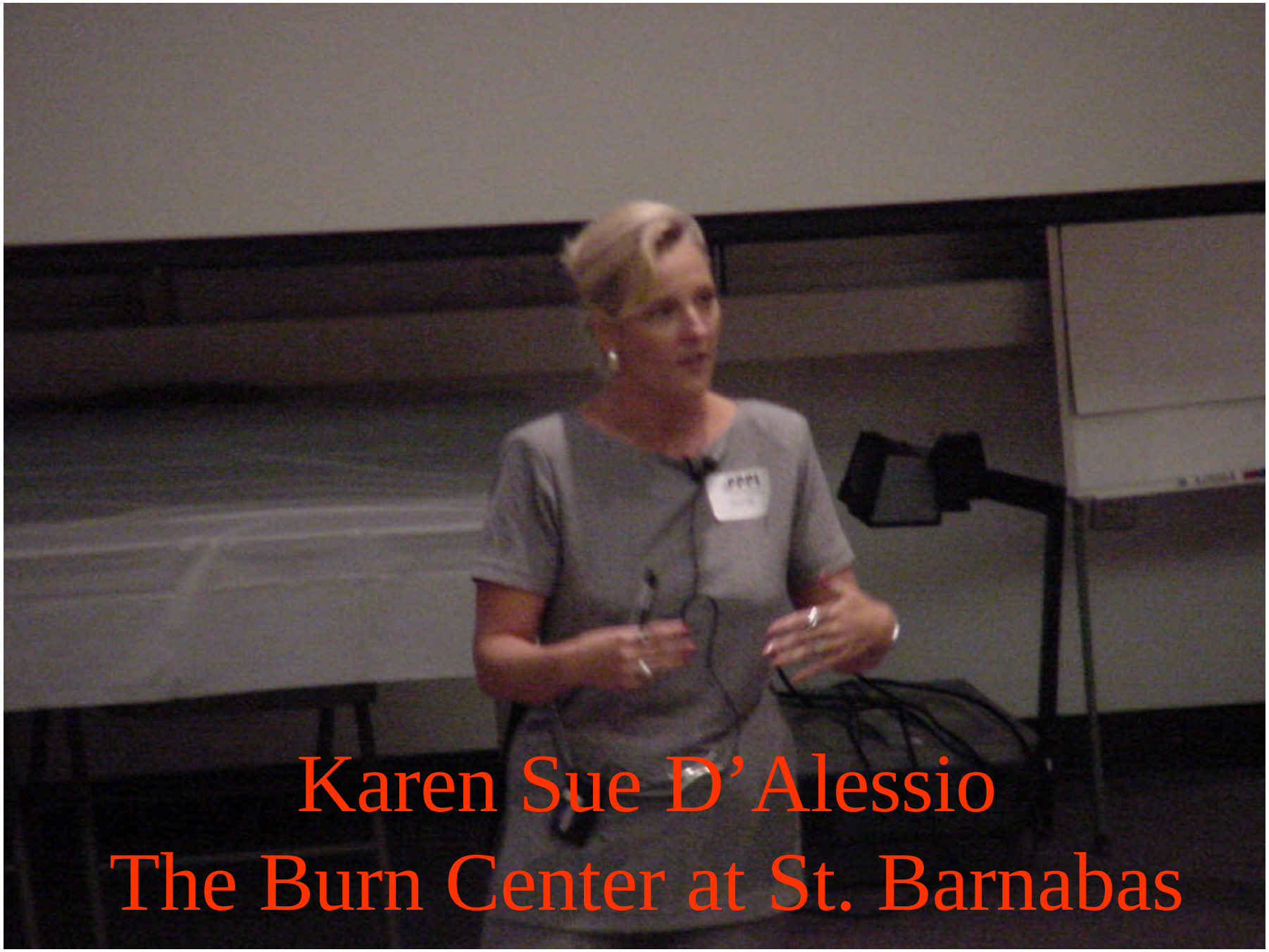

Karen Sue D'Alessio
The Burn Center at St. Barnabas

Electrical Injury

Sue D'Alessio, RN, LNC
Community Educator
The Burn Center at Saint Barnabas

History

- 1879: Stage carpenter killed by 250 volt alternating current
- 1918: Reported deaths from tensions as low as 30-50 volts
- 1927: “ Keep one hand in your pocket ” Kennelly

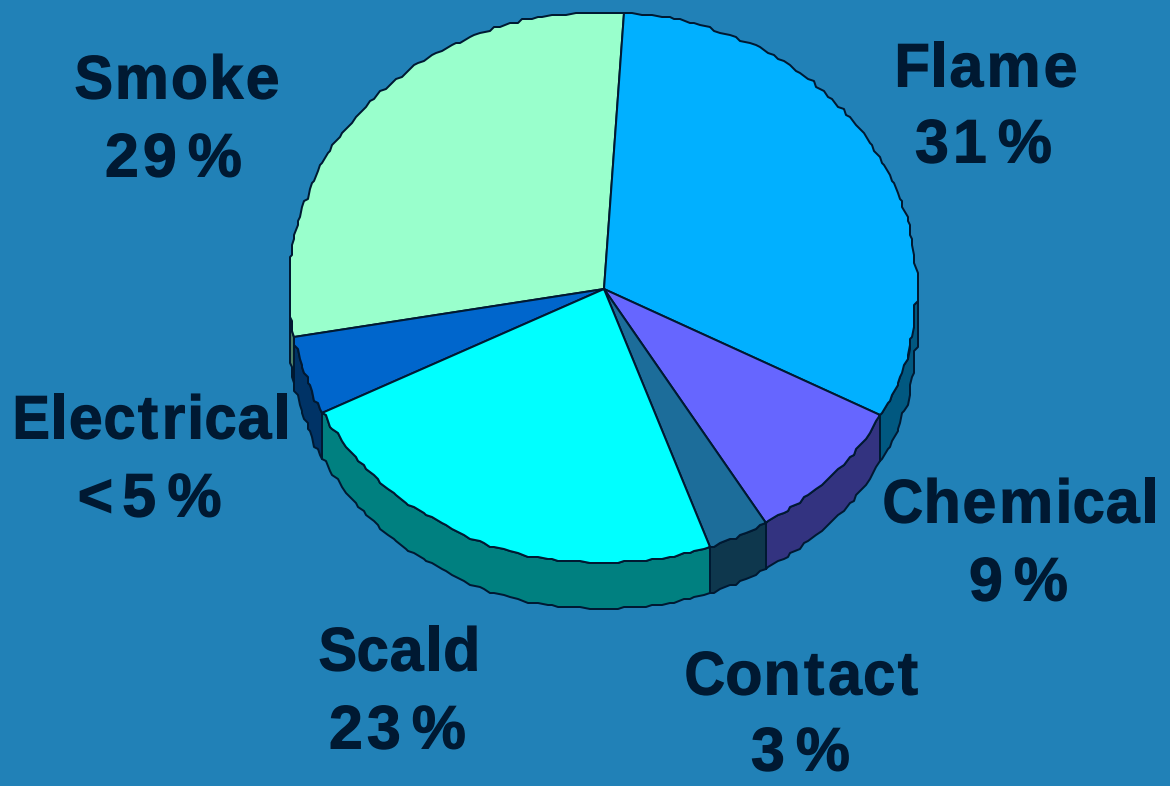
Mortality

- 1,000 deaths annually
- 3% -15% mortality rate
- Cardiopulmonary arrest at the scene
- Contact with >70,000 volts is <u>usually</u> not survivable

Morbidity

- Severe functional impairment
- Scarring
- Limb deformity
- High rate of major limb amputation

Prevalence:



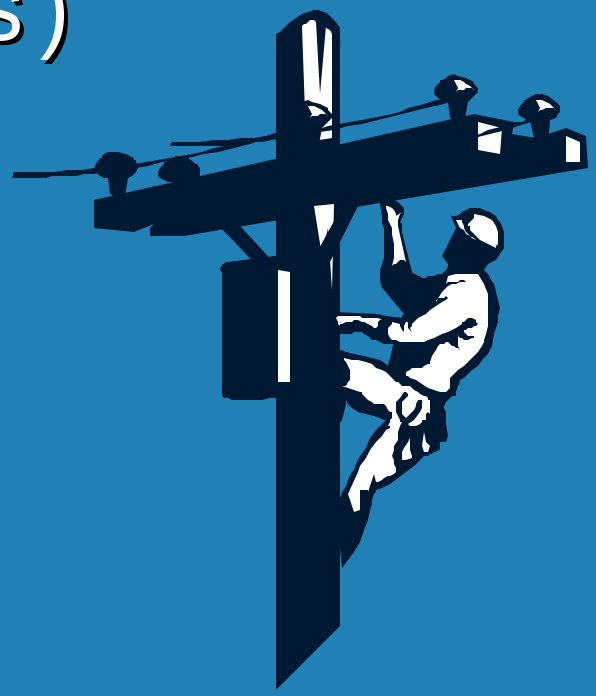
% Burn Center Admissions

Electrical Injury Study

- Memorial Medical Burn Center
- 129 patients from 1980 to 1993
- 38 high tension injuries
- 91 low tension injuries

Patient Profile

- Average age 33.7 years
  - (r = 5 mo. to 63 years)
- 85% male
- 72.9% work related



Hospital course

- 323 acute surgical procedures
- Average length of stay 21.6 days:
  - Low-tension – 11 days
  - High-tension – 38 days

Factors Determining Severity of Injury

1. Voltage

- Low- voltage
  - Major cardiopulmonary complications
- High-voltage
  - Severe tissue destruction
  - Cardiopulmonary complications

2. Resistance

- Body tissue type
- Altered by presence of moisture
  - Dry skin = 1 million ohms
  - Wet skin = 1000 ohms
    - Keeble & Lamb 1987

Relative Tissue Resistance

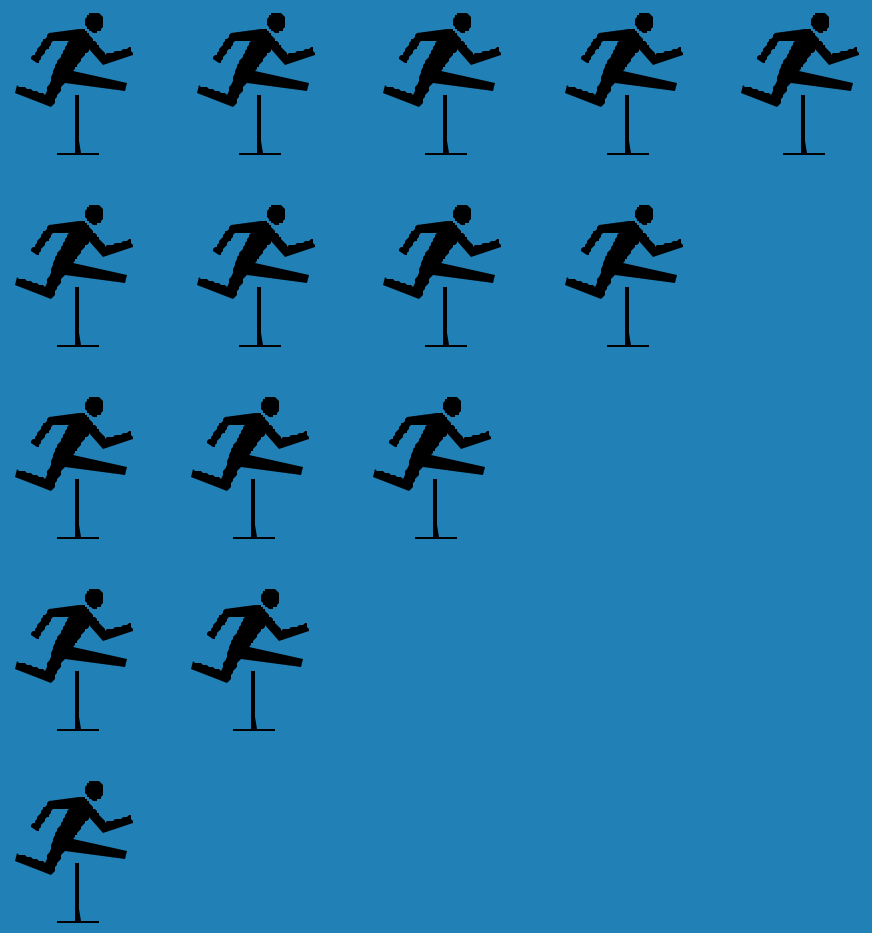
BONE

FAT and TENDON

SKIN

MUSCLE

VESSELS and NERVES

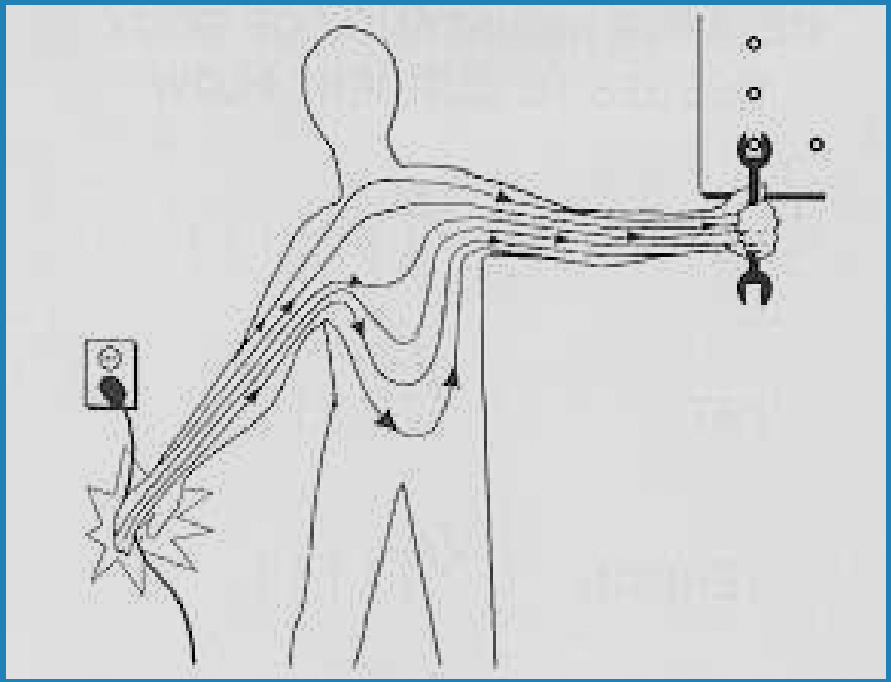


3. Pathway of current

- Head entrance
  - Respiratory arrest
  - Severe neurological impairment
- Upper limb to lower limb
- Hand to hand or torso
  - Cardiac fibrillation

Hand to hand

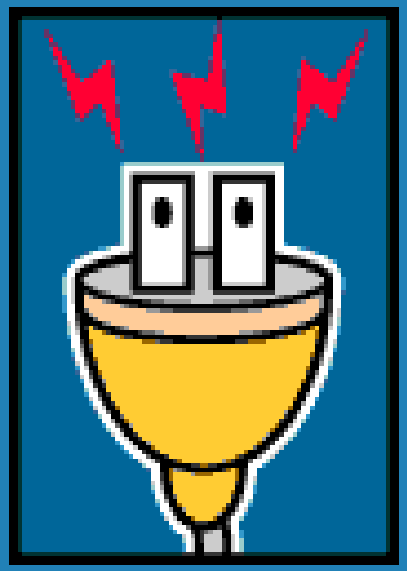
- Reported immediate mortality of 60%



4. Type of current

- Low- voltage direct
- Low- voltage alternating
- High- voltage alternating
- High-voltage direct

  * Least to most damaging



5. Duration of contact

- Prolonged contact with AC
- Injury is related to tetanic muscle contractions
- Spinal and long bone fractures
- Respiratory arrest

Type of Injury

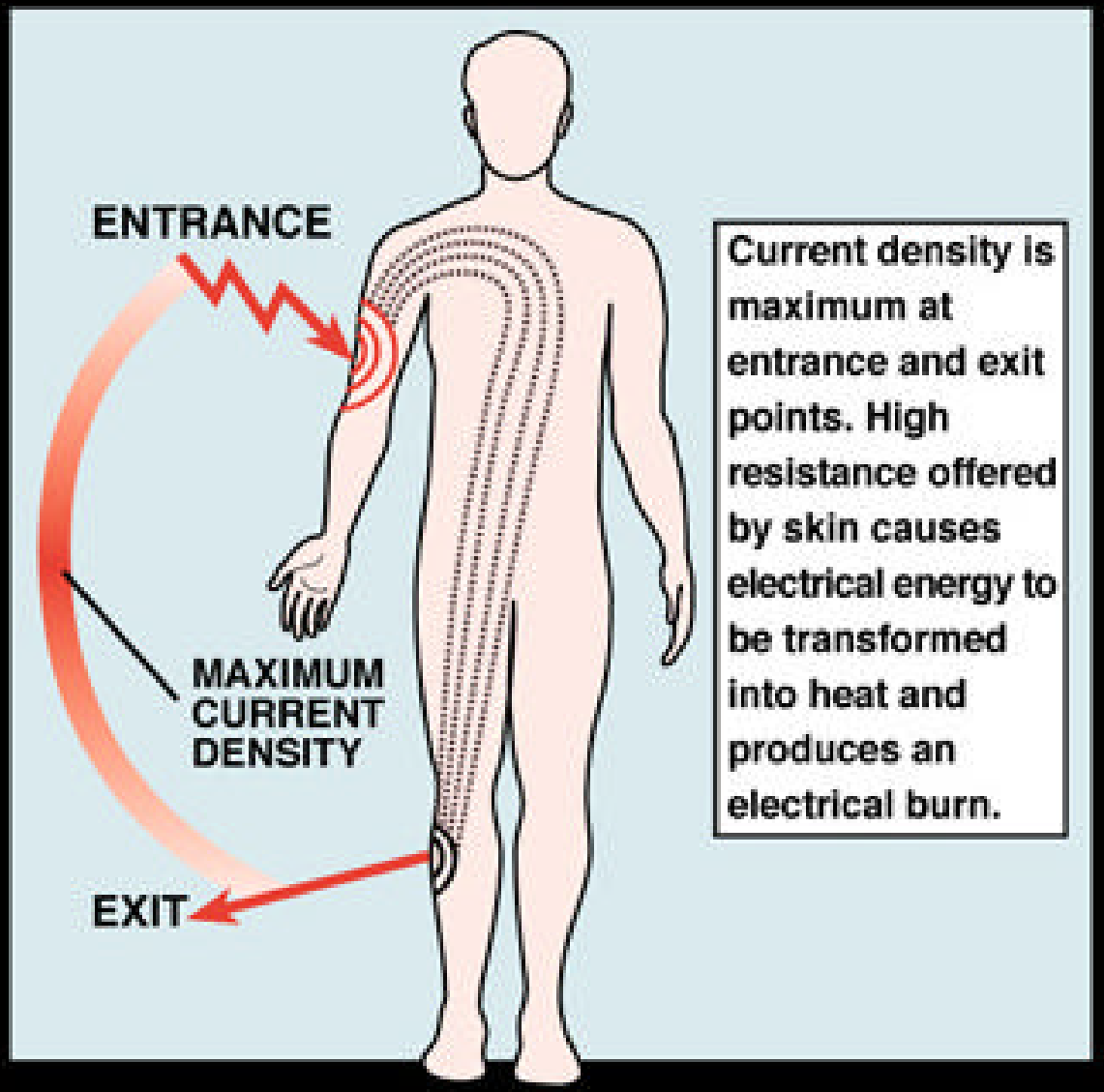
1. Surface burns

- Injury related to
  - Thermal flash
  - Ignition of clothing

2. Conduction Injury

- Actual passage of current through the body
- Extent of tissue damage is directly related to amperage of the current
- Evidenced by entrance and exit wounds

Electrical Current



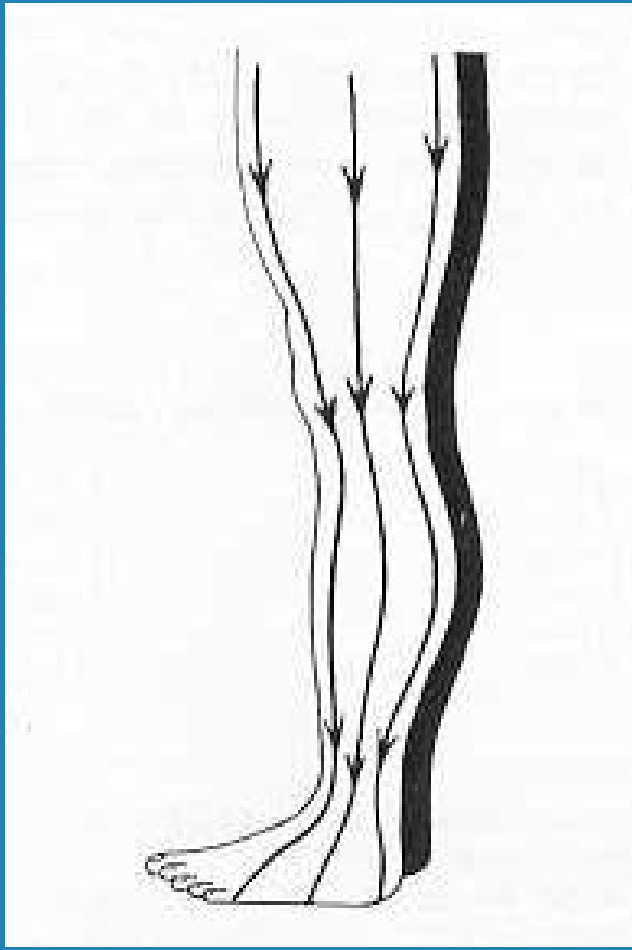
Current density is maximum at entrance and exit points. High resistance offered by skin causes electrical energy to be transformed into heat and produces an electrical burn.

Mechanisms of Injury

- Thermal damage
- Cellular damage by strong electrical fields
- Rupture of cellular membrane
- Biochemical alteration

Cross-sectional diameter

- diameter =
- **c**urrent density =
- damage



Progression

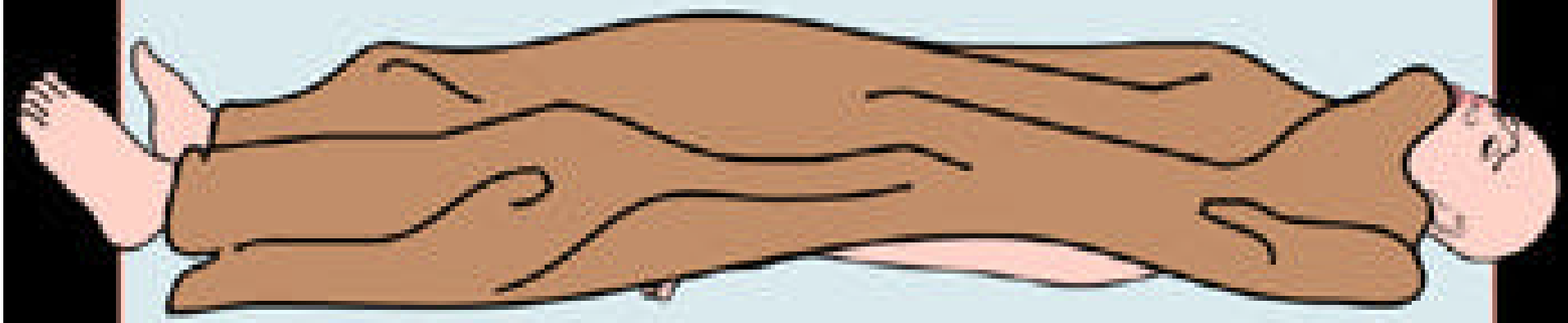
- Absolute tissue destruction does not fully manifest for several days
- Early debridement and / or amputation

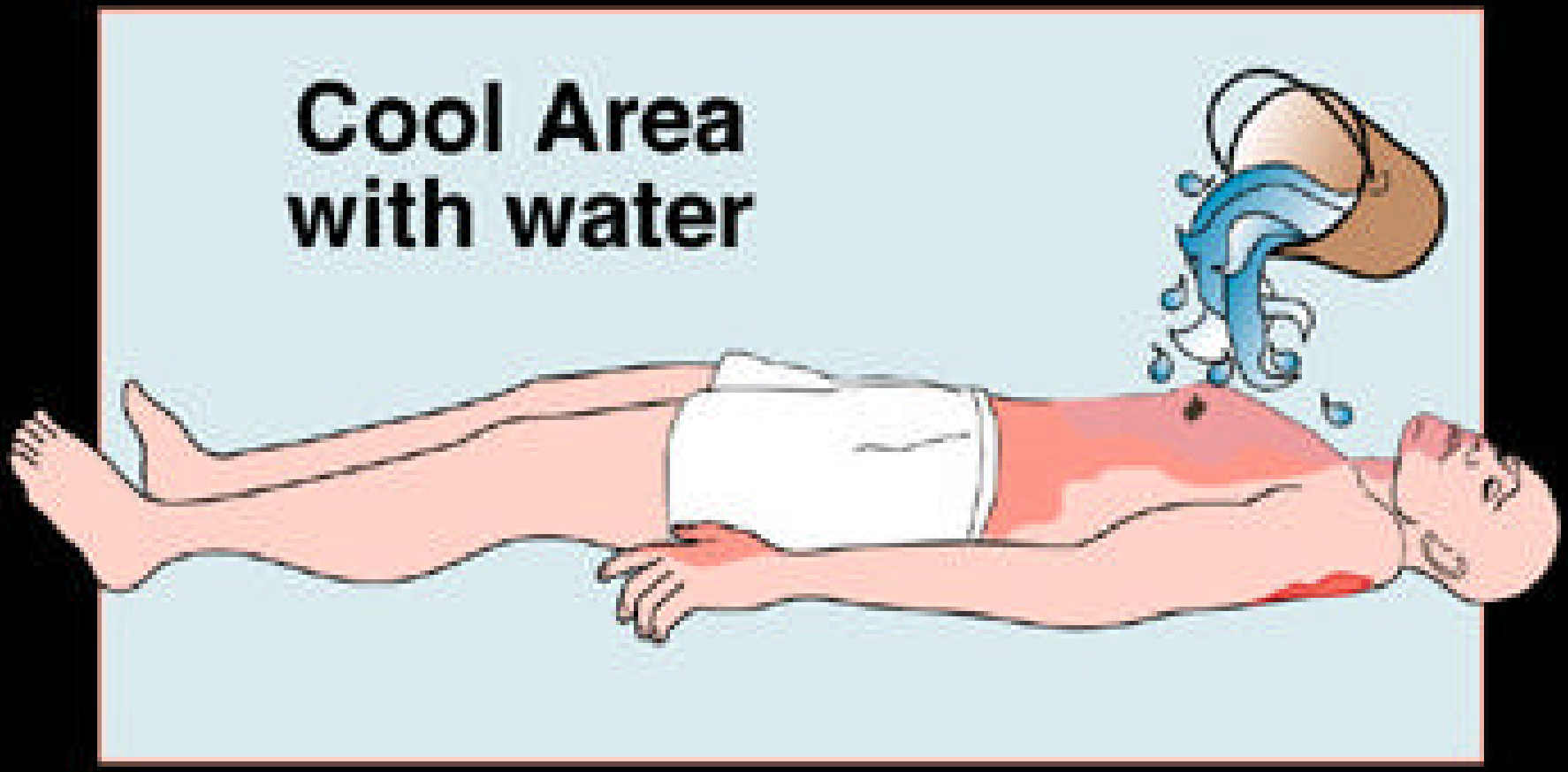
Emergent Care

Management Of The Burn Victim At The Scene

Flame Burns

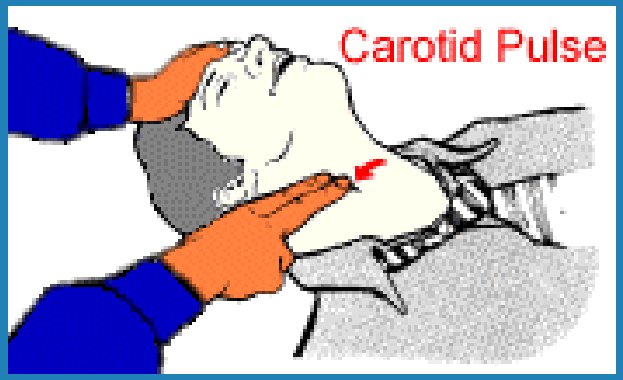
Smother flames with water or blanket




Cool Area
with water

ABC's – Initiate CPR

- Airway
- Breathing
- Circulation



AED's

Automated

External

Defibrillator

Concomitant injuries

- Greater than 50% of high voltage injuries occur to workers 20 or more feet above the ground
- Associated injuries are often overlooked
- Treat as multiple trauma victim

Wound Care

- Cool the wound for 5-15 minutes
- Remove clothing
- Clean, DRY sheets and blankets to maintain body temperature
- Do not apply any ointments
- Never apply ice to a burn

WaterGel

- Good alternative when water is not readily available
- Do not leave on large areas for extended periods of time

Disposition

- Rapid transport to nearest emergency or trauma facility
- Stable patients can be flown directly to a burn center

All Electrical Injuries Require Burn Center Care

ABA Transfer Criteria; 2001

The Burn Experience:

Admission:

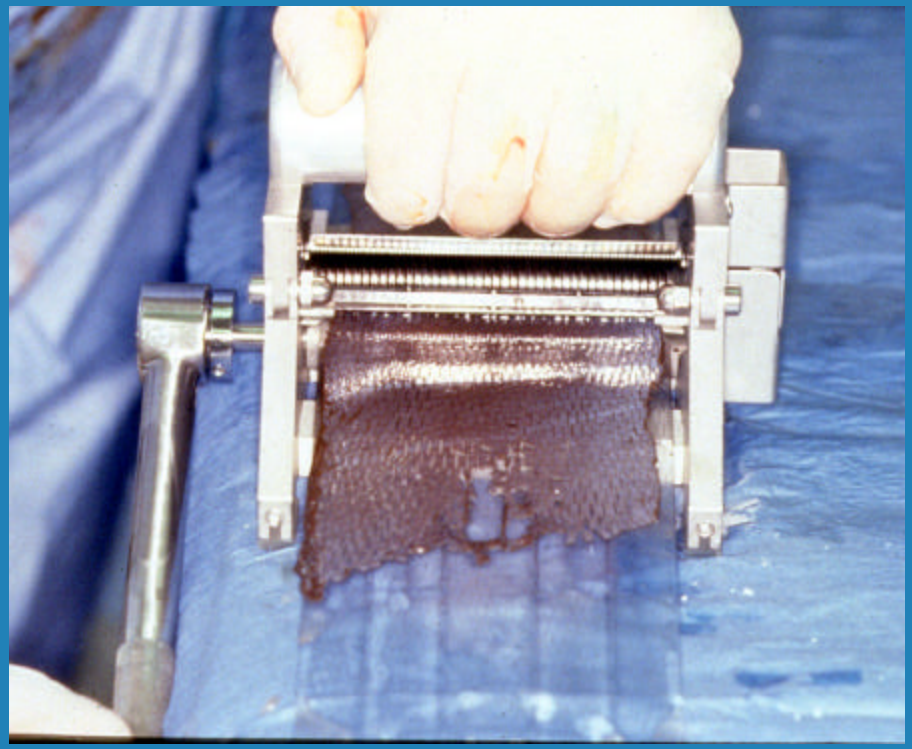
Wound Healing Requires:

- Adequate fluids
- High calorie/high protein diet
- Adequate oxygen
- Infection free environment

Full-thickness injury

- All layers of the skin are destroyed
- Dead tissue is surgically removed
- Permanent wound closure is achieved by use of skin grafts

Skin Grafting:

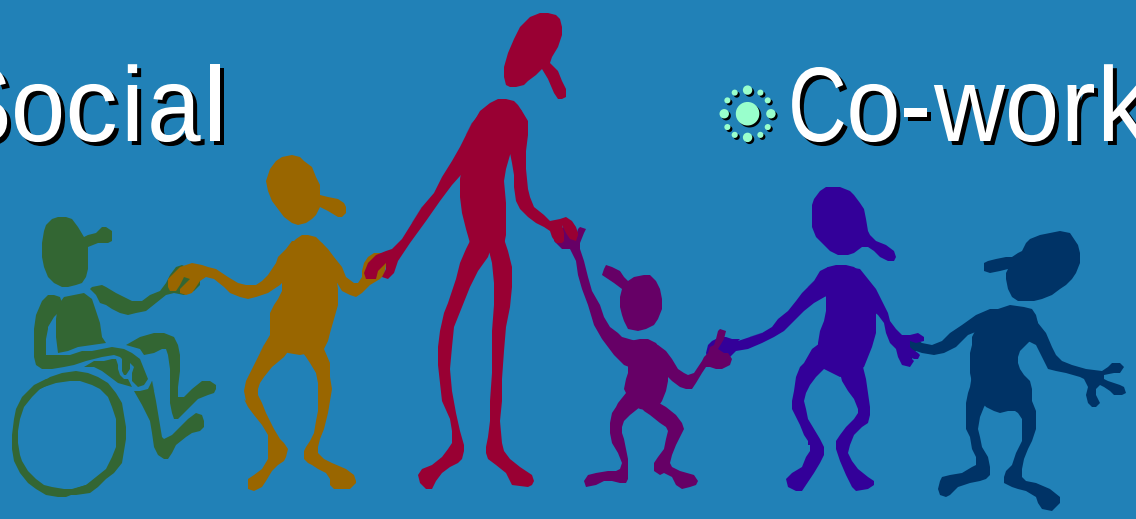


Physical/Occupational Therapy

- Essential part of daily burn care
- Begins on admission
- Painful
- Continues for years

Rehabilitation

- Physical
- Emotional
- Financial
- Social
- Patient
- Family
- Friends
- Co-workers



Re-entry Programs

- Only 5.3% of high voltage injury victims are able to return to their premorbid job
- Burn Center and rehab staff prepare employers and co-workers for employees return

Most common cause:

Failure to maintain electrical safety practices and procedures

-Tredget *et al.*

Prevention

- >90% of all burn injuries are preventable injuries
- Enforcement of safety policy and procedure
- Burn education programs

Thank You, Stay Safe

Questions?

Phil Peist
Federal OSHA

ELECTRICAL SAFETY – 8/1/01

PHILIP M PEIST

AREA DIRECTOR - OSHA

TARRYTOWN, NY

914 – 524-7510

WHAT IS OSHA?

A town in Wis.?

What is a Phil Peist?

The simple stuff!!!

OHMS LAW

- Current multiplied by the resistance equals the potential
  - $I \times R = V$
- Power equals the current multiplied by the potential
  - $I \times V = P$

Example

- How much current does a 60 watt light bulb, on a 120 volt circuit, use and what is its resistance:
- I x V (120 volts) = P (60 watts)
- I = P/V= .5 amps = 500ma
- I (.5amps) x R = V (120 volts)
- R = V/I = 240 ohms

EXAMPLE

- What is the resistance of a 2 amp drill on a 240 volt circuit and how much power does it use:
- I (2amps) x R = V (240 volts)
- R = V/I = 120 ohms
- P= I (2amps) x V(240 volts)
- P = 480 watts
- Note that the drill uses 8 times the power but only 4 times as much current.

EFFECTS OF CURRENT ON HUMANS

- 1 ma - Faint Tingle
- 5ma - Slight Shock
- 6 - 25ma (women) - Painful Shock - can not let go
- 9 - 30 ma (men) - Painful Shock
- 50 - 150ma (Less than a light bulb)- Extreme Pain - Death Possible
- 1,000 - 4,300ma - Fibrillation - Death Likely
- 10,000 ma - Severe burns - Probable Death

RESISTANCE OF HUMAN BODY

- Unbroken, dry skin - up to 100,000 Ohms
- Wet broken skin - 1,000 Ohms
- Internal - 500 - 1,000 Ohms

Example

- 120 volt source, dry skin
- I x R (100,000 Ohms) = V (120 volts)
- I = V/R = .00012 AMPS = .12 ma
- Wet broken skin
- I x R (1,000) = V(120 volts)
- I = V/R = .120 amps = 120ma

- **DEATH POSSIBLE**

IS MY BODY BETTER ABLE TO HANDLE CURRENT IF I'M A QUALIFIED ELECTRICIAN?

- NO., DID YOU NOTICE THAT THERE WAS NOTHING SAYING THAT THERE WAS A DIFFERENCE IN THE EFFCTS OF CURRENT IF ONE IS ELECTRICALLY QUALIFIED OR NOT QUALIFIED TO WORK AROUNFD LIVE PARTS?

NORMAL CIRCUIT

- Hot conductor always has the “voltage” on it.
- Neutral conductor is at 0 voltage until a circuit is completed
- Grounding conductor is at 0 voltage unless a circuit is completed

HAZARDS

- Contact with Live Electrical Parts
- Fault Currents
- Arcing
- Fire

Any Questions on the basics before I go on to hazard prevention and OSHA standards?

PREVENTION

LIVE PARTS

- DEENERGIZE:
  - IF NO NEED FOR CURCUIT TO BE LIVE , THEN MUST DEENERGIZE
  - LOCKOUT/TAGOUT
  - TEST TO ENSURE DEAD

PPE

- USED IF MUST WORK LIVE - MUST BE RATED FOR THE VOLTAGE BEING WORKED.

FAULTS

- Install wiring properly to prevent fault from happening
- Install the proper size wires and overcurrent devices
- Use Grounding
- Use GFCI

ARCING

- Proper installation of equipment
- Inspection of equipment and wiring to check for items such as loose connections and warped parts such as switches and busbars - There are published schedules of PM for electrical equipment.

FIRES

- Do not overloading circuits
- Proper sizing of overcurrent devices
- Install the properly classified equipment in hazardous Location

STANDARDS

- OSHA's: 29 CFR 1910 and 1926
- NEC - National Electric Code - Can be used by OSHA as a basis for a General Duty Clause Violation, when there is a serious hazard and no OSHA standard.
- ANSI
- DOD
- DOE
- LOCAL AND STATE
- Etc.

OSHA STANDARDS – 1910 - Subpart S

- 1910.303 - General requirements:
  - 303(a) - Conductors and Equipment must be approved (UL, FM CSA etc)
  - 303(b)(1) - Must be free from recognized hazards and suitable for installation
  - 303(f) - Disconnecting means must be identified
  - 303(g)(2) - Live parts must be guarded

WIRING DESIGN & PROTECTION

- 1910.304
  - 304(a)(2) - No reversed polarity
  - 304c(1) - Describes clearance for outside conductors
  - 304(e)(1)(I) - Requires that circuits be protected by overcurrent devices in accordance with their ability to safely carry current
  - 304(e)(1)(iv) - Overcurrent devices shall be readily accessible

1910.304(f) - Grounding

- 304(f)(1) - List what systems are required to be grounded
- 304(f)(4) - Requires that any grounding path be permanent and continuous
- 304(f)(5) - List equipment that is required to be grounded, this includes cord and plug equipment

Grounding

- 303(f)(1) - Systems that are required to be grounded:
  - AC SYSTEM 50-1,000 VOLTS if can get less than 50 volts to ground
  - 480Y/277 3 phase, 4 wire
  - 240/120 volt 3 phase, 4 wire

304(f)(5) - grounding

- Metal enclosures for equipment such as metal cable trays
- Frames of electric ranges and clothes dryers
- Exposed non-current carrying metal parts of fixed equipment which may became energized - within 8ft v and 5 ft h: wet location

304(f)(5) Cont'

- Hazardous location
- Cord and plug equipment - hand held tools and appliances, used in damp/wet locations and hand lamps

1910.305 - WIRING METHODS

- 305(a)(2) - Requirement for temporary wiring, including its prohibition as a substitute for fixed wiring (Extension cords used instead of permanent outlets)
- 305(a)(2)(iii)(G) - Flexible cords must be protected from damage

1910.305 - cont.

- 305(b)(1) - Conductors entering boxes and fittings must be protected from abrasion and unused openings (Such as openings for circuit breaker) must be closed
- 305(b)(2) - Pull boxes , junction boxes, etc. shall be covered

1910.305(g) - Flexible cords

- 305(g)(1(iii) - States where flexible cords can not be used
- 305(g)(2)(ii) - Can splice size 12 or greater

Receptacles

- 305(j)(2)(ii) - A receptacle in a wet /damp location must be suitable for such location

1910.307 - HAZARDOUS LOCATIONS

- This section requires that all electric equipment used in hazardous locations, such as areas where flammable liquids (Class I), combustible dust (Class II) or easily ignitable (Class III) are present , be approved for such locations, or intrinsically safe

GFCI

- 306(J)(2)- Receptacles within 15 ft of swimming pools, fountains and similar equipment are required to have GFCI protection.
- 306(f)(4)(I) - GFCI required on branch circuits supplying underwater fixtures operating at 15 volts or greater.
- Required for temporary receptacles used for construction work - Re 1926

1910. 331 - 335 - SAFTY RELATED WORK PRACTICES

- Qualified - One Familiar with the construction and operation of the equipment and the hazards involved (1910.399)
- 1910.332(b)(3) - Training for qualified persons includes that:
  - They are familiar with the techniques to distinguish live parts, determine nominal voltages, clearance distances in 1910.333(c)

1910.333(a)

- (a)(1) - Requires that all live parts be **deenergized** before employees work on or near them *unless* it is infeasible to do so or creates a greater hazard. This includes qualified persons!
- (a)(2) - Requires the use of safety-related work practices if can not be energized. Only qualified persons can work on live parts!
  - **Note if not locked out, equipment is considered live!**

What is the difference if a qualified persons contacts live parts compared to an unqualified person?

What are electrical safe work practices?

There is no OSHA Standard listing what these safe practices are!

1910.333c(2)

- A qualified person shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, ppe, insulation and shielding materials.

1910.334 - Use of equipment

- 334(a)(2) - Requires a visual inspection of cord and plugs before using
- 334(a)(3)(iii) - Prohibits the use of adapters that interrupt the continuity of the grounding path
- 334(a)(5) - Requires dry hands to plug in equipment

1910.335 - SAFEGUARDS FOR PERSONNEL PROTECTION

- 335(a) - Requires that appropriate PPE be provided and used

Power Generation

- 1910.269 - cover generation and transmission -
- 269(r) - covers Tree Trimming

CONSTRUCTION - ELECTRICAL

1926.404(b)(1) - GFCI

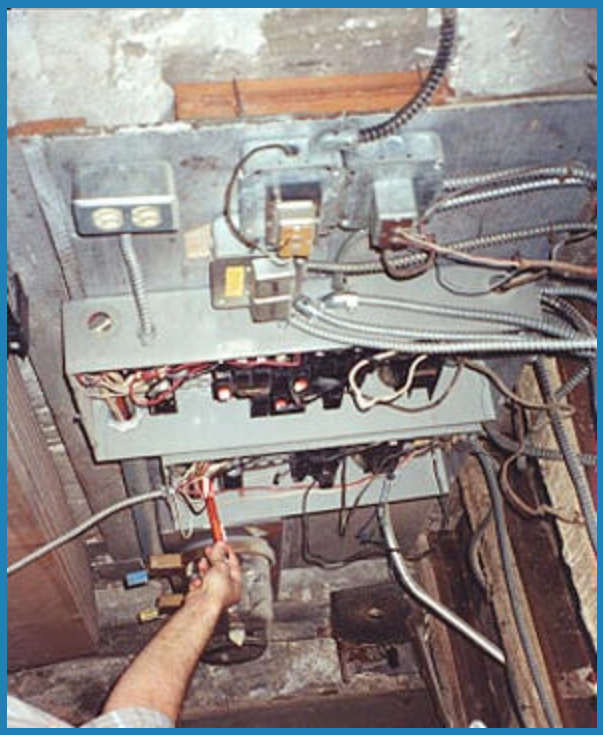
- Required that there is GFCI protection for all temporary receptacles, including those on extension cords, or an assured grounding program.

1926.416 - GENERAL REQUIREMENTS

- 416(a) - No employer shall permit any employee to work in such proximity to any power circuit, that the employee could contact, unless the circuit is :
  - Deenergized and grounded
  - Guarded effectively
  - Protected by Other Means

1926.417 - Locking and tagging of circuits

- 417(a) - **Controls** that are deactivated during the course of work shall be tagged
- 417(b) - Equipment/circuits that are deenergized shall be **rendered inoperative** and have tags attached at all points where they can be energized



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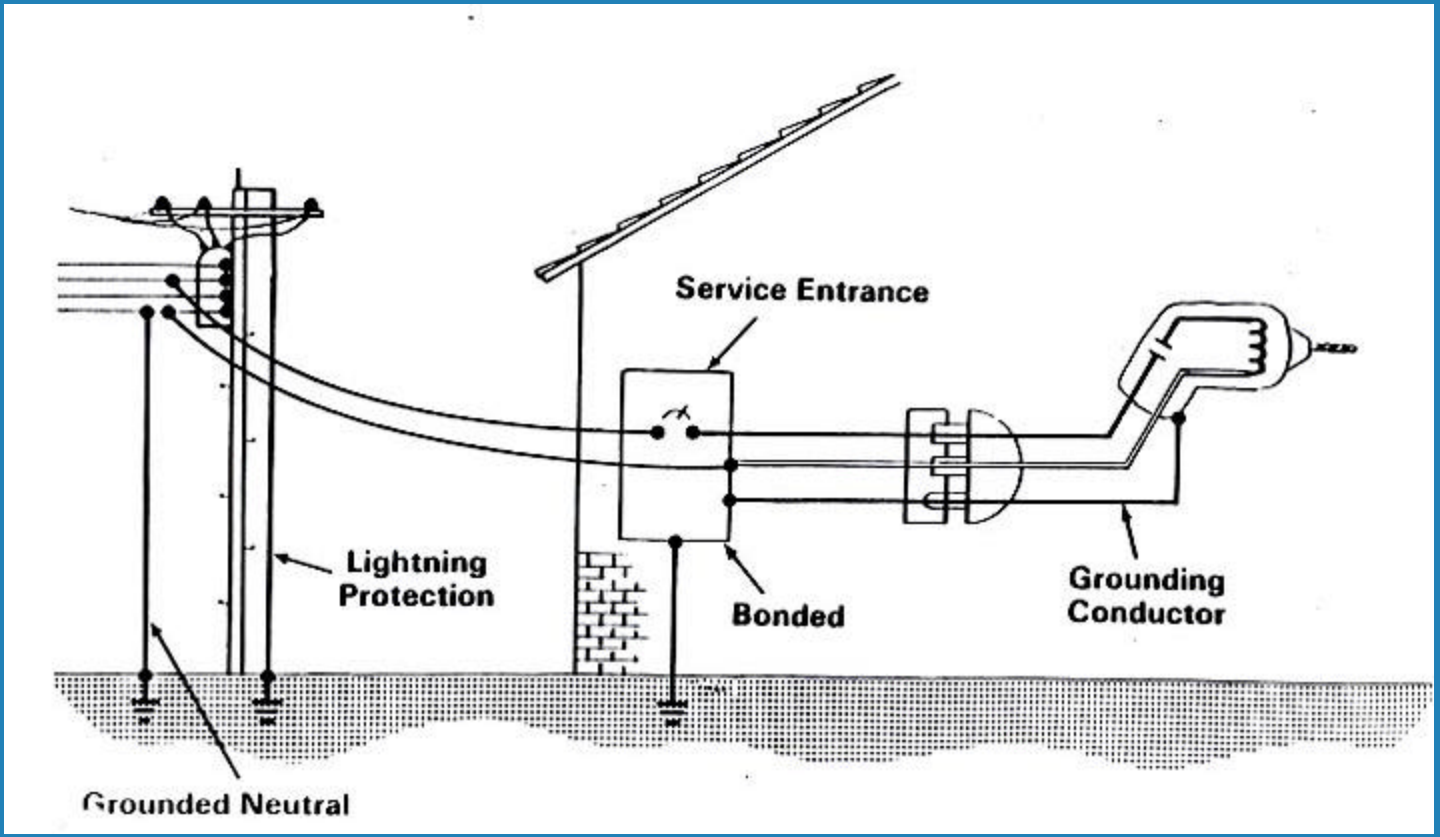
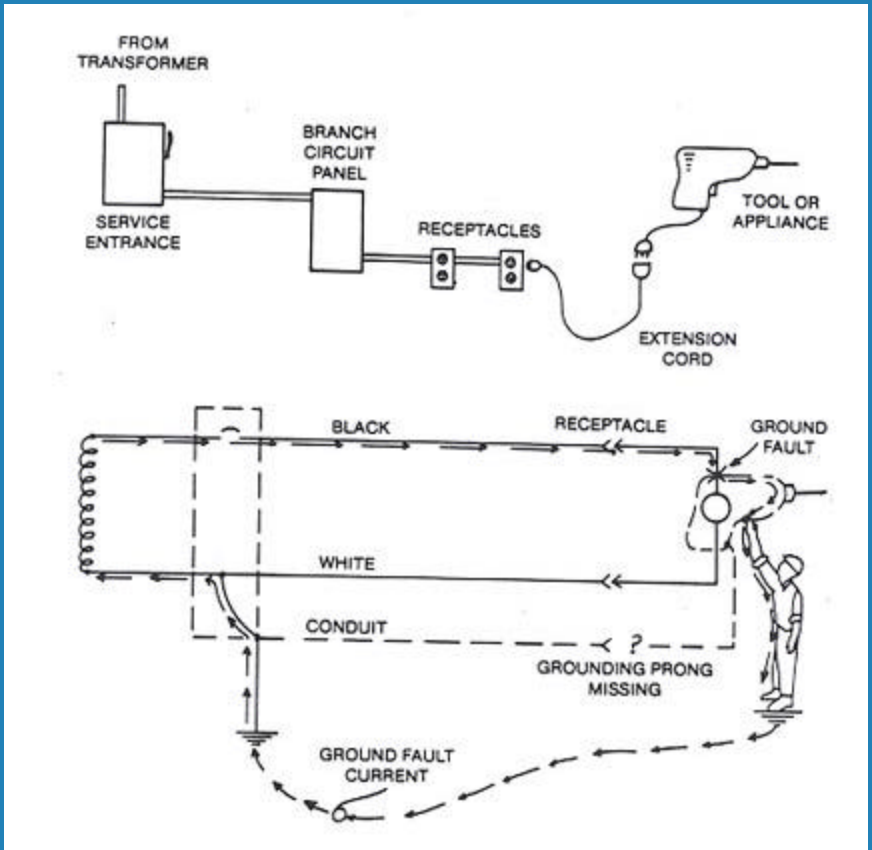

Service Entrance
Lightning Protection
Bonded
Grounding Conductor
Grounded Neutral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?
GROUNDING PRONG
MISSING
GROUND FAULT
CURRENT

QUESTIONS?

2002 Proposed Changes

James Stallcup

PROPOSED CHANGES IN THE 2002 NEC

By: James Stallcup, Sr.

- **The next edition of the National Electrical Code is now half way towards its final form. The National Electrical Code Committee has processed the 4,700 proposals that were submitted to revise the 1999 edition. Each of the 20 code-making panels (CMP's) has processed the proposals within their scope, and the Correlating Committee has reviewed the action taken. The results of this review are presented in the Report of Proposals (ROP), which is available for the asking from the code sponsor, the National Fire Protection Association (NFPA) in Quincy, MA. Proposal submitters and committee members receive copies automatically.**

- **It must be emphasized that none of these actions can be regarded as final. They are all subject to panel review following public comments. In this article, the authors have referenced sections and used terms and symbols based on how they were used in the 1999 NEC.**

CODE ADMINISTRATION AND ENFORCEMENT
ARTICLE 80 – NEW

- A new article in the NEC has been accepted which covers the code administration and enforcement rules. Included in this article are provisions for existing nonconforming installations and appointment requirements for the authority of electrical inspectors and inspection procedures. Other items covered are the creation of an electrical board having the power to appoint, regulate and discipline inspectors. The new article also has requirements for plan review, permits and record keeping. These requirements, in the past, have always appeared in building codes and the electrical department normally adopts these regulations. The rule that has the greatest impact is the authorization to connect and disconnect power from a source of power supplying a premises wiring system. For such article to be enforceable, its provisions must be adopted by a jurisdiction. Until it is adopted, its rules can only function in an advisory capacity.

INTRODUCTION
90-1(d) – NEW

- **A new subsection and FPN has been accepted to clarify that the NEC is fundamentally compatible with International Electrotechnical Commission (IEC) performance rules and regulations. The IEC Standard 60364 is considered a performance code where the NEC is more of a prescriptive code or complete document.**

DEFINITIONS
ART. 100 (LUMINAIRE) – NEW

- A new definition "luminaire" (lighting fixture) has been accepted to replace the term "fixture" which has been used in Article 410 and other articles in previous editions of the NEC. In conjunction with this rule change, the term "fixture" or "lighting fixture" will now be referred to as "luminaire" throughout the NEC. The acceptance of this new term is due to the interest of international harmonization and terminology.

- The TCC directed that the former terminology will remain in the code for the current cycle of the NEC.

DEFINITIONS
ART. 100 (QUALIFIED PERSON) – REVISION

- CMP 1 has attempted to make this definition interface with other standards such as OSHA and NFPA 70E. A qualified person must not only be “familiar” but also must possess “skill and knowledge” and “safety training” which is related to the exposure involved with the electrical equipment that he or she is working on.

DEFINITIONS
ART. 100 (STRUCTURE) – NEW

- **A new definition pertaining to the term "structure" has been accepted and it is a simple term that states, "that which is built or constructed". However, as written, it is not consistent with several of the model building codes definitions when explaining such a term. It appears that this definition needs to be worked on by CMP 1.**

FLASH PROTECTION
110-15 – NEW

- **This new section requires that panelboards , switchboards and motor control centers which are installed in other than residential occupancies shall be marked in the field to indicate the incident energy in calories per square centimeter for a worker at a distance of 18 in. These requirements attempt to correlate such rules with those appearing in NFPA 70E (2000), Electrical Safety Requirements for Employee Workplaces.**

- **Author's Note: If the incident energy level is known, the worker knows the type of protective equipment and tools to wear and use while servicing the equipment.**

DEDICATED EQUIPMENT SPACE
110-26(f) – REVISION

- **Section 110-26(f) has been revised to require the dedicated space running from the floor to the structural ceiling or 6 ft. above the electrical equipment in locations with high ceilings. Note that this rewrite will ensure that electricians will have assured access to the equipment after the equipment has been installed, inspected and accepted by the owner.**
- **Author's Note: It appears that it's the intent of this code change to prohibit foreign items from being installed in this space, except for suspended ceilings.**

MEANS OF IDENTIFYING GROUNDED CONDUCTOR

200-6 – REVISION

- **Section 200-6 has been revised to delete the word "natural" from the term "natural gray." The expression "natural gray" came into the NEC in 1923 to reflect uncolored latex and the cotton cloth served around it. This insulation hasn't been manufactured since the obsolescence of that technology roughly two generations ago. The electrical industry has widely controlled and used the color gray to identify a neutral conductor on 480/277 volt, three-phase, four-wire systems. Gray is also used to identify the grounded conductor on a corner grounded three-phase delta system. A FPN has been added to alert electricians that caution must be exercised when working on gray colored conductors used in electrical systems.**

ARC-FAULT CIRCUIT-INTERRUPTION
210-12(b) – REVISION

- **This section has been revised to require all outlets such as receptacles plus luminaires installed in bedrooms of dwelling units to be connected to AFCI (arc-fault circuit-interruption) protected circuits.**

RECEPTACLE OUTLET LOCATION
210-52(c)(5) – REVISION

- **This section has been revised to include three adjustment rules for receptacles located above dwelling unit kitchen countertops and they are as follows:**

- **The vertical limit of acceptability for the height of a receptacle above a countertop changes from 18 in. to 20 in. to accommodate receptacles in the underside of upper cabinets over islands.**

- **• If an island or peninsular countertop overhangs the base by more than 6 in., a receptacle on the underside of the countertop must be installed so that it isn't more than 6 in. from the edge. Note that a tombstone receptacle can be installed above the counter.**

OVER 600 VOLTS
ART. 225, PART C – REVISION

- Part C has been revised to provide specific requirements for facilities supplied with over 600 volt systems. Allowances have been accepted for facilities having their electrical systems designed and installed under engineering supervision and under the supervision of qualified maintenance personnel. Such personnel must have proof of documented training and experience in electrical systems rated over 600 volts.

- Note that the comprehensive requirements for calculating and sizing outdoor medium-voltage feeder and branch-circuit conductors based on the 125 percent rule for loads "operated simultaneously" have been added. At least 100 percent must be considered for transformer nameplate ratings. In other words, use 100 percent of XFMR nameplate plus 125 percent of the "designed potential load". For supervised installations, provisions have been added pertaining to calculations based on assessments of loads and their characteristics of use. Such loads must be evaluated by qualified personnel while under engineering supervision. Note this supervised installation technique is optional to the 125 percent plus 100 percent rule above. Overhead clearances of conductors based on the National Electrical Safety Code (NESC) are also included for the first time. The actual height in ft. and in. from finished grade is listed instead of referring to the NESC to obtain such dimensions. (See Sec.'s 225-60 and 225-61 in the NEC)

LOCATION
230-70(a) – REVISION

- **This section has been revised to add proximity requirements for outdoor service disconnects. This rule change requires outdoor service disconnects to be on or within sight of the building or structure supplied. The requirement for inside disconnects to be located "nearest the point of entrance" of the service conductors remains the same as previous editions of the NEC.**

- **Author's Note: There was a similar rule change in Article 225 pertaining to such disconnects.**

USED AS SWITCHES
240-83(d) – REVISION

- **This section has been revised to require a circuit breaker used as a switch to control HID lighting to be marked "HID." Such circuit breakers can also be used to switch and control fluorescent lighting units. Note that circuit breakers marked "SWD" can be utilized to switch and control fluorescent lighting units but shall not be used for "HID" units.**

FEEDER AND BRANCH-CIRCUIT CONDUCTORS
240-92(b)(1) – REVISION

- **It appears that this new section extends the tap allowances for large industrial facilities by permitting a 100 ft. secondary connection where 150 percent primary-side protection is reflected in the winding ratio. The 75 ft. allowance including differential relays or engineered short-circuit calculations, may disappear, which will allow unlimited lengths under certain conditions of use.**

GROUNDING ELECTRODE CONDUCTOR
250-30(a)(2) – REVISION

- **The requirements have been revised to permit a No. 3/0 grounding electrode conductor to be extended from the grounding electrode system and run through the building and the connection made at an accessible location near the separately derived system required to be grounded. Connections of the grounding electrode conductor from the separately derived system to the No. 3/0 copper conductor must be made with irreversible crimp connectors. Exothermic welding or connections to copper busbars not smaller than 1/4 in. x 2 in. may also be used for this purpose.**

GROUNDING ELECTRODE CONDUCTOR
250-32(f) – REVISION

- **This section has been revised to require that the grounding electrode conductor for bonding and grounding the electrical system to the grounding electrode system to be sized per Sec. 250-66. This rule change does not require such conductor to be larger than the largest ungrounded supply conductor. This rule ends the controversy of whether Table 250-122 is applied based on the OCPD ahead of the feeder-circuit conductors or Table 250-66 based on the size of the feeder supply conductors.**

- **Author's Note: The term "grounding conductor" has been reidentified as the "grounding electrode conductor."**

SURFACE MOUNTED BOX
250-146(a) – REVISION

- This section has been revised to permit direct metal-to-metal contact as an adequate bonding means for surface mounted boxes only. The current requirements in the 1999 NEC allow this method of bonding for flush and surface mounted boxes. There was concern whether adequate bonding could be accomplished where this method is used with flush mounted device boxes.

GAS PIPE BONDING
250-104(b) – DELETION

- CMP 5 has deleted the gas pipe bonding requirement which was extracted from NFPA 54 (National Fuel Gas Code). This requirement was one of the most controversial rule changes in the 1999 NEC. The rule basically required a bonding connection to the aboveground gas piping system upstream from the equipment shutoff valve. This was in addition to the bonding connection required in Sec. 250-104(c) on the load side of the equipment using the equipment grounding conductor of the circuit that might energize the gas piping.

TRANSIENT VOLTAGE SURGE SUPPRESSORS
ART. 285 – NEW

- **A new proposal which provides a new Article 285 for "Transient Voltage Surge Suppressors" (TVSS) has been accepted. The use of TVSS products has greatly increased in residential, commercial and industrial installations. TVSS devices are installed on the load side of the service disconnect and overcurrent protection devices. UL 1449 tests theses devices at lower surge current levels than those for surge arresters which are covered in Article 280 in the NEC and evaluated under IEEE standards. Requirements in this new article provide unique rules for TVSS devices and clarify the differences between these devices and surge arresters.**

WIRING METHODS
CHAPTER 3 – COMPLETELY REVISED

- Electricians installing wiring methods and equipment will not recognize any of the Articles in Chapter 3 in the 2002 NEC. If the usability task group proposal of renumbering Chapter 3 in the NEC is approved at the ROC stage, articles with even numbers will be used for the renumbering scheme and it seems that odd numbers are reserved for future use. Note that Articles 380 and 384 were relocated into Chapter 4 and Article 305 was moved to Chapter 5.

358	372	Cellular Concrete Floor Raceways
356	374	Cellular Metal Floor Raceways
362A	376	Metal Wireways
362B	378	Nonmetallic Wireways
353	380	Multioutlet Assemblies
342	382	Nonmetallic Extensions
352C	384	Strut-Type Channel Raceway
352A	386	Surface Metal Raceway
352B	388	Surface Nonmetallic Raceways
354	390	Underfloor Raceways
318	392	Cable Trays
324	394	Concealed Knob-and-Tube Wiring
321	396	Messenger-Supported Wiring
320	398	Open Wiring on Insulators
380	404	Switches
384	408	Switchboards and Panelboards

- The chart above shows the renumbering scheme of the article to be implemented in Chapter 3 in the 2002 NEC. Note that there are only three articles that retain their previous numbering scheme.

SEALING
300-7(a) – REVISION

- **This subsection has been revised to require the sealing of all raceways that are exposed to different temperatures in such a manner so that warm air does not migrate into the colder parts of the raceway. If seals are not provided, the results may cause condensation, which causes corrosion of raceways and components.**

- **Author's Note: With this rule change, it appears that raceways routed from inside to the outside of a building are included as well as the raceways inside.**

90 DAYS
305-3(b) – REVISION

- **This subsection has been revised to permit the use of holiday decorative and similar lighting for longer periods of time than 90 days, if arc-fault circuit-interrupter protection is provided on the supplying circuits. Note that this rule change recognizes temporary wiring as a permanent wiring method without applying any time restrictions.**

RECEPTACLE OUTLETS
305-6(a), Ex. 2 – DELETION

- **The exception to Sec. 305-6(a) has been deleted which permitted industrial establishments to employ an assured equipment grounding conductor program as an alternative to GFCI-protection for 125 volt, single-phase, 15, 20 and 30 amp receptacles used for construction, remodeling and maintenance purposes. Note that industrial establishments will no longer be permitted to utilize the AEGCP for such receptacle outlets.**

ADJUSTMENT FACTORS
310-15(b)(2)(a), Ex. 5 – NEW

- This new exception to Sec. 310-15(b)(2)(a) permits up to 20 No. 12 copper current-carrying conductors in a group of bundled Type AC and MC cables without applying ampacity adjustment factors. Additional cables can be run, however, a 60 percent derating factor must be applied for runs longer than 24 in. For this rule to be applied, each cable is limited to three current-carrying conductors.

TABLE – MULTICONDUCTOR CABLES
310-21 – NEW

- **This new section relocates Table B-310-1 from Appendix B to Sec. 310-21. This rule change upgrades the Table within the requirements of the NEC, enabling it to be used without engineering supervision by installers and inspectors. The Table provides ampacities for multiconductor cables installed in raceway systems.**

BOXES AT LIGHTING LUMINAIRE OUTLETS
370-27(a) – REVISION

- Based on information from UL, this section has been revised to permit small fixtures weighting not more than 7 kg (15 lbs.) to be supported on other boxes or plaster rings that are secured to other boxes provided the fixture or its supporting yoke is secured with No. 6 screws or larger. Note that the 16 in. dimensional limitation and the wall-mounted restriction were lifted as well, allowing the use of G-string fixtures and ceiling fixtures respectively.

MADE OF INSULATING MATERIAL
410-18(b), Ex. – NEW

- This new exception allows a luminaire (lighting fixture) with exposed conductive parts to be installed at an existing outlet where the wiring method does not provide an equipment grounding conductor. In such cases, a separate equipment grounding conductor is permitted to be installed and used in accordance with Sec. 250-130(c). This rule change provides a legal means for installing a luminaire (fixture) with exposed metal parts on existing branch-circuits without the existing wiring method having an equipment grounding conductor means.

SPECIFIC LOAD
430-62(a) – REVISION

- **This subsection has been revised to clarify once and for all that the "maximum permitted value" for the branch-circuit OCPD is permitted to be based on an OCPD selected by the percentages in Table 430-152 as modified per Sec. 430-52(c)(1), Ex. 1. This means that it's permissive to automatically round up to the next higher size. If the motor fails to start and run after using the smaller size OCPD (round down) or next higher size (round up) per Sec. 430-52(c)(1) and Ex. 1, the motor OCPD is also permitted to be sized per Sec. 430-52(c)(1), Ex. 2.**

MOTOR
430-102(b) – REVISION

- This subsection has been revised and it seems, that you are only able to avoid installing the local disconnecting means in sight of the motor if such location is impracticable or introduces additional or increased hazards to personnel or property.

SIGN MARKINGS
490-4(b); 490-21(b)(7); 490-21(c)(2) – REVISION

- **These proposals revise the text in Article 490 to allow for appropriate development of hazard signs which will comply with ANSI Z535. It is felt that, in some cases, the existing NEC warning in these sections and other sections in different articles may not have provided the proper warnings for the particular hazards involved with the equipment.**

HAZARDOUS (CLASSIFIED) LOCATIONS
500-2, FPN – NEW

- **A new definition has been accepted for the term "identified" to be applied in Articles 500 through 516 pertaining to the acceptance of equipment. With respect to equipment clarification, the hazardous location articles in the past editions of the NEC have always used the term "approved" (acceptable to the AHJ) where equipment was not listed. The FPN points to other acceptable sources of identification, including manufacturer's self certification or plant engineering evaluations, if acceptable to the AHJ. The material in the FPN is more liberal on approval of equipment than the rules of OSHA 1910.399 in Subpart S of CFR 29. The panel replaced the word "approved" with "listed" in some articles and the term "identified" in other articles. However, "approved" was retained for acceptance of equipment in many sections of existing articles.**

- **Author's Note: The TCC balked at having two different definitions and have asked CMP 1 and CMP 5 to work together and solve the problem of the definition and FPN.**

SUPERVISION OF WORK
505-7 (EXISTING 505-6(a)) – REVISION

- The term "qualified registered professional engineer" was introduced in the 1996 NEC as a means of controlling the design of the US "Zone 0" classification methodology. At the time, information was not properly defined for installations in Zone 0 locations as will be the case for the 2002 NEC. Therefore, after two cycles of the NEC, the requirements for such supervision by a qualified registered professional engineer will be deleted from the NEC. For this reason, the panel felt that the rule was no longer needed in the NEC.

BONDING AND EQUIPOTENTIAL PLANES
547-9 – REVISION

- Section 547-9 requiring an equipotential plane for livestock areas has been revised and rewritten to be much more specific on which areas must have an equipotential plane. For buildings, equipotential planes shall be installed in concrete floors of livestock confinement areas that contain metal equipment accessible to livestock that is likely to become energized.

- Outdoor dirt and concrete surface confinement areas such as feedlots, and indoor and outdoor dirt surface areas such as horse stalls and feedlots shall have equipotential planes installed around metallic equipment that is accessible to animals and likely to become energized. The equipotential plane shall encompass the area around the equipment where animals will stand while accessing the equipment.

- Equipotential planes shall be bonded to the building or stucture electrical grounding system. The bonding jumper shall be copper, insulated, covered or bare and not smaller than No. 8 AWG. The means of bonding to wire mesh or conductive elements shall be by pressure connectors or clamps of brass, copper, copper alloy or an equally substantial approved means.

- Slatted floors that are supported by structures that are a part of an equipotential plane shall not require bonding.

OUTPUT WIRING AND LISTING OF AMPLIFIERS
640-9(c) – REVISION

- **A second and third paragraph have been added to Sec. 640-9(c) for output wiring and listing of audio amplifiers that allows audio amplifier output circuits to be installed and treated as Class 1 circuits. The former text not allowing audio output circuit conductors to be installed in the same raceway as other audio circuits wired as Class 1 and the same for Class 2 and 3 circuits has been deleted. The accepted second paragraph reads as follows: "Audio amplifier output circuits wired using Class 1 wiring methods shall be considered equivalent to Class 1 circuits and be installed in accordance with Sec. 725-25, where applicable.**
-
- **Audio amplifier output circuits wired using Class 2 or Class 3 wiring methods shall be considered equivalent to Class 2 or Class 3 circuits, respectively. They shall use conductors insulated at not less than the requirements of Sec. 725-71 and shall be installed in accordance with Sec.'s 725-54 and 725-61.**

RECEPTACLE
ART. 680 – REVISION

- **Article 680 has been totally rewritten by CMP 20. For example, a new (3) has been added to Sec. 680-6(a) allowing one receptacle outlet to be installed at least 5 ft. from the inside wall of a pool or fountain. This was added since many small residential lots do not allow a pool to be installed adjacent to the house and still comply with the outdoor receptacle outlet requirements per Sec. 210-52(e). Note that if the pool or fountain cannot be installed more than 10 ft. from the existing dwelling unit, than one receptacle can remain if such outlet is located at least 5 ft. from the pool or fountain. Also covered are the requirements for bonding and grounding DI motors at a pool.**

UNSUPPORTED CABLES
725-5; 760-5; 770-7; 800-5; 820-5 – REVISION

- **Sections 725-5, 760-5, 770-7, 800-5, and 820-5 were revised to allow limited numbers of cables to be installed as unsupported cables for buildings with existing cabling systems. To apply this rule, the following requirements must be complied with:**

•Access to equipment shall not be denied by an accumulation of wires and cables that prevents removal of panels.

• Cables shall be installed in such a manner that the cable will not be damaged by normal removal of panels.

• Cables shall be installed in such a manner that the cable will not be damaged by normal building use.

• Where practicable, installation of cables shall comply with Sec. 300-11 and where impracticable to comply with Sec. 300-11, cables less than 13mm (0.5) in. in diameter shall be permitted to be installed unsupported by the building structure under certain conditions of use

• In areas having ceilings with access points or access panels, it shall be permissible to fish a maximum of three cables between access points in the ceiling.

• In areas having suspended lay-in ceilings, it shall be permissible to install a maximum of three unsupported cables on top of any one ceiling tile. The cables shall be run parallel to the ceiling grid.

Vince Saporita

Role of Current Limiting Fuses in Limiting Arc Energy

The Use Of Low Voltage Current Limiting Fuses To Reduce Arc Flash Energy

Dick Doughty, Dr. Thomas Neal - DuPont

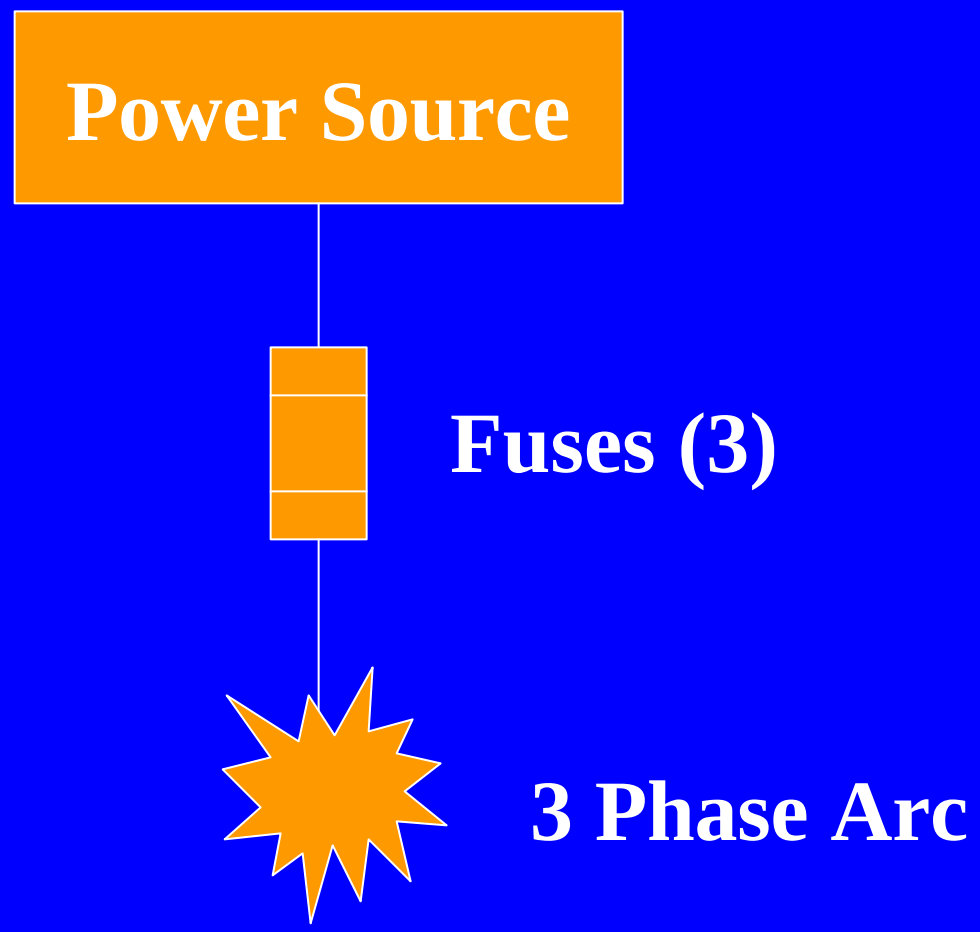
Vince Saporita, Terry Macalady &

Ken Borgwald - Cooper Bussmann

Presentation Outline

- Current Limiting Fuse Characteristics
- 3-Phase Fuse Arc Test Program
- Test Results
- 2nd-Degree Burn Boundary Limits
- Design Considerations For Reducing Arc Flash Hazard
- Impact of System Grounding
- Recommendations/Conclusions

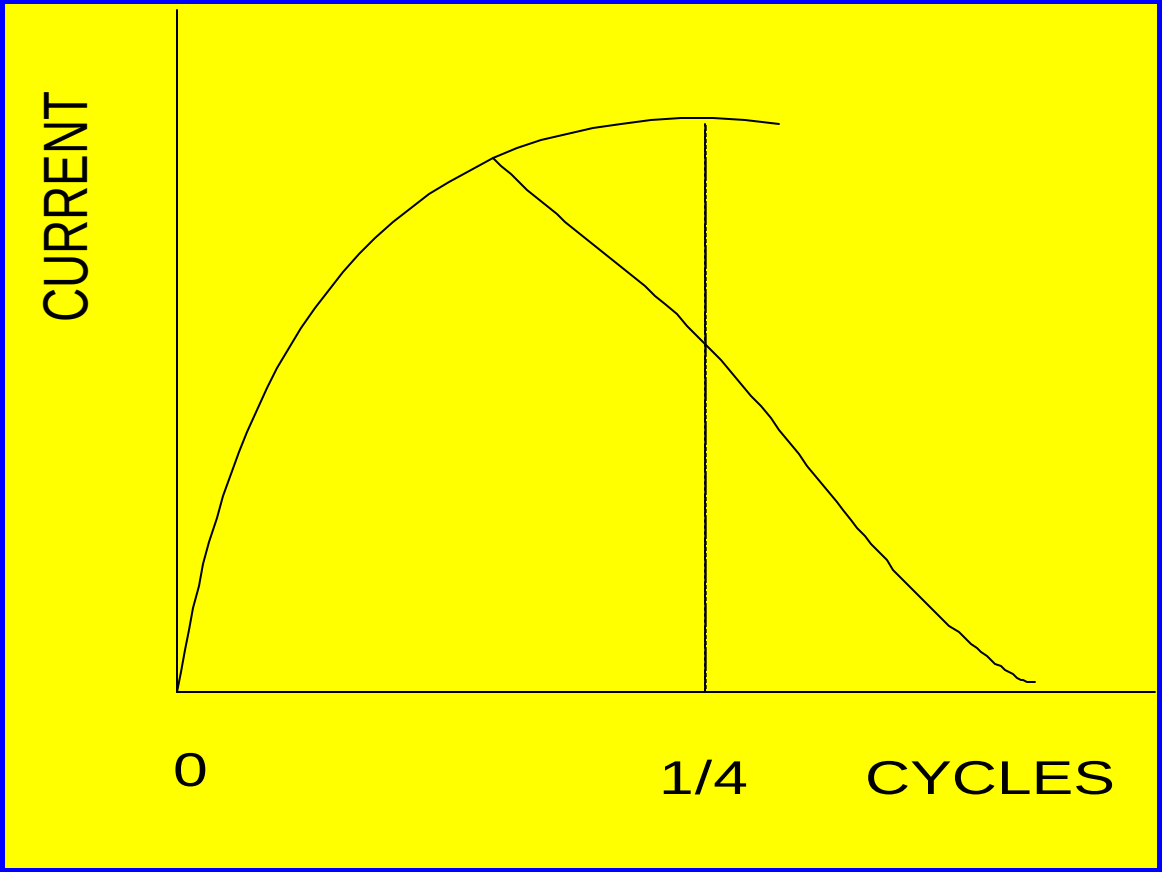
Equivalent Circuit



Why Do Current Limiting Devices Reduce Arc Flash Energy ??

- Arc Flash Energy Is Directly Proportional To The Time Duration And The Magnitude of the Arc Current Squared
- Current Limiting Devices Like Fuses, When In Their Current-Limiting Range, Interrupt the Circuit Very Quickly And Limit The Current Magnitude, Reducing Arc Flash Energy

Current Limiting Fuse Characteristic



Selected Test Fuses

- 600 A Class RK1
- 400 A Class RK1

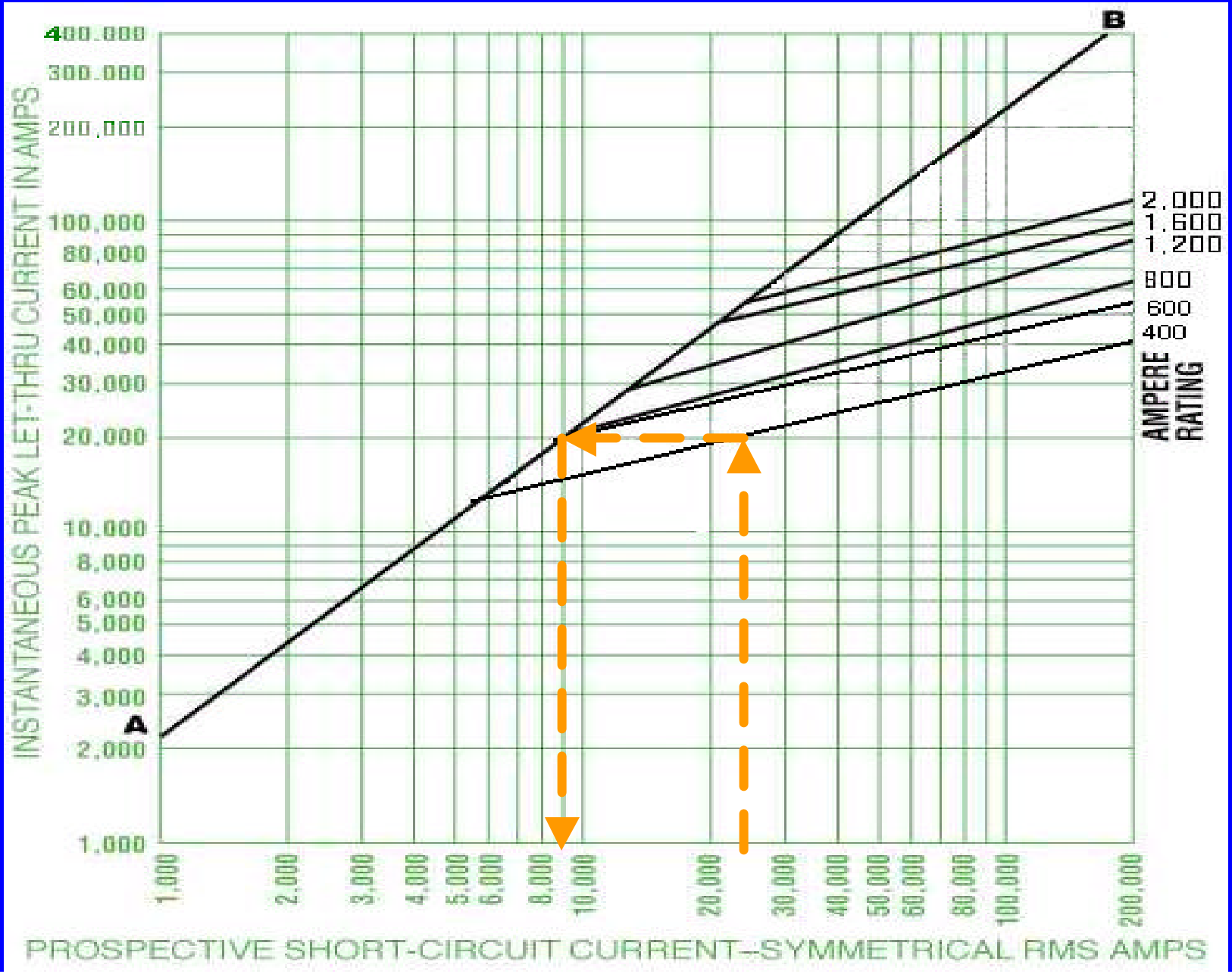
- 2000 A Class L
- 1600 A Class L
- 1200 A Class L
- 800 A Class L

Smaller Fuses Were Not Tested Because, In Their Current-Limiting Range, They Produced Arc Energy Below The 2nd-Degree Burn Threshold At A Distance of 18"

UL Fuse Tests

- Fuse Characteristics Are Determined From UL Single-Phase Bolted Fault Tests
- Tests Based Upon UL/CSA/ANCE Tri-National 248 Series of Standards
- Fuse Let-Through Charts Derived From UL Test Data
- These Charts Do Not Directly Reflect The Performance of The Fuse With A Downstream Arcing Fault

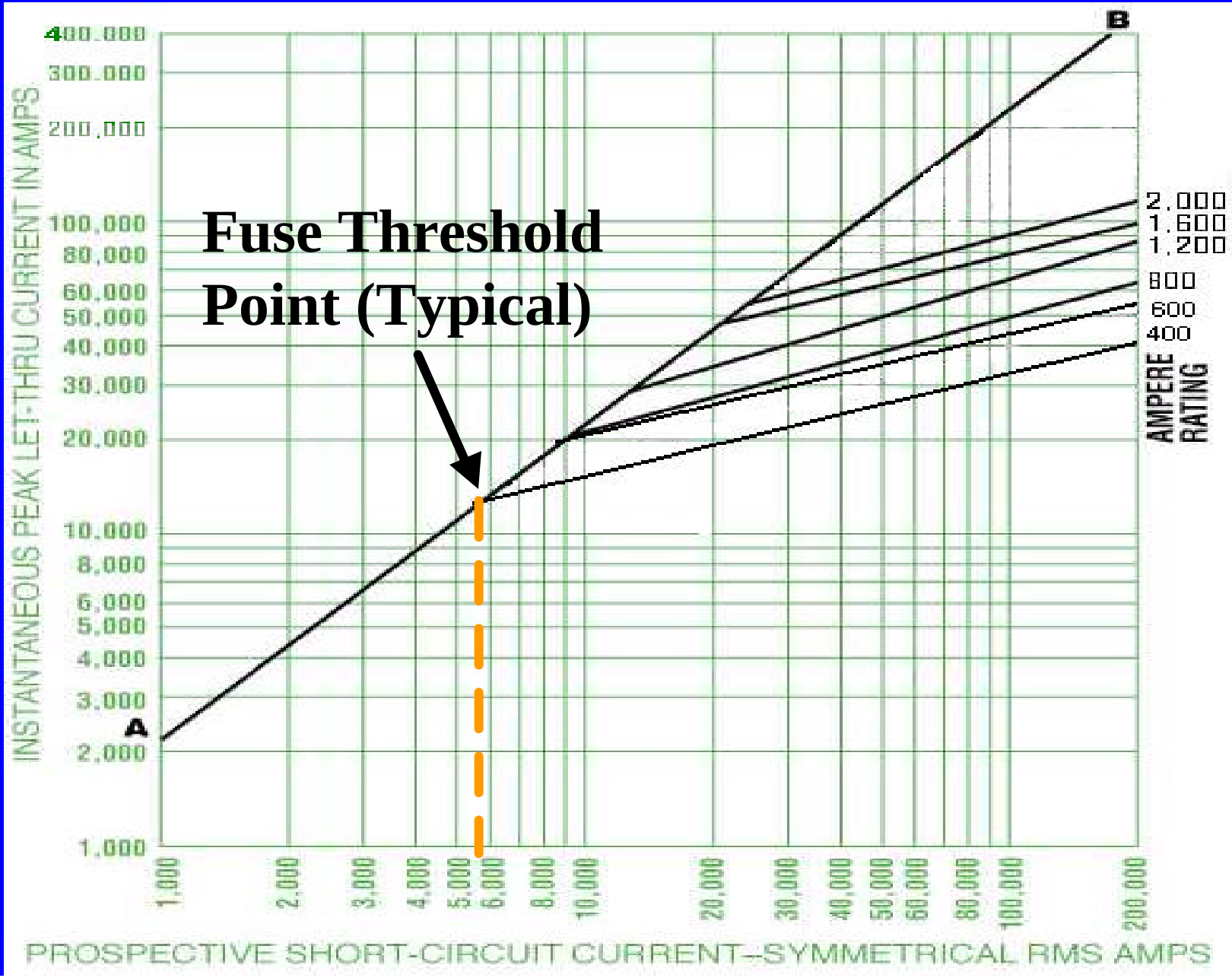
Fuse Bolted-Fault Let-Through Characteristic



Fuse Current Limiting Threshold

- The Fuse Current Limiting Threshold Is The Minimum Value of Current At Which The Fuse Is Current Limiting.
- Introduction of Arc Impedance Into The Electrical Circuit Has The Effect of Reducing The Fault Current Below The Bolted Fault Value.
- If This Reduced Fault Current Is Below The Fuse Threshold Current, The Fuse Will Not Operate In The Current-Limiting Mode.

Fuse Bolted-Fault Let-Through Characteristic



Why Were Arc Tests Needed?

- **No Data Was Available To Quantify The Effect of Current Limiting Fuses On Reducing Incident Energy During Arc Flashes**

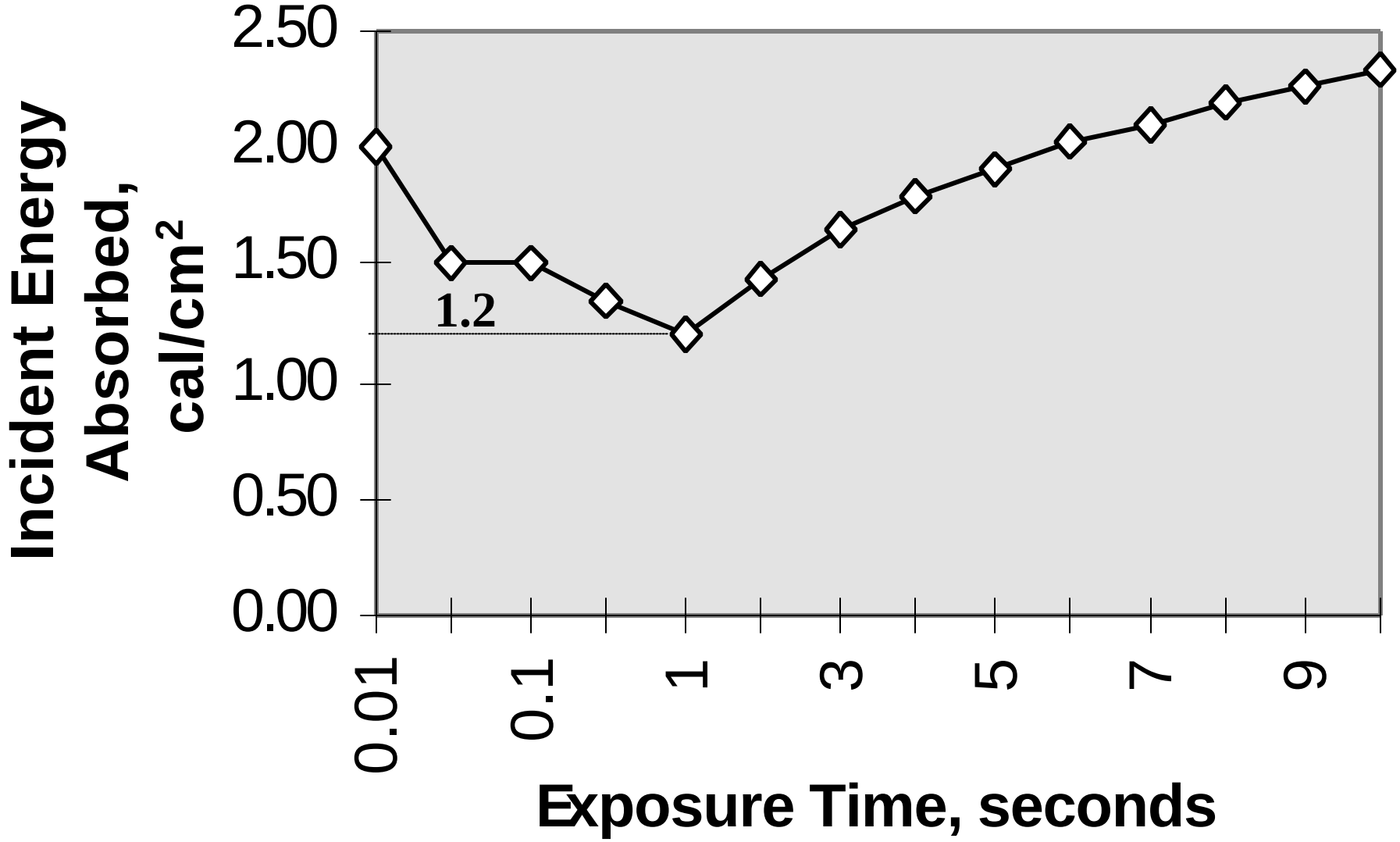
3-Phase Arc Test Objectives

- Measure Incident Energy As A Function Of Available Bolted Fault Current With No Fuse In The Circuit
- Measure The Incident Energy Reduction Caused By Insertion of Class L & RK1 Fuses Into The Circuit Ahead Of The Arc

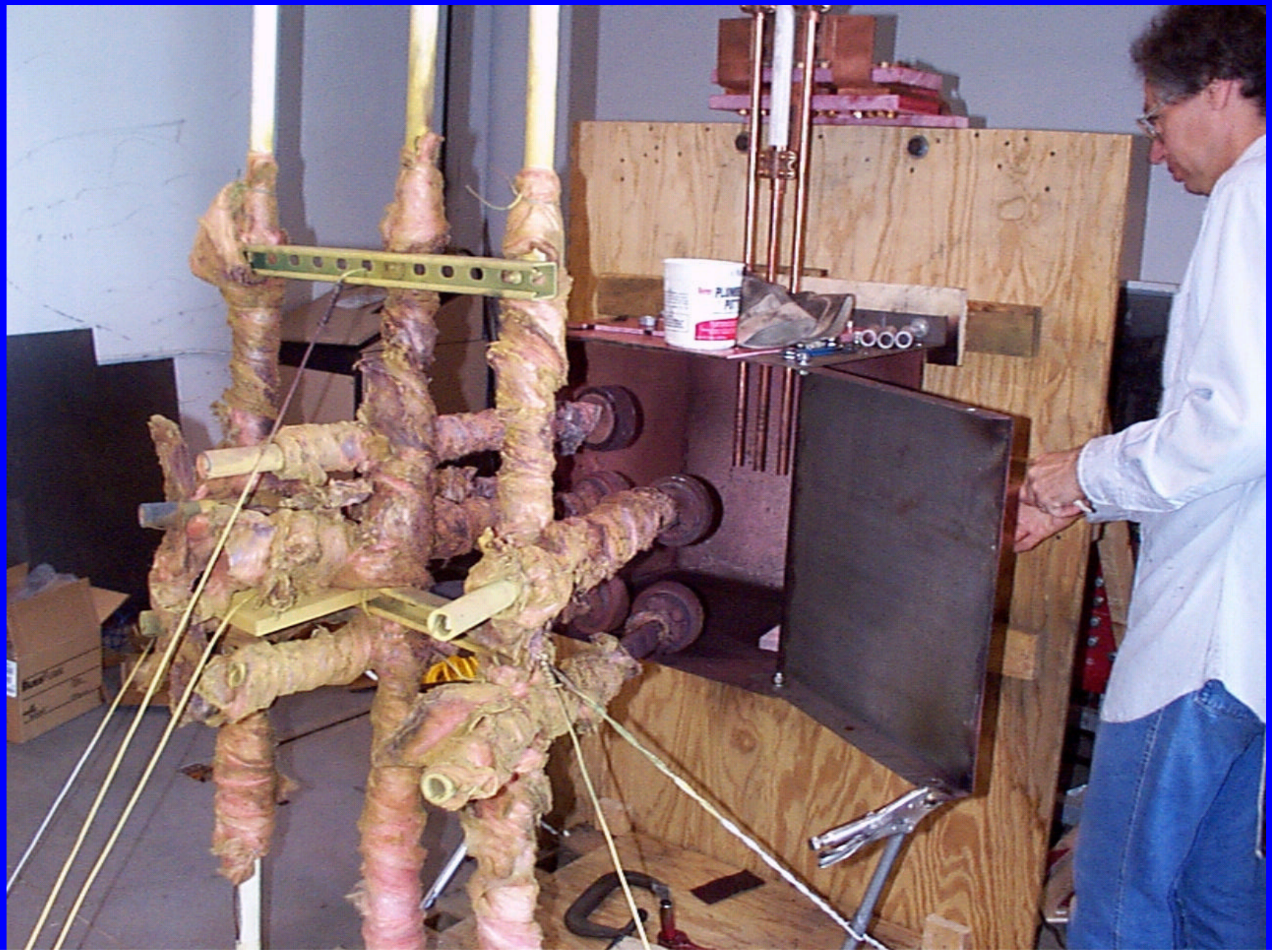
Incident Energy Measurement

- Incident Energy Units - cal/cm^2
- Copper Calorimeters Are Used To Measure Temperature Rise
- Temperature Rise Data Is Converted Into Incident Energy And Can Be Related To 2nd-Degree Burn Criteria
- 1 cal/cm^2 Is Equivalent To The Energy Produced By A Cigarette Lighter Flame In One Second

Human Tissue - Tolerance To Second Degree Burn



Test Setup - 20" Cubic Box

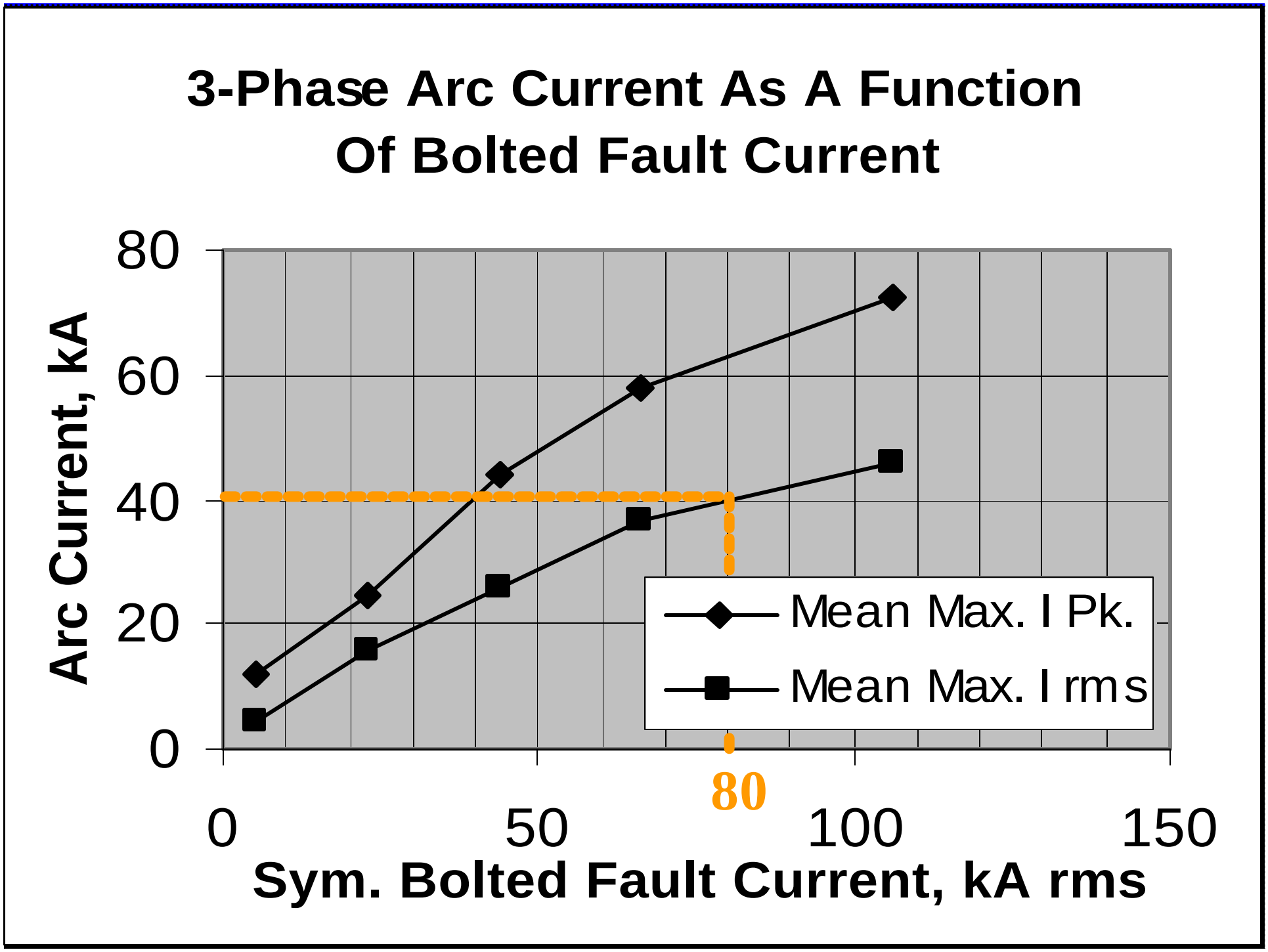


3-Phase Arc Test Parameters

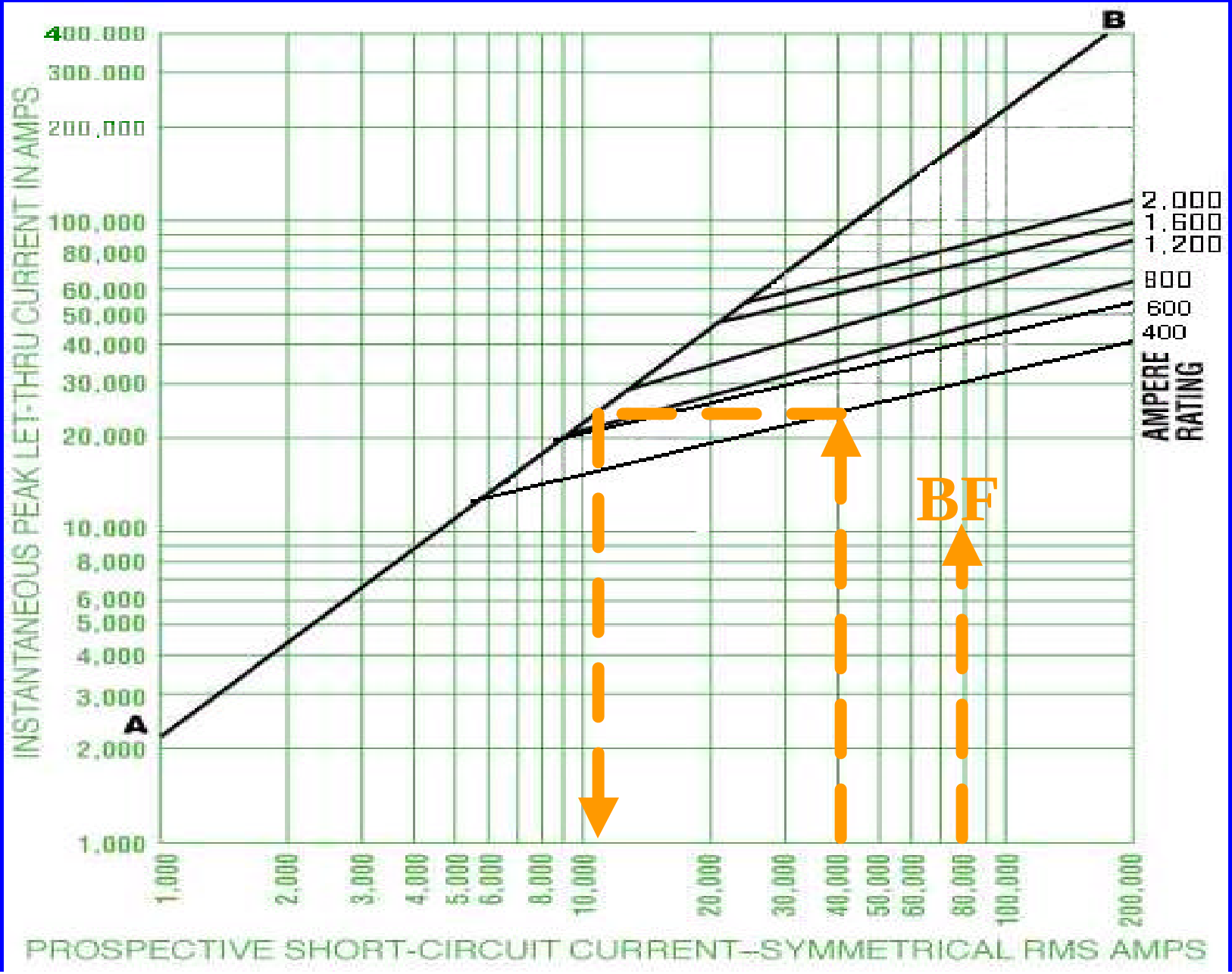
- Open Circuit Voltage - 600 V
- Electrode (Conductor) Gap - 1.25 inches
- Bolted Fault Current - 4 to 100 kA
- Arc Duration - 6 Cycles
- Array Of Seven Calorimeters Located 18" From The Electrodes To Measure Incident Energy
- Multiple Tests Run For Each Setup

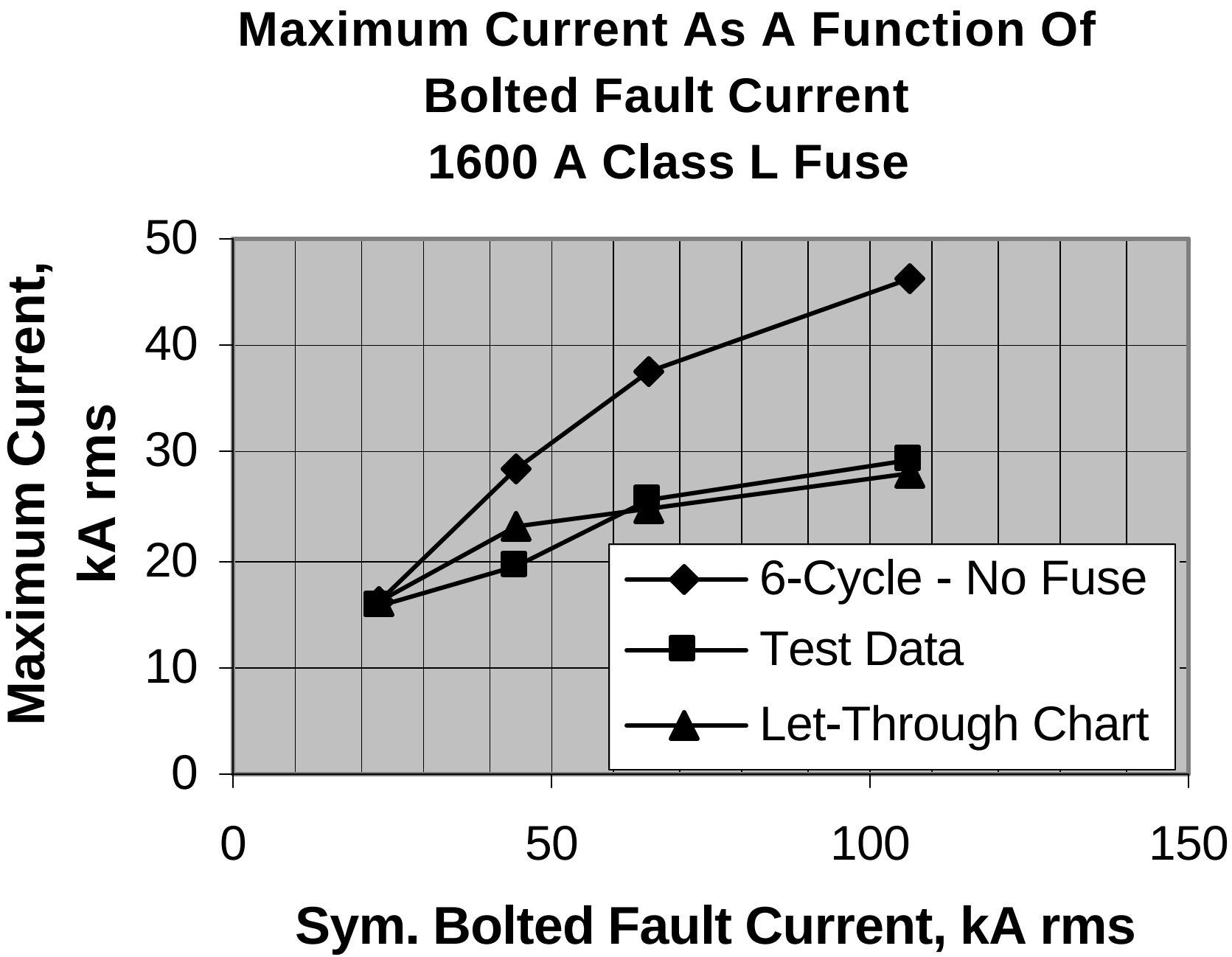
Review of Test Results

- 3-Phase Arc Current With No Fuse As A Function of Bolted Fault Current
- Maximum Fuse Current As A Function of Bolted Fault Current
- Arc Incident Energy With & Without The Fuse As A Function of Bolted Fault Current
- Fuse 2nd Degree Burn Criteria

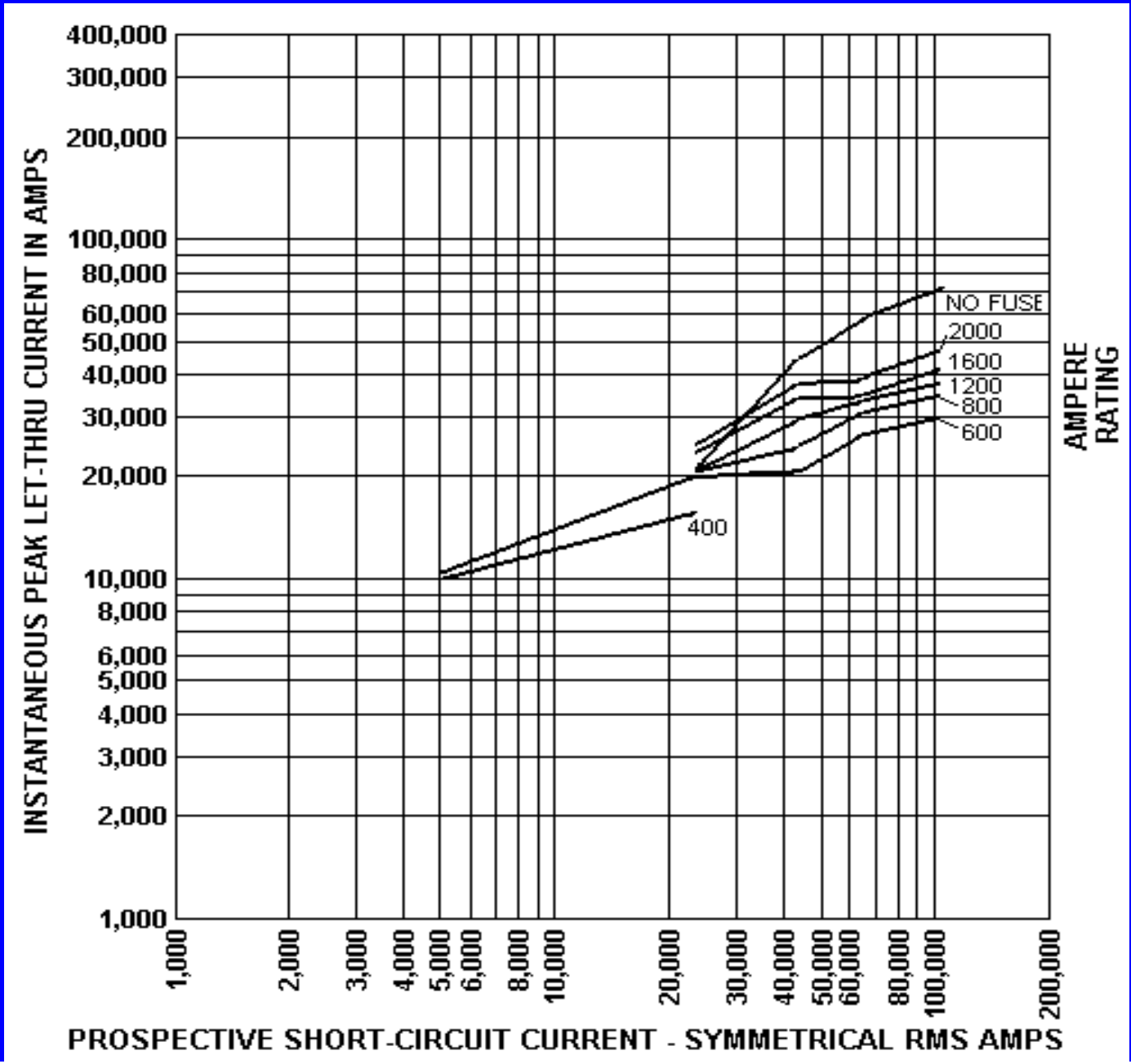

3-Phase Arc Current As A Function Of Bolted Fault Current
Arc Current, kA
80
60
40
20
0
0
50
100
150
80
Sym. Bolted Fault Current, kA rms
Mean Max. I Pk.
Mean Max. I rms

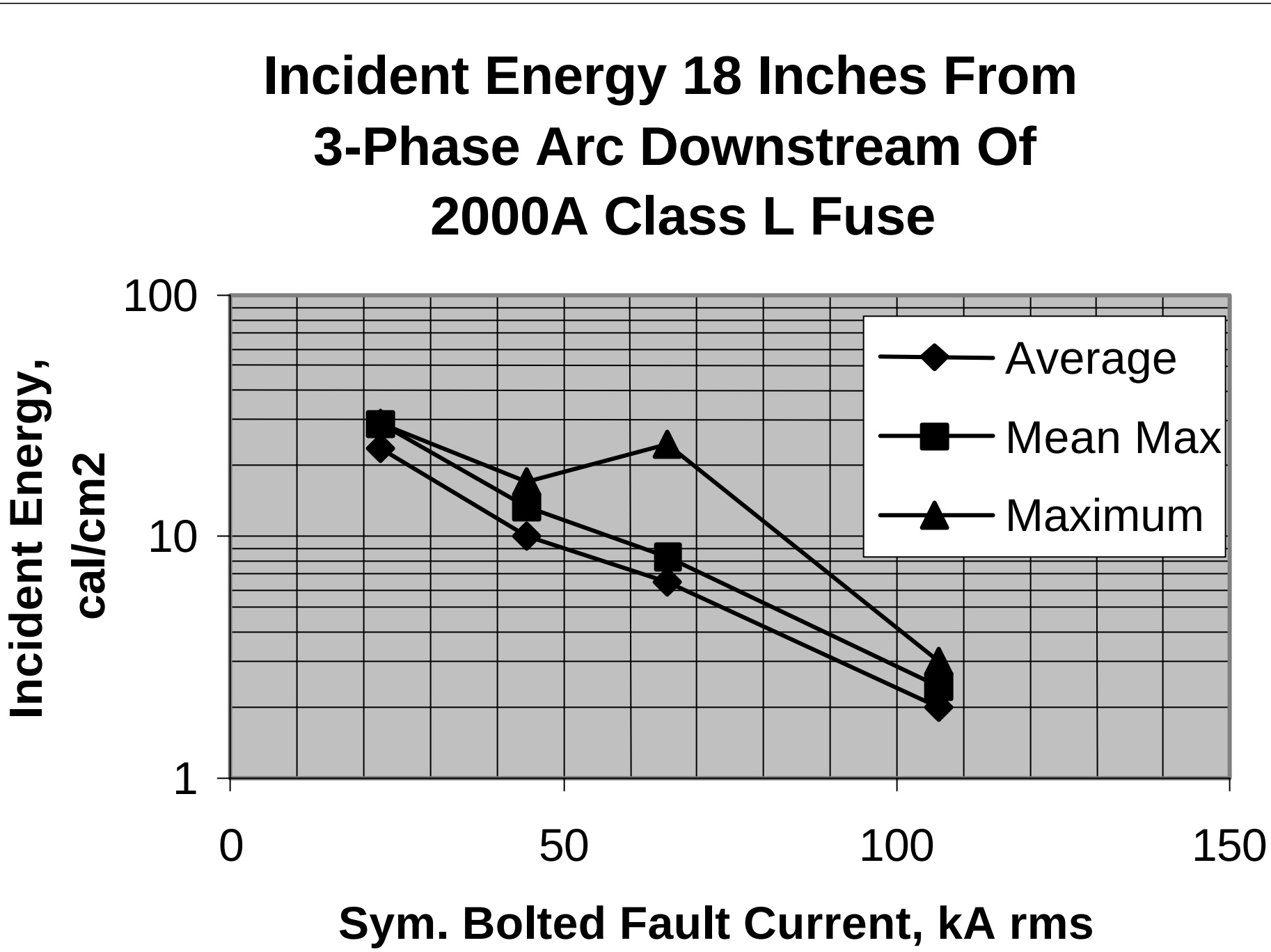
Fuse Arcing-Fault Let-Through - Example



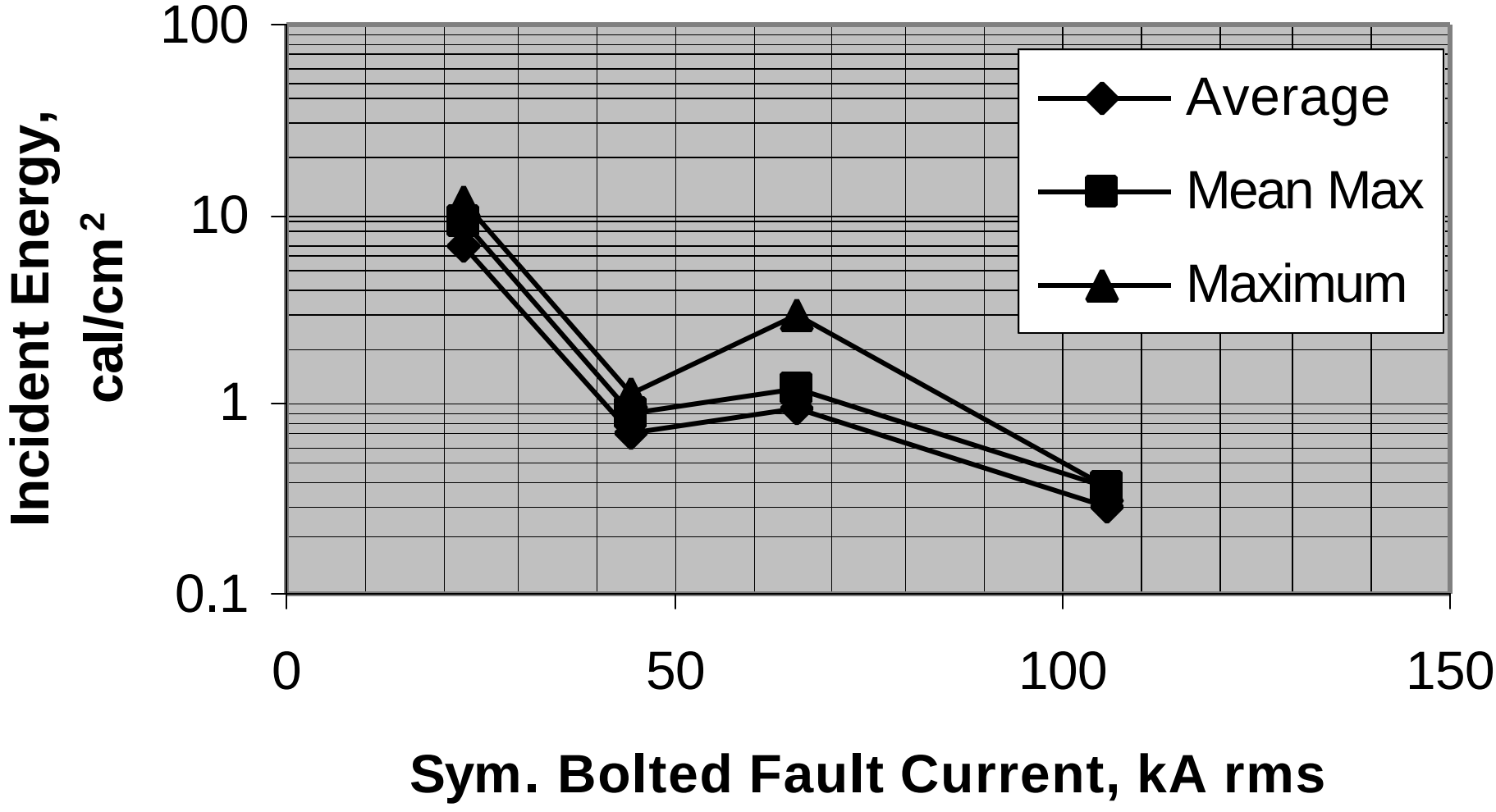

Maximum Current As A Function Of
Bolted Fault Current
1600 A Class L Fuse
Maximum Current, kA rms
50
40
30
20
10
0
0
50
100
150
Sym. Bolted Fault Current, kA rms
6-Cycle - No Fuse
Test Data
Let-Through Chart

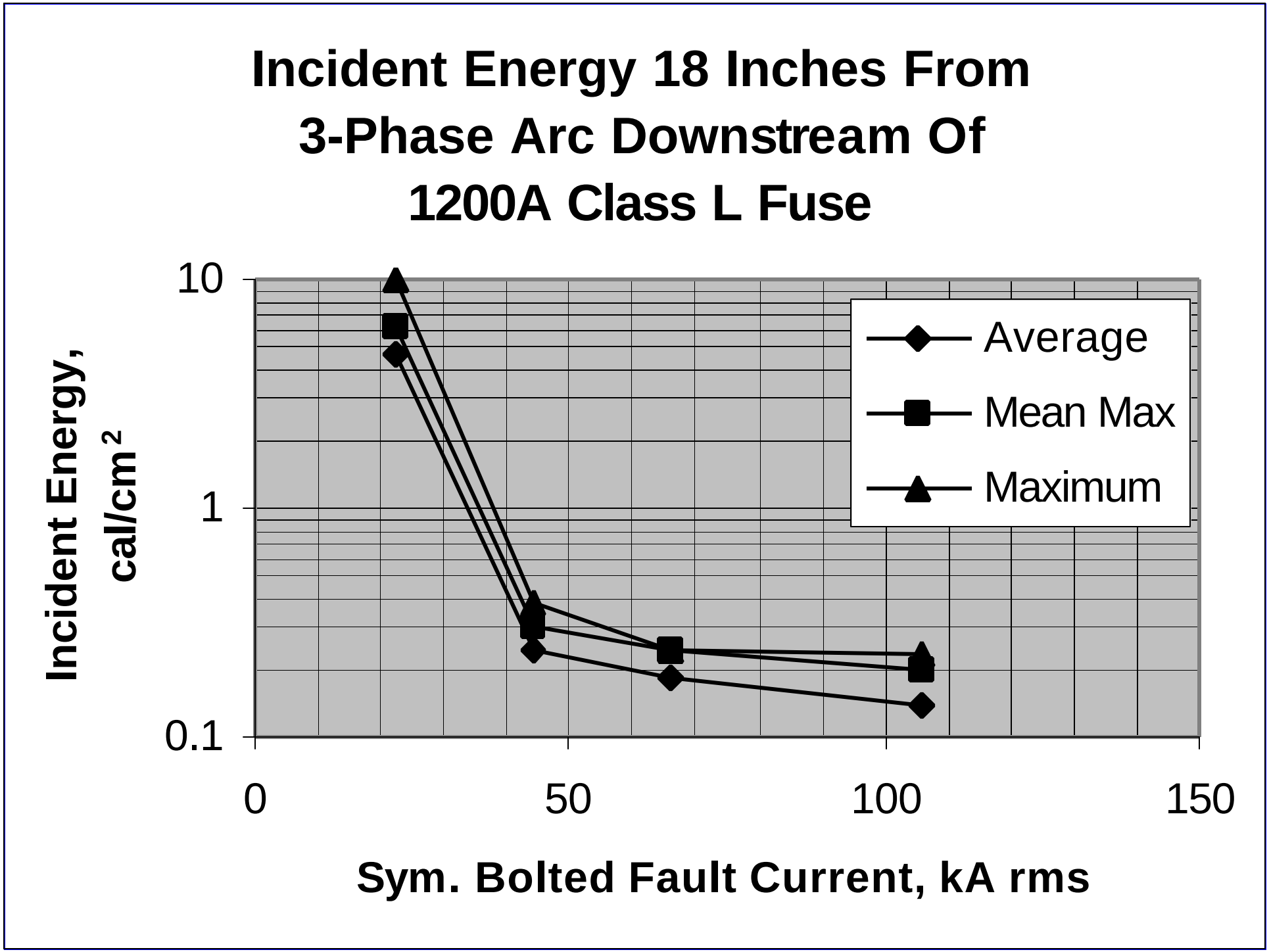
Fuse Performance - Downstream 3-Phase Arc

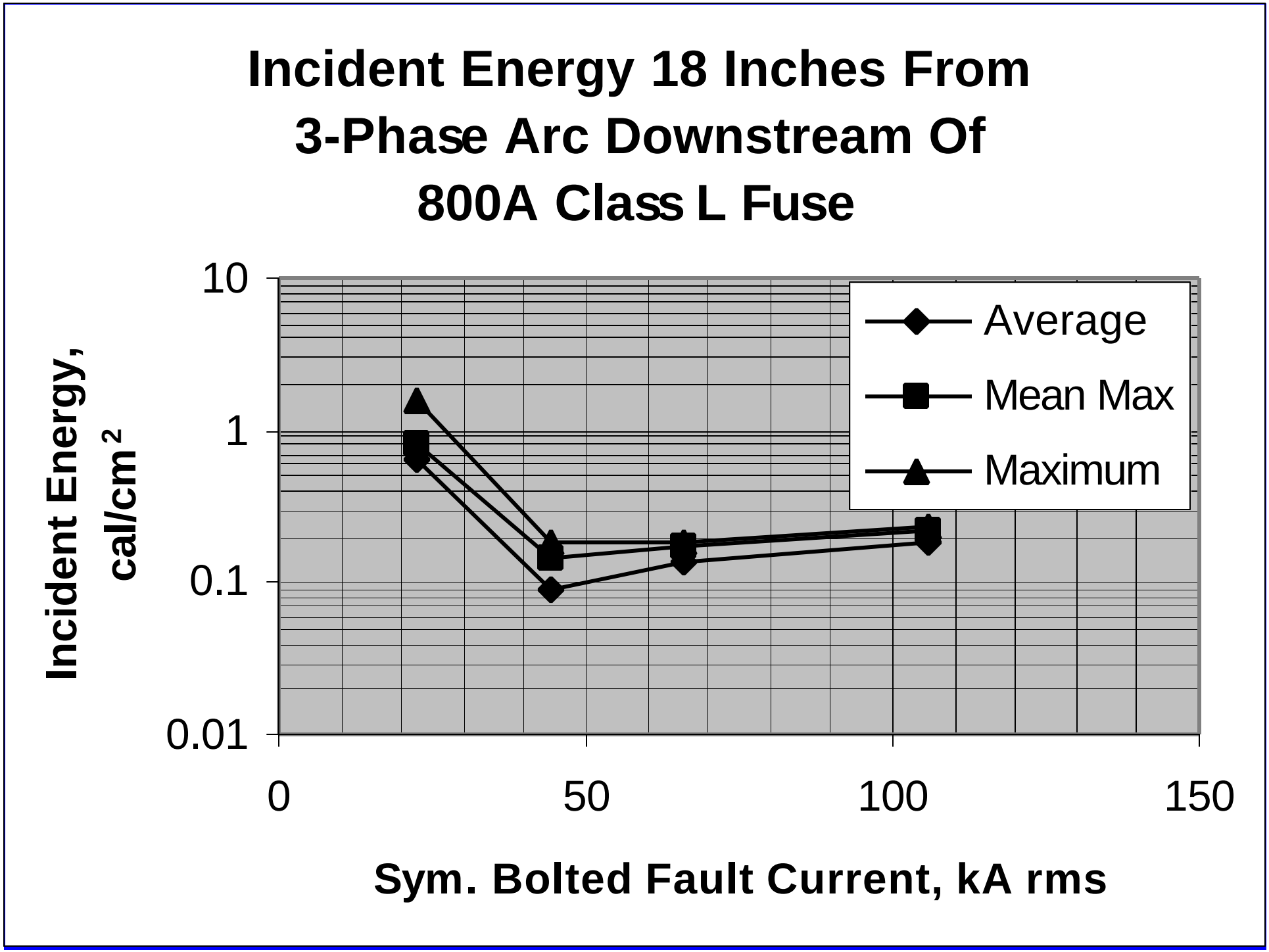



Incident Energy 18 Inches From
3-Phase Arc Downstream Of
2000A Class L Fuse
100
10
1
Incident Energy,
cal/cm2
0
50
100
150
Sym. Bolted Fault Current, kA rms
Average
Mean Max
Maximum

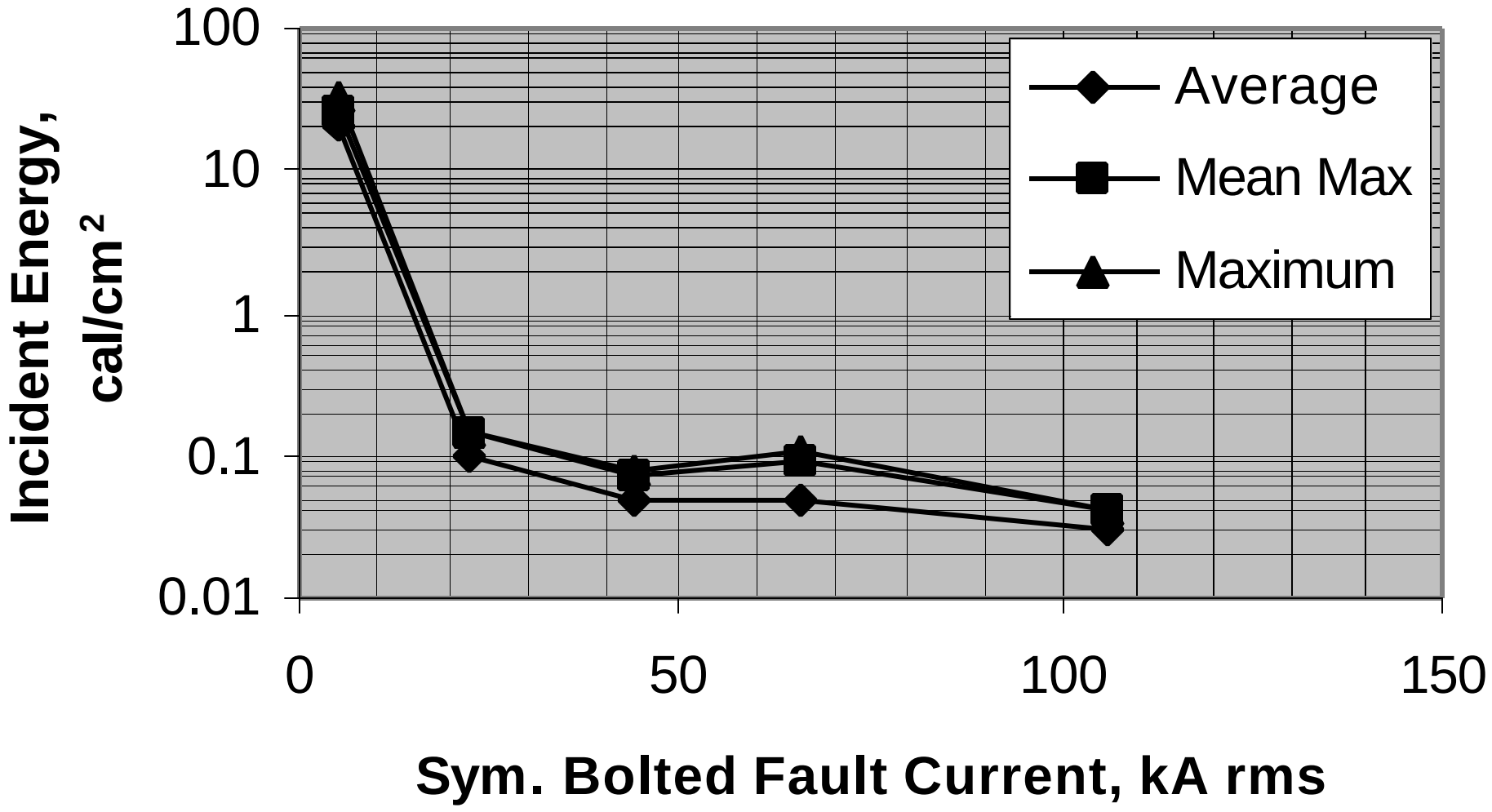
Incident Energy 18 Inches From 3-Phase Arc Downstream Of 1600A Class L Fuse



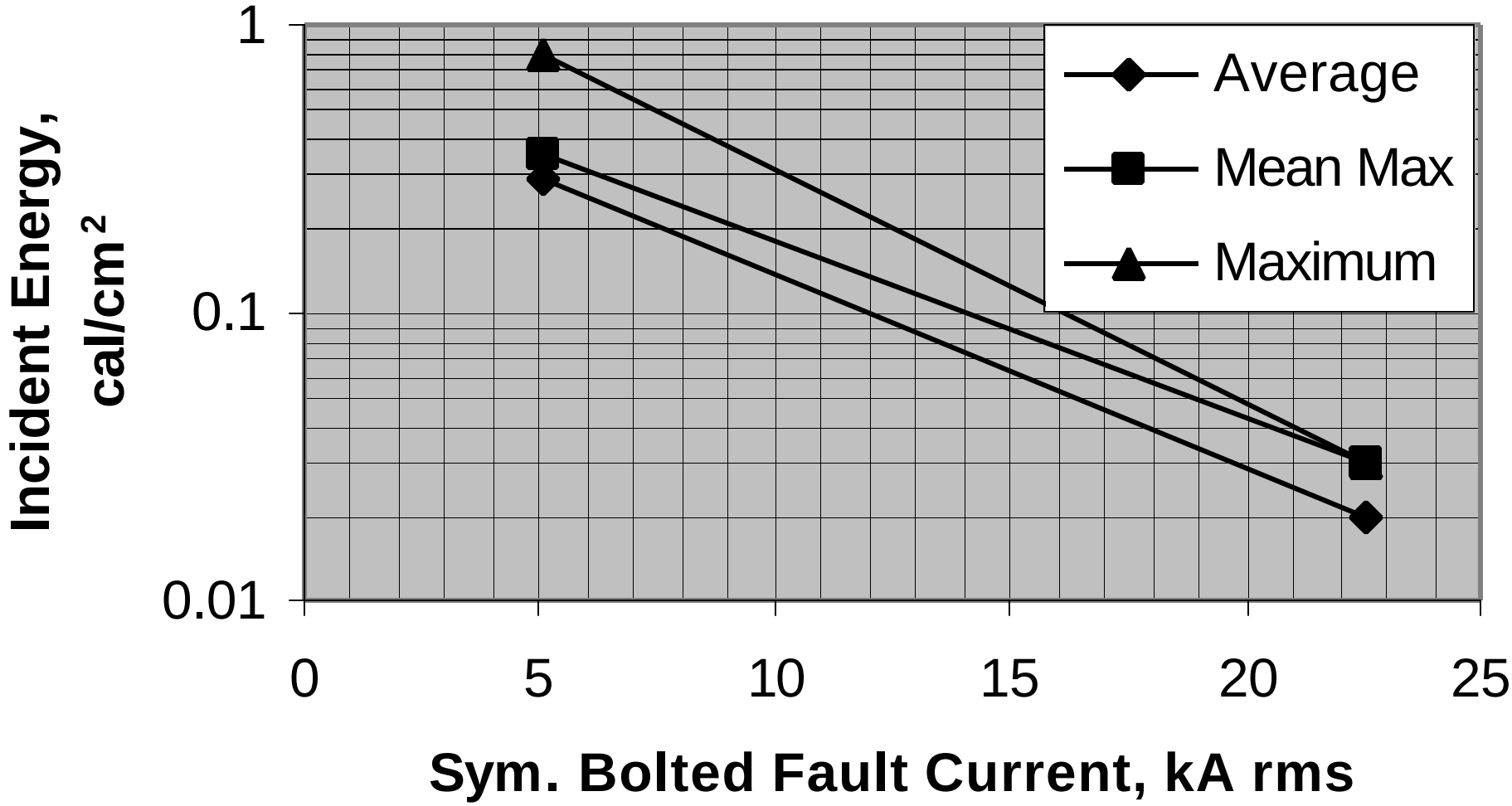

Incident Energy 18 Inches From
3-Phase Arc Downstream Of
1200A Class L Fuse
10
1
0.1
Incident Energy,
cal/cm2
0
50
100
150
Sym. Bolted Fault Current, kA rms
Average
Mean Max
Maximum


Incident Energy 18 Inches From
3-Phase Arc Downstream Of
800A Class L Fuse
Incident Energy, cal/cm2
10
1
0.1
0.01
0
50
100
150
Sym. Bolted Fault Current, kA rms
Average
Mean Max
Maximum

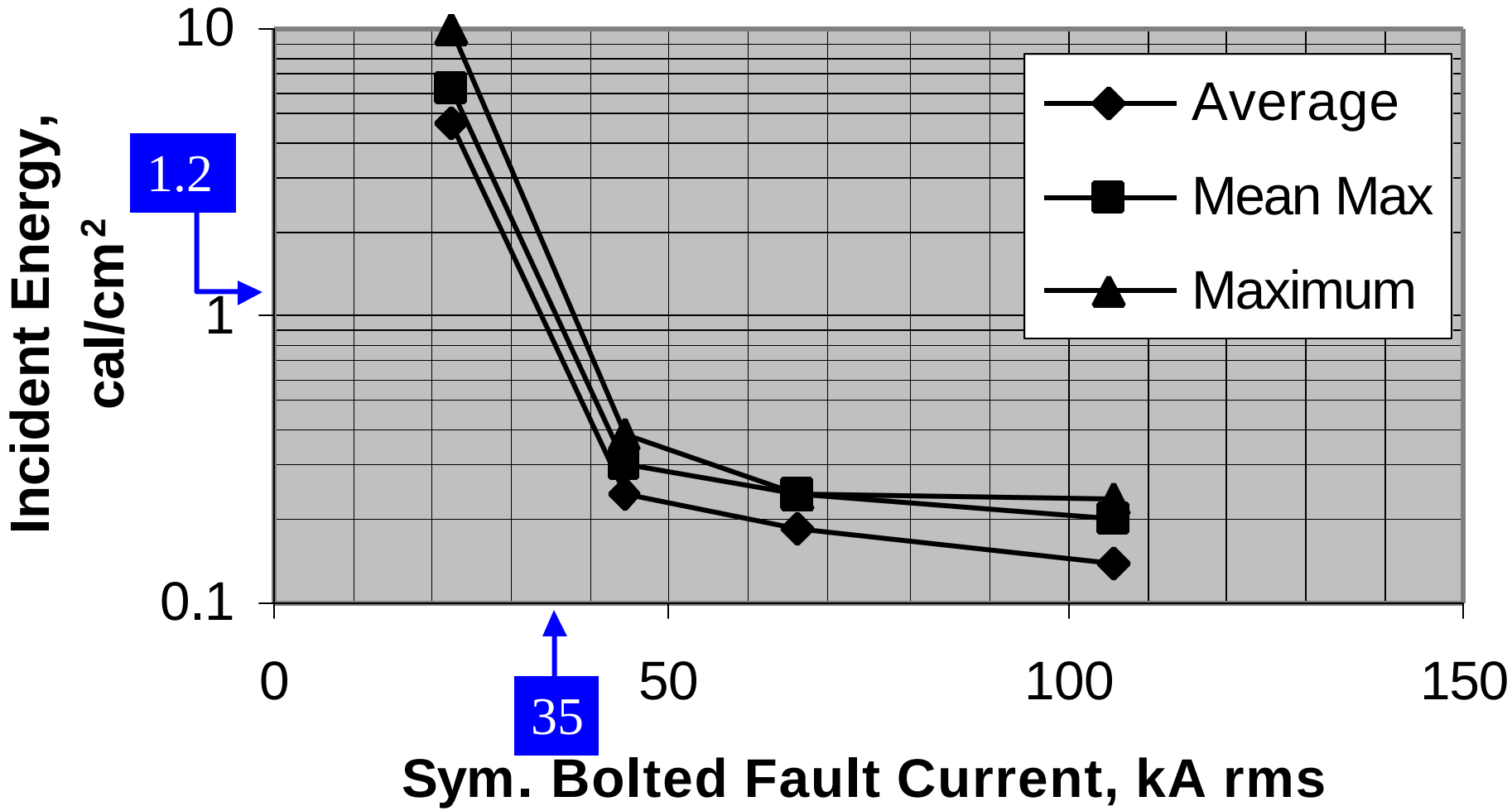
Incident Energy 18 Inches From 3-Phase Arc Downstream Of 600A Class RK1 Fuse



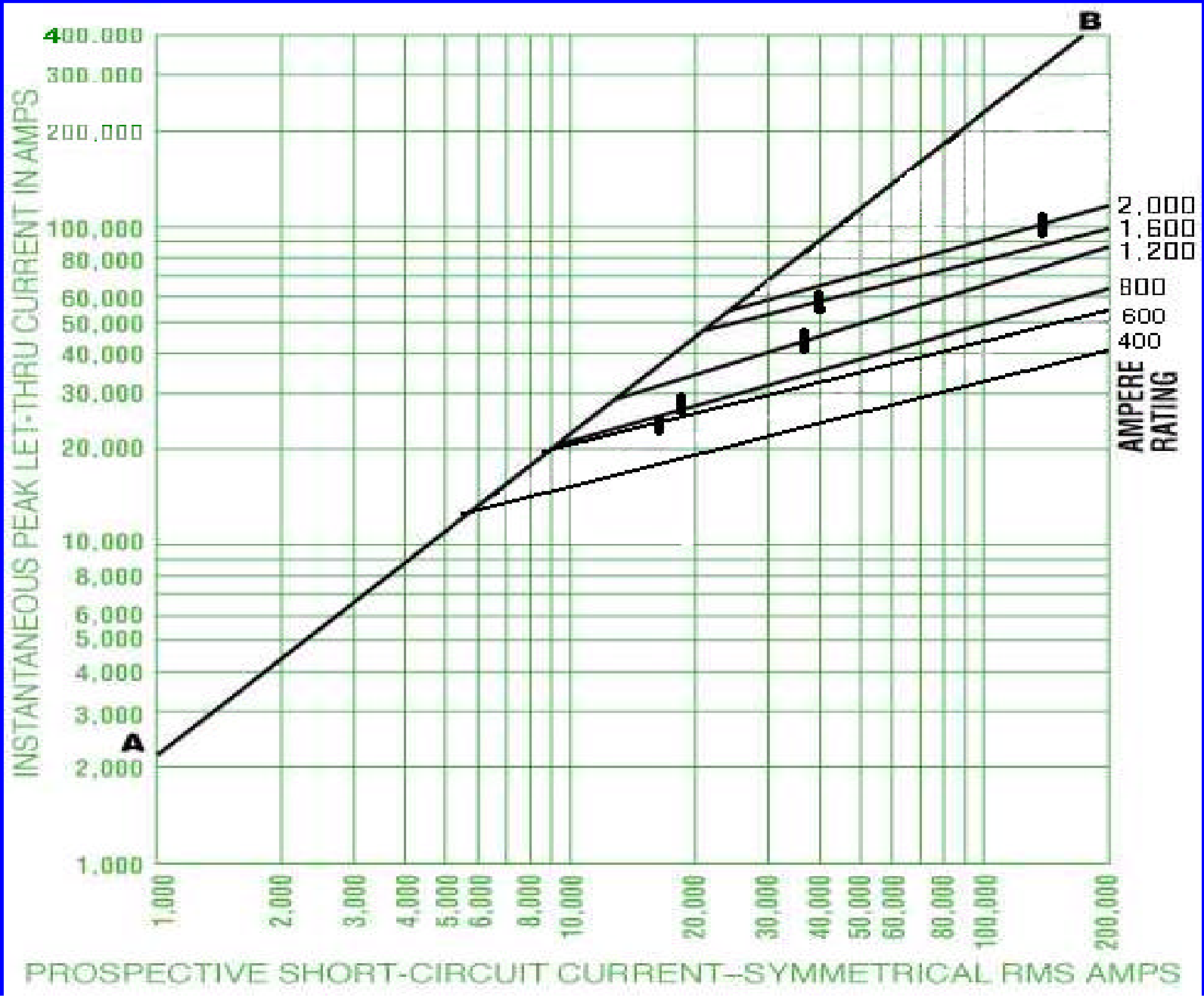
Incident Energy 18 Inches From 3-Phase Arc Downstream Of 400A Class RK1 Fuse



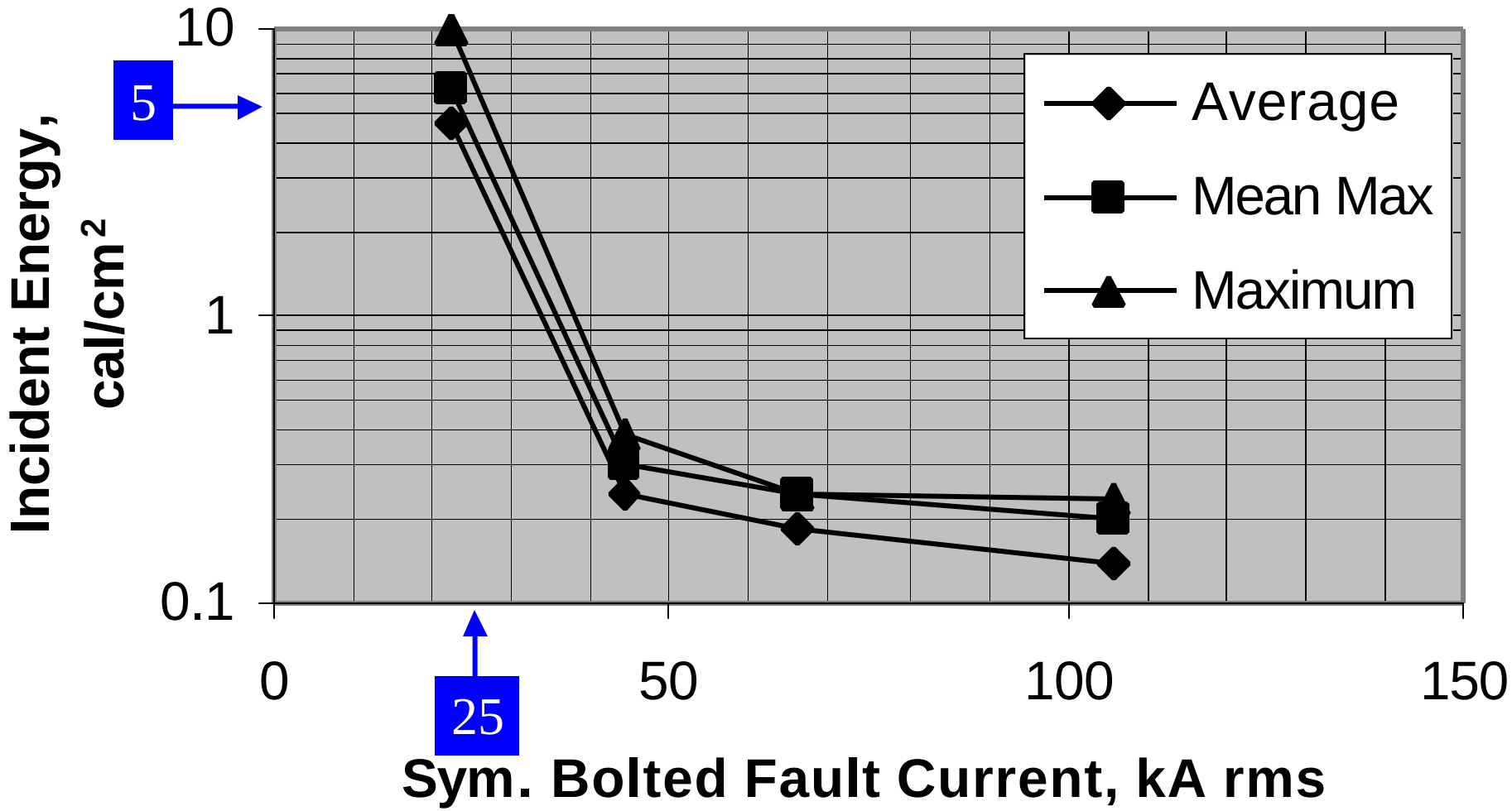
Incident Energy 18 Inches From 3-Phase Arc Downstream Of 1200A Class L Fuse



2nd Degree Burn Limit @ 18 Inches - Bare Skin



Incident Energy 18 Inches From 3-Phase Arc Downstream Of 1200A Class L Fuse



2nd-Degree Burn Limit Chart
3-Phase Arcing Fault

System Description	Minimum Available Prosp. S. C. Current @ Fault Loc. To Minimize The Possibility Of 2nd Degree Burn @ 18"			
	Cl. L Fuse 2000A	Cl. L Fuse 1600A	Cl. L Fuse 1200A	Cl. L Fuse 800A
Bare Human Skin 1.2 cal/cm 2	130 kA sym.	45 kA sym.	35 kA sym.	20 kA sym.
Class 1 FR Clothing 5 cal/cm 2	80 kA sym.	30 kA sym.	25 kA sym.	15 kA sym.

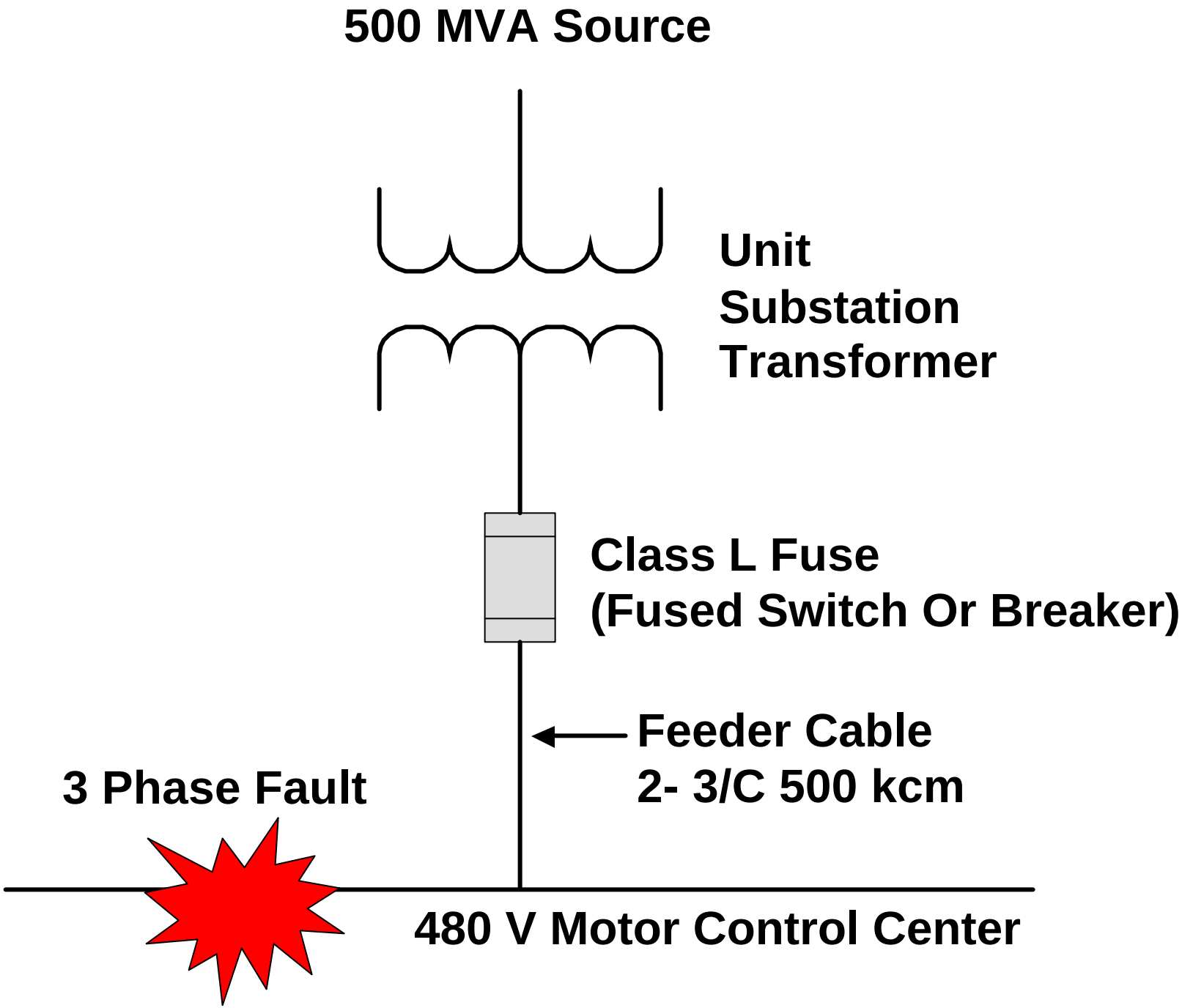
Presentation Outline

Part II - Vince Saporita

- Design Considerations For Reducing Arc Flash Hazard
- Impact of System Grounding
- Recommendations/Conclusions

Impact On LV System Design

- Must Provide The Minimum Required Available Short-Circuit To Minimize The Possibility Of 2nd-Degree Burn @ 18”
- Available Short Circuit Current Depends upon the following factors:
  - Available Fault Level At Transformer Primary
  - KVA Rating & Impedance Of The Transformer
  - Size & Length Of Secondary Conductors


500 MVA Source
Unit
Substation
Transformer
Class L Fuse
(Fused Switch Or Breaker)
Feeder Cable
2- 3/C 500 kcm
3 Phase Fault
480 V Motor Control Center

Max. MCC Feeder Length
2-3/C 500 kcm Conductor - Bare Skin

Transf. KVA	Maximum Feeder Length, Ft., To Minimize 2nd- Degree Burn Of Bare Skin @ 18"			
	Cl. L Fuse 2000A	Cl. L Fuse 1600A	Cl. L Fuse 1200A	Cl. L Fuse 800A
1000	none	none	none	10
1500	none	none	none	275
2000	none	none	50	395
2500	none	25	130	460
3000	none	80	185	505
3750	none	130	230	550

Max. MCC Feeder Length
2-3/C 500 kcm Conductor - Class 1FR*

Transf. KVA	Maximum Feeder Length, Ft., To Minimize 2nd-Deg. Burn with Cl. 1 FR Clothing @ 18"			
	Cl. L Fuse 2000A	Cl. L Fuse 1600A	Cl. L Fuse 1200A	Cl. L Fuse 800A
1000	none	none	none	285
1500	none	none	110	530
2000	none	130	240	645
2500	none	205	310	710
3000	none	255	355	750
3750	none	300	400	795

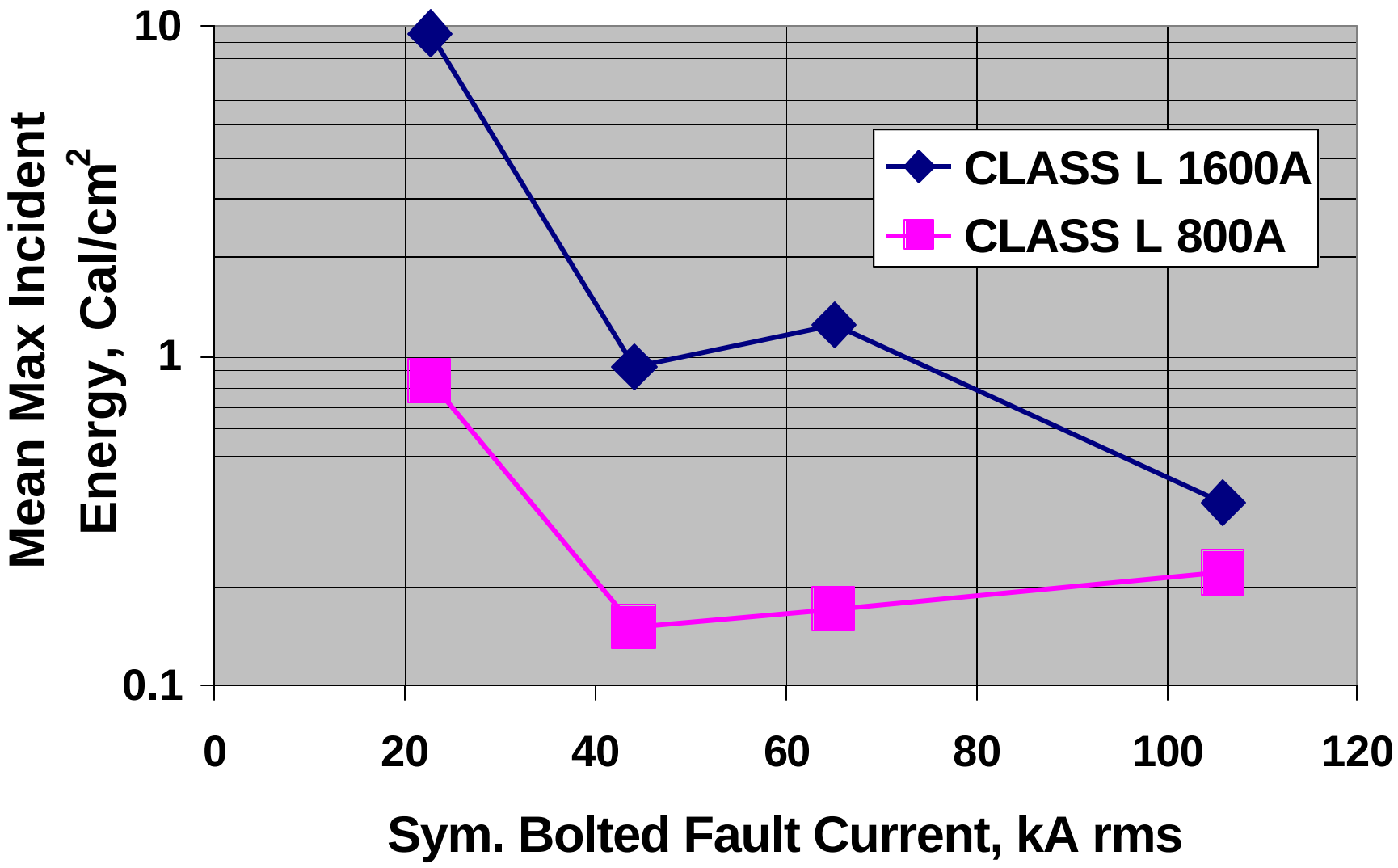
*** Class 1 FR Clothing Rated 5 cal/cm^2**

Design Impact
Number of Fused Circuits

- **Multiple Smaller Capacity Fused Circuits Provide A Significantly Greater Degree Of Arc Flash Hazard Reduction Than One Large Capacity Fused Circuit**

Example - Two 800A Fused Circuits vs. One 1600A Fused Circuit

Incident Energy Comparison
1600A and 800 A Class L Fuses



Using Current-Limiting Fuses With High Resistance Grounded Systems

- Current-Limiting Fuses Minimize Arc Flash Hazards For High Level Three-Phase, Phase-to-Phase and Multiple Phase-Ground Arcing Faults
- A High Resistance Grounded System Will Prevent A High Level Arcing Fault For The First Phase-to-Ground Fault

Using Current-Limiting Fuses On Solidly-Grounded Wye Systems

- **Current-Limiting Fuses Minimize Arc Flash Hazards For High Level Three-Phase, Phase-to-Phase, Phase-to-Neutral, and Phase-to-Ground Arcing Faults**

Using Current-Limiting Fuses With Corner-Grounded Delta Systems

- Current-Limiting Fuses Minimize Arc Flash Hazards For High Level Three-Phase, Phase-to-Phase and Phase-to-Ground Arcing Faults
- On Corner-Grounded Delta Systems, A Phase-To-Ground Fault Can Be The Same Magnitude As A Phase-to-Phase Fault
- There Can Be No Ground Fault On The Intentionally Grounded Phase

Using Current-Limiting Fuses With Ungrounded Systems

- Current-Limiting Fuses Minimize Arc Flash Hazards For High Level Three Phase, Phase-to-Phase, And Multiple Phase-Ground Arcing Faults.
- As With High Resistance Grounded Systems, Ungrounded Systems Will Prevent A High Level Arcing Fault For The First Phase-to-Ground Fault.

Conclusions

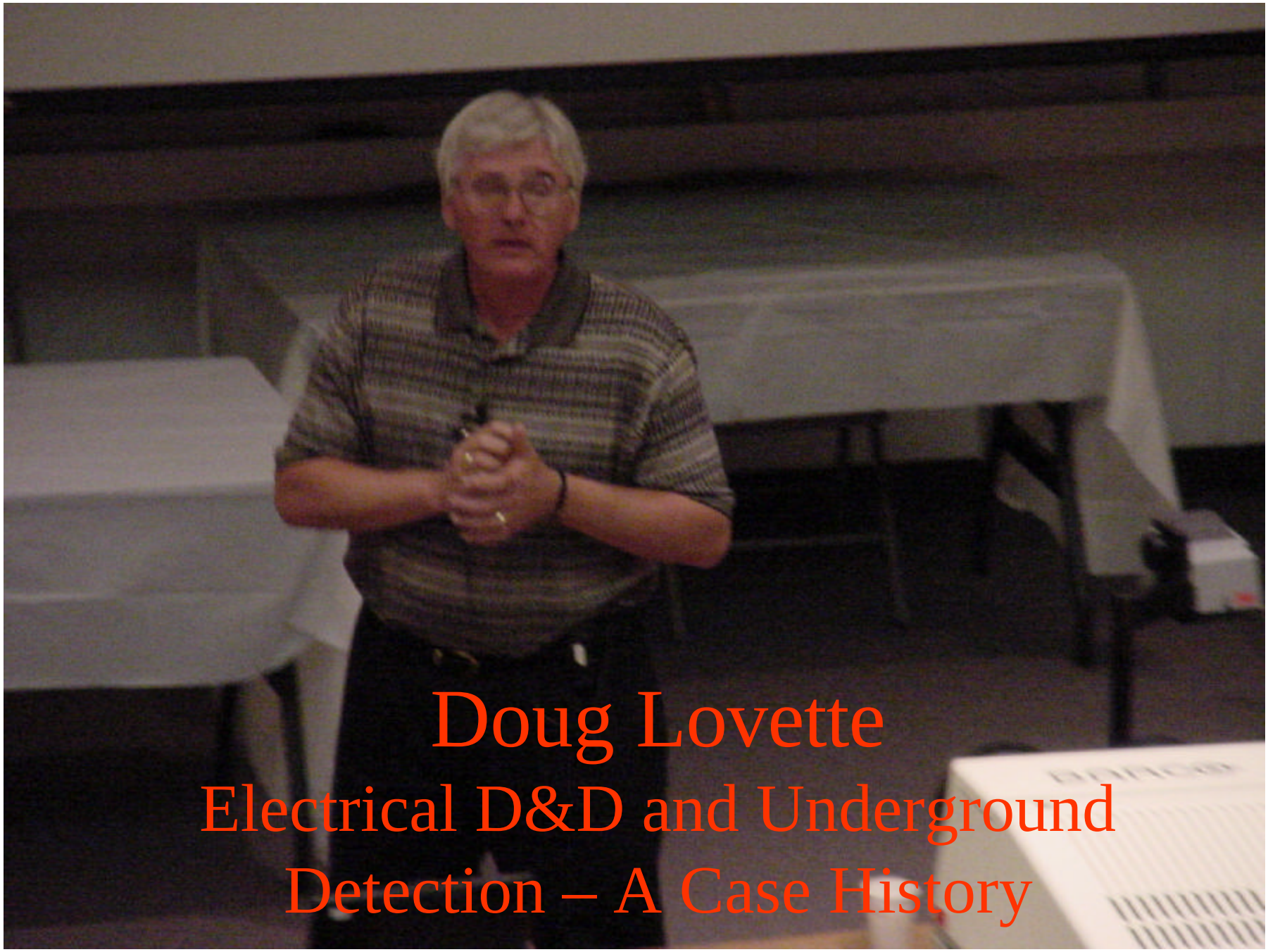
- The Benefit Provided By Correctly Applied Current-limiting Fuses In Minimizing Arc Flash Exposure Has Been Verified
- Arc Impedance And Current Limiting Fuses Reduce Arcing Fault Current Below Bolted Fault Values

Conclusions (Continued)

- The Minimum Required 3-Phase Bolted Fault Current To Minimize 2nd-Degree Burn Of Human Skin @ 18" Has Been Determined For The Tested Fuses
- Minimizing The Length of Cable Runs To Provide The Required Bolted Fault Current Will Allow Fuses To Operate In Their Current Limiting Range, Thereby Minimizing The Arc Flash Hazard

Conclusions (Continued)

- Multiple Small Capacity Fused Circuits Provide A Significantly Greater Degree Of Arc Flash Hazard Reduction Than One Large Capacity Fused Circuit (Two 800A Fused Circuits vs. One 1600A Fused Circuit).
- System Grounding Also Affects Arc Flash Hazard Exposure.



Doug Lovette

Electrical D&D and Underground Detection – A Case History

D&D Electrical Safety and Underground Detection

DOE Electrical Safety Conference

Princeton, N.J.

August 2 and 3, 2001

Project Scope

- Isolation of electrical power and alarm/telemetering systems
- Involved 7 buildings and 9 trailers
- Work began in 1999

Project Details

- The 7 buildings were built during WW II
- Six of the seven buildings were used for multiple purposes
- Six of the seven buildings were placed in “Stand-by” in the 1970’s
- Trailers installed in 1970’s
- One building and trailers in use until D&D

Plant Changes

- Most personnel familiar with modifications were unavailable
- Moving from M&O concept to M&I
- Responsibilities for electrical system were split in March 1999
- New organization formed to self-perform electrical operations and maintenance

Plant Changes

- In October 1999, electrical operations and maintenance awarded to subcontractor
- In 1998, utility system (water, steam, air, sewage) operations and maintenance performed by OMI
- Prime contractor to CROET

Old Philosophy

- Review drawings
- Locate above ground valves/conduits
- Involve knowledgeable personnel
- Dig

New Philosophy

- Locating equipment procured by OMI and Power Operations
- Each had two competent locators
- Locates were performed for every excavation permit
- Joined Tennessee One Call

New Philosophy

- Review drawings
- Locate above ground valves/conduits
- Involve knowledgeable personnel
- Perform locates
- Mark location of all UG systems detected

New Philosophy

- Document excavation restrictions on permit
- Review information with personnel performing the excavation work
- Dig
- Locators were available for any questions
- As-built drawings

Isolation Philosophy

- Assume drawings were incorrect until proven correct
- Provide physical break in systems at accessible locations
- No LO/TO or PDWP permits required for D&D

Isolation Philosophy

- If both ends of system were not known, assume system was in service until proven otherwise
- Assume nothing was known until system located, ends found, routing known
- Be able to account to D&D subcontractor for location of system isolation

Initial Information

- Drawings in excavation package
- Visual area walk down

Other information needed

- Drawings held by OMI
- Drawings and cable listings held by LMES
- Discontinued feeder route maps and manhole drawings drawn in 1940’s

Other Techniques Used

- Used UG detection equipment to follow cable routings
- Induced, Clamp around, Clip on, 60 cycle
- Talked out cables
- Performed absence of voltage verification in each building at each panel/terminal block

K-1301

- Three OH telemetering cables
- One OH power service
- One UG telemetering cable
- Two outdoor switchgear
- Power entered UG in three locations

K-1302

- One OH telemetering cable
- One OH power service
- Two UG power/alarm cables
- One outdoor substation
- One indoor substation
- Power entered UG in two locations

K-1303

- Two OH telemetering cables
- One OH power service
- One UG alarm cable
- Two substations on each end of building
- Power entered UG in three locations

K-1405

- One OH telemetering cable
- One overhead service
- Three UG telemetering cables
- One substation
- Power entered UG from one location

K-1407

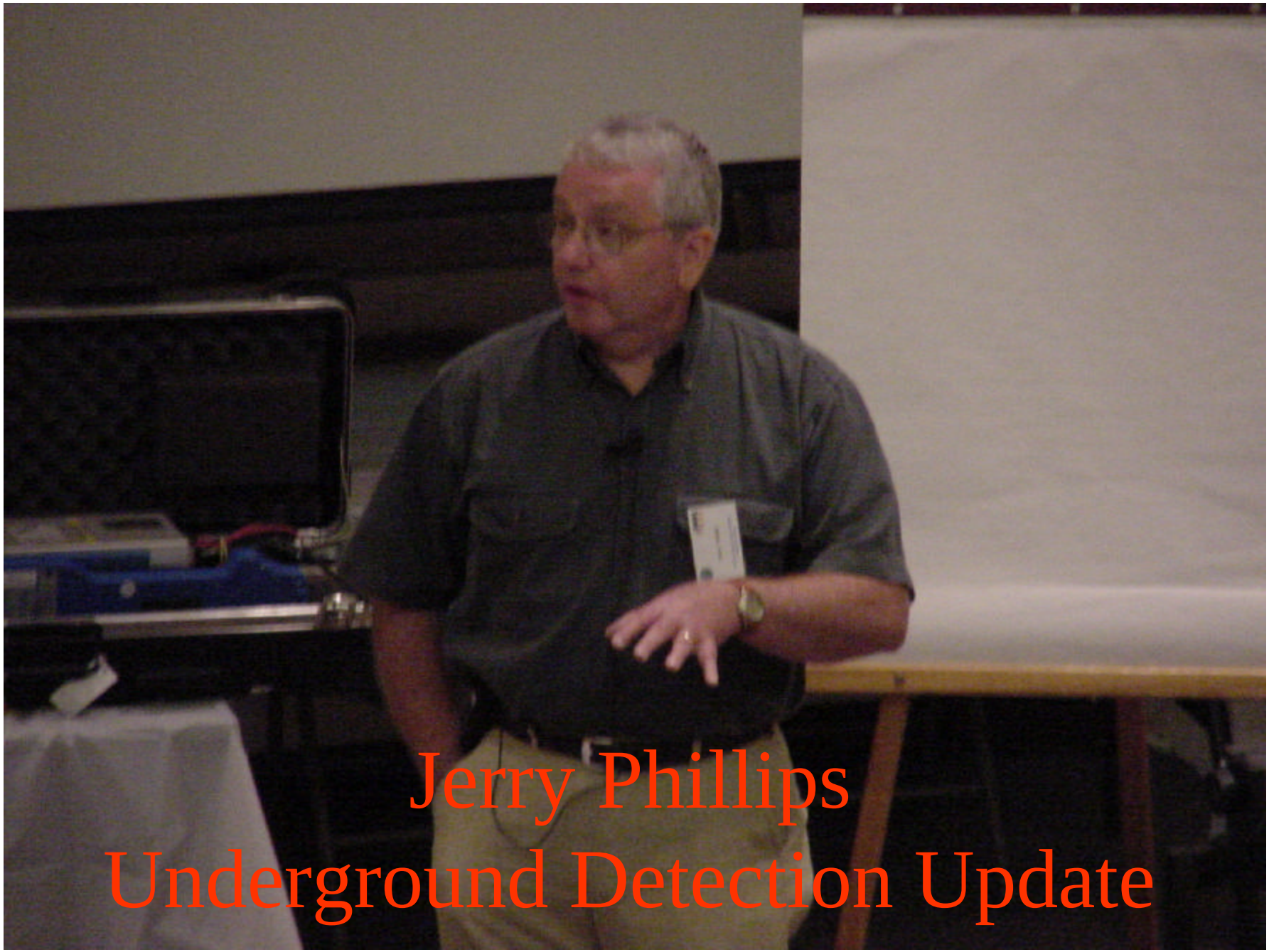
- Six OH telemetering cables
- One OH power service
- Two UG telemetering cables
- One UG power feed to second facility

K-1413

- Three OH telemetering cables
- Two OH power feeds
- One indoor switchgear
- Power entered UG in three locations

K-1001

- Two outdoor substations
- One OH power service
- Power/Telemetering entered/exited facility in fourteen UG locations
- Power/Telemetering entered/exited facility in four OH locations



Jerry Phillips
Underground Detection Update

UNDERGROUND DETECTION UPDATE

Jerry Phillips

The majority of underground utility locators being used today apply a signal to the underground structure being located. This signal may either be of an audio frequency or a radio frequency. An active signal is applied to the underground utility by various methods from the signal being generated from the transmitter unit of the location system. The best and most desired method of applying the signal is the direct or conductive mode, where there is access to a contact point on the utility to be located. Another method is the inductive or indirect mode, where the transmitter is placed on the surface of the ground above the utility and the signal from the transmitter is induced into the utility, making location possible. The third standard method of applying signal to an utility is the inductive clamp or coupler, where signal is induced to the utility without grounds being disturbed.

By far the most important aspect of utility location is the proper setup of the transmitter. With proper setup of the transmitter it becomes much easier to locate with the receiver unit. Even though the shape, size, controls, weight, and operation vary with the brand of locator, there are basic operating principles that apply to all locators that use the application of a signal to locate underground utilities.

It must be understood that the utility line to be located is part of a circuit that must be completed for the location of the utility to be possible. Starting with the direct method of location it is possible to explain this circuit which is the most important part of the location process. The red and black leads of the direct connection assembly may be thought of as the beginning of the circuit to be completed.

It must be recognized that the signal is leaving the red lead and trying to get back to the black lead. The setup of the transmitter is completing the circuit and controlling the path that the signal takes in going from the red lead to the black lead.

The ability of the utility to complete the circuit is determined by the composition of the utility. Copper utilities carry the signal best, with jacketed copper conductors being better that bare copper conductors. Aluminum is also an excellent conductor of the location signal. Steel is not as good as copper or aluminum for carrying the signal; but will be locatable, especially if the conductor is coated or wrapped. Cast iron is the poorest conductor of signal; however with proper transmitter setup, frequency selection, and power output, a location of cast iron utilities is possible.

Various factors must be taken into account for an accurate, successful locate. As mentioned in the previous paragraph the signal conducting ability of the utility is very important. A conductor which is wrapped, coated, or insulated will not bleed off the signal to the surrounding soil as rapidly as a bare conductor will. An utility can be traced further if the utility is insulated and thereby not as easily influenced by the environment. Size of the utility is also a factor, a signal cannot travel as far on large diameter pipe as it can on small-insulated cable. Soil conditions also become part of the influence on the signal circuit. Wet compact soil is clearly a much better return signal conductor than sandy soil or frozen ground. Bare conductors in areas where salt water incursion is present can be very difficult to locate due to the high conductive nature of the soil in these locations.

As the operator approaches the location of the underground utility he needs to understand the capabilities of the instrument being used with regards to frequencies available, power settings, and proper use. As mentioned before the direct connection is always the best method of applying the signal to the utility, as the operator has the most control of the signal with this method. Proper use of the transmitter and grounding assembly cannot be over emphasized. The secret of a good location is setting up the transmitter properly and the secret to setting up the transmitter is the grounding method. It can very safely be said that at

least 80% of all mislocates result from the failure to properly control the signal on the target utility.

Inductive couplers and clamps all apply signal to the utility in basically the same manner. The signal is induced onto the utility to be located by an electromagnetic field created by the coupler or clamp. It must be noted; however that the utility must have grounds in place at both ends of that section to be located. Missing ground bonds it to telephone cables will prevent this connection from being used. Couplers and clamps must be positioned below the electrical grounding point on CATV, electrical, and telephone cables. Cables which do not used earth ground, such as railway signal cables, cannot be located with couplers and clamps. Gas meters with insulated couplings should not be jumped and should be direct connected, due to possible floating ground conditions.

Inductive use of the transmitter, using the internal antenna contained within the transmitter, should be used as an absolute last result method for locations. Inductive use can lead to serious tracing errors especially if other utilities are in the area.

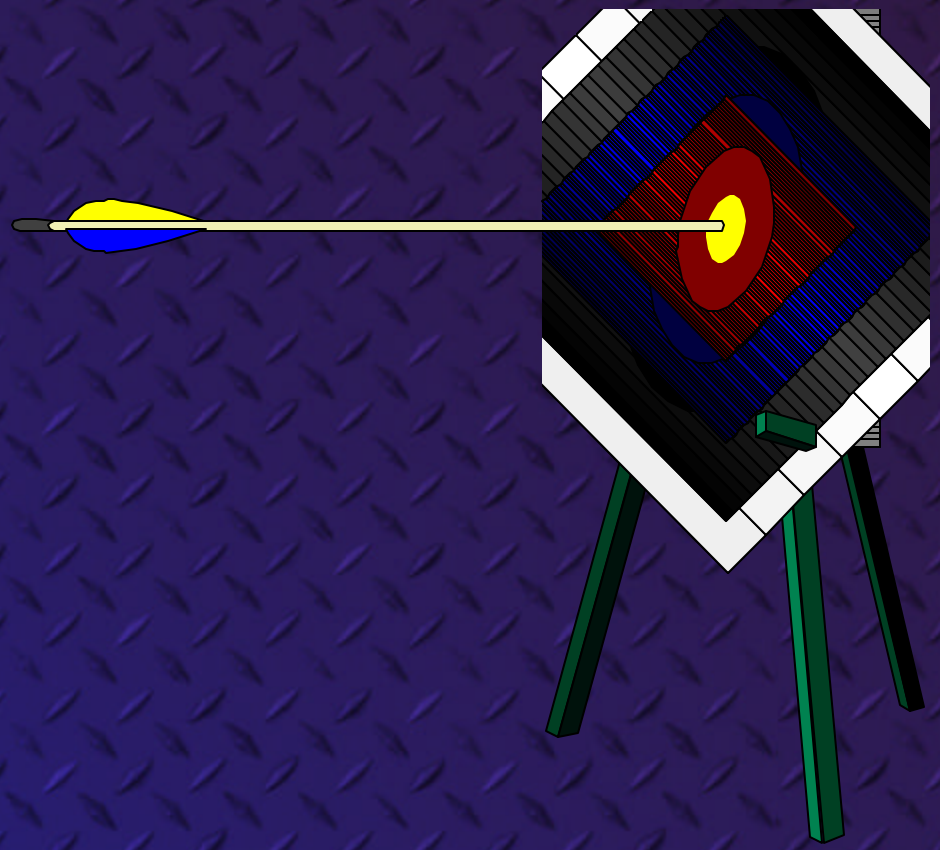
After proper setup of the transmitter the use of the receiver will be much easier. Background noise and interfering signals can greatly be reduced with digital signals. Proper use of the receiver requires that that the

antennas be moved in a straight path and not a swinging motion. This is the cause of a great number of mislocates. Do not use a wrist movement, but move the entire lower arm to accomplish this. With receivers consisting of both the peak and null method of location, the peak will be the most accurate, while the null is easier to use. Good location practice calls for the use of both location methods while locating utilities. When using receivers with digital readouts showing depth, pay constant attention to the depth of your utility. Be aware that depth readings are electronic principles and not laws of physics. Depth readings will not be accurate at risers, bends in conductors, or in area of a cable fault. Use the depth readings for your own use and do not give them to anyone else. A good answer to a depth question is "About normal for this area"; if pushed for normal, the answer is "Somewhere between 3 inches and 8 feet".

The purpose of this brief paper is to stimulate your thinking in the realm of utility location. For years the evolution of underground locators was very gradual; however in the past two decades with the increasing density of underground utilities, the need for the more advanced locator has become quite clear. The quality location instrument of today with digital signal processing, electronic guidance, automatic gain control, current measurement and all of the other features have made the operator even more important. Today's operator is more than 50% of the location

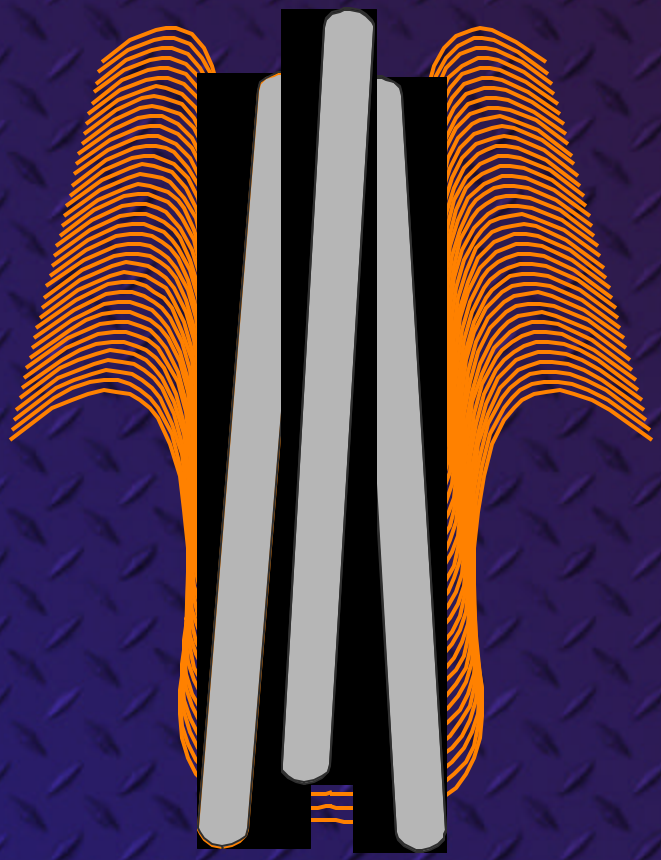
solution. A well trained properly equipped operator can locate almost any structure that man can bury. This author has located cables under thirty-five feet of water, four feet of cover and twenty-five thousand feet from the hookup point and the cable was at the located point when the diver went down to verify location. This was accomplished using standard location equipment and through the bottom of a fiberglass boat. This is the kind of location one can expect from modern locators.

What is the Only Way to be 100% certain of a utility's location?



METROTECH

To See the Utility Exposed or to Dig It Up!



METROTECH

Digging may not be practical or desirable.

We rely on pipe and cable locators to determine the utility's location with a high (but never 100%) level of confidence.

METROTECH

Puzzle Pieces Are Elements of Information

Such as:

- Method of connection
- Frequency
- Grounding
- Signal Strength

METROTECH

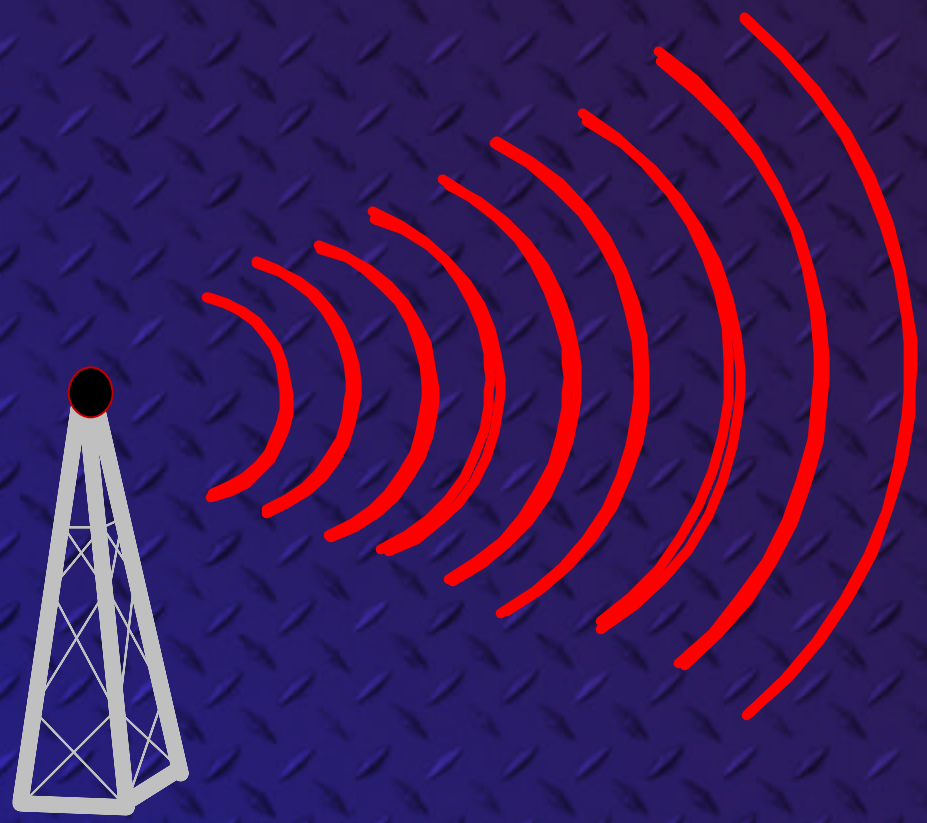
SECTION 1

Basic Locating Theory

(Inside the "Magic")

METROTECH

How Locating Works



Visualize the Transmitter as a "Radio Station" transmitting one or more specific frequencies.

METROTECH

Imagine your Receiver as a Car Radio receiving signals transmitted from your selected station's frequency.

3 Radio Stations

= 3 signals

METROTECH

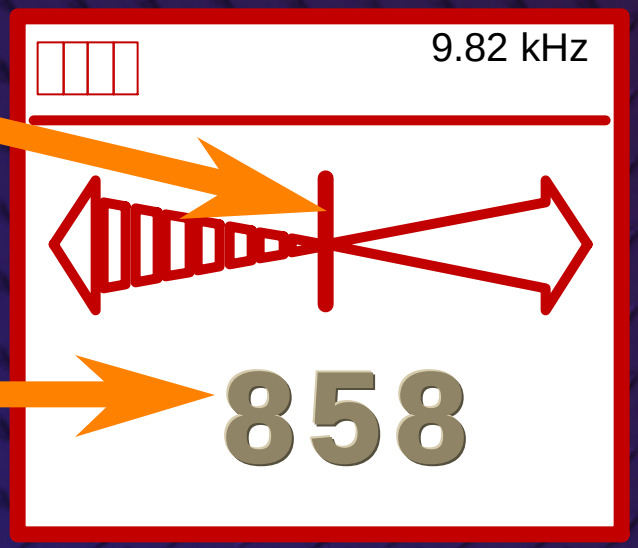
Locator Receiver

A Receiver receives the signal applied to a target conductor by the Transmitter. Information is computed, then displayed by the Receiver.

Locator Receiver

Centerline (L/R)

Signal Strength



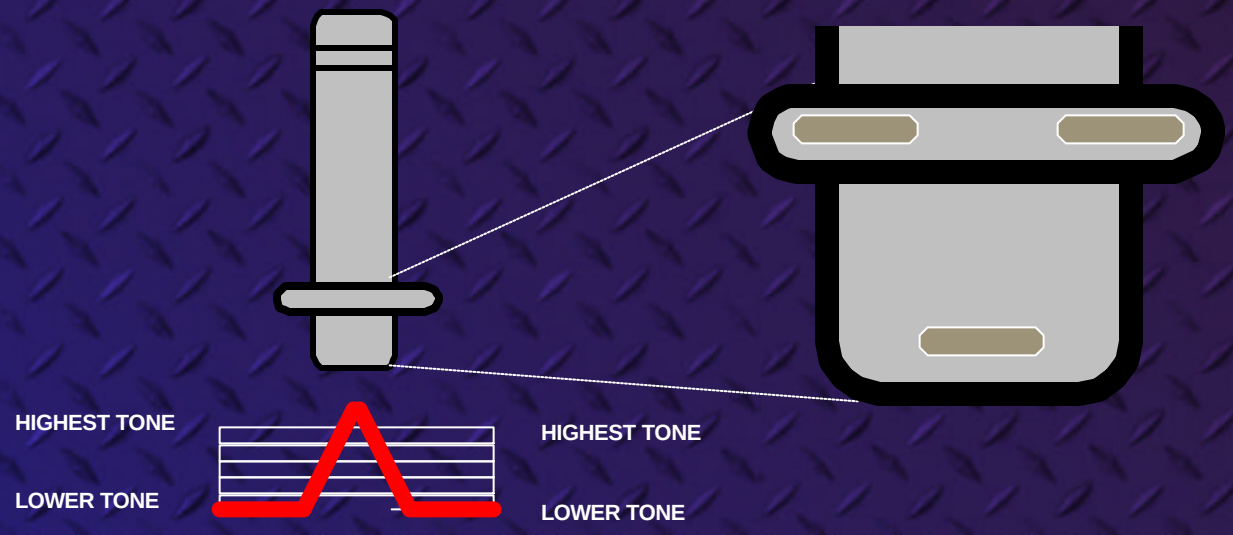
Audible Tone

Good signal strength indications are: crisp L/R, high signal strength and clear tone.

METROTECH

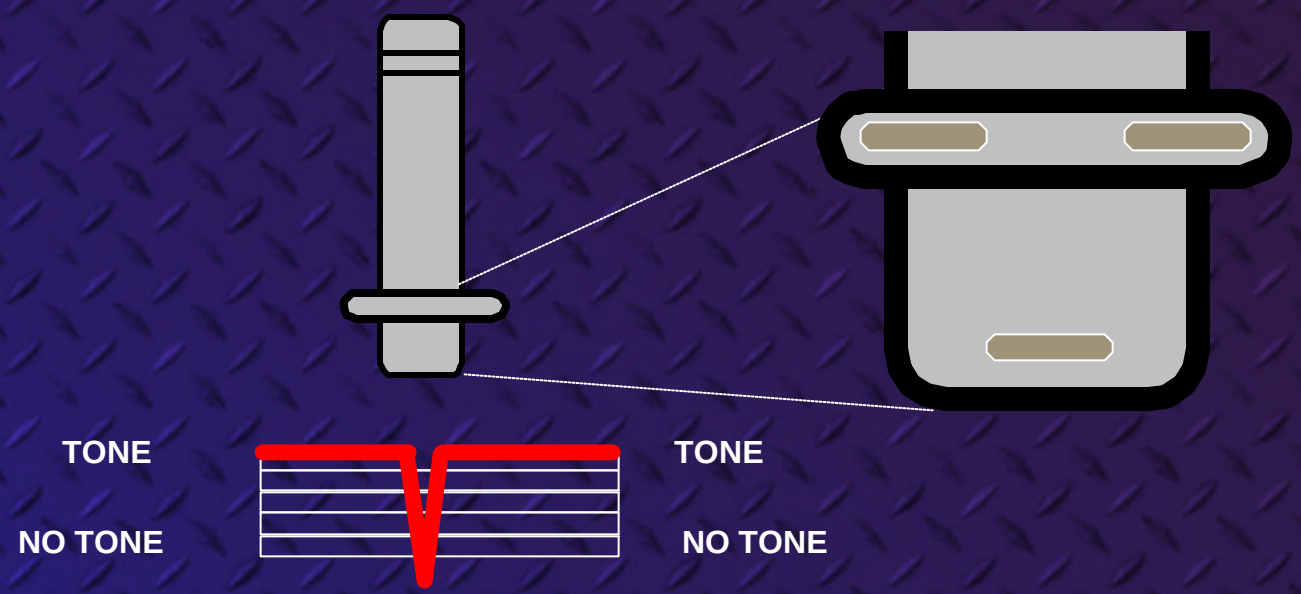
Most Locator Receivers work in two modes: "Peak" and "Null"

" PEAK" gives a maximum indication over your target conductor - loudest tone and highest signal strength. Use this method to find the general location of your target conductor.



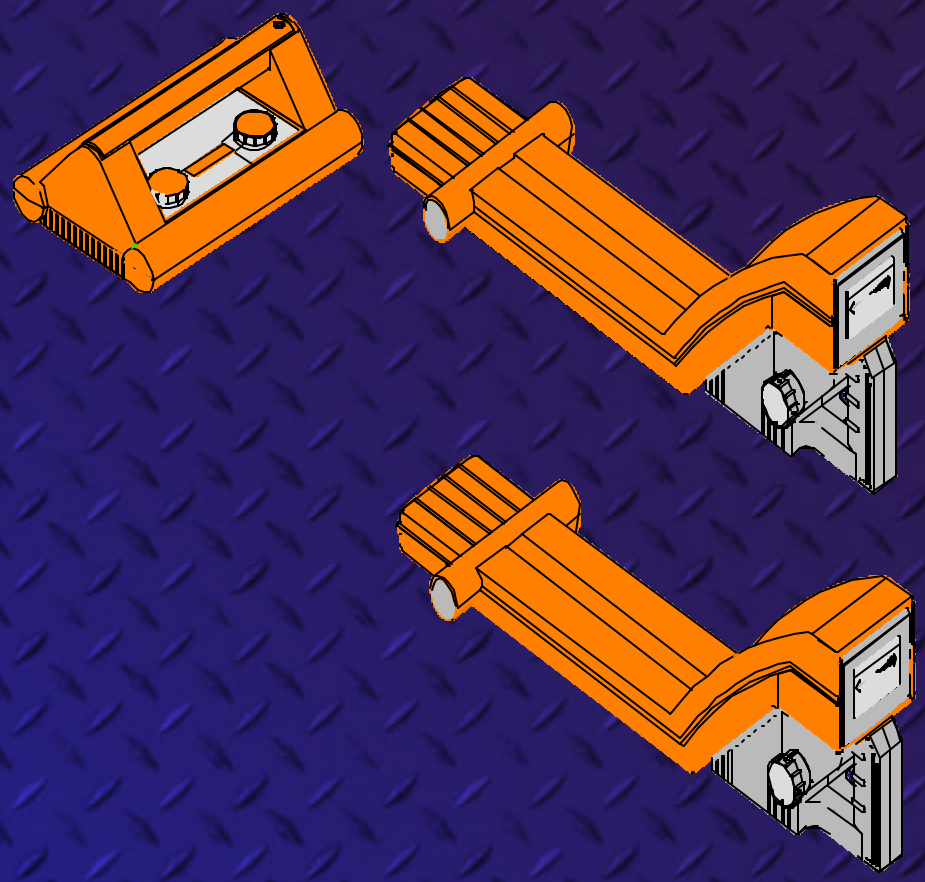
METROTECH

“ NULL” gives a minimum indication - NO tone and highest signal strength at the exact centerline of your target conductor. Use Null for precise pinpointing of your conductor.



METROTECH

Two Types of Locating



Active Locating

Transmitter & Receiver

Passive Locating

Receiver Only

(Verification Only)

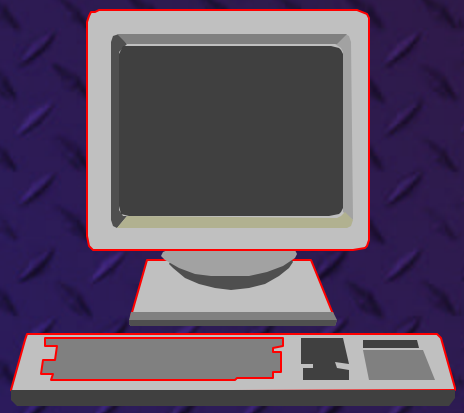
METROTECH

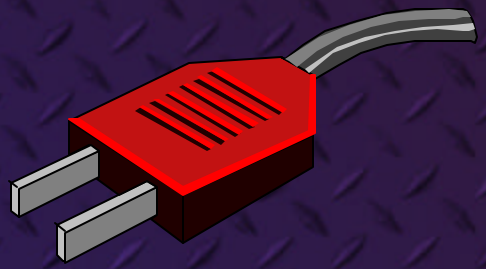
Passive Locating

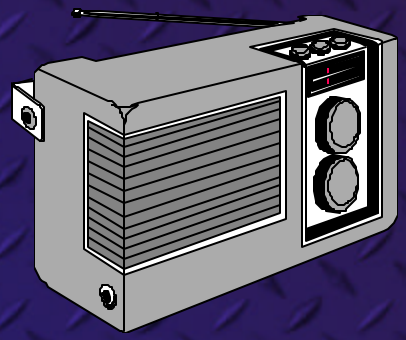
Using frequencies transmitted by common sources.

50/60HZ
Only if power drawing appliances are "ON" (31kHz CRT, TVs, video monitors)

Electronic Noise
Many sources
14kHz - 22kHz
(Radio transmitters of all variety)







Drawbacks of Passive Locating

- Lack of any signal on a buried conductor when the power source is off.
- No control over frequency or intensity of the signal.
- Non-specific frequency (RF).
- Signal path may be unrelated to the signal source (60Hz on water pipes).
- May be inaccurate or misleading.
- CAUTION: A conductor may be present without receiving a signal.

METROTECH

Active Locating
Direct Connect = Best Results

- Strongest Signal Strength
- Most Accurate Locate Method

METROTECH

Active Locating - Signal Transmission

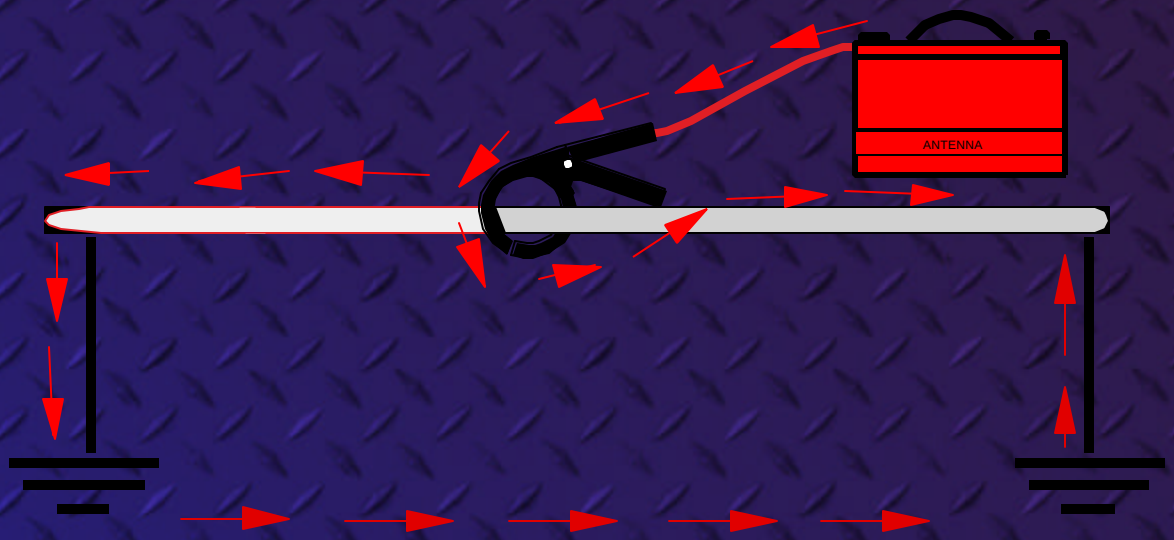
3 methods of applying a signal to your target conductor:

1. DIRECT CONNECT (CLIPS)

METROTECH

Active Locating - Signal Transmission

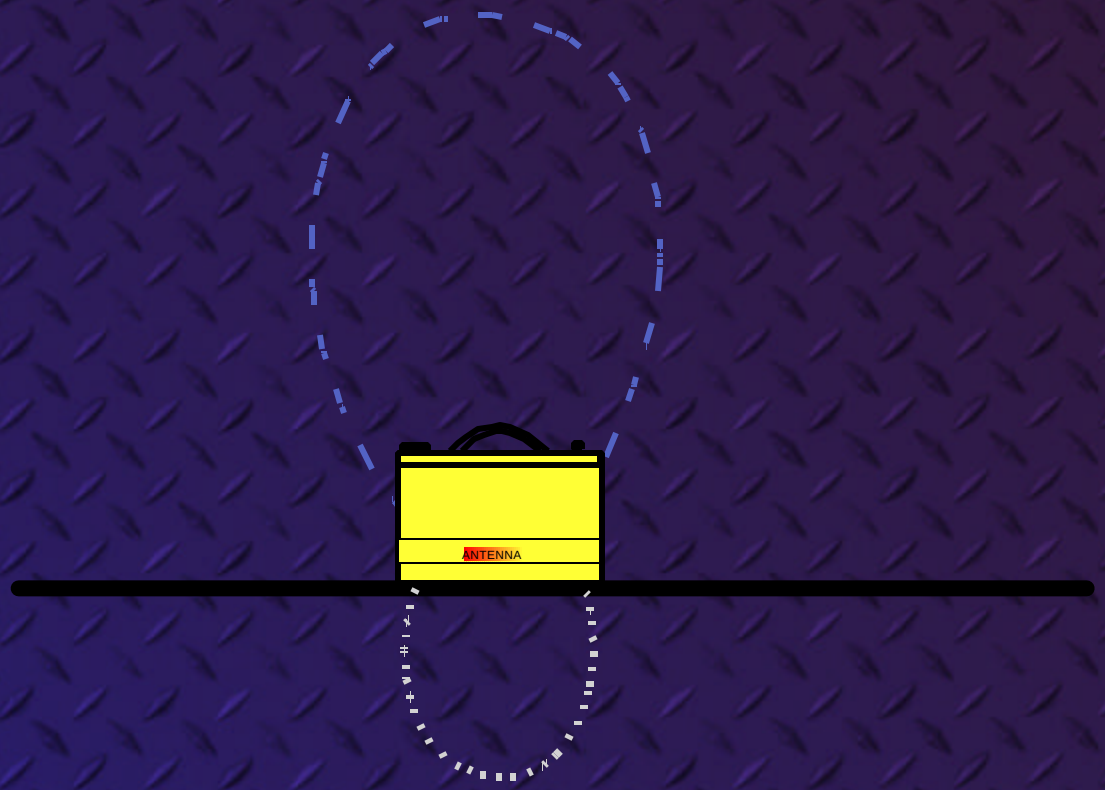
2. INDUCTIVE COUPLING (CLAMP)



METROTECH

Active Locating - Signal Transmission

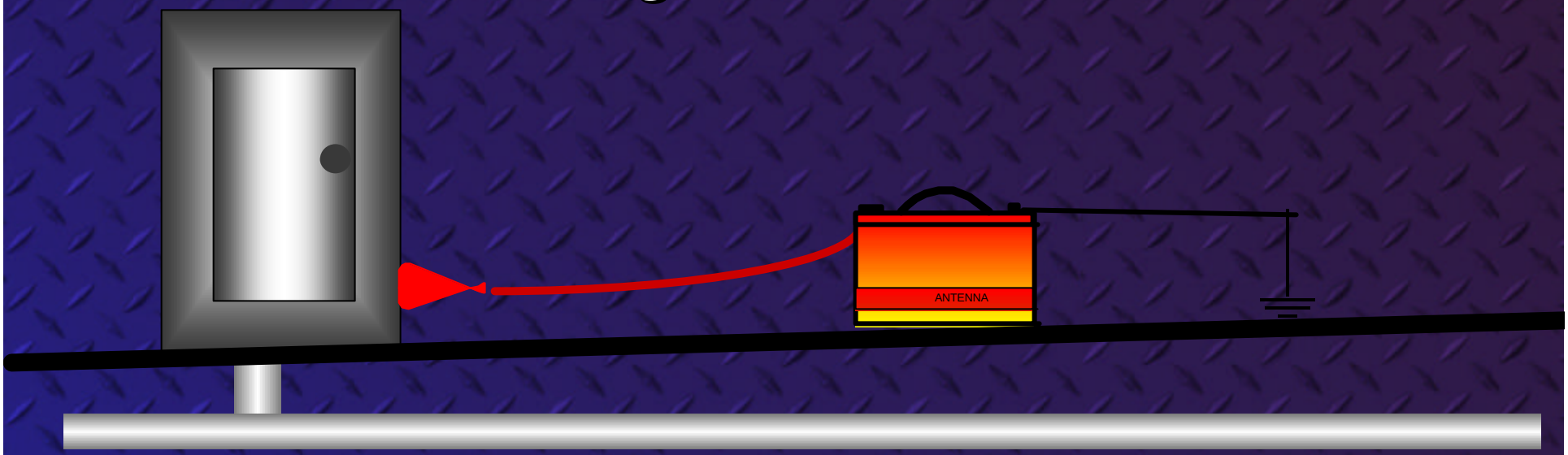
3. INDUCTIVE (BOX)



METROTECH

Direct Connect (Clip)

Most efficient way of transmitting signal onto the target conductor



Transmitter is direct connected to the conductor

METROTECH

Possible Direct Connection Points

Water - Hydrant, Meter, Curb Stop, Valves, Hose Bib

Gas - Meter, Valve, Trace Wire, Test Leads

Possible Direct Connection Points

Power - Neutral phase, Transformer Case, Pole Ground, House Ground, Meter Box, Conductor (if disconnected)

Telephone - Sheath, Vacant Cable Pair (on tip side)

CATV - Sheath, Pedestal Case (if properly bonded and grounded)

Direct Connect Using the Clip

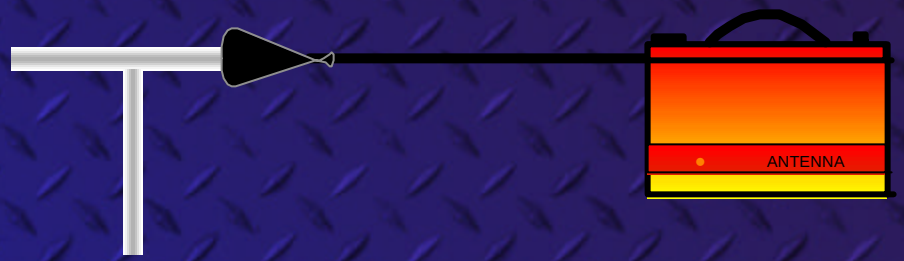
Signal is transmitted through the cable to the conductor

Air- Coupling is not a factor when direct connected.

METROTECH

Attaching the Direct Connect Clip and Ground Lead

Red Lead to conductor

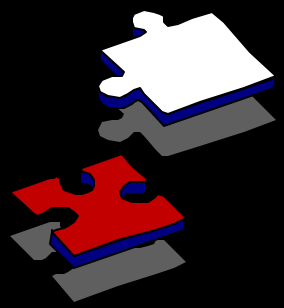


Black Lead to ground

METROTECH

SECTION 2

Importance of Grounding



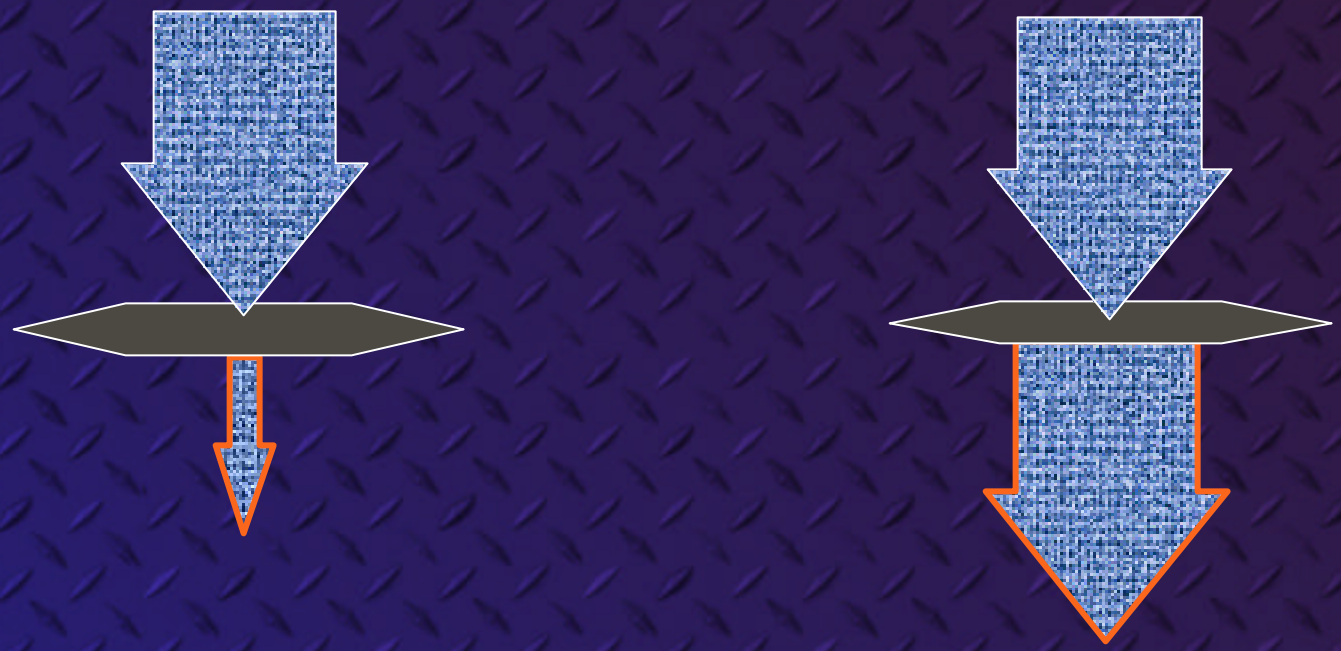
METROTECH

Importance of Grounding

Grounding is the Most Important Factor in the Direct Connect Method

- The signal (current) must "flow" in a loop to be detected by the Receiver.
- A metal earth/ground provides a focal point for the signal to travel back to the signal source - closing the circuit (loop).
- The larger the metallic surface, the stronger the signal loop.

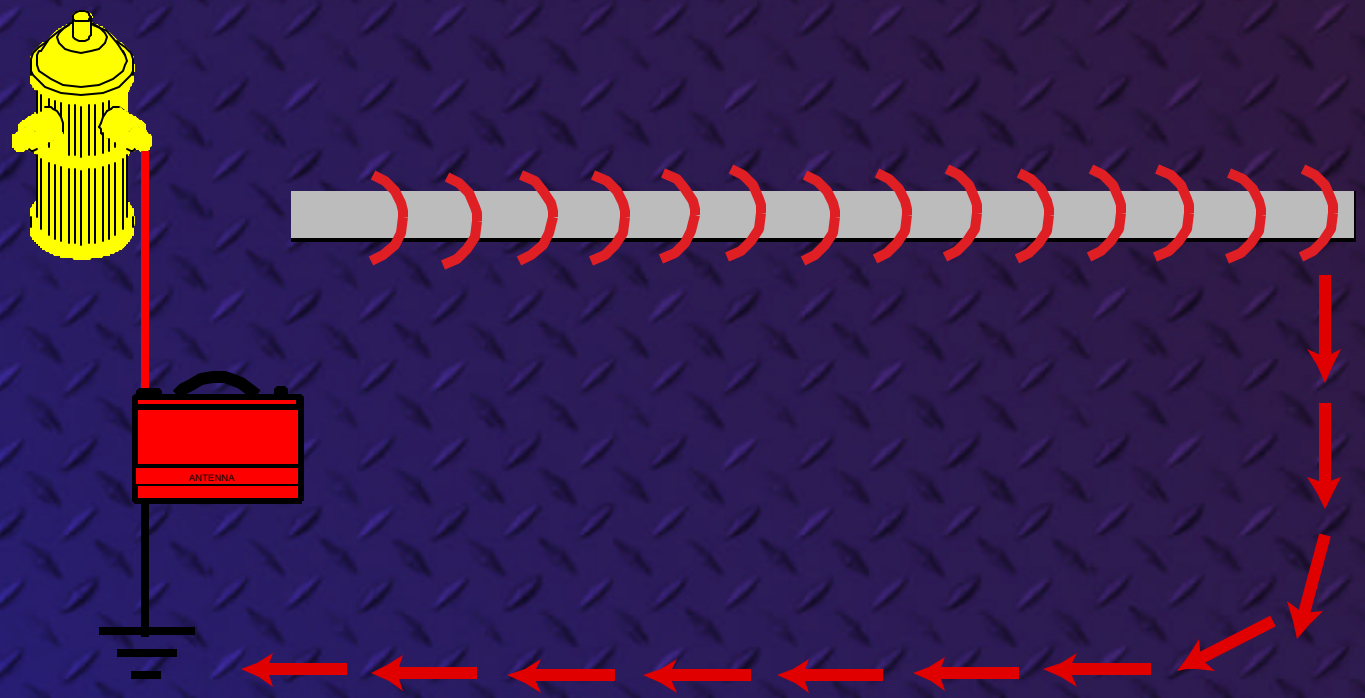
Principle of Grounding



If the current was water, the earth/ground would be a drain - the better the drain, the better the water flow.

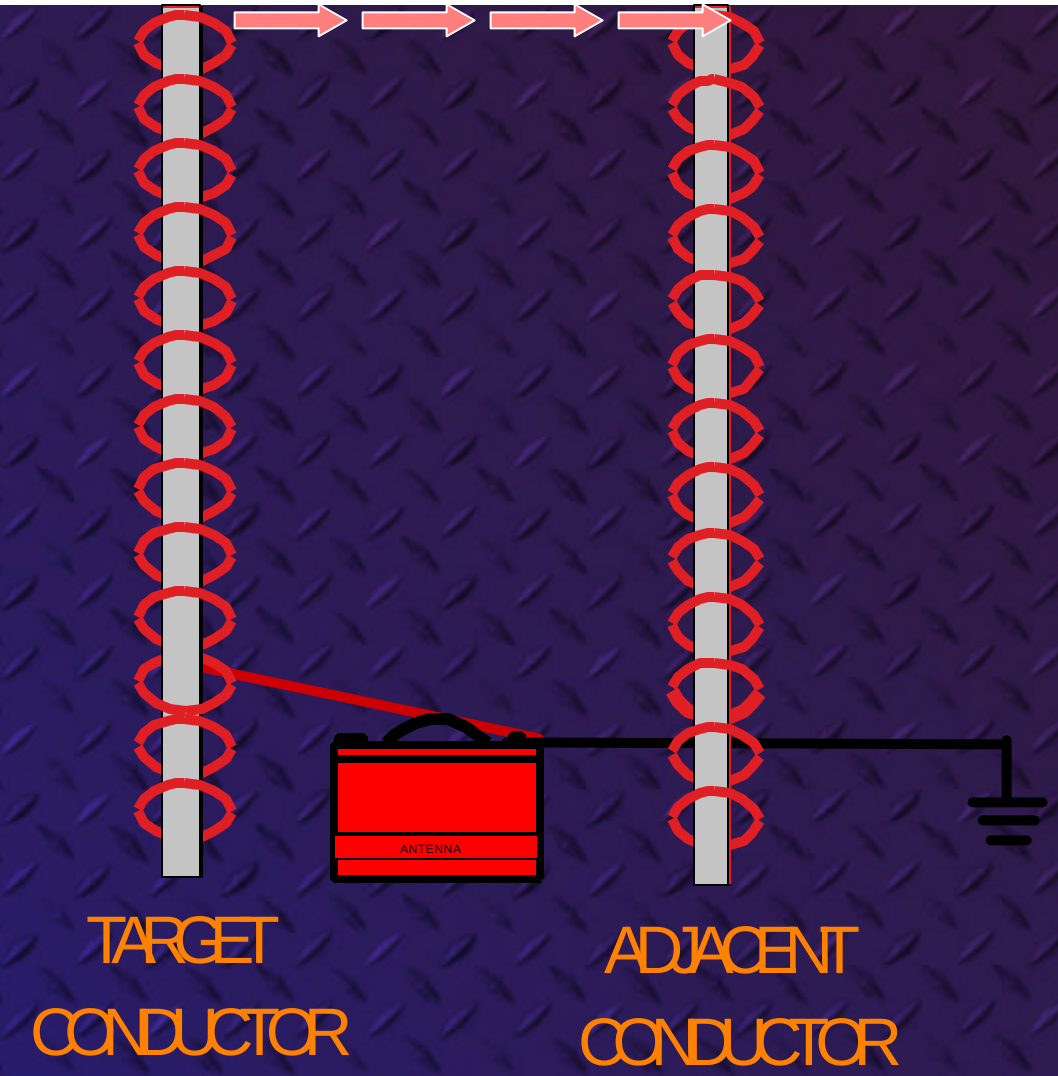
METROTECH

Ground Rod Placement



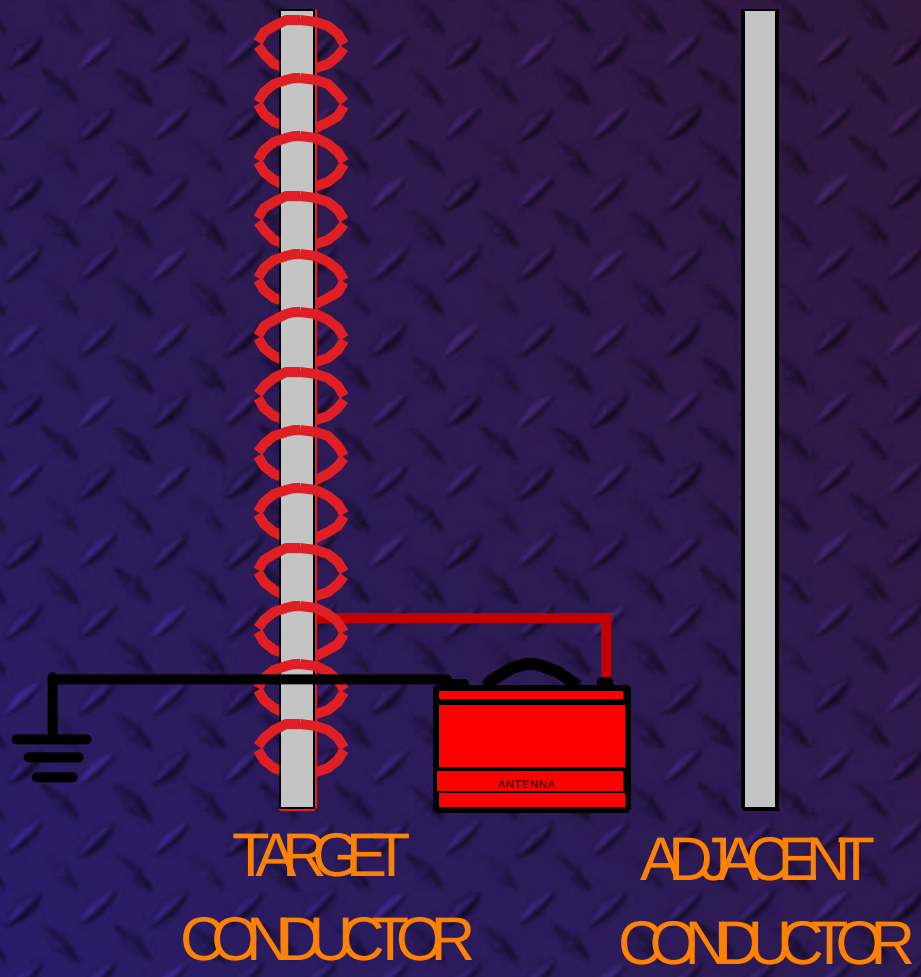
Attach Black Lead to Ground Rod at right angle to conductor.

METROTECH



Crossing over an adjacent conductor places unwanted signal on that conductor.

METROTECH



Place ground lead away from other conductors.

METROTECH

Avoid "Destructive Interference"

Connect Ground at right angle.

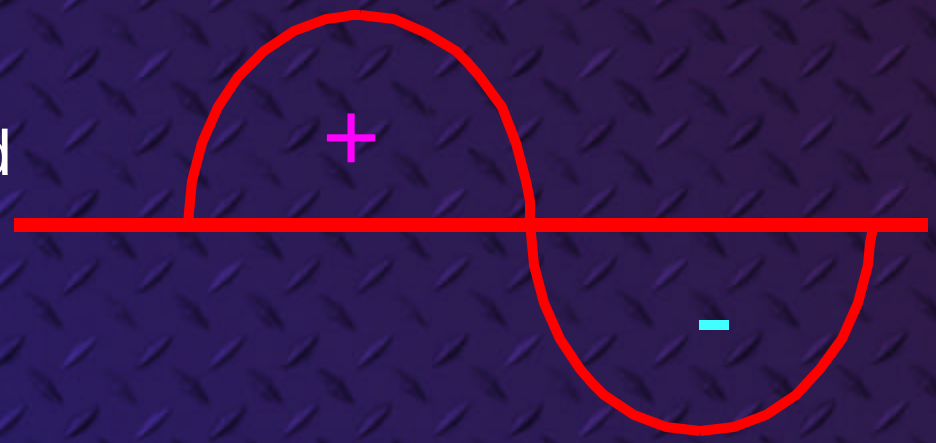
This rare situation most commonly occurs when two (or more) conductors are physically connected, e.g. common trenching

METROTECH

A Few Important Terms Describing Alternating Current:

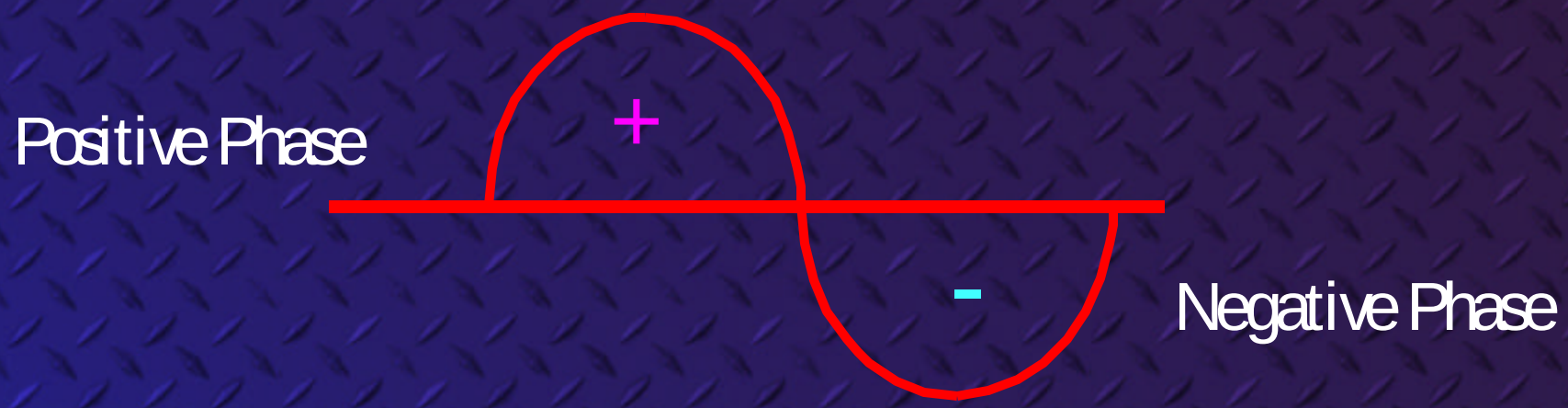
<u>Cycle</u> One round of "up and down" or positive and negative potential.

One cycle per second



"Alternating Current" Terms

<u>Phase</u> Signal goes both "up" and "down".



METROTECH

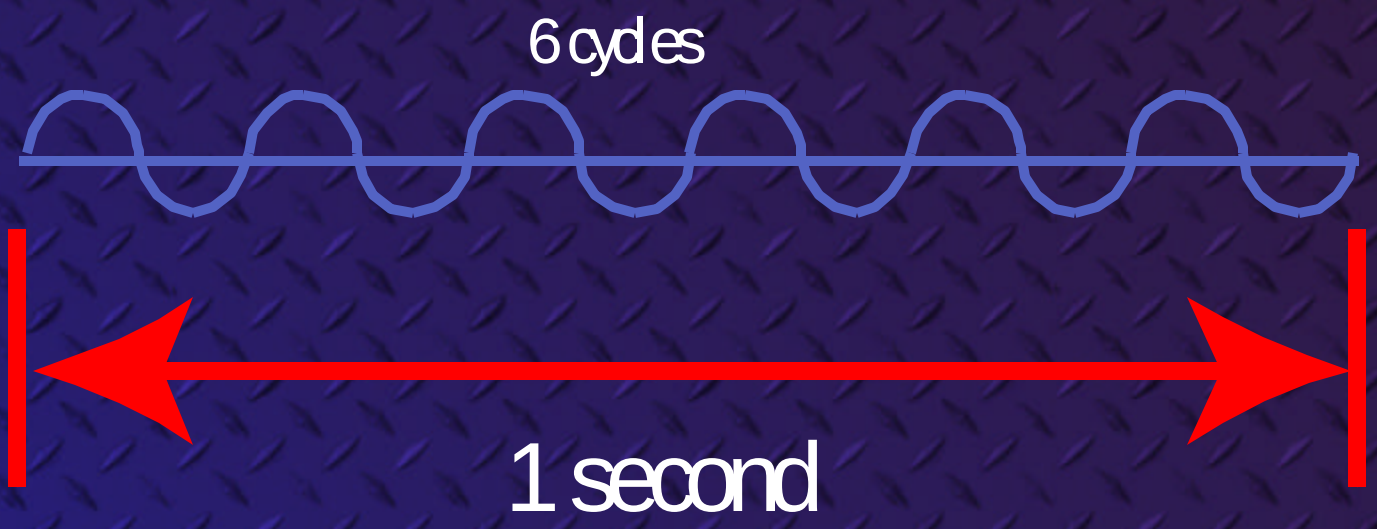
"Alternating Current" Terms

<u>Frequency</u> The number of cycles that occur within one second.

METROTECH

"Alternating Current" Terms

<u>Amplitude</u> The height (or depth) of a phase. (Volts)

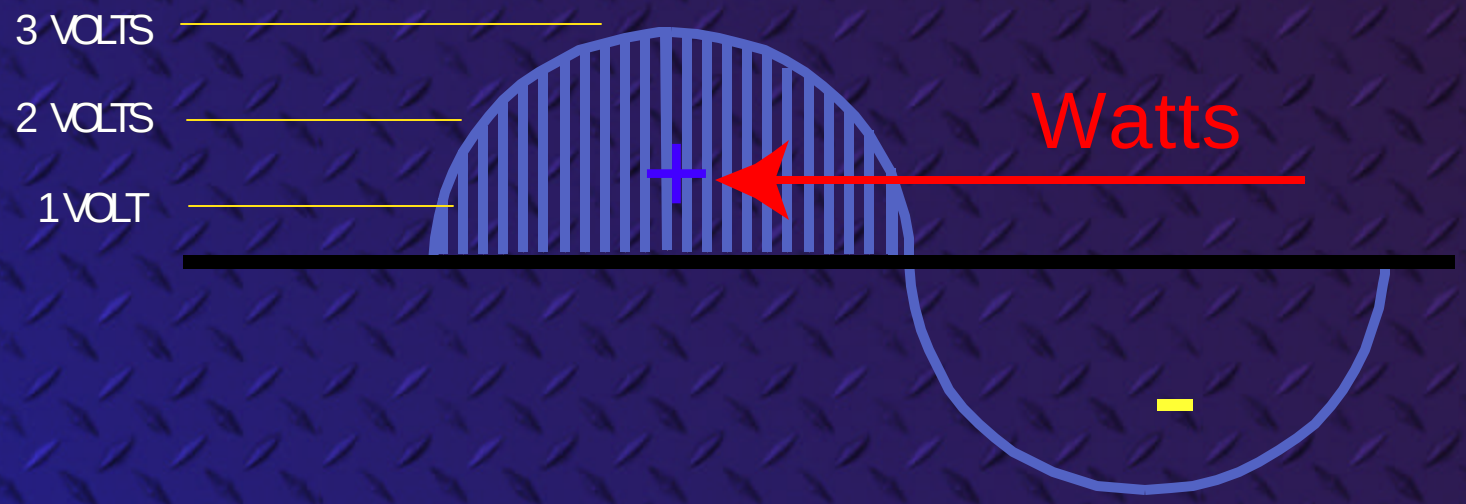


6 cycles per second = 6 Hz

"Alternating Current" Terms

<u>Power</u>

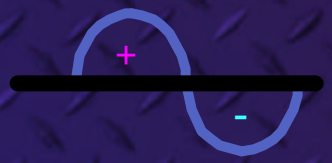
The area under the curve.
(Watts)



METROTECH

"Alternating Current" Terms

Cycle



One "up and down" or positive and negative potential.

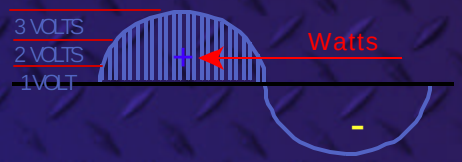
Phase

Signal is going both "up" and "down".

Frequency

Number of cycles occuring within one second.

Amplitude (Volts)

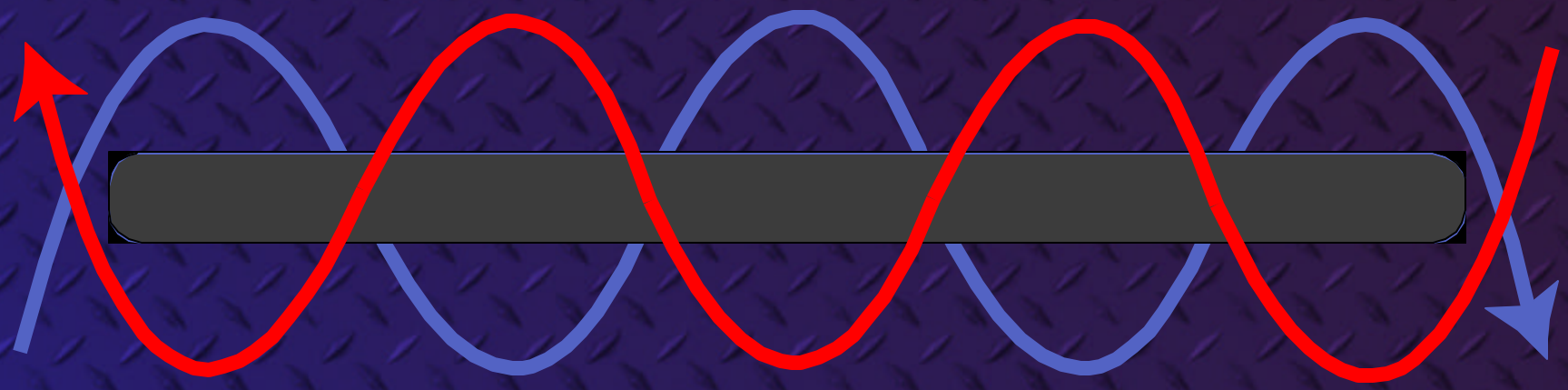


Height (or depth) of a phase.

Power (Watts)

Area under the curve.

“ Destructive Interference”



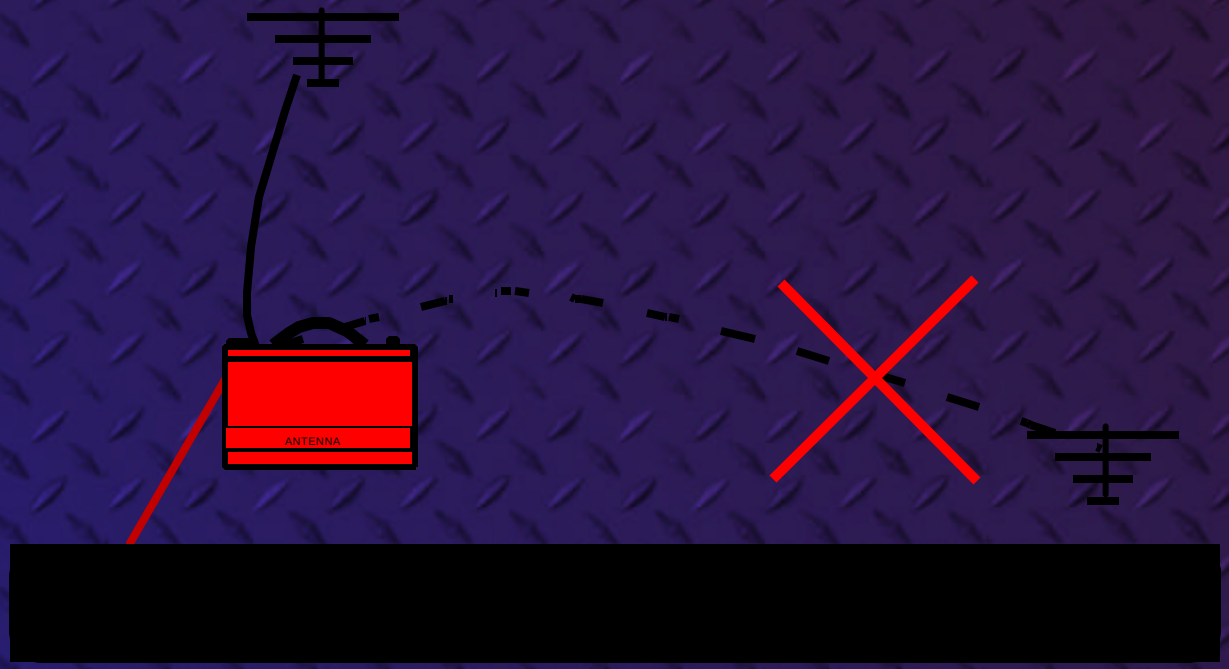
When a transmitted signal on the target conductor meets a returning signal in the opposite phase, the signals cancel or distort each other.

Symptoms of "Destructive Interference" or Poor/No Ground

- Fluctuating signal strength (by a constant 50+ points up and down).
- Inconsistent Centerline or Peak.
- Inconsistent or Non-repeatable Depth Readings.

METROTECH

Avoid "Destructive Interference"



Determine probable path of your conductor and move your ground rod accordingly.

METROTECH

Destructive Interference

Locating is Possible

Recognize the Problem

- Fluctuating Signal Strength
- Inconsistent Centerline or Peak
- Non-Repeatable Depth

Determine the Source

- Common Bonding
- Ground Rod Placement

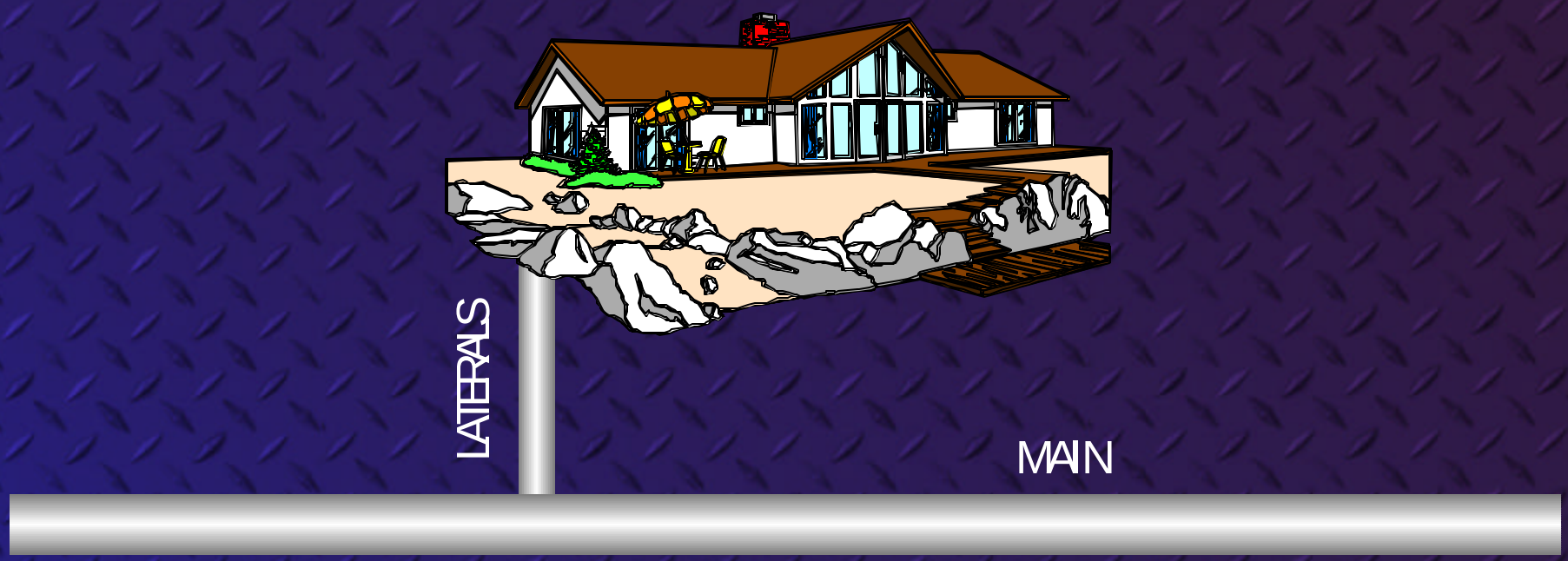
METROTECH

I know I am supposed to attach the ground at right angles to the conductor.

How do I know which way the conductor is running?

METROTECH

“ Read the Street”



"Large delivery" (water main) is typically parallel to the street. Small delivery (laterals, house connections) is perpendicular to the street.

METROTECH

Industry Terms for Delivery Systems

Water	-	Main and Lateral (Service)
Gas	-	Main and Lateral (Service)
Power	-	Primary and Secondary
Telephone	-	Underground and Aerial Cables (F1 and F2) and Service Drops
CATV	-	Trunk Lines and House Drops

METROTECH

More Clues to the Probable Path of Your Conductor

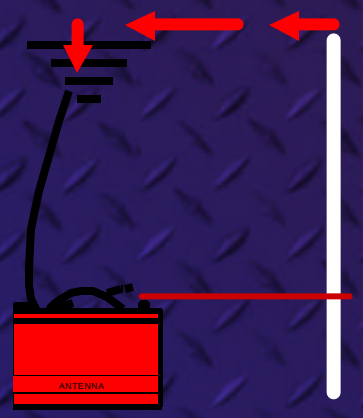
Note Positions of:

Water	-	valves, curb stops, meters, hose bibs
Gas	-	meters, electrical test points
Power	-	transformer boxes, switch gear, risers
Telephone	-	pedestal boxes, risers, manholes, terminals, protector
CATV	-	pedestals, risers, protector

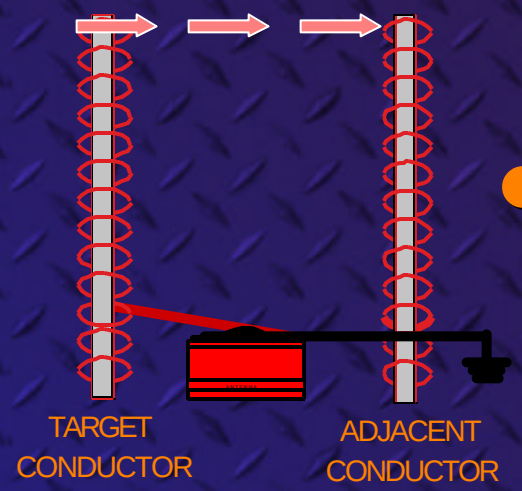
METROTECH

Avoid Destructive Interference

When placing the ground rod:



- Do not lay ground attachment (black) parallel or adjacent to the target conductor.

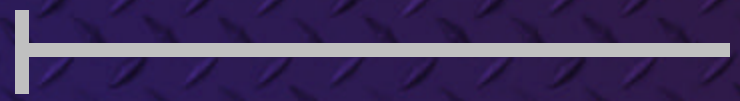


- Do not cross over adjacent conductor.

Methods to Improve Your Ground

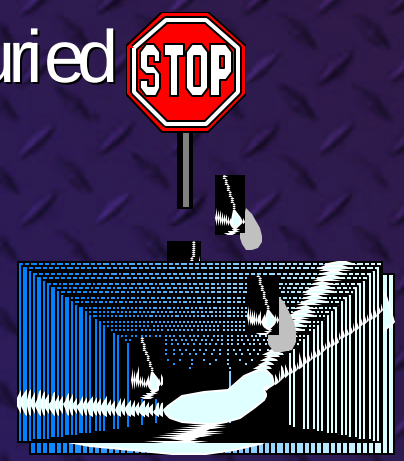
Create larger surface area to attract signal -

- Longer ground rod - be careful not to penetrate another line



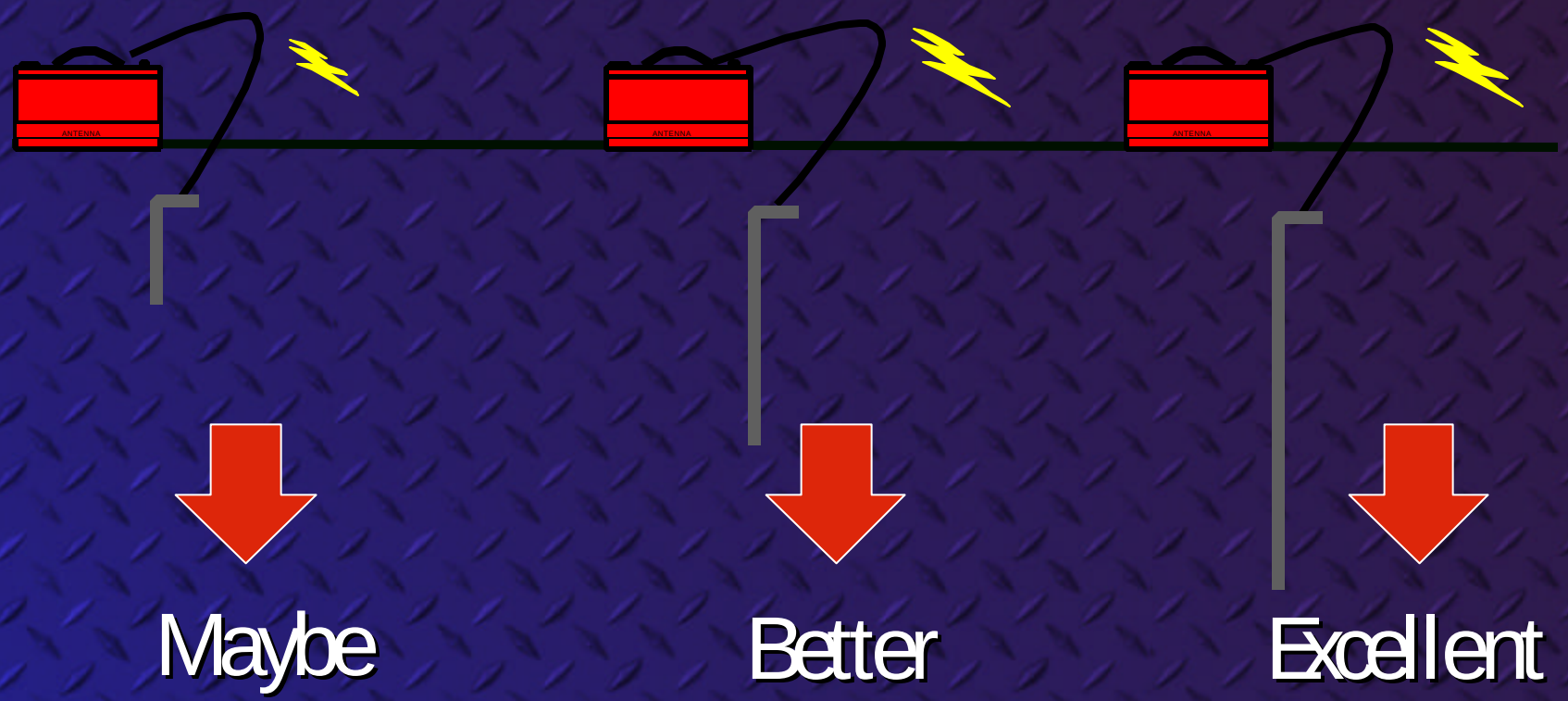
- Multiple rods connected

- Use an available ground that is deeply buried



- Water/moisture improves conduction

Larger Surface Area Attracts More Signal (Current)

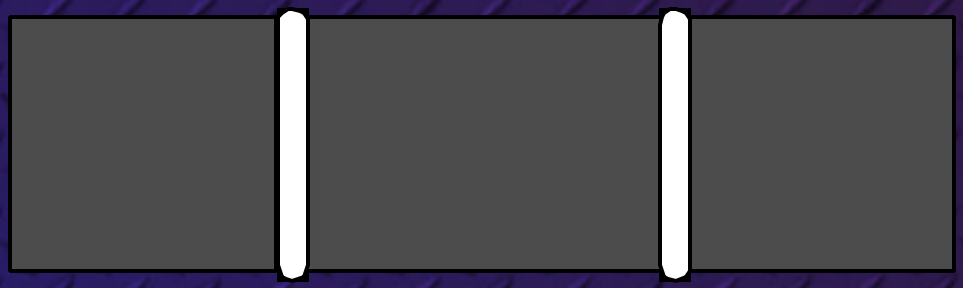


METROTECH

Convenient Available Grounds That Provide More Surface Area

Stop Sign/Street Sign

Metal fence post



Do not use if parallel to your conductor's path

METROTECH

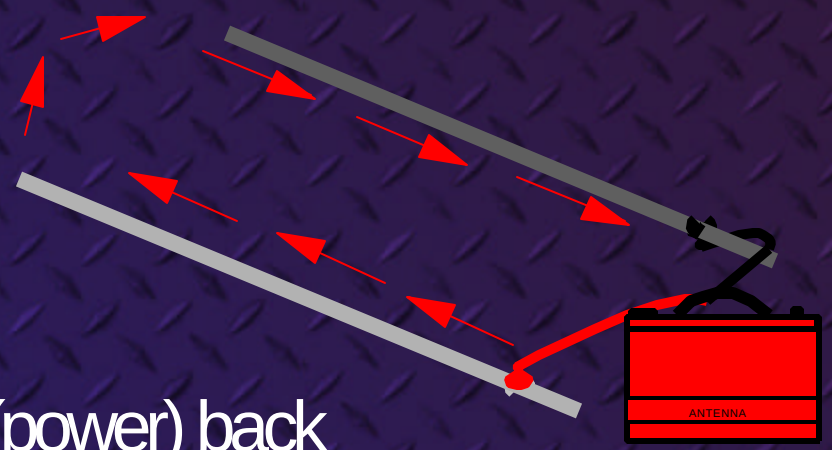
Alternative Ground

If you are cautious - it is possible to use a parallel utility as your return signal path.

When you do this, verify that you start out and end up at a termination point that is specific to the utility that you are tracing.

Parallel Utility Ground - Return Locate

Convenient for user who is locating multiple utilities (such as a contract locator).



If grounded to adjacent utility -
Locate one (water) out and the other (power) back
You don't need to move your Transmitter.

<u>Important to verify terminations</u>

METROTECH

In Conclusion -

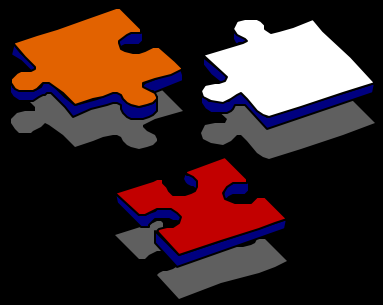
Direct Connect Provides a Superior Locate Because It:

- Isolates conductor from adjacent conductors.
- Get more signal distance - don't need to move Transmitter.
- Provides the strongest signal to the best Receiver, resulting in the best Receiver accuracy.

METROTECH

Section 3

Determining Depth



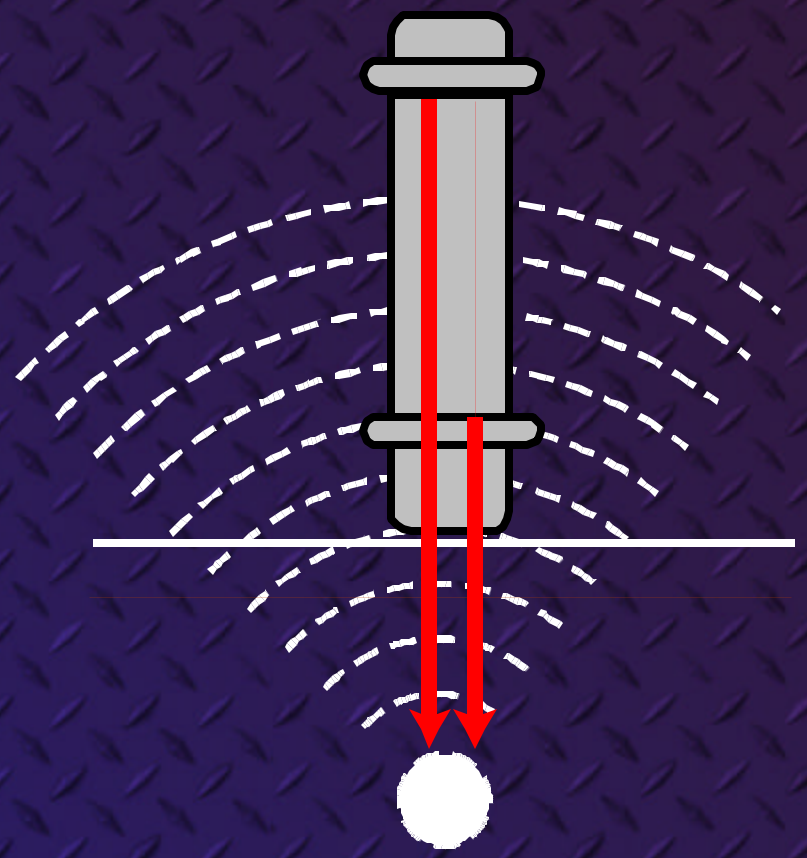
METROTECH

Push-Button Depth

How the Receiver Measures the Depth of Your Conductor

Two coils in Receiver are picking up signal from your conductor.

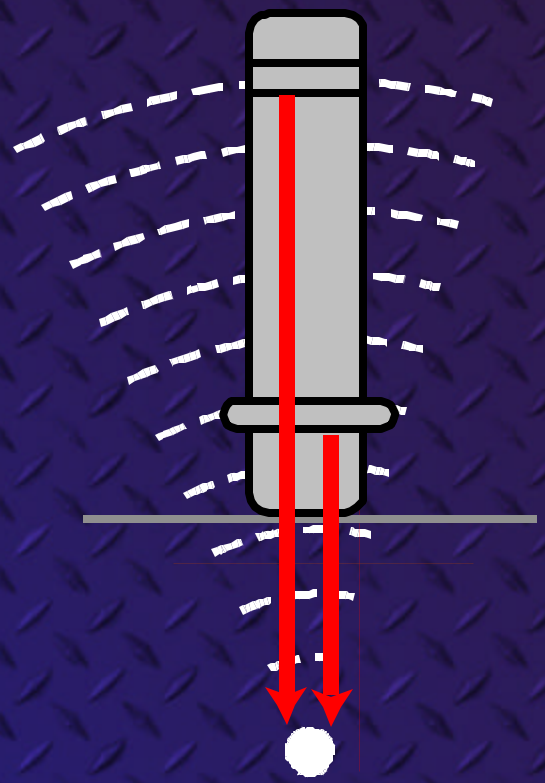
Microprocessor measures signal differential between coils and determines depth based on fixed distance between coils.



METROTECH

Strong Signal Receiver Can Calculate Accurate Depth

Signal Strength strong enough to calculate depth



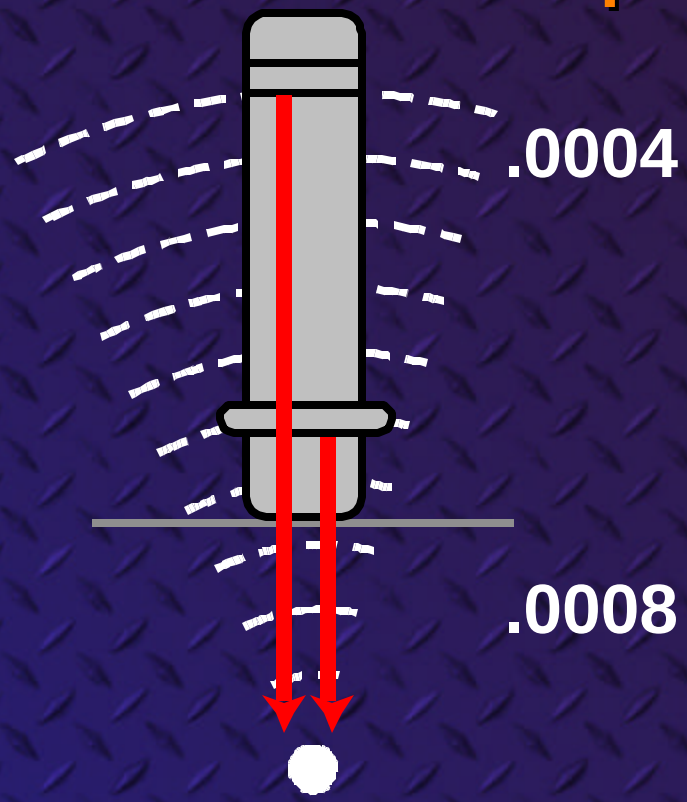
4.0 weaker signal farther from source

8.0 stronger signal doser to source

METROTECH

Weak Signal - Receiver Cannot Accurately Calculate Depth

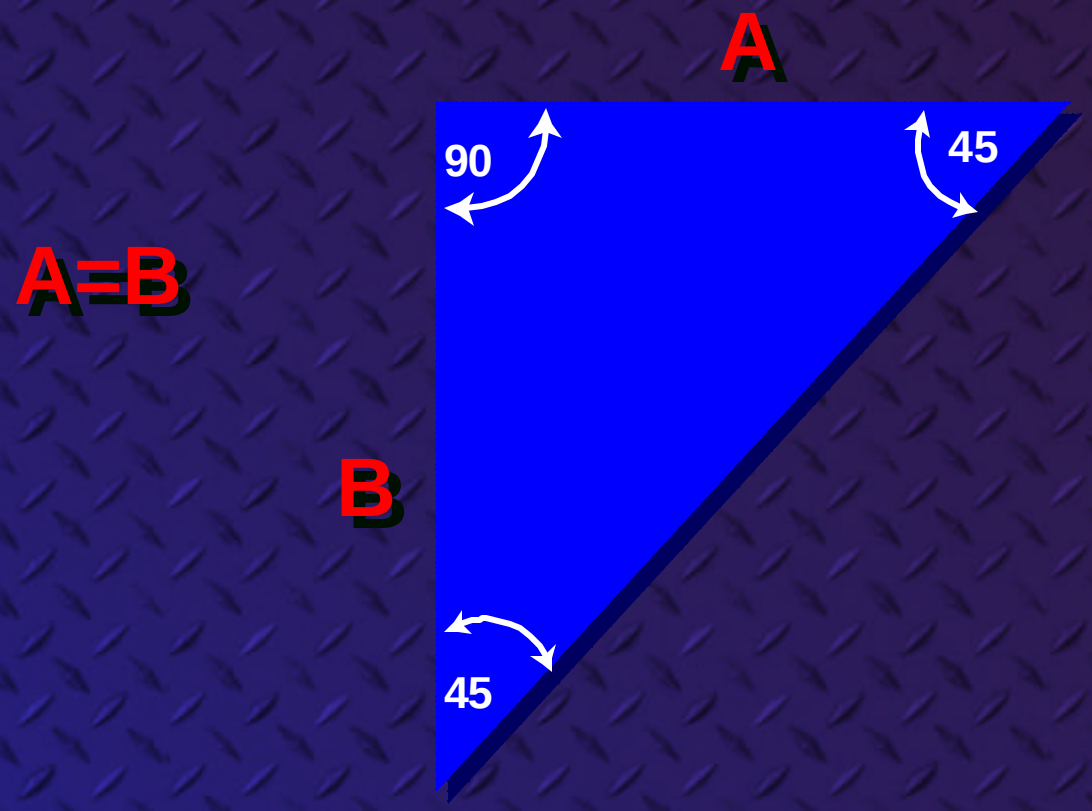
Signal Strength is too weak to calculate depth



The signal difference between the two coils is too small for the processor to calculate. This results in inaccurate depth readings.

METROTECH

When Signal is Weak
Alternative - Triangulation

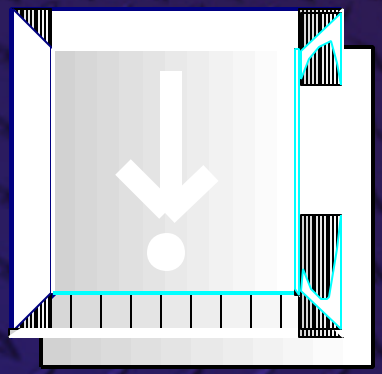


METROTECH

Use Triangulation for Depth Measurement

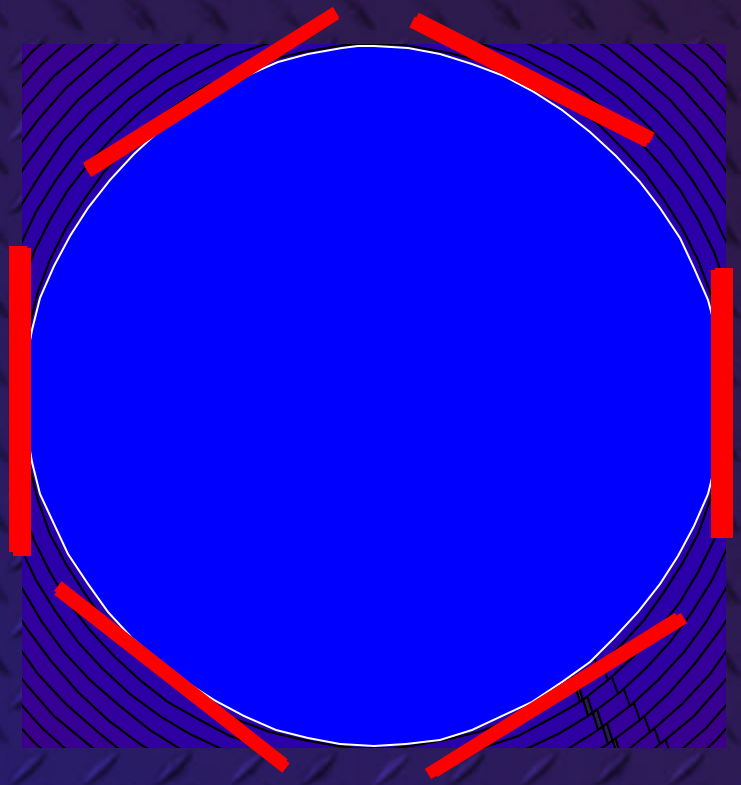
- When you have a weak signal due to distance, attenuation, or other locating methods. (Inductive Coupling, Inductive)
- When interference prevents accurate depth measurement.
- Verifies Signal Distortion

Triangulation Can Also Be Used to Verify Depth Measurement



METROTECH

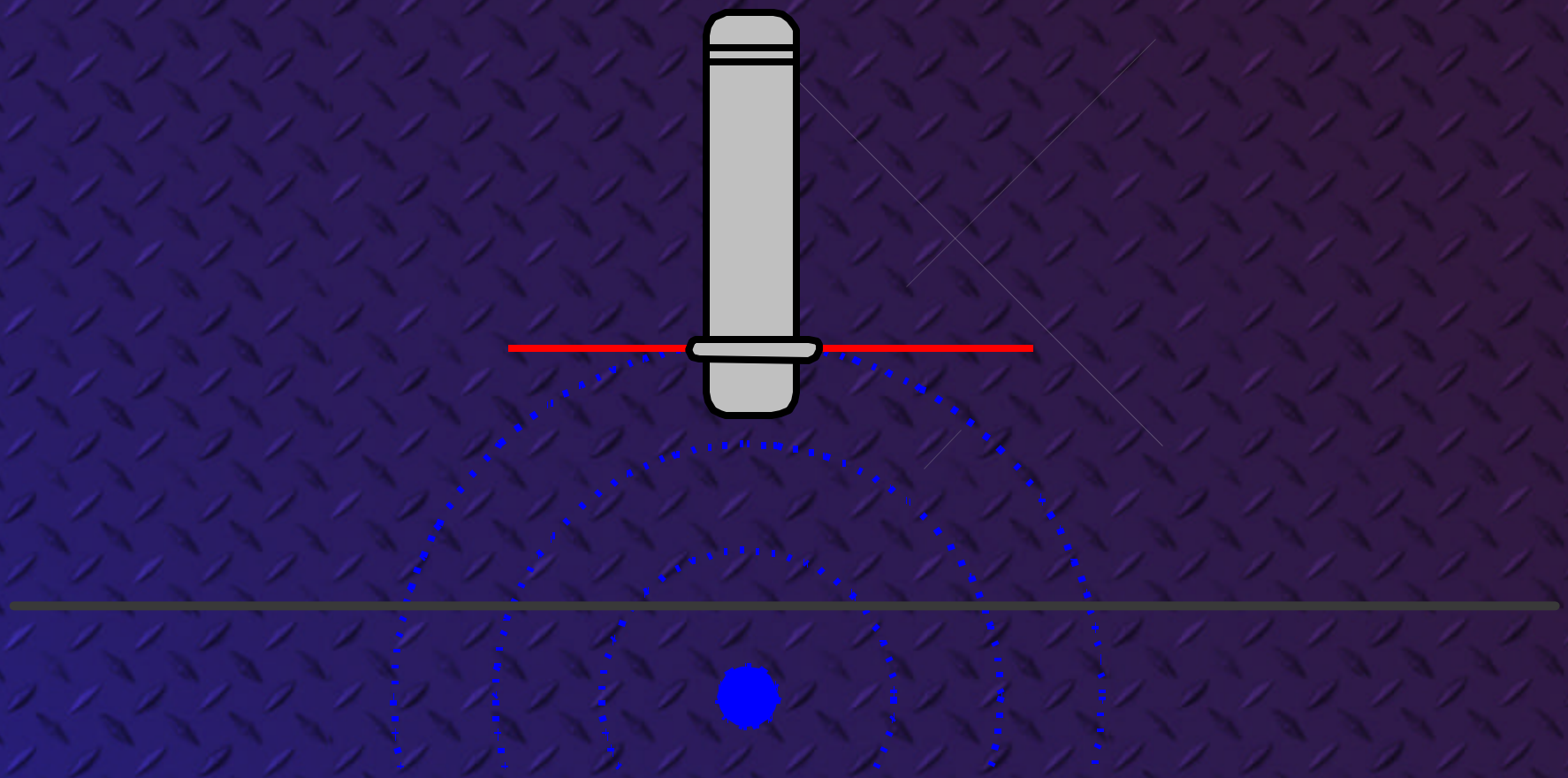
Triangulation Method Based on Three Geometric Principles



1 Tangent

A tangent can be formed at any point on a circle.

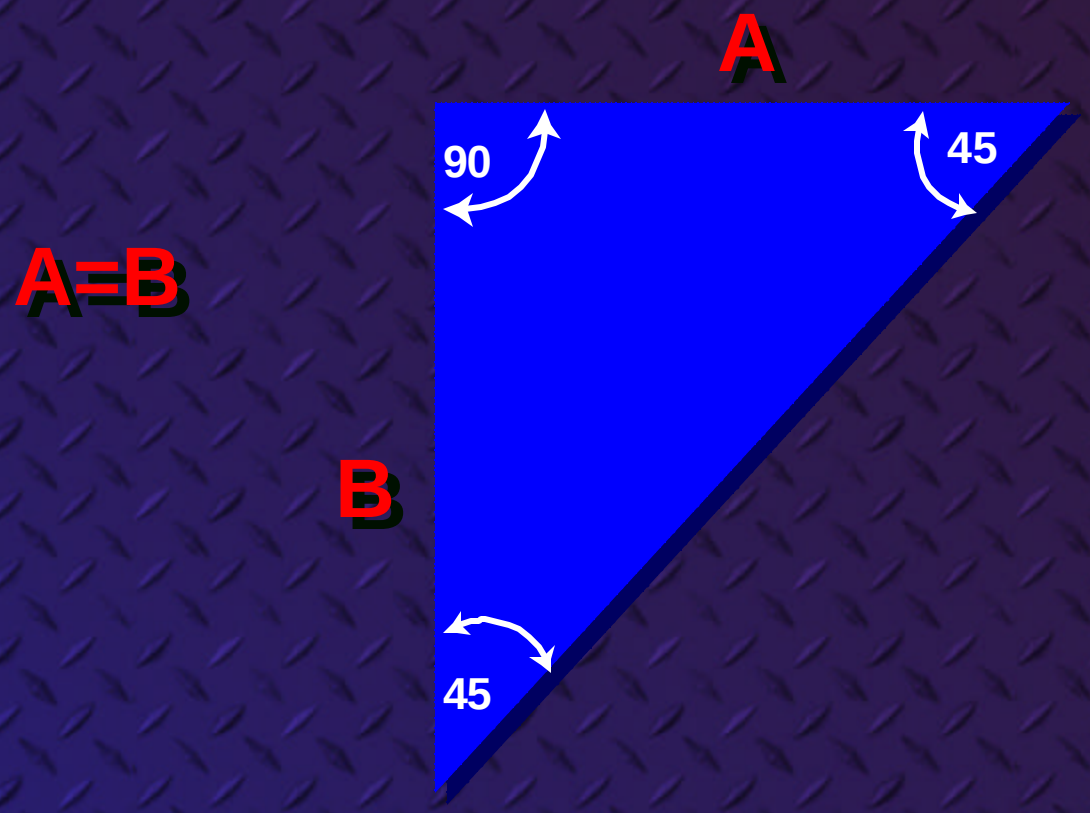
METROTECH



2 Receiver Peaks When Tangent to Signal Circle

A peak Receiver coil senses its peak when it is tangent to an ideal circle of signal.

METROTECH



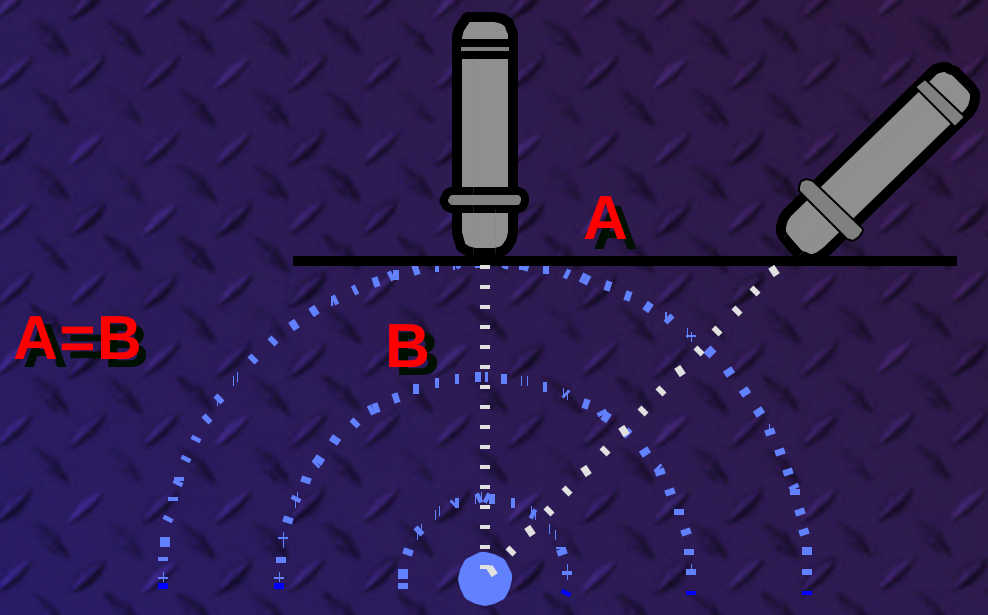
3 Receiver Peaks When Tangent to Signal Circle

A peak Receiver coil senses its peak when it is tangent to an ideal circle of signal.

How Does All This Relate To Locating?

METROTECH

Combine the Three Principles



- Superimpose a Right Isosceles Triangle over the signal circle.
- Find "Second" centerline when Receiver at a 45 degree angle.
- Move to the side of your first centerline.
- Your depth equals the distance A.

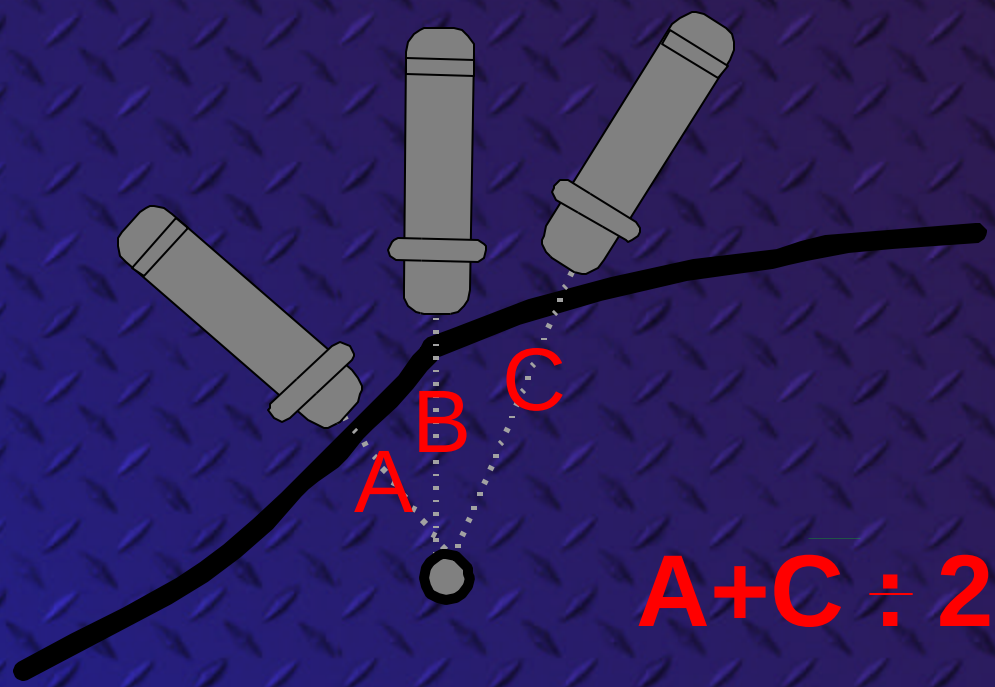
How to Use the Triangulation Method for Determining Depths in Common Trench

Use this same principle to determine depths of multiple conductors in a common trench.

Verify the type of utility by tracing to the point of termination. If you can "Direct Connect" to each utility, you can determine the depth of each one.

METROTECH

Triangulate for Depth on Both Sides of Your Centerline, Compensating for Uneven Ground and Signal Distortion



Uneven Ground

Average the two sides to compensate for the slope.

A+C ÷ 2 = B

METROTECH

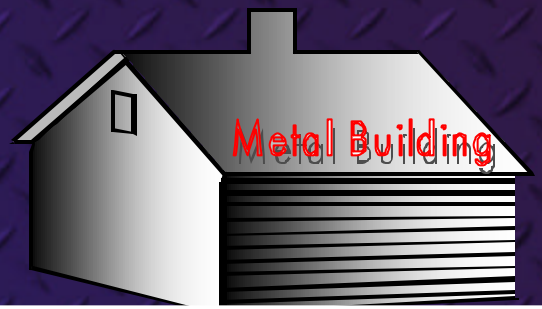
"Signal Distortion"

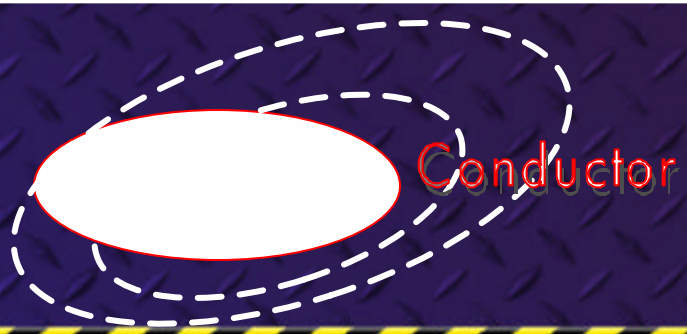
- Buried Metal Objects

  Large Storage Tanks

- Metal Buildings

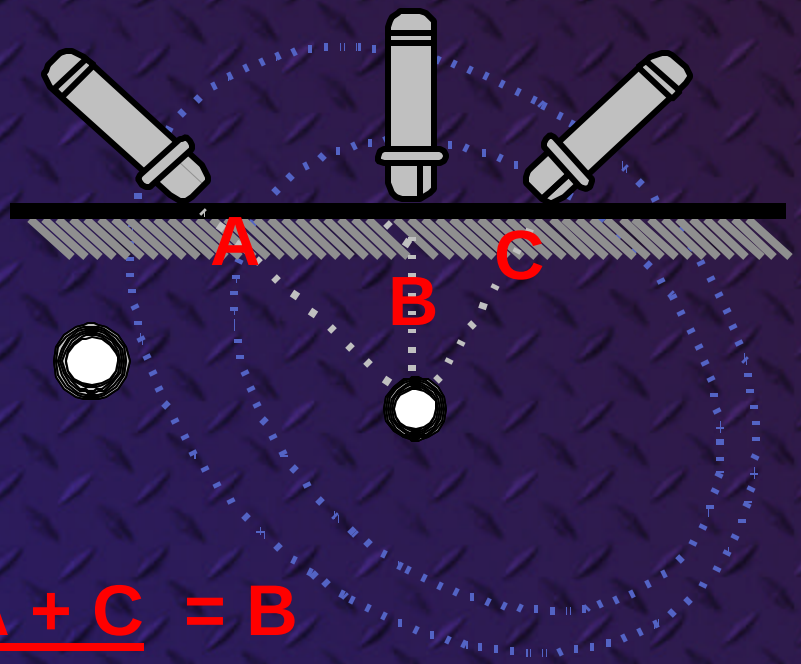
  Grain Storage





The Same Theory Applies to "Signal Distortion" Situations

If the two triangulated distances (A&C) are different, but the ground is level, this indicates "signal distortion". This is normally caused by bleedover from an adjacent conductor. Depth can be determined by averaging distances A and C.



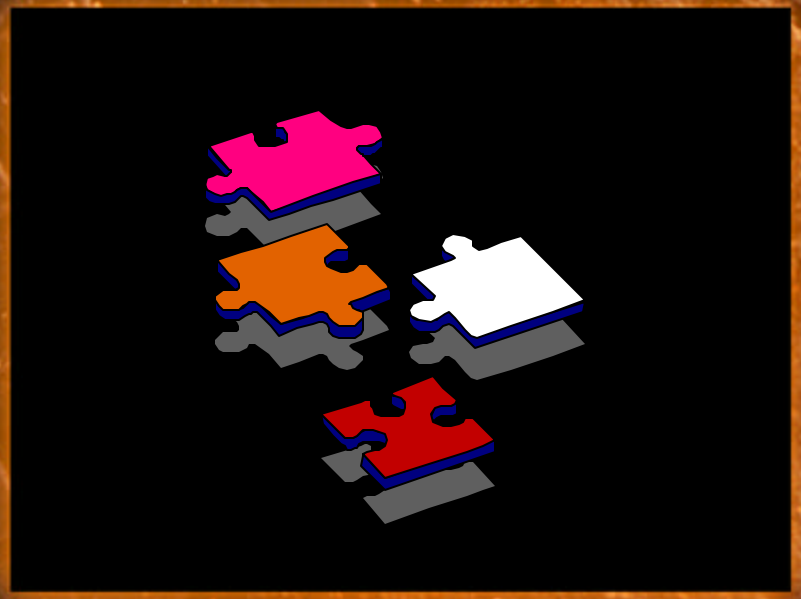
$$\text{DEPTH: } \frac{A + C}{2} = B$$

Verify Your Push Button Depth Measurement With Triangulation

METROTECH

Section 4

Inductive Coupling (Clamp)



METROTECH

When to Use Inductive Coupling (Clamp)

Use this method when:

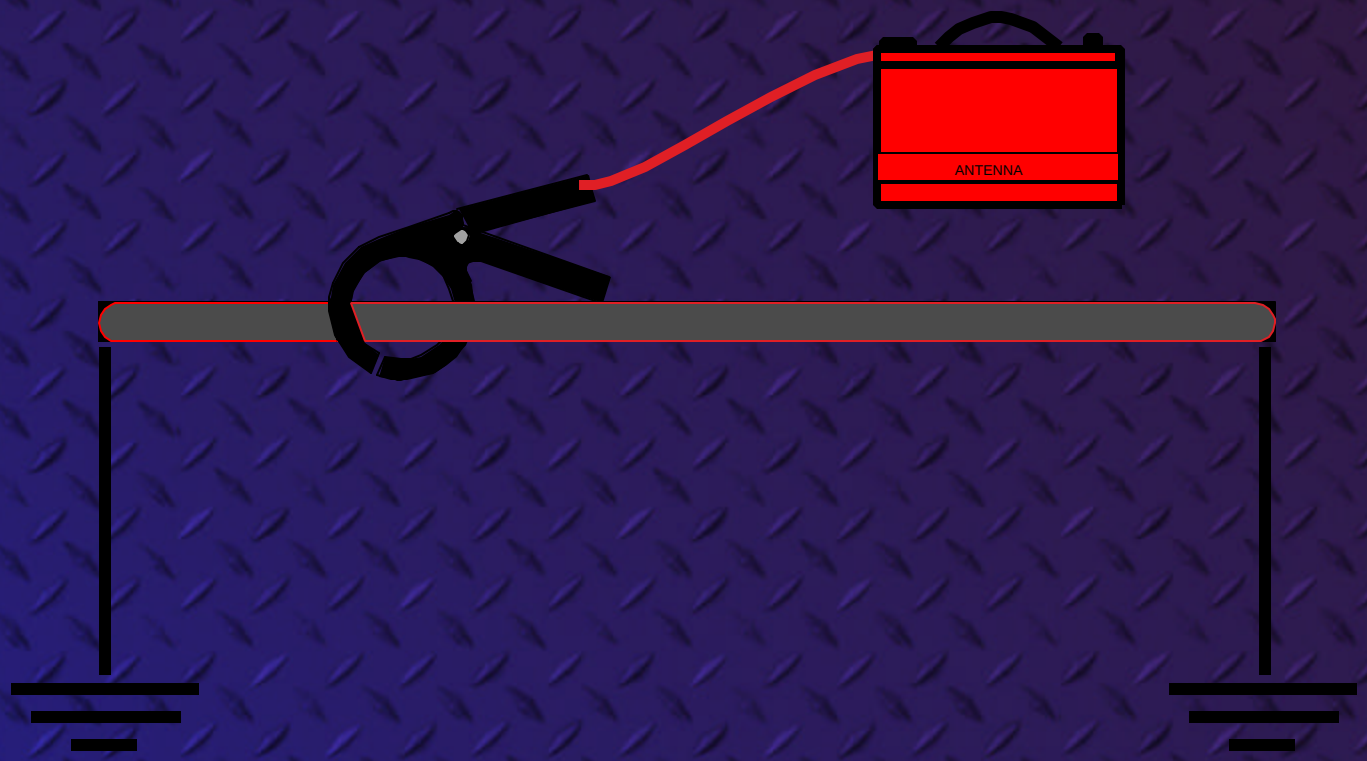
- You have no access to direct connect.
- You are tracing energized primary or secondary cable.
- It is convenient and effective.
- Conductors are common bonded.

Caution: both ends of cable must be grounded

Inductive Coupling (Clamp)

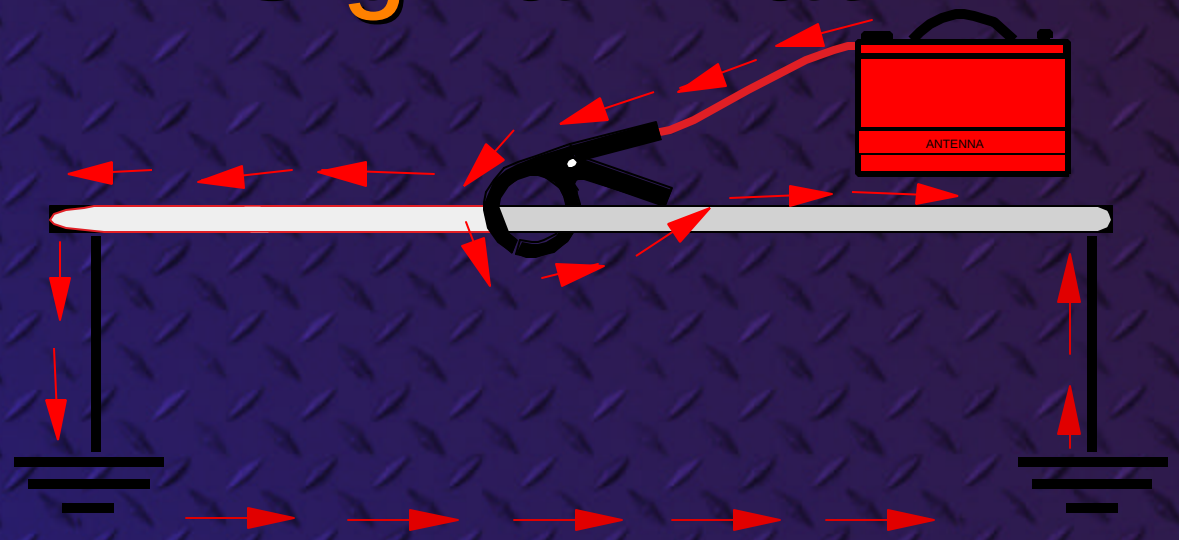
Signal travels from the Transmitter around and around the clamp. This sets up a magnetic field which is induced onto your target conductor.

Clamps only work when the conductor is grounded at both ends!



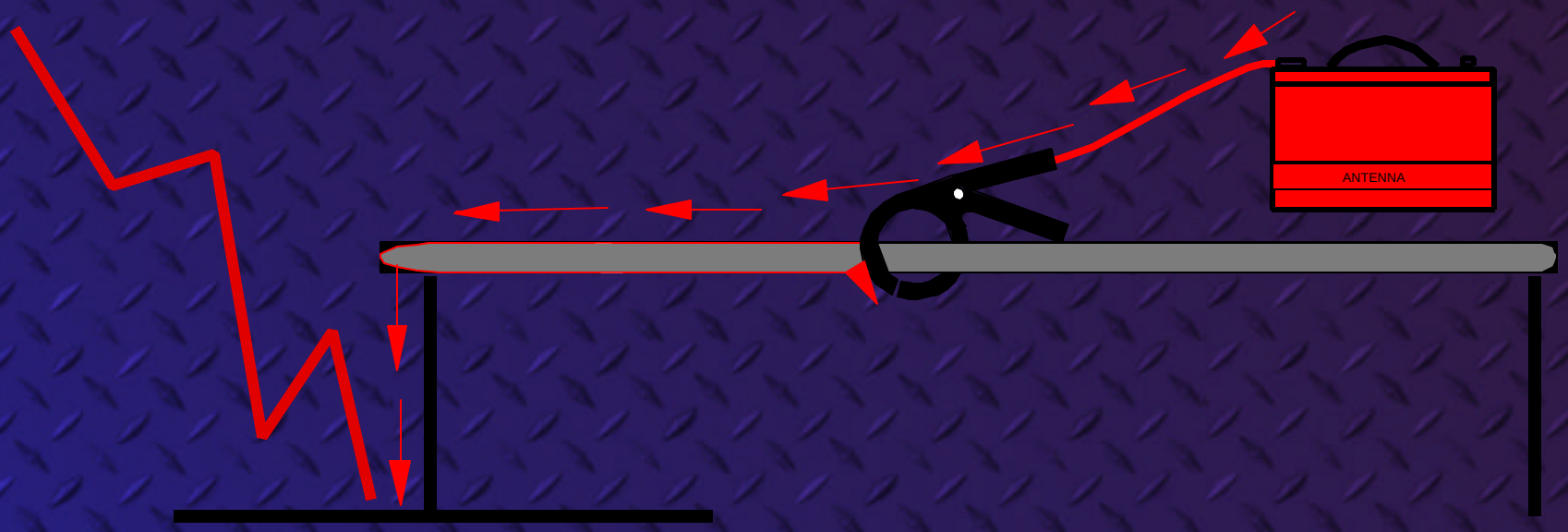
METROTECH

Grounds at Both Ends Allows Signal Path



The placement of the grounds may not be obvious to the user. Normally grounds are found at splices or other connection points, intentionally placed in the normal course of safe utility construction practices. This allows the signal to move along a circuit path.

If You Cannot Get A Signal with Your Receiver - the Grounds Are Missing



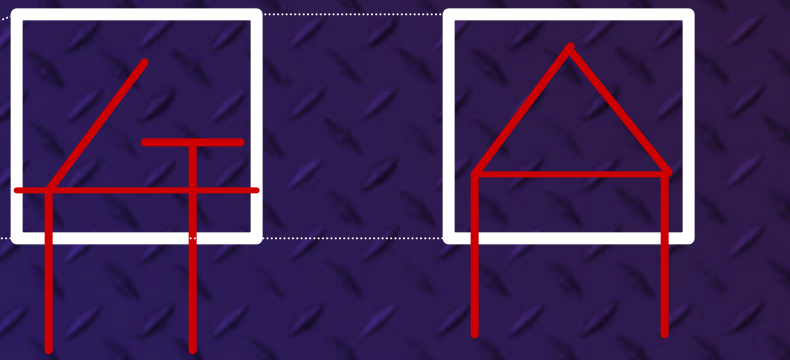
This could be for a variety of reasons - improper construction, someone before you forgot to replace the bonding straps, etc.

METROTECH

Inductive Coupling Tips

- Clamp does not transmit low audio

- Street lights with photo electric cells form opens.



OPEN CLOSED

Clamp Hints

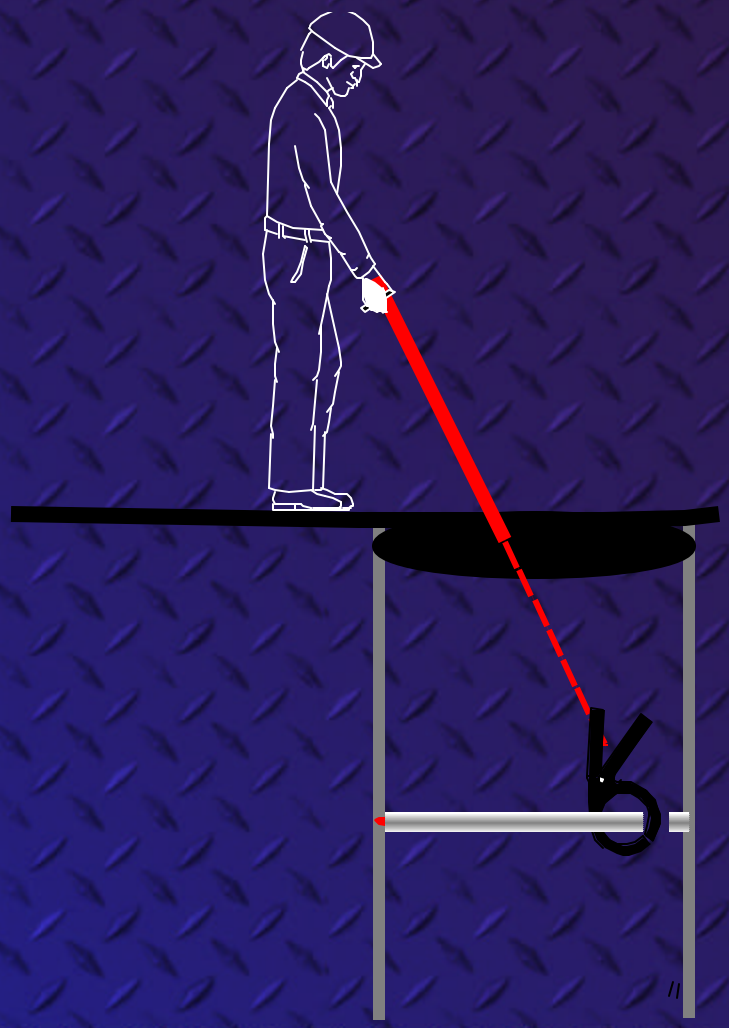
Does Your Clamp Work?

Use handles do not pull on wires

Be Sure the Clamp is completely closed

METROTECH

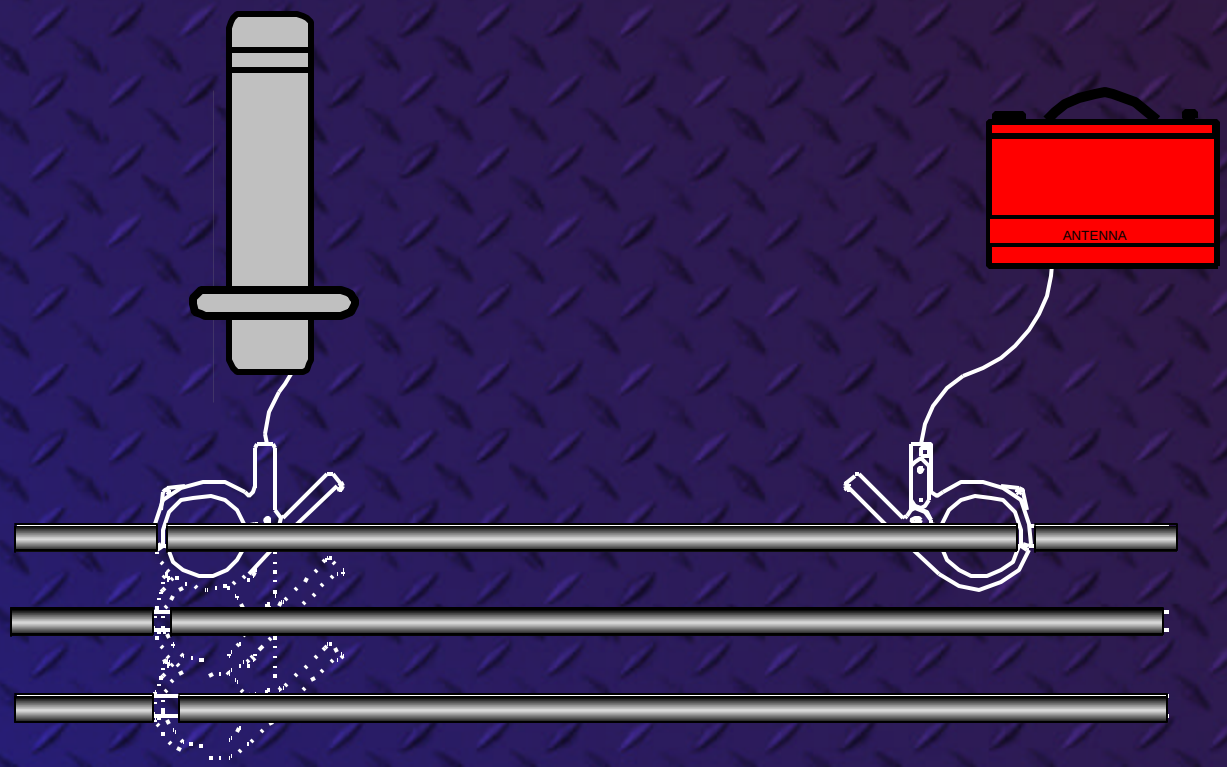
Additional Clamp Uses



A "hot stick" can be attached to a damp for inserting into a confined space or manhole without having to ventilate.

METROTECH

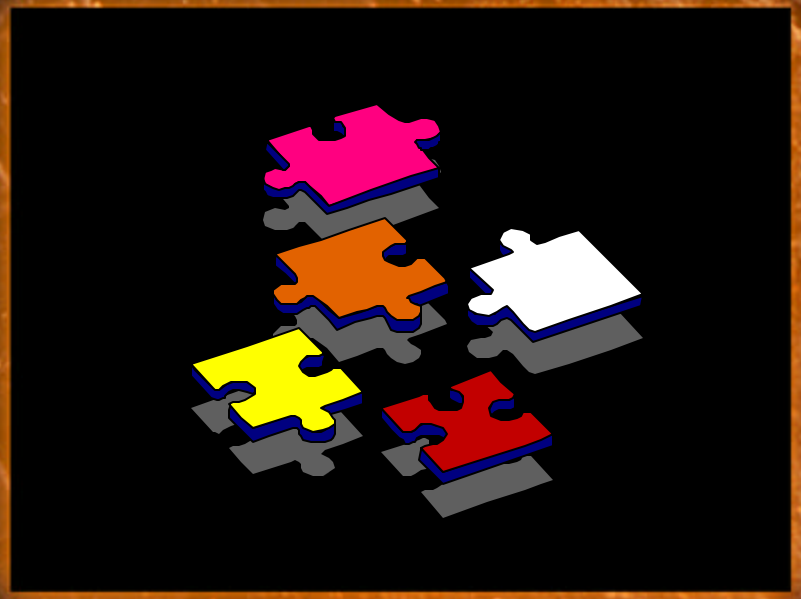
Use Two Clamps to Isolate Your Conductor Among Multiple Conductors



METROTECH

Section 5

Inductive (Box) Locating



METROTECH

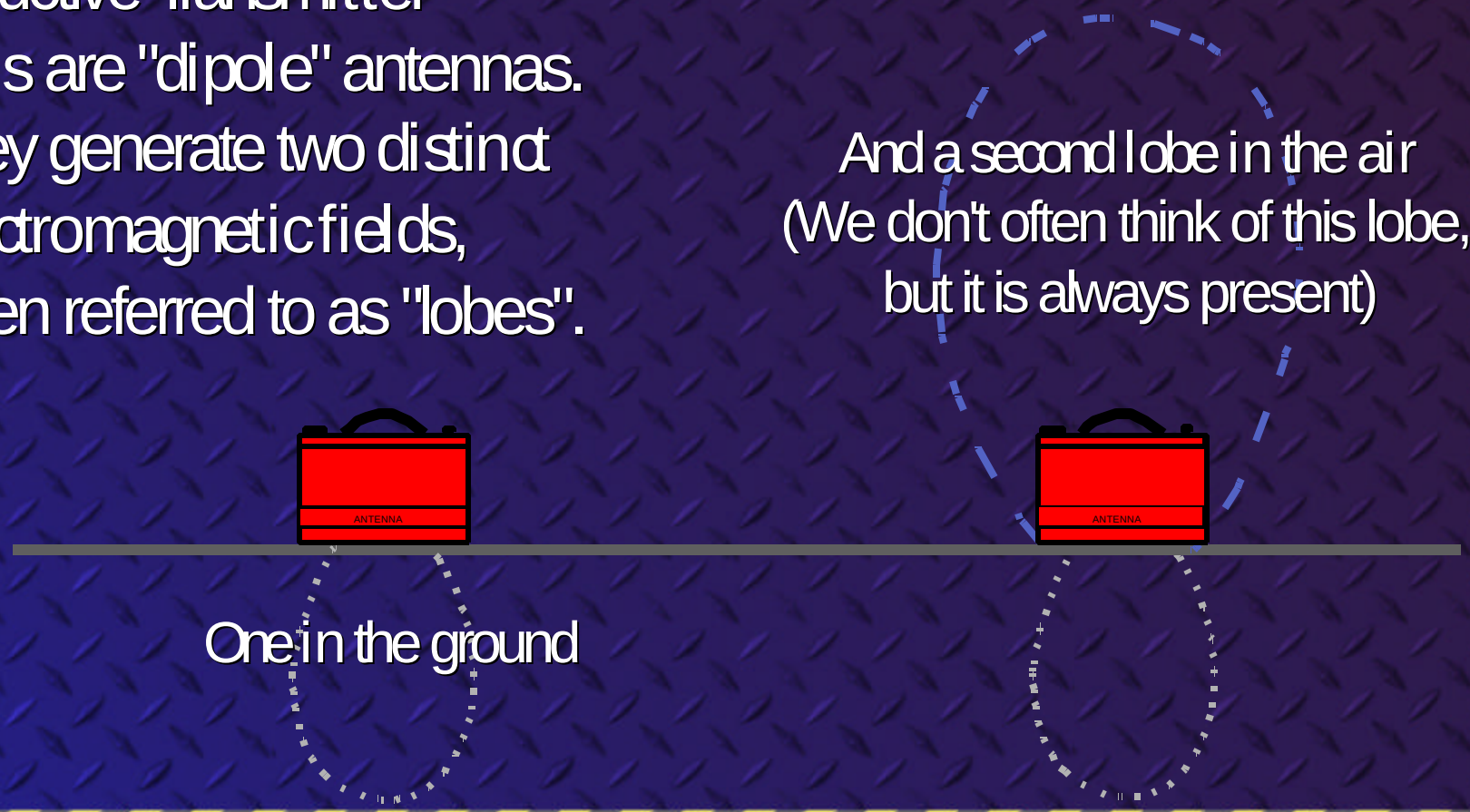
Inductive (Box) Locating

For Induction, remove direct connect leads or damp from Transmitter.

If no connectors are plugged into the Transmitter, it will transmit signal from antenna.

How Induction Works

Inductive Transmitter coils are "dipole" antennas. They generate two distinct electromagnetic fields, often referred to as "lobes".



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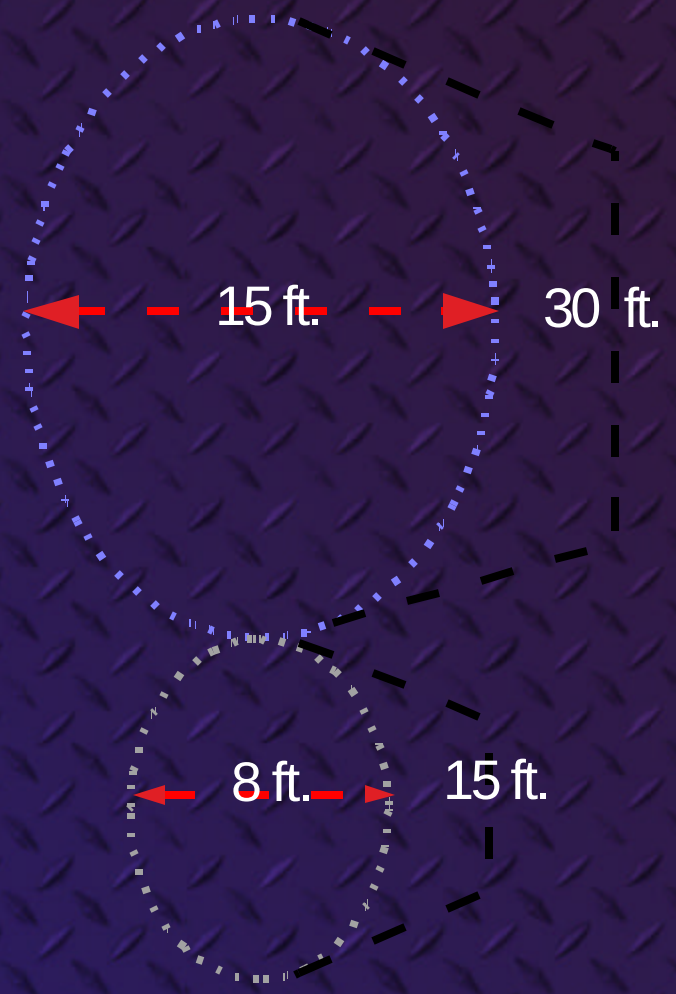
Inductive Signal

Just to give a general idea of scale, the upper lobe (air) is nearly twice the size of the lower lobe (ground).

This size difference is caused by the dampening effect of the soil on the lower lobe.



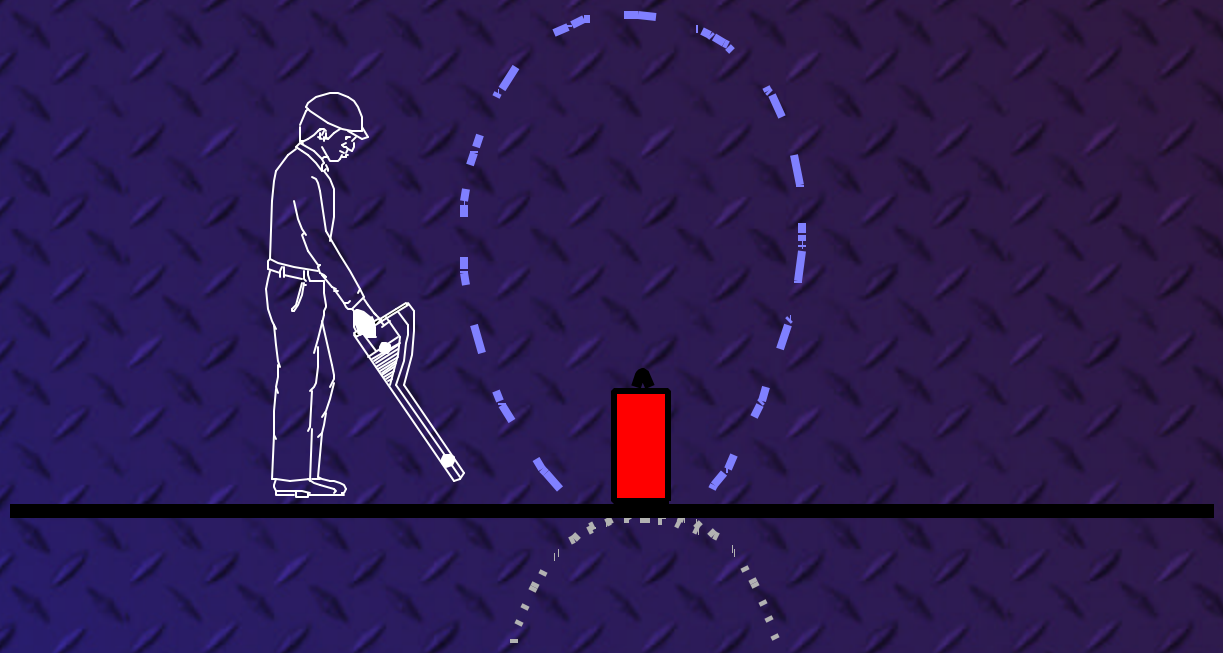
Air Coupling and Overhead Signal

Because of this dipole field, two problems can occur during inductive locating.

Air-coupling and Apparent Overhead "Interference"

METROTECH

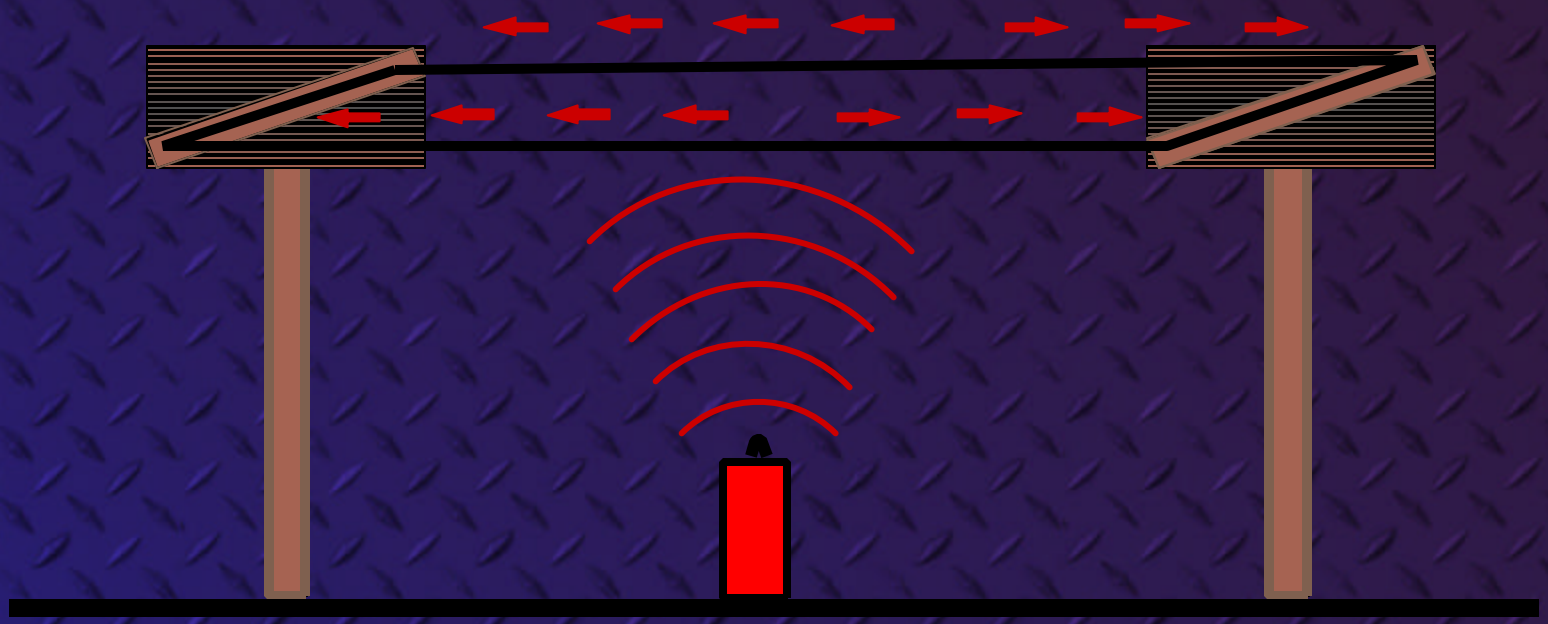
Air-coupling



Air coupling occurs when the Receiver is too close to the Transmitter and it appears as if the Receiver is detecting a pipe or cable. In fact, the Receiver is seeing the Transmitter signal directly through the air.

METROTECH

Apparent Overhead "Interference"



This phenomenon is similar to "air-coupling". In this case, the user, unaware of the existence of the upper lobe and/or visually missing the overhead utility lines, inadvertently transmits the inductive signal directly onto the overhead lines through the air. Users often mistake this self-caused event as some sort of "interference" from overhead power.

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What Do You Do to Check for Air-Coupling or Apparent Overhead "Interference"?

Think about it . . .

If you go further away from the pipe or cable, your field strength should go . . .

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So... if you raise the Receiver straight up into the air, your field strength should go:

A. Up

B. Down

C. None of the Above

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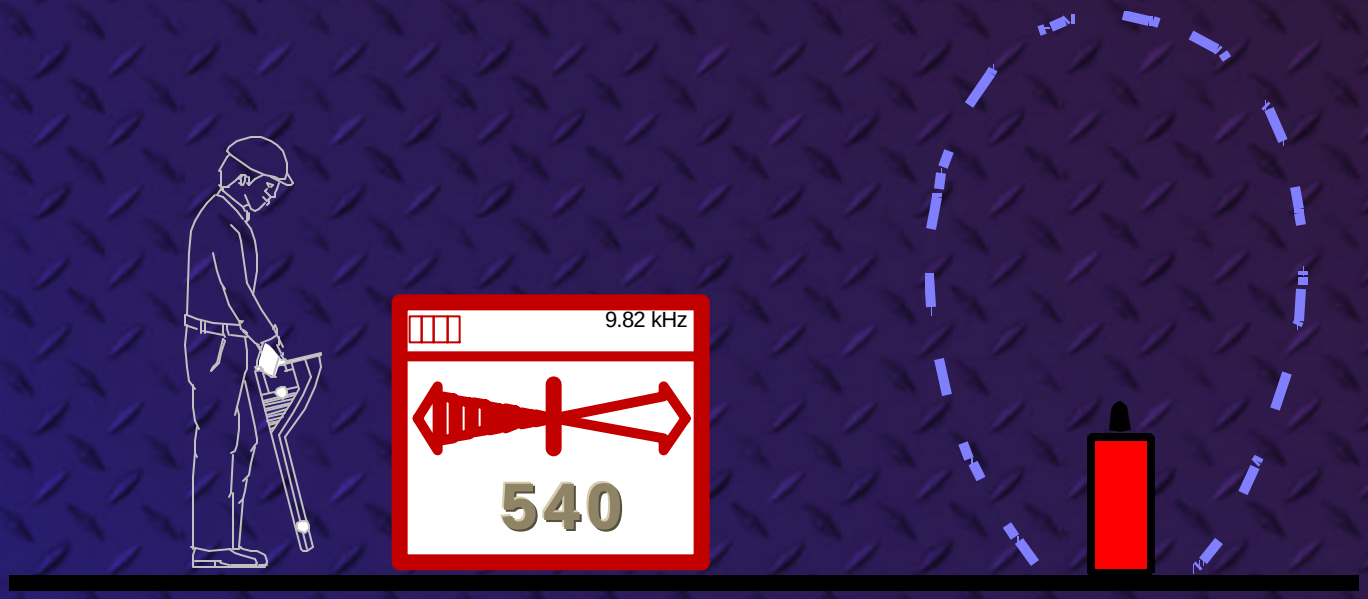
Lift Receiver From This Position



You are air coupled if the signal strength increases as you raise the Receiver above the ground.

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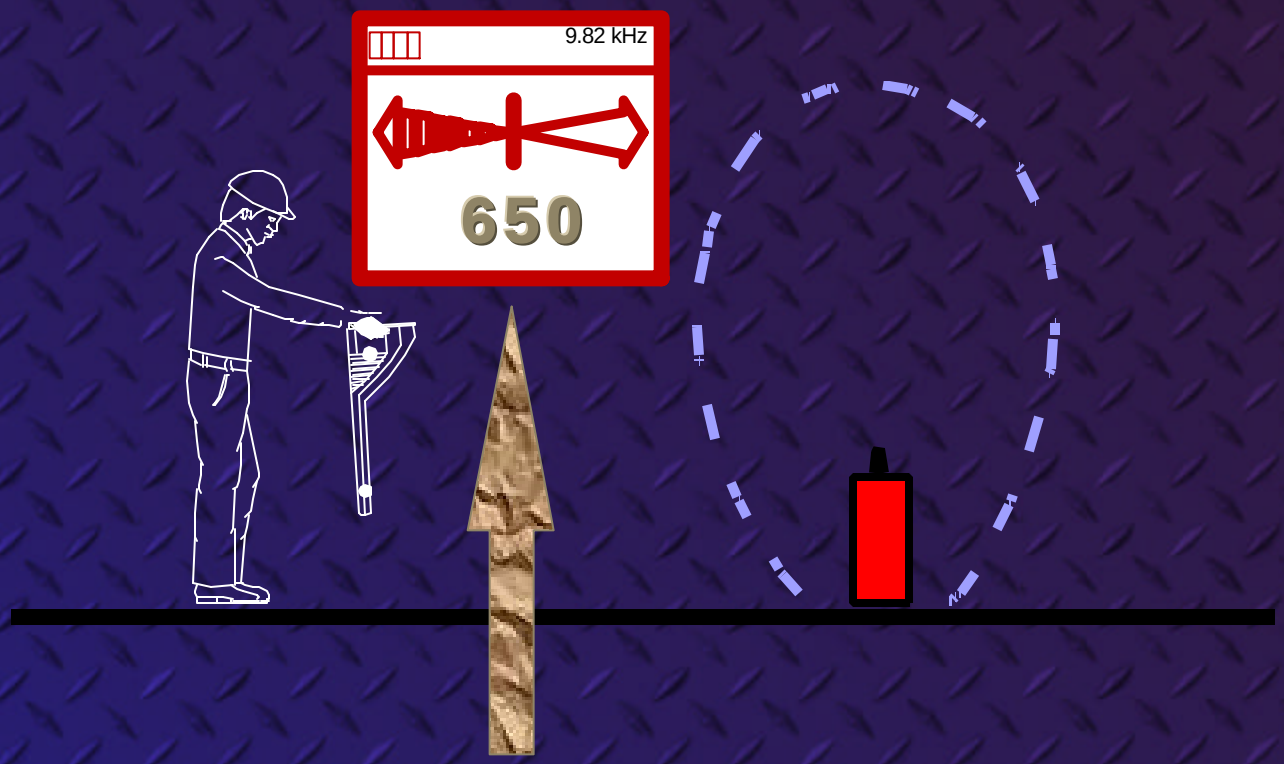
Lift Receiver Straight Up



Air coupling occurs when the Receiver is too close to the Transmitter and it appears as if the Receiver is detecting a pipe or cable. In fact, the Receiver is seeing the Transmitter signal directly through the air.

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Solution for Air-Coupling

Move the Receiver further away from the Transmitter until you are out of the upper lobe signal field. (Double check for air-coupling.)

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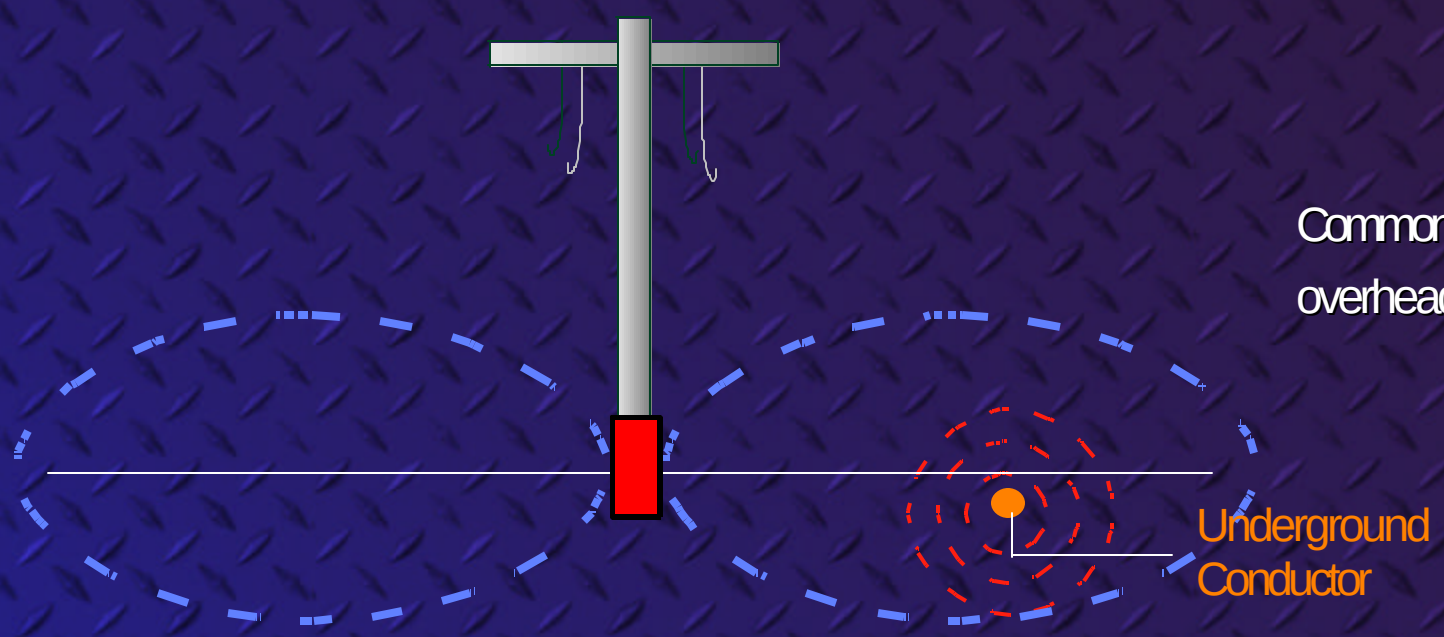
Solution for Overhead "Interference"

Reposition the Transmitter -

Move it away from the overhead lines. Or re-position the Transmitter on its side, directly under the overhead lines, so that the signal does not reach the overhead lines.



CAUTION

Common Bonds may cause overhead interference.

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Position of Transmitter for Inductive Locating

Two types of Transmitter antennas-

Ferrite Antenna -

Most upright locators

Position Across Conductor

Loop Antenna -

All split-boxes

Position Parallel to Conductor

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Radio Frequency

The most effective inductive Transmitters use a high frequency between 33kHz and 400kHz. These Transmitters are commonly called "radio frequency" locators.

Inductive Locating Benefits & Drawbacks

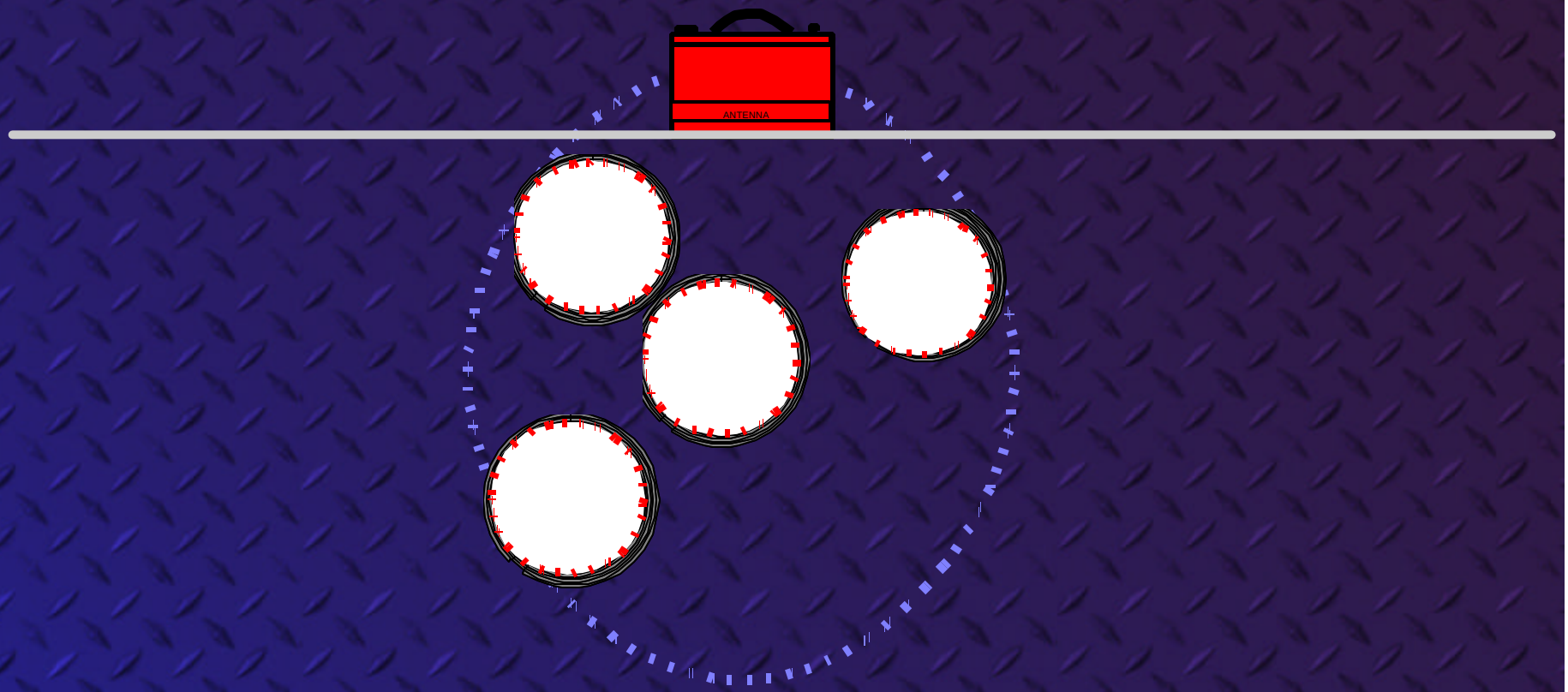
Benefits of High Frequency:

- Ability to penetrate insulators.
- Less dependent on the "electrical circuit" theory - signal returns more easily through the ground.

Drawbacks of High Frequency:

- Disperses quickly - Attenuation.
- Shorter locating distance.
- Bleeds off - "lights up" everything in the area.
- Prone to signal distortion.

High Frequency "Bleed Off" - Lights Up Everything



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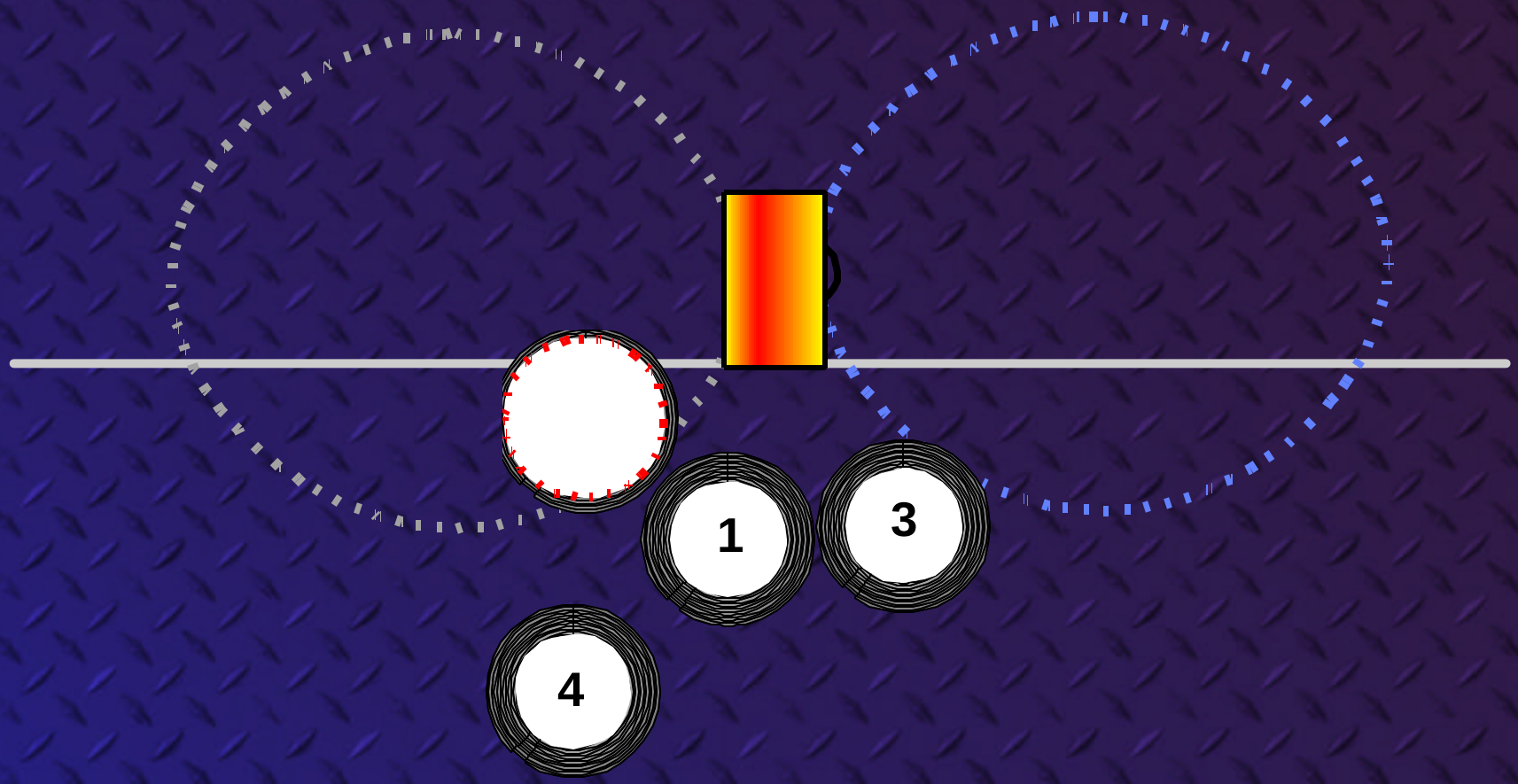
To Isolate Conductors



Stand Transmitter on End to Redirect Signal

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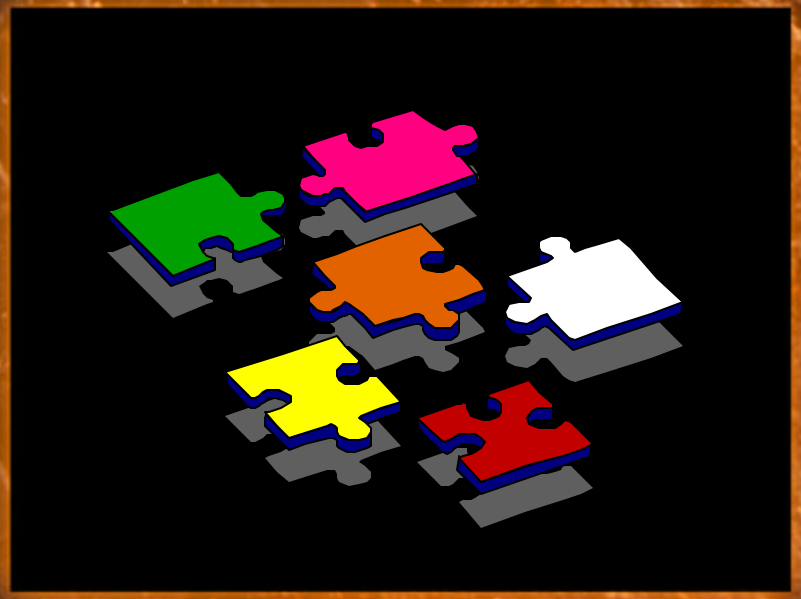
Inductive Locating Conclusion

- Use only when all other methods fail.
- Requires higher frequency.
- Be aware of bleed over caused by high frequency.

Section 6

Choice of Frequency



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Choice of Frequency

High 65kHz & above	-	Penetrates interruptions, bleed-off liability
Medium 8kHz & above	-	Requires continuity moderate distance
Low 1kHz & below	-	Requires perfect continuity, greater distance

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High (Radio)

Use on conductors (usually pipe) which are "insulated" by:

- Earth (in Inductive)
- Gaskets
- Corrosion
- Plastic Joints
- Resistive Joints
- Street Lighting (high resistance open)

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Medium (Audio)

Good Direct Connect Frequency -

Use on:

- Power, Telephone, and CATV cables
- "Coated" pipes (gas)
- "Uncoated" pipe (depending on condition)
- Pipeline (good cathodic protection)
- Irrigation Control Wire

Low (Audio)

Use on long, uninterrupted conductor (usually cable), such as:

- Fiber
- Gas Transmission lines with good coating integrity
- Trunk or Toll cables

or where ever not common bonded. Disconnected Power Lines.

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Different Ranges of frequencies react differently when they encounter a path to ground.

High Frequency - Short distance, and not easily distracted.

Medium Frequency - Moderate travel, easily distracted.

Low Frequency - Capable of goin long distance, but will take route of first distraction.

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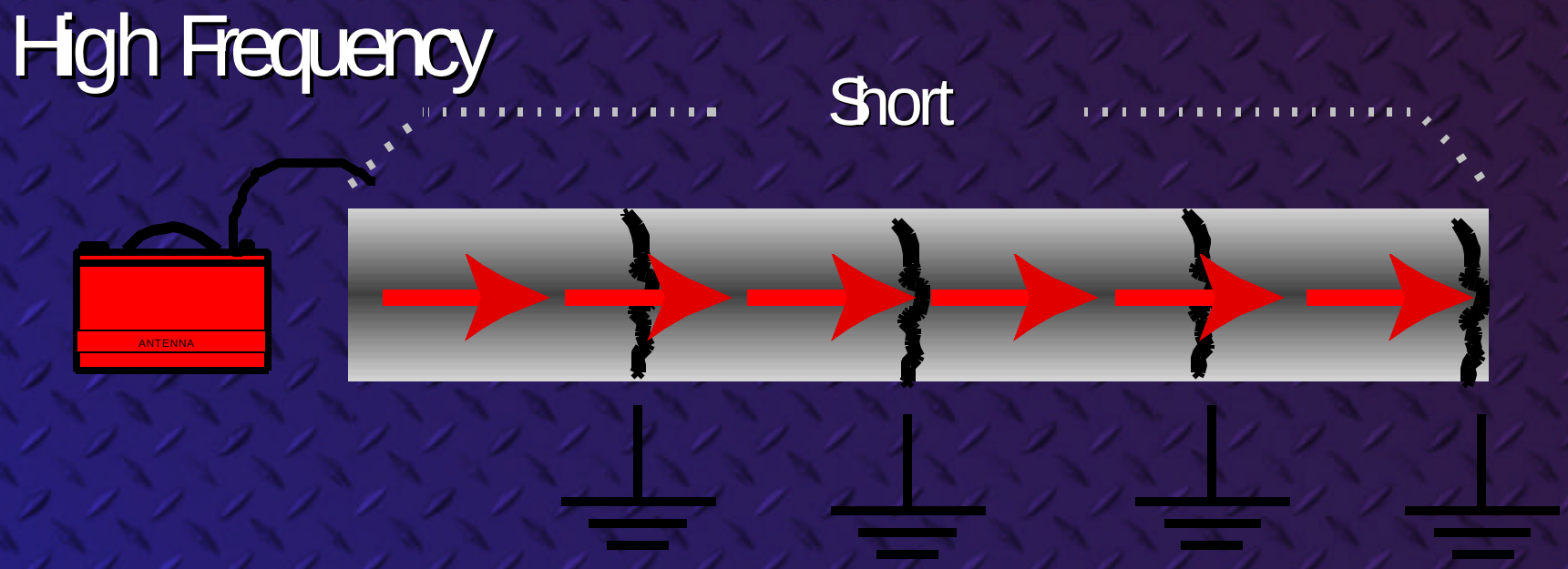
Consider Earth/Ground Conditions When Selecting Frequency



Short Distance, and not easily distracted.

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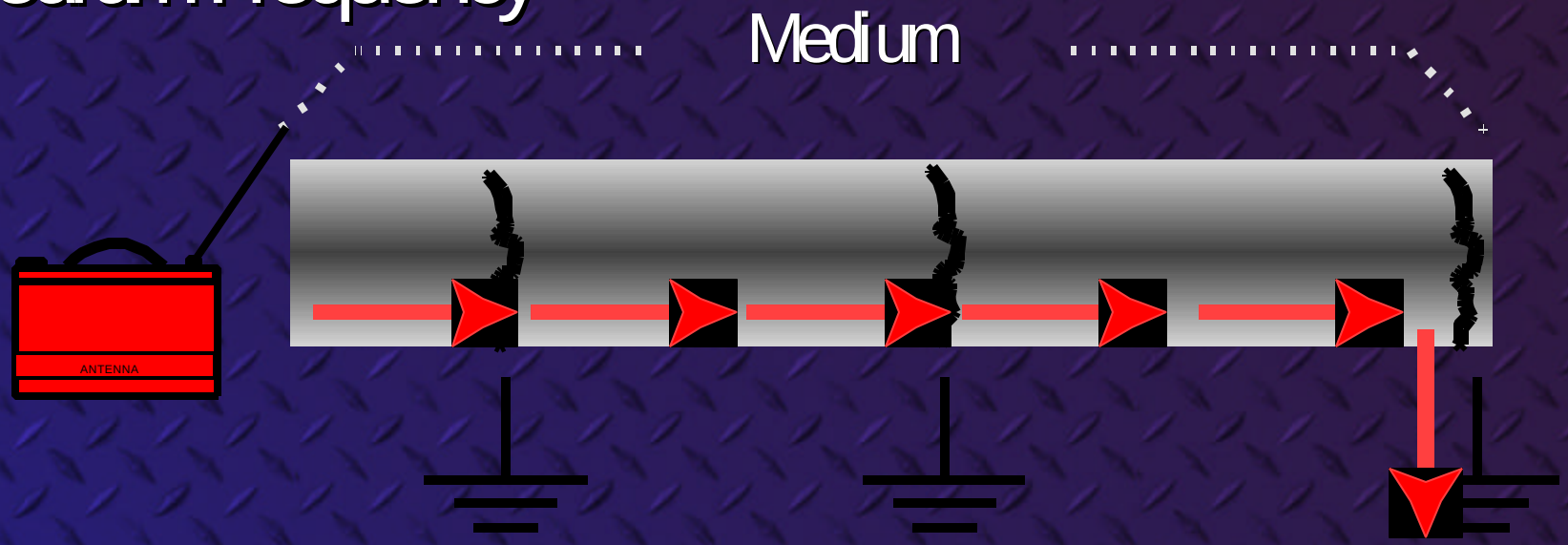
Medium Frequency



Moderate travel, easily distracted.

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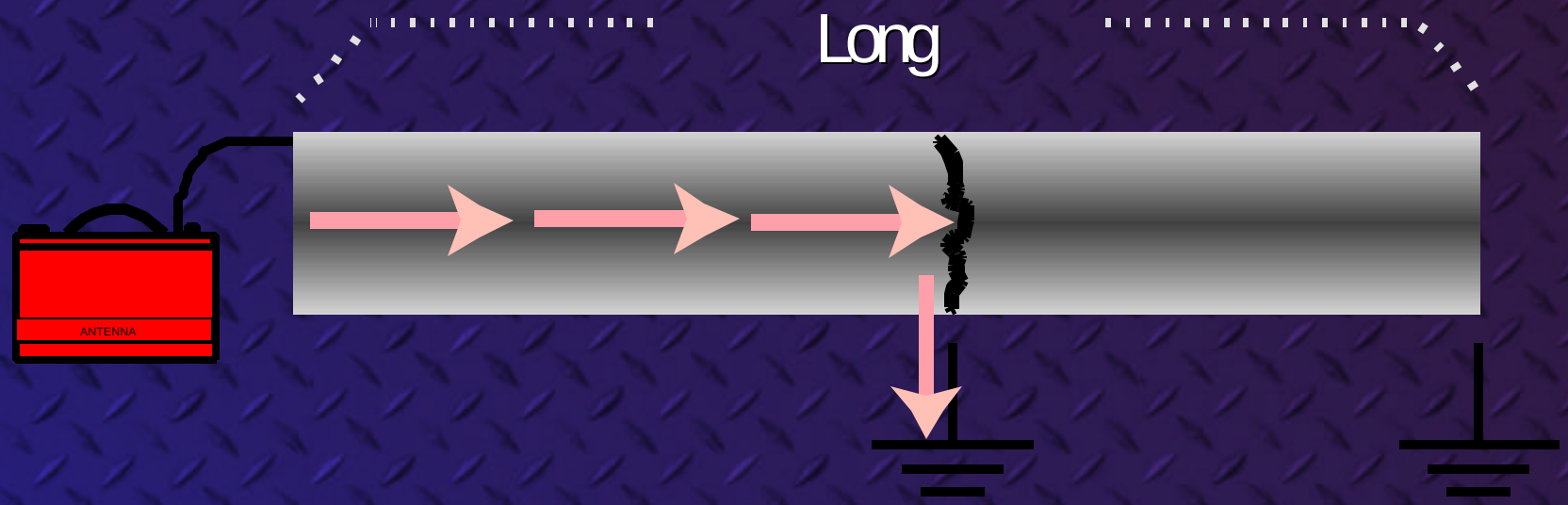
Low Frequency



Long distance, will take route of first distraction.

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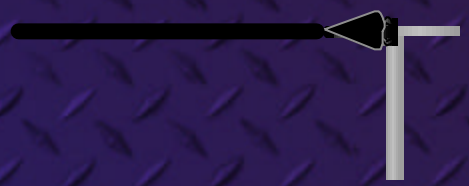
Having Locating Problems? Evaluate Factors

Conductor/Conductivity -

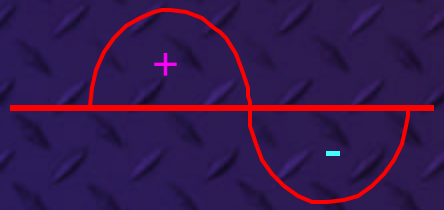
Improve Ground

Improve Hook Up



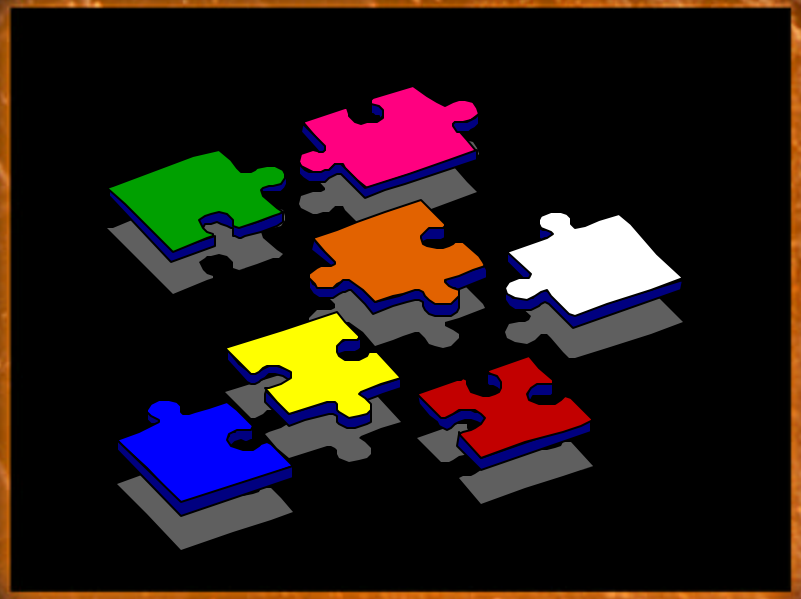
Frequency Choice -

Change to higher or lower



Section 7

Summary



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"The Locating Picture"

Combine your technical knowledge of your instrument with common sense to do your job with confidence.

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Each Element Contributes To Your Confidence In Locating

Locator Capabilities	30%
Visual	15%
Conductor Material (Copper, steel, aluminum, iron,etc.)	15%
Transmission Method	15%
Ground/Earth	15%
Blueprints	5 to 10%
Depth	10%
End Point Negative	30%
End Point Positive	15%
Signal Strength	30%

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Ultimately, the Success of Your Locate Depends Mostly On YOU!

- Your Own Resourcefulness and Problem-Solving Abilities.
- Type and Condition of Soil.
- Type and Condition of Target Conductor.
- Your Choice of Connection.
- Your Choice of Frequency and Power Setting.

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Qualities of a Locating Champion

Good Problem Solver

Quick at the Trial and Error Process

Unafraid of Experimentation and Minor Setbacks

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Now You Have All the Knowledge to:

TAKE CHARGE of YOUR Locates -

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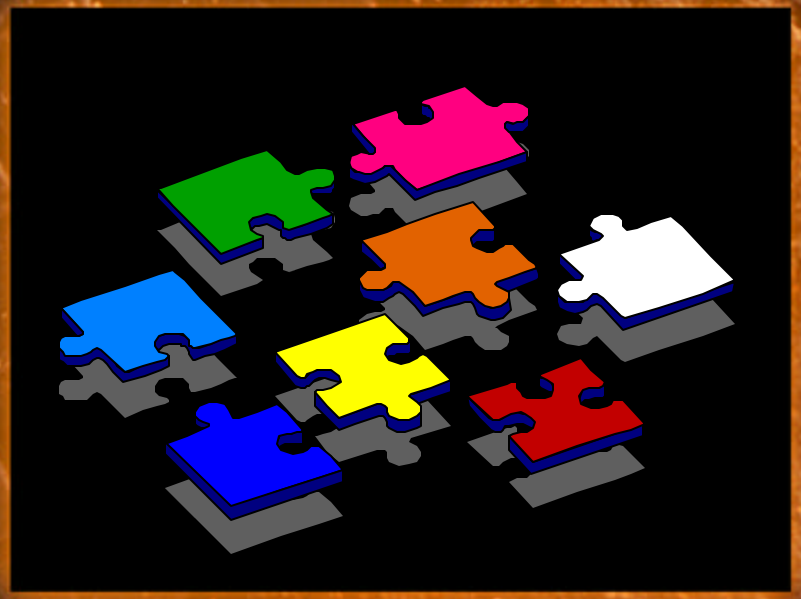
Section 8

Field Calibration



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Combine Technical Knowledge with Common Sense To Do Your Job With Confidence

Begin Your Locate In Control

Establish Your Confidence in the Locator's Accuracy

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Before Starting Your Locate-

Be Sure Your Instrument is Working by Testing It

Establish Your Own Test Site at a convenient place, such as your home or work place.

Choose a "Known Conductor" at Your Test Site.

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Choose a "Known Conductor" at Your Test Site

This will become your benchmark for measurement accuracy

Choose:

- A utility at approximately 3 feet in depth (average depth for a utility).
- Establish the signal strength and depth of this conductor.
- Mark the site for future reference.
- Use this information for instrument test comparison.
- A utility with an access point for direct connection.

When to Test Your Instrument

If your instrument is new.

[redacted]

Before leaving for your job - the night before in case you need to recharge.

After someone else has used your locator.

[redacted]

If you have problems during your locate.

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Check Your Instrument

Check the Batteries -

- ✓ Transmitter and Receiver

Check the Operating Features -

- ✓ Left/Right, Signal Strength (Receiver)
- ✓ Depth (Receiver)
- ✓ Direct Connection Leads

Check the Battery Power

15 % of instruments into repair are in need of new batteries

Both Transmitter and Receiver -

- ✓ If battery power is low

Recharge or Replace (depending on model)

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Check the Instrument Operation

Left/Right Indicator and Signal Strength:

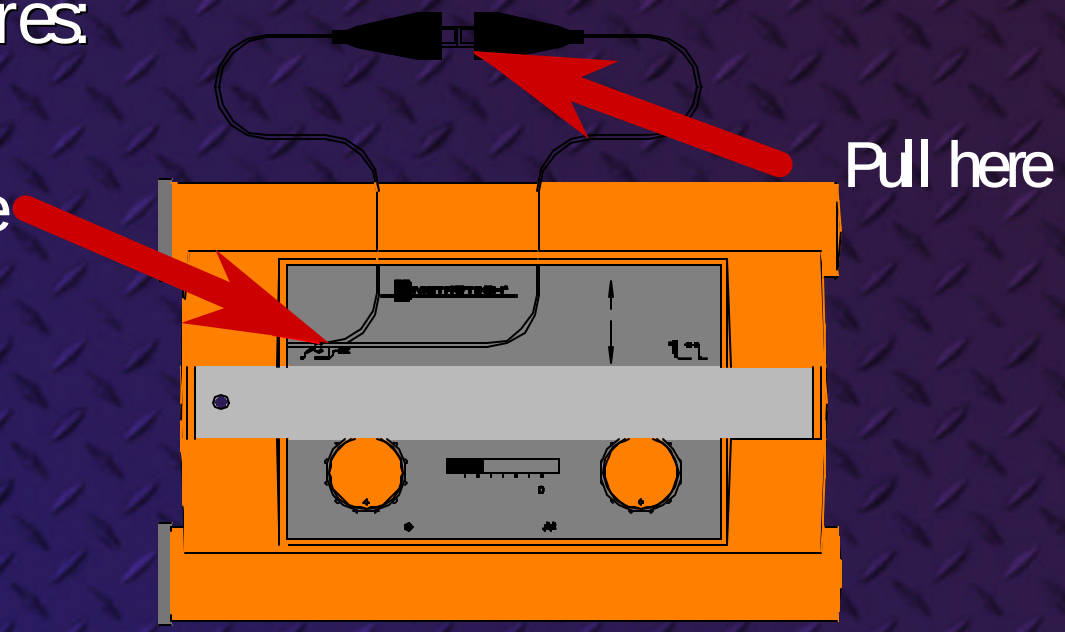
- ✓ Apply signal onto your conductor
- ✓ Turn the Receiver "ON"
- ✓ Move the Receiver back & forth over your conductor
- ✓ Look for your known centerline and signal strength

Depth:

- ✓ Take a depth measurement
- ✓ Compare with a known depth

Check the Direct Connection Leads

Test for loose or broken wires:



With the Transmitter "OFF", plug the Direct Connection Leads into the Transmitter and attach them to each other.

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- Turn the Transmitter "ON".
- Turn the Receiver "ON". Note the signal strength - pull on the wires near the attachment points (clip and jack). Signal fluctuation indicates loose or broken wires.

Check Inductive Clamp

- Plug the joined Direct Leads into the Receiver AUX jack.

Check Inductive Clamp

- Plug the Clamp into the Transmitter jack.

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Check Inductive Clamp

- Turn the Transmitter "ON".

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Check Inductive Clamp

- Note Receiver signal strength - pull on the wires near the attachment points (damp and jack) signal fluctuation indicates loose or broken wire.

Check the Transmitter Inductive Coil

1 Turn the Transmitter "ON" in the Inductive mode.

2 Wave the Receiver toward the Transmitter.

3 Check the Left/Right and Signal Strength functions on the Receiver.

Metrotech wishes you many successes!

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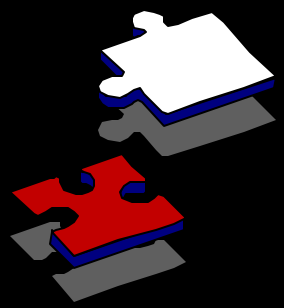
SECTION 2

Importance of Earthing



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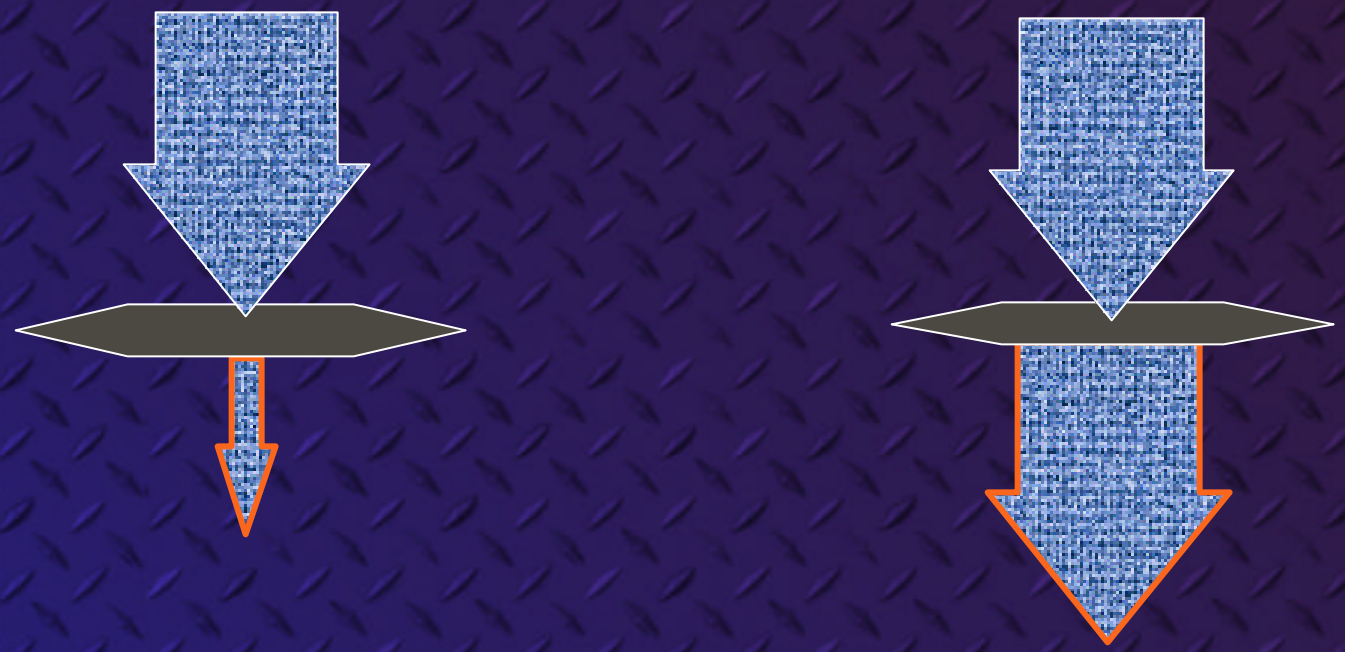
Importance of Earthing

Earthing is the Most Important Factor in the Direct Connect Method

- The signal (current) must "flow" in a loop to be detected by the Receiver.
- A metal earth/ground provides a focal point for the signal to travel back to the signal source - closing the circuit (loop).
- The larger the metallic surface, the stronger the signal loop.

Principle of Earthing



If the current was water, the earth/ground would be a drain - the better the drain, the better the water flow.

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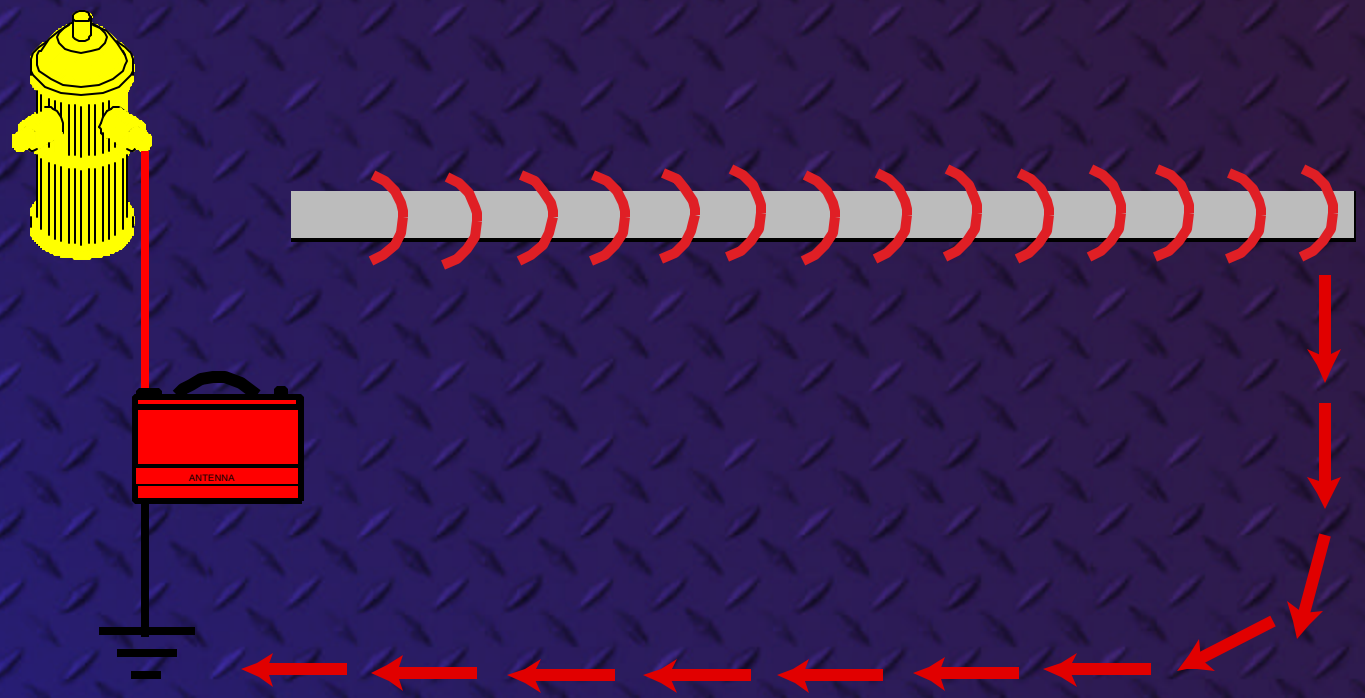
Ground Rod Placement



Attach Black Lead to Ground Rod at right angle to conductor.

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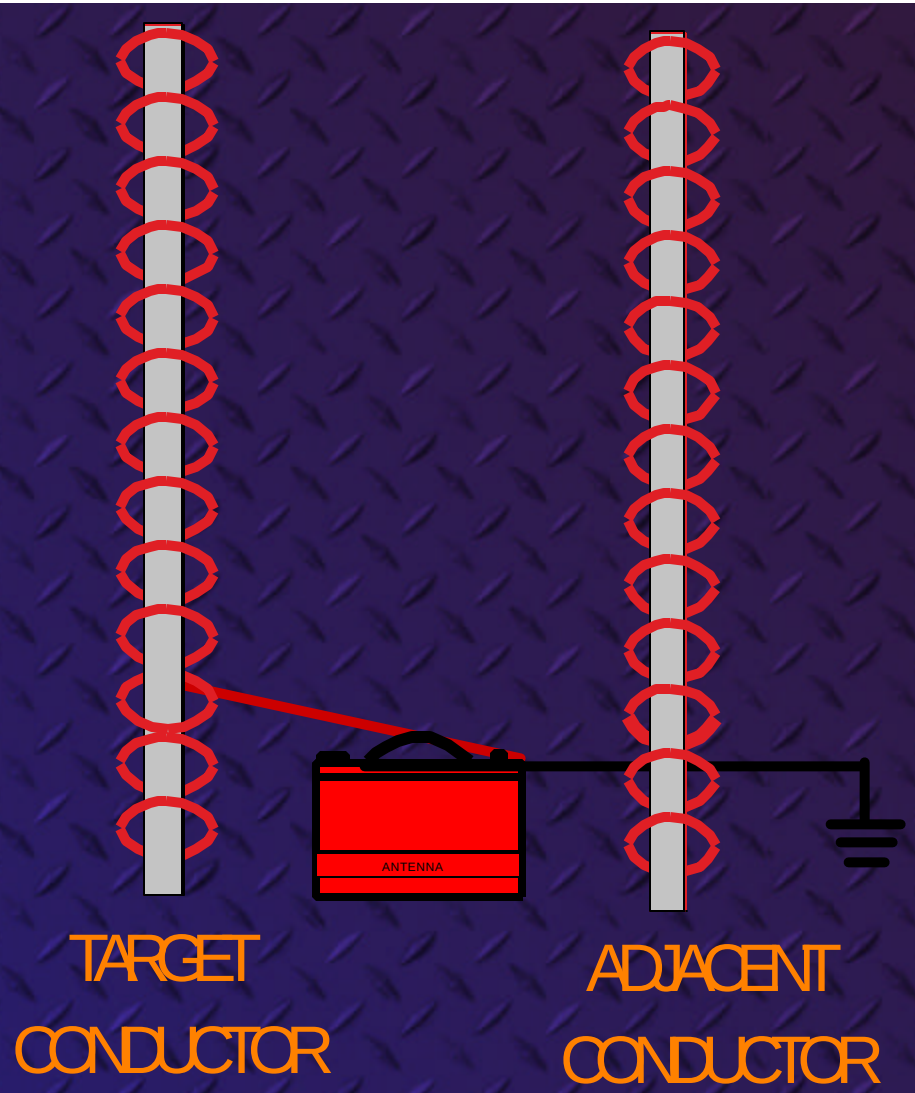

Crossing over an adjacent conductor places unwanted signal on that conductor.

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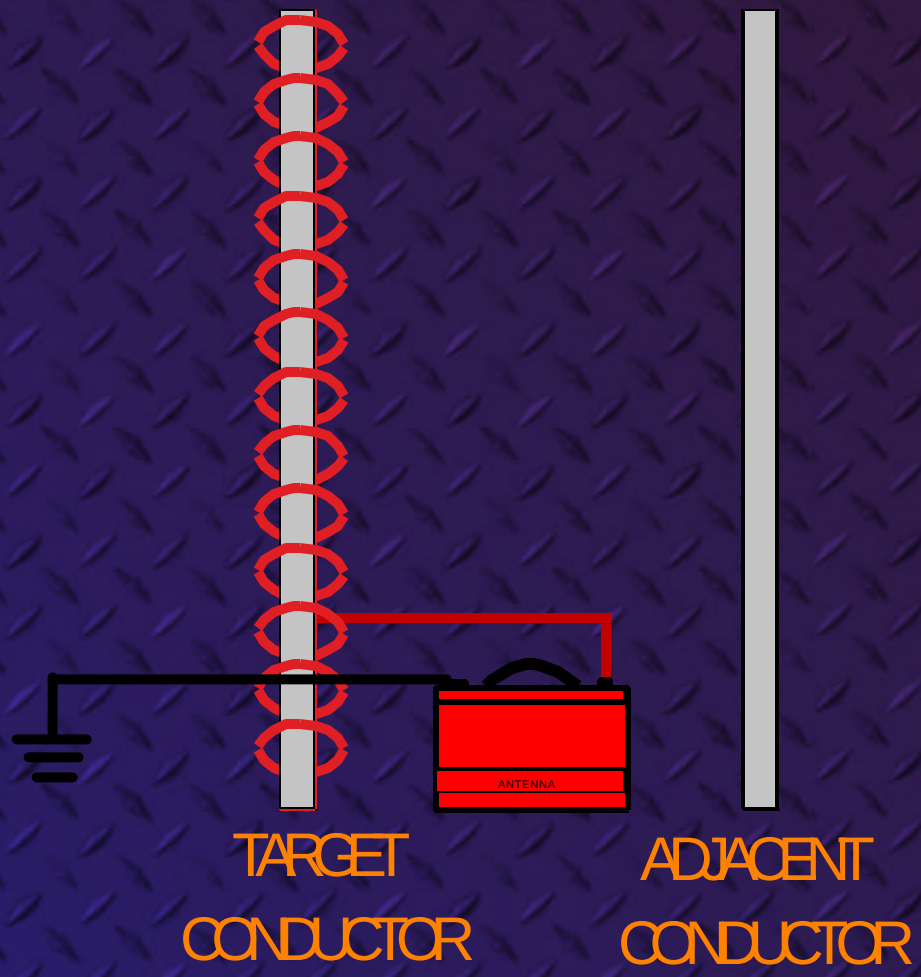

Place ground lead away from other conductors.

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Avoid "Destructive Interference"

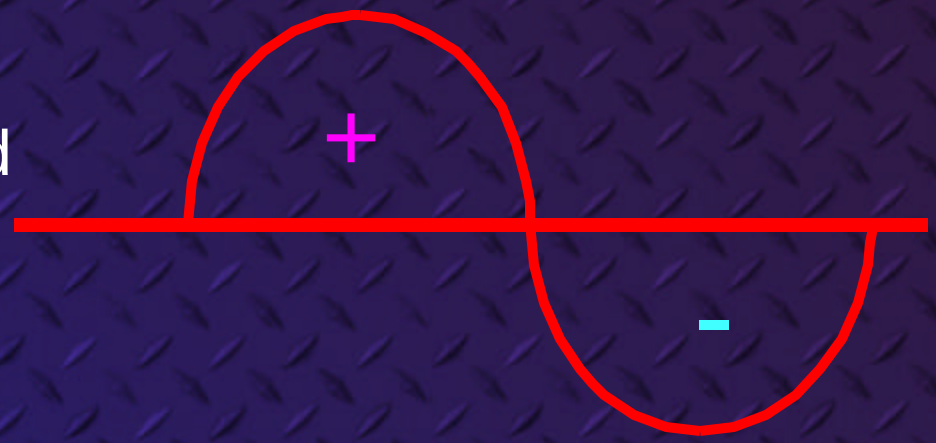
Connect Earth/Ground at right angle.

This rare situation most commonly occurs when two (or more) conductors are physically connected.
e.g. common trenching

A Few Important Terms Describing Alternating Current:

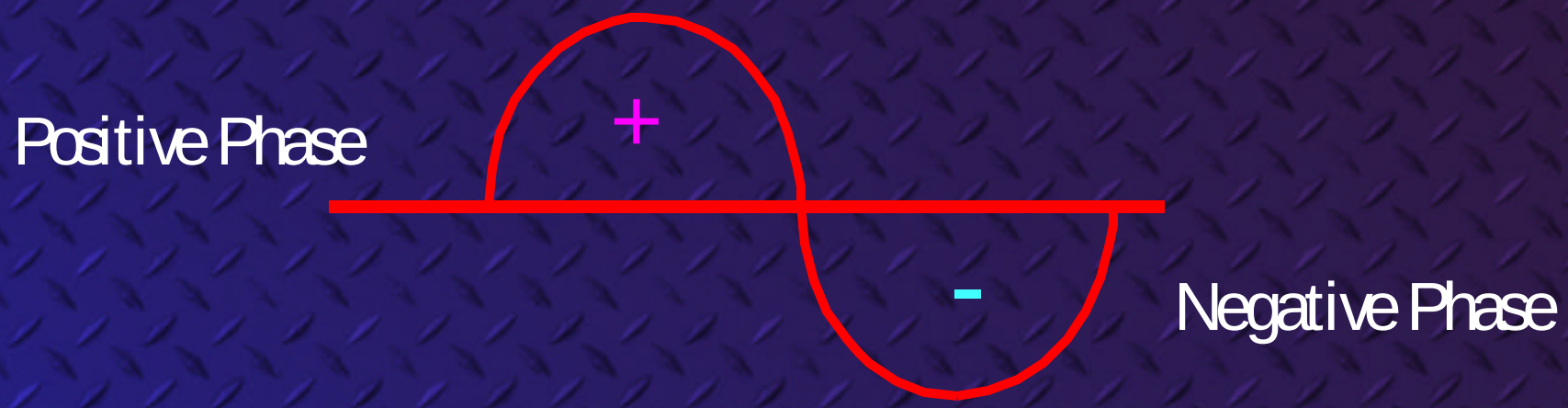
<u>Cycle</u> One round of "up and down" or positive and negative potential.

One cycle per second



"Alternating Current" Terms

<u>Phase</u> Signal goes both "up" and "down".



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"Alternating Current" Terms

<u>Frequency</u> The number of cycles that occur within one second.

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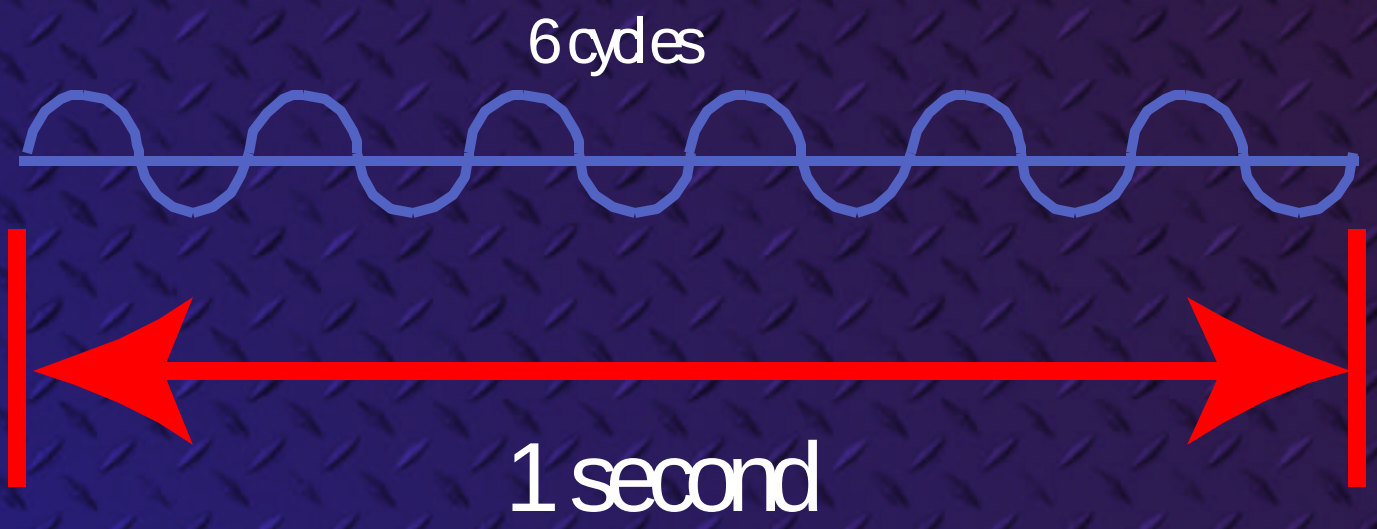
"Alternating Current" Terms

<u>Amplitude</u> The height (or depth) of a phase. (Volts)

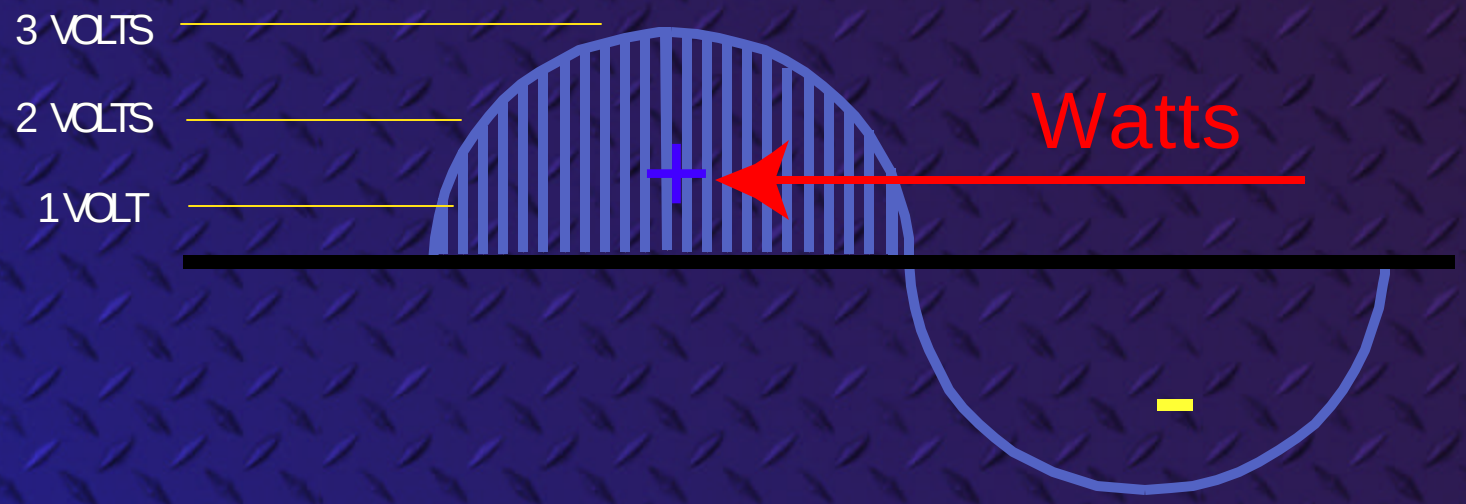


6 cycles per second = 6 Hz

"Alternating Current" Terms

<u>Power</u>

The area under the curve.
(Watts)



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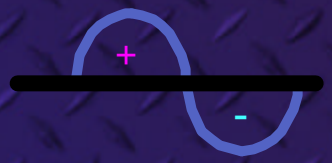
"Alternating Current" Terms

Cycle



One "up and down" or positive and negative potential.

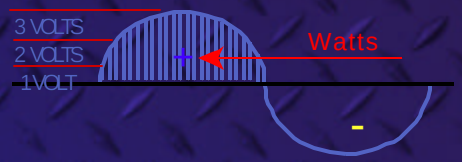
Phase

Signal is going both "up" and "down".

Frequency

Number of cycles occuring within one second.

Amplitude (Volts)

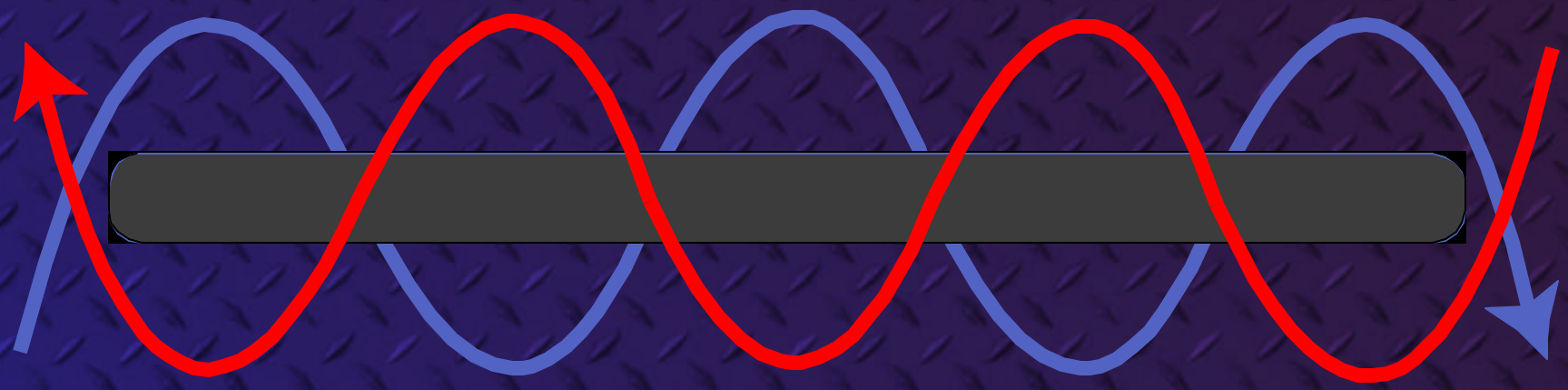


Height (or depth) of a phase.

Power (Watts)

Area under the curve.

“ Destructive Interference”



When a transmitted signal on the target conductor meets a returning signal in the opposite phase, the signals cancel or distort each other.

Symptoms of "Destructive Interference" or Poor/No Earth

- Fluctuating signal strength (by a constant 50+ points up and down).
- Inconsistent Centerline or Peak.
- Inconsistent or Non-repeatable Depth Readings.

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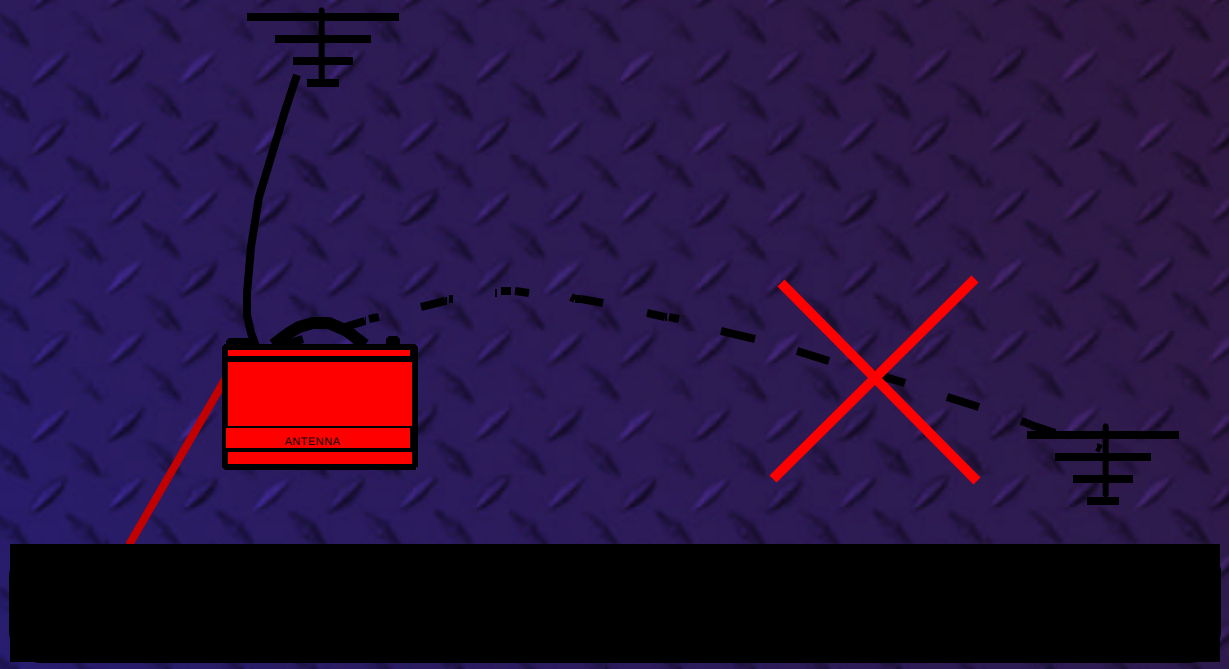
Avoid "Destructive Interference"



Determine probable path of your conductor and move your ground rod accordingly.

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Destructive Interference May Be Unavoidable

Locating through Destructive Interference is possible when the cause is recognized and determined, e.g. common bonding.

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I know I am supposed to attach the earth at right angles to the conductor.

How do I know which way the conductor is running?

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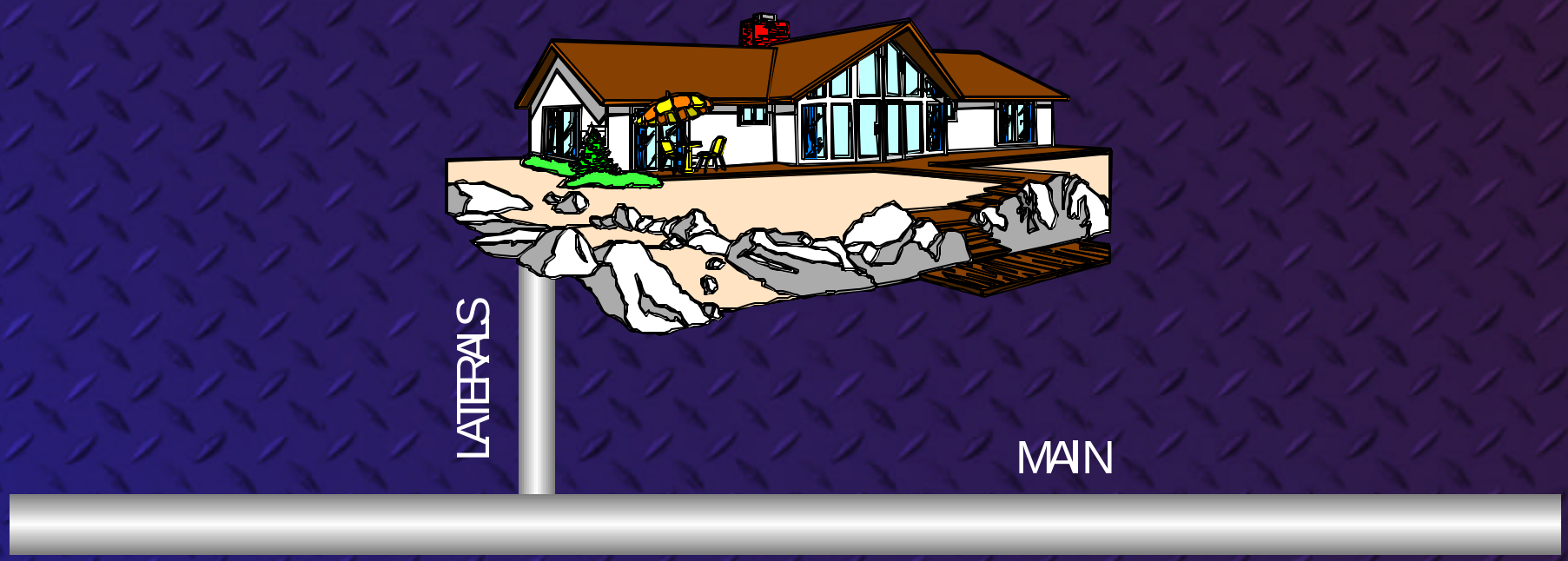
“ Read the Street”



"Large delivery" (water main) is typically parallel to the street. Small delivery (laterals, house connections) is perpendicular to the street.

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Industry Terms for Delivery Systems

Water	-	Main and Lateral (Service)
Gas	-	Main and Lateral (Service)
Power	-	Primary and Secondary
Telephone	-	Underground and Aerial Cables (F1 and F2) and Service Drops
CATV	-	Trunk Lines and House Drops

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More Clues to the Probable Path of Your Conductor

Note Positions of:

Water	-	valves, curb stops, meters, hose bibs
Gas	-	meters, ETS points
Power risers	-	transformer boxes, switch gear,
Telephone	-	pedestal boxes, risers, manholes, terminals, protector
CATV	-	pedestals, risers, protector

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When Placing Your Ground Rod

Do not lay attachment parallel to your target or adjacent conductor. (To avoid "Destructive Interference")

Do not cross over adjacent conductor. (To avoid transmitting signal onto an unwanted conductor)

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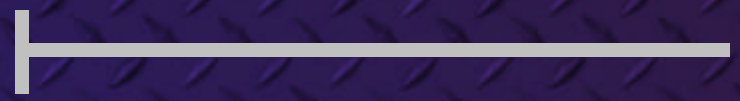
Methods to Improve Your Earth

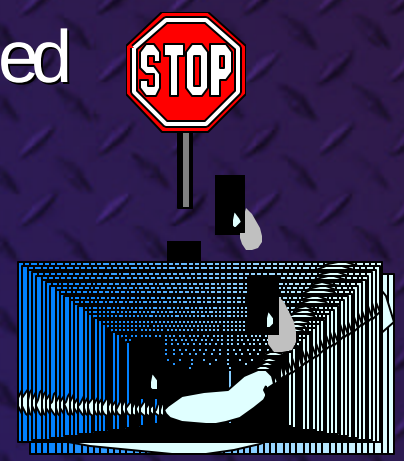
Create larger surface area to attract signal -

- Longer ground rod - be careful not to penetrate another line



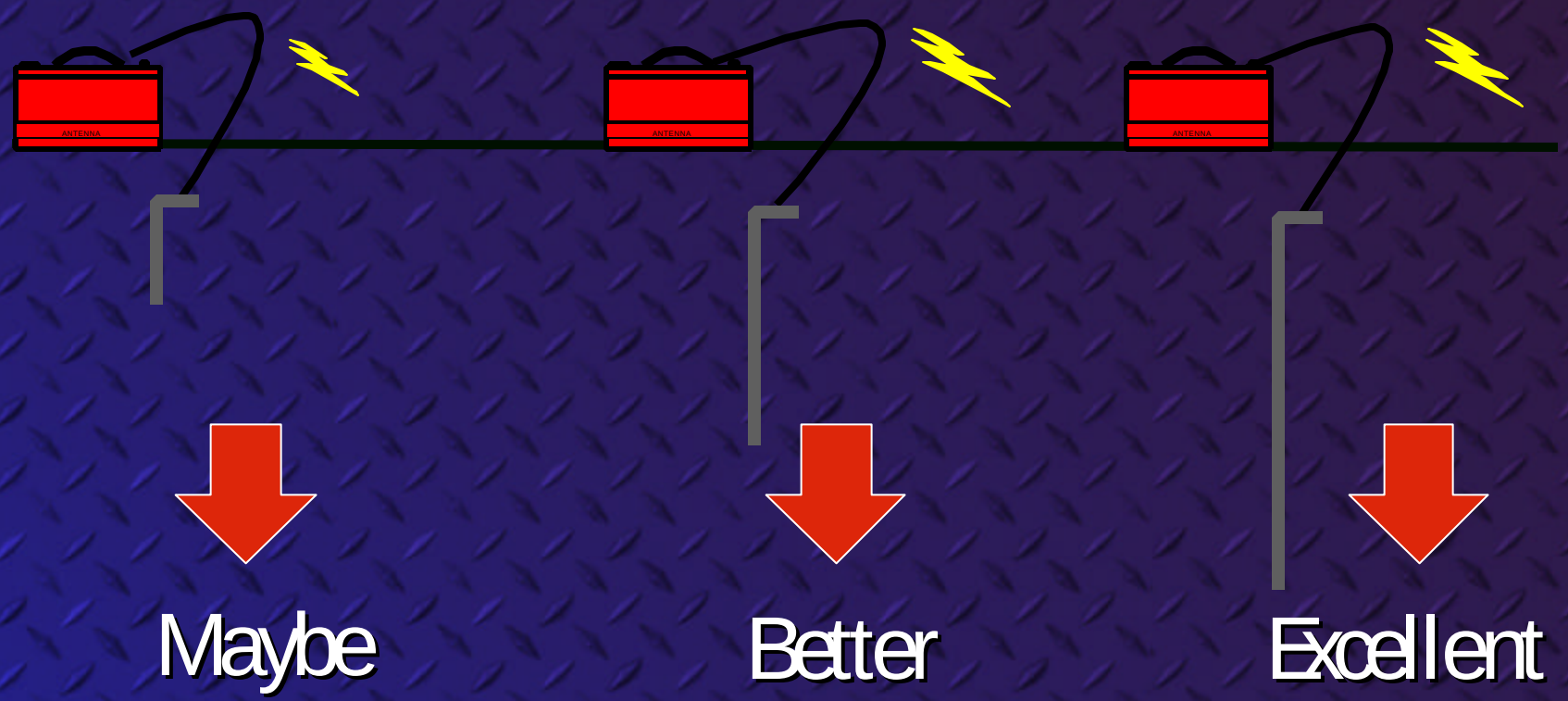
- Multiple rods connected

- Use an available earth that is deeply buried



- Water/moisture improves conduction

Larger Surface Area Attracts More Signal (Current)

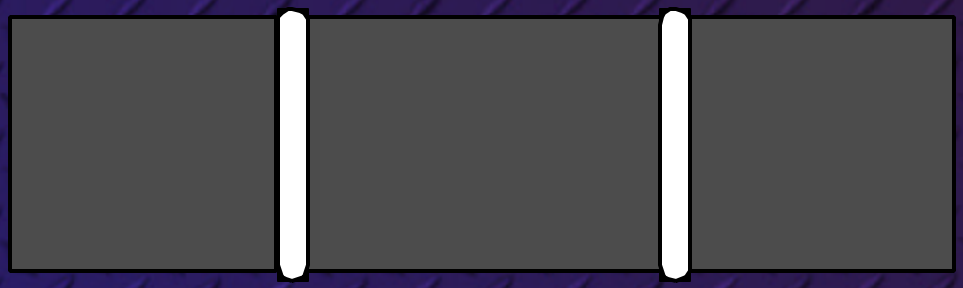


METROTECH

Convenient Available Earths That Provide More Surface Area

Stop Sign/Street Sign

Metal fence post



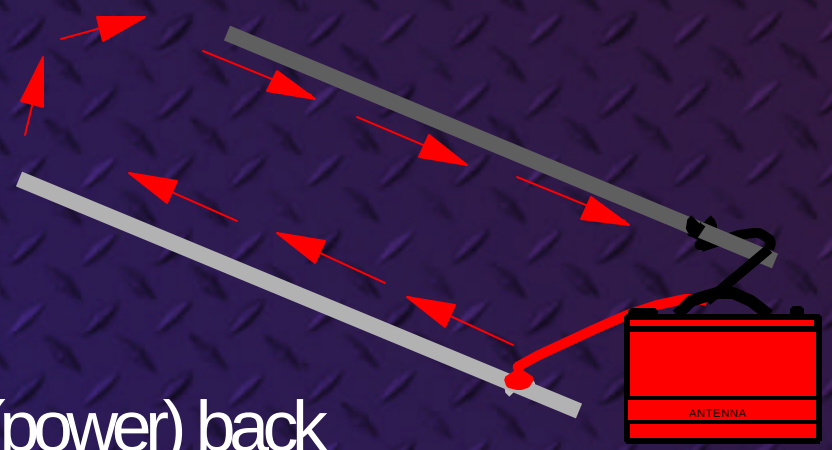
Alternative Earth

If you are cautious - it is possible to use a parallel utility as your return signal path.

When you do this, verify that you start out and end up at a termination point that is specific to the utility that you are tracing.

Parallel Utility Earth - Return Locate

Convenient for user who is locating multiple utilities (such as a contract locator).



If grounded to adjacent utility -
Locate one (water) out and the other (power) back
You don't need to move your Transmitter

<u>Important to verify terminations</u>

METROTECH

In Conclusion -

Direct Connect Provides a Superior Locate Because It:

- Isolates conductor from adjacent conductors.
- Get more signal distance - don't need to move Transmitter.
- Provides the strongest signal to the best Receiver, resulting in the best Receiver accuracy.

METROTECH

Curt Geeting
Electrical Meter Update

Electrical Measurement Safety

Understanding hidden hazards and new safety standards

Goals

? Awareness of electrical measurement hazards

? Understand international safety specifications for DMMs and Scopes

? Understand the 4 installation overvoltage categories

? Learn how to minimize and avoid electrical measurement hazards

Agenda

- What Electrical Power can do to a DMM
- IEC Safety Standards
- Arc Blast
- Electrical Tester Safety
- Scope Safety

Handheld Test Tool Safety

How not to save time...

Last known earthly residence of automative fuse used to replace original fuse

Test leads survived intact

Handheld Test Tool Safety

The wrong meter to use on a power circuit.

250V fuse didn't open in time

Poor quality leads and probes led to injury.

Probe tips burned off

Handheld Test Tool Safety

Fingerprints burned into probes

The electrician suffered severe burn injuries on his hand and arm.

Typical work environment

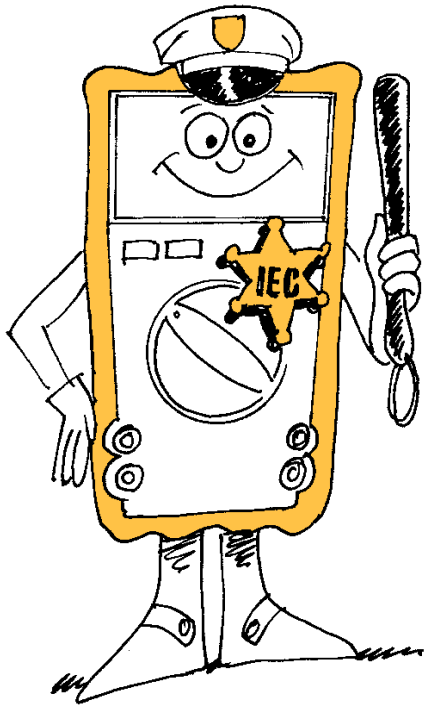
Handheld Test Tool Safety

Aftermath of an accident

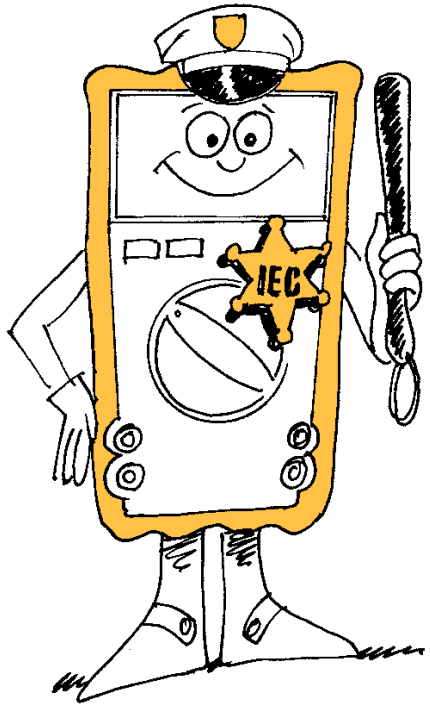
Handheld Test Tool Safety

If it melts metal, what does it do to people.

New IEC Safety Standards



International Electrotechnical Commission



- **IEC 1010 is the new standard for *low voltage* "test, measurement and control equipment".**
- **IEC 1010 provides much improved protection against "overvoltage impulse transients" - voltage spikes.**
- **IEC 1010 is the basis for:**

  ANSI/ISA-S82.01-94 (US)

  CAN C22.2 No. 1010.1-92 (CAN)

  EN61010-1:1993 (EUR)

IEC 1010 Key Concepts

Protection against Overvoltage Transients

- **CATEGORIES: CAT I to CAT IV**

  The greatest danger from transients is in the high Categories, because they could trigger an *arc blast*.

- **IMPULSE TESTING: No failure allowed**

  Meters must be tested by being hit with a specified number of transients, with specified peak voltages.

- **INTERNAL SPACING: increased**

  Clearance (distance through the air) and

  Creepage (surface distance) are increased.

[redacted]

Overvoltage Category

- **The level and energy of voltage impulses is dependent on the *location*.**
  The closer the location is to the power source, the higher the available fault current, the higher the Category

- **IEC 1010 defines four locations or *Categories*:**

  CAT IV **"Origin of installation"**

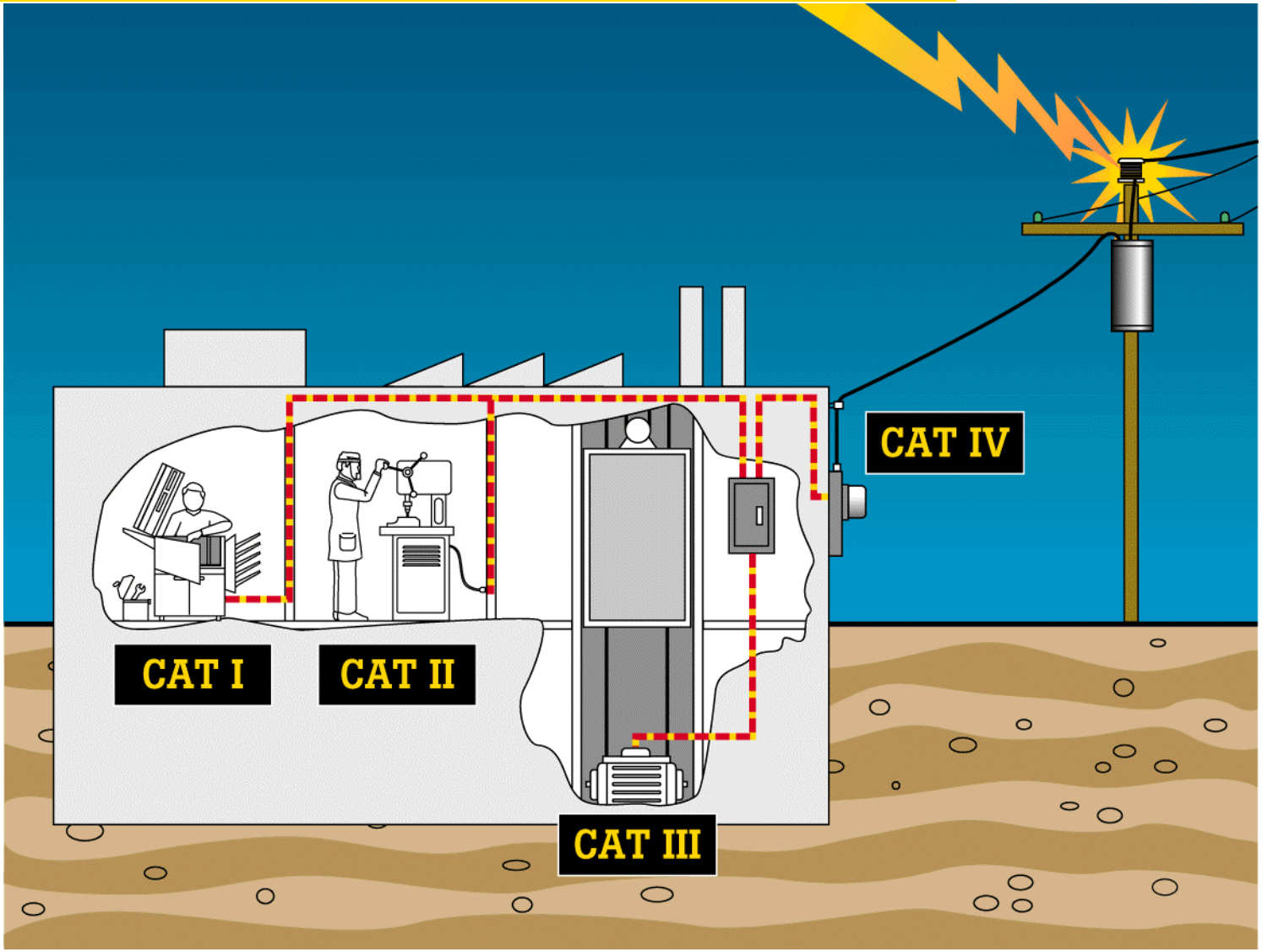
  Utility level and any outside cable run

  CAT III **Distribution wiring, including "mains" bus, feeders and branch circuits; permanently installed loads.**

  CAT II **Receptacle outlet circuit; plug-in loads.**

  CAT I **Protected electronic circuits**

Category Locations



Overvoltage Category

Common sense ways to think of Categories

- **The higher the *short circuit fault current* available, the higher the Category**
  - **High energy transients are much more dangerous, because they can trigger an arc blast**
- **The greater the *source impedance*, the lower the Category**
  - **Transients are dampened by system impedance as they travel from the point where they were generated.**
- **TVSS (Transient Voltage Surge Suppression) devices are sized larger (more joules) at the panel than at the receptacle outlet.**

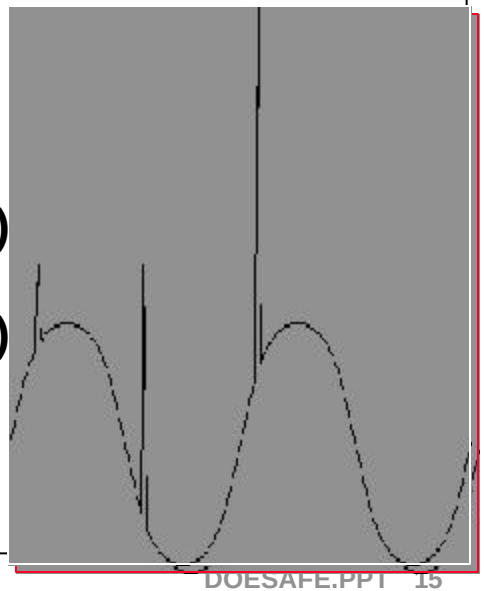
Working voltage

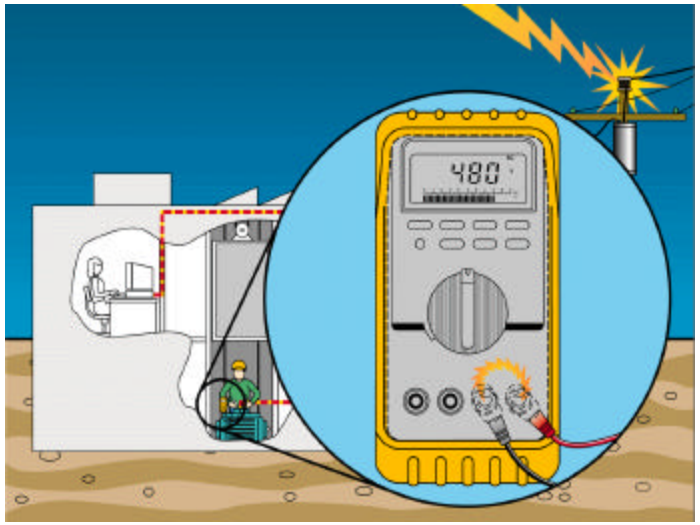
- "working voltages' within each category

  50, 150, 300, 600, 1000V

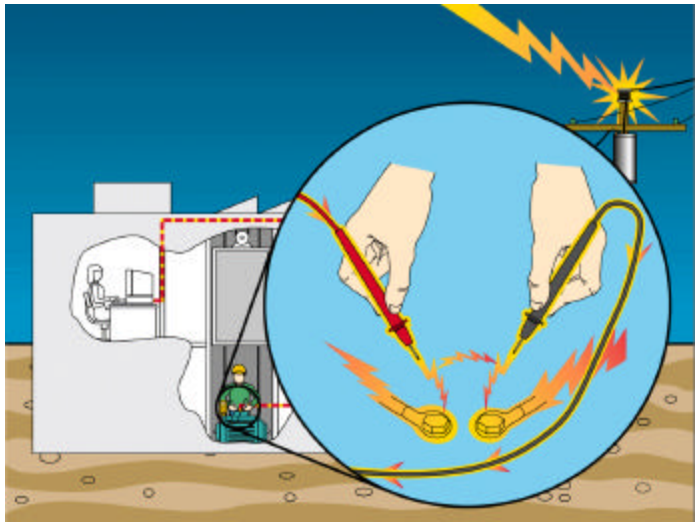
  Higher working voltage has greater transient withstand

- CAT IV - 600V: 8 kV impulse (2 W source)
- CAT III - 1000V: 8 kV impulse (2 W source)
- CAT III - 600V: 6 kV impulse (2 W source)
- CAT II - 1000V: 6 kV impulse (12 W source)
- CAT II - 600V: 4 kV impulse (12 W source)

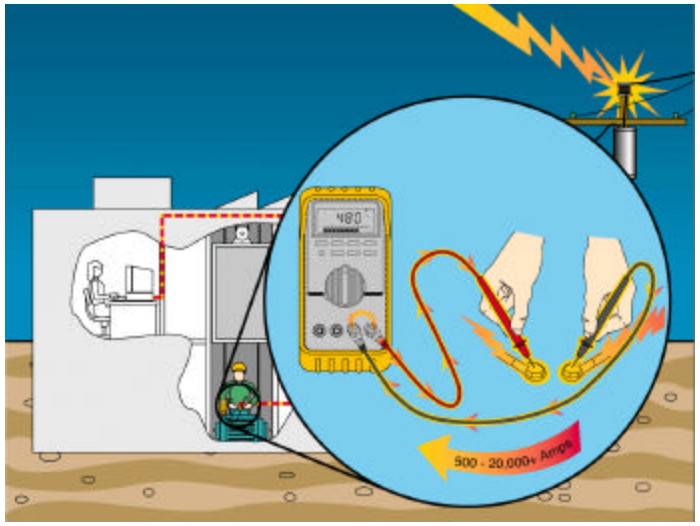




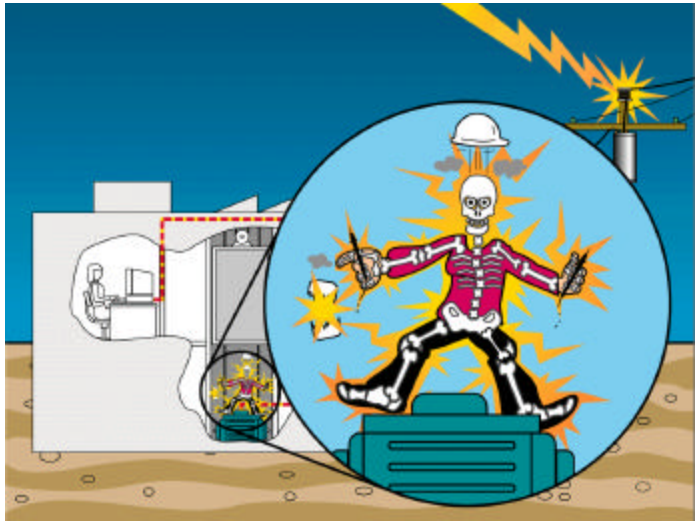
1) Flashover inside meter



3) Arcing at the terminals



2) Fault current in test leads



4) Arc blast

IEC 1010 Reinforced Insulation

- **Dielectric withstand**

  Shock hazard protection

  Higher working voltage has greater transient withstand

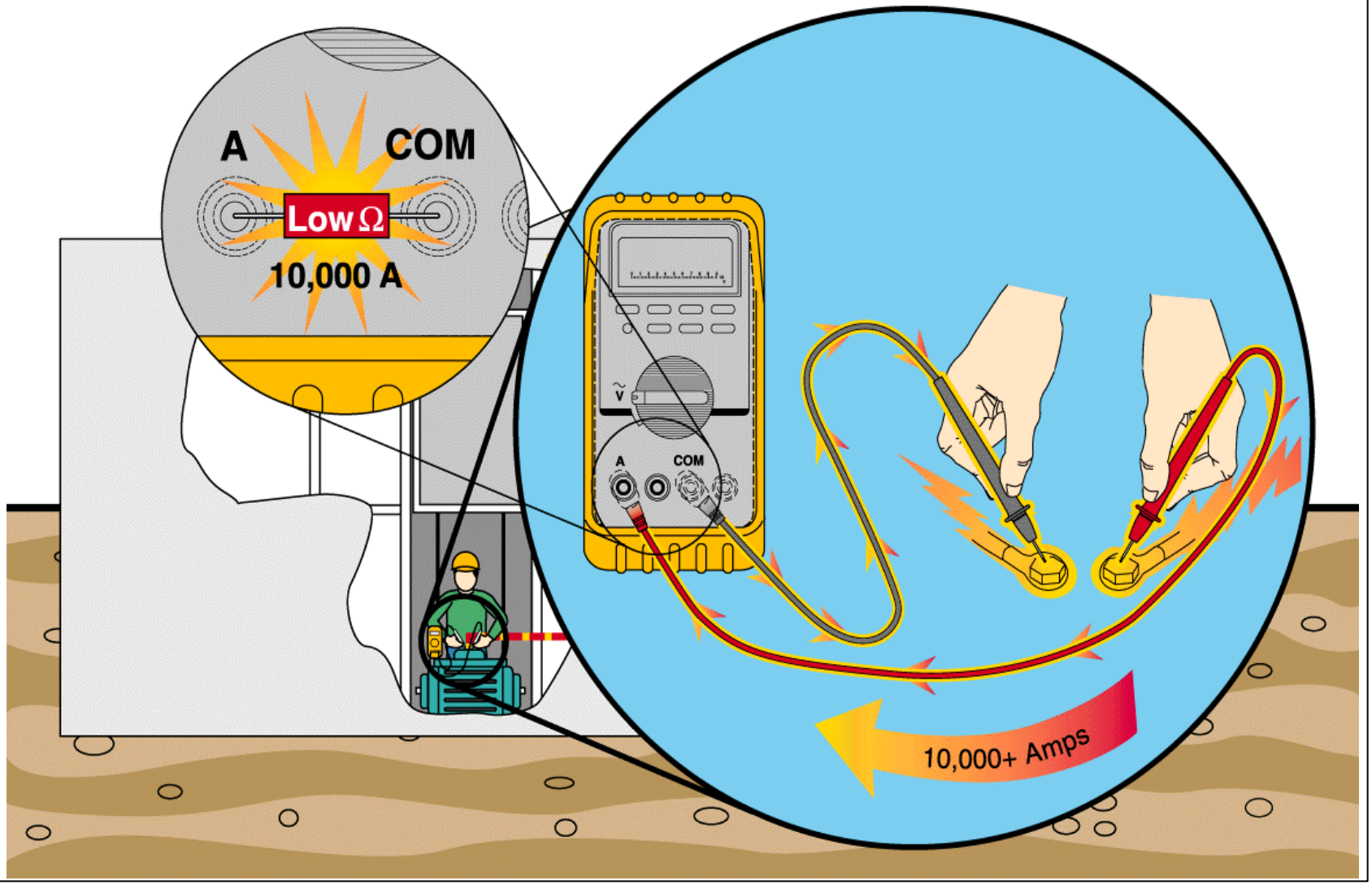
- **CAT III - 1000V:**

  7,400 VAC (rms) / 10,450 VDC for 1 minute

- **CAT III - 600V:**

  5,500 VAC (rms) / 7,850 VDC for 1 minute

Misuse of DMM in Ammeter Mode



Electrical Tester Safety

Protection from Arc Blast

- **Over Voltage Category Ratings**
  - **for Industrial use CAT-III 1000V**
- **Protected for all tester functions**
  - **Ohms / Continuity**
  - **VDC**
  - **Current**
- **High impedance (1 Mohm)**

Electrical Tester Safety

Test Leads and Probes

- Safety rated (to the same or better than tester)
- Double Insulated
- Non removable test leads

  No banana plugs

  No banana jacks to make contact elsewhere

  Not inter changeable with ‘electronic’ style leads

  … more difficult to misuse

Electrical Tester Safety

Function Selection

- **Auto selection of AC and DC**
  - **one less switch position**
  - **reduced complexity / fewer mistakes**
  - **on DC function some models read zero on VAC**

- **Bright visual and audible warning**
  - **when connected to hazardous voltage**
  - **AC or DC and even Ohms**

Electrical Tester Safety

In-Line Current Measurement

- Can be hazardous if misused
  - – leads in Amps jack and measure volts = SHORT
  - – some fuses may not interrupt (250V fuses in 1000V meters) causing an arc
  - – proper fuse replaced with improper fuse

- Remove in-line / Add isolated current
  - – no Amps jacks to mis-use
  - – no fuses to replace
  - – needed function for electrical crafts
  - – 'Open Jaw' reduces complexity

What about my old meter?

- **Older meters, when re-evaluated for their CAT rating, almost never qualify as CAT III-600V.**
- **Unless a meter was specifically designed (in the last few years) to meet CAT III-600V or higher, it is probably a CAT II meter.**

***Old* 70 Series-II CAT II-600V**

***New* 170 Series CAT IV-600V CAT III-1000V**

Common DMM / Tester hazards

- **Arc from transients (lightning, load switching)**

  Protection: **Independent certification to meet CAT III-1000V**

[redacted]

- **Voltage contact while in continuity or resistance**

  Protection: **Overload protection in OHMs up to the meter's Volt rating**

- **Measuring voltage with test leads in current jacks**

  Protection: **High energy fuses rated to the meter's voltage rating**
  Use meters / testers without current jacks

- **Shock from accidental contact with live components.**

  Protection: **<u>Test Leads</u> double insulated, recessed / shrouded, finger guards, CAT III - 1000V.** ***Replace when damaged***

- **Using meter or tester above rated voltage**

  Protection: **Good karma**

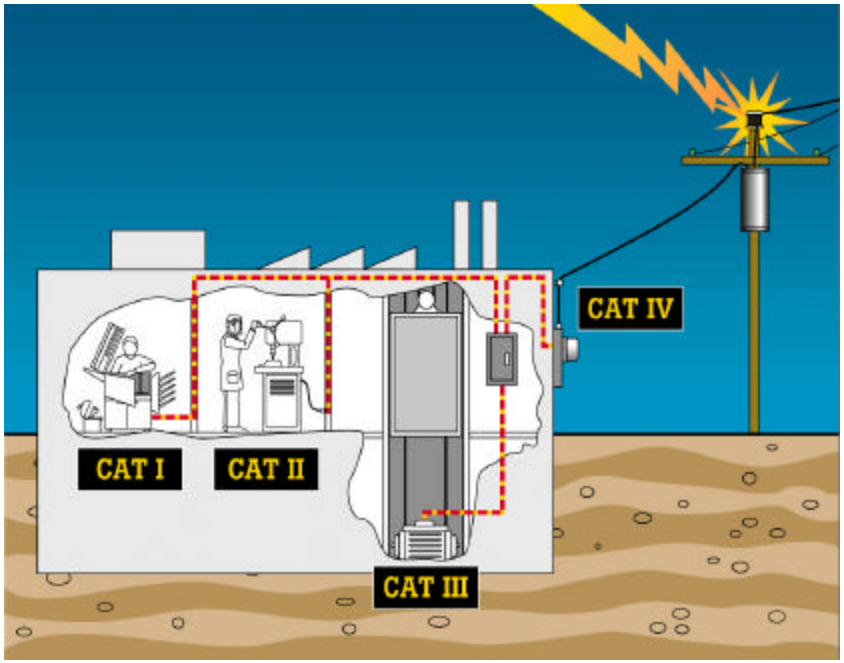
No Substitute for Safe Work Practices

Safe practices include..

- **Use equipment rated for the task**
  - **CAT-III 1000V not suitable for medium voltage**
- **Training**
- **Protective clothing equipment**
- **Lockout / Tagout**

Oscilloscope Safety

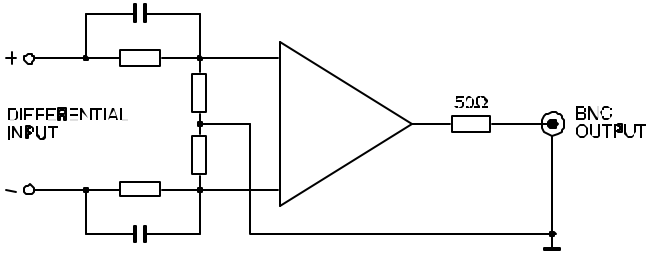
- **Category ratings**
  - **Select a scope <u>and</u> probes <u>and</u> clamps for the worst case category**
- **Voltage ratings**
  - **Working voltage**
  - **Transient voltage**



Oscilloscope Safety

Line Powered Bench Scopes

- Use a differential or isolation probe to separate the earth ground connection of the scope from high energy circuits that are also referenced to earth ground.
- Isolate bench scope grounds *only* in conjuction with differential/isolation probes.



Oscilloscope Safety

FLUKE

Battery Powered Scopes -

- Have inherent ground isolation for superior common mode noise rejection
- Some come standard with CAT III 600 volt probes for measurements in high energy circuits

Oscilloscope Safety

FLUKE

Probes

- Beware of bench scope probes - they are usually CAT I - 500 volts
- Don’t use CAT I or II divider probes on CAT III circuits
- Don’t use probes with exposed metal parts
- Don’t use probes without specified ratings
- Read the manual for safe probe connections - they may vary greatly between instruments

Oscilloscope Safety

Current Clamps

- Clamps have Category and working voltage ratings
- Do not exceed them

[redacted]

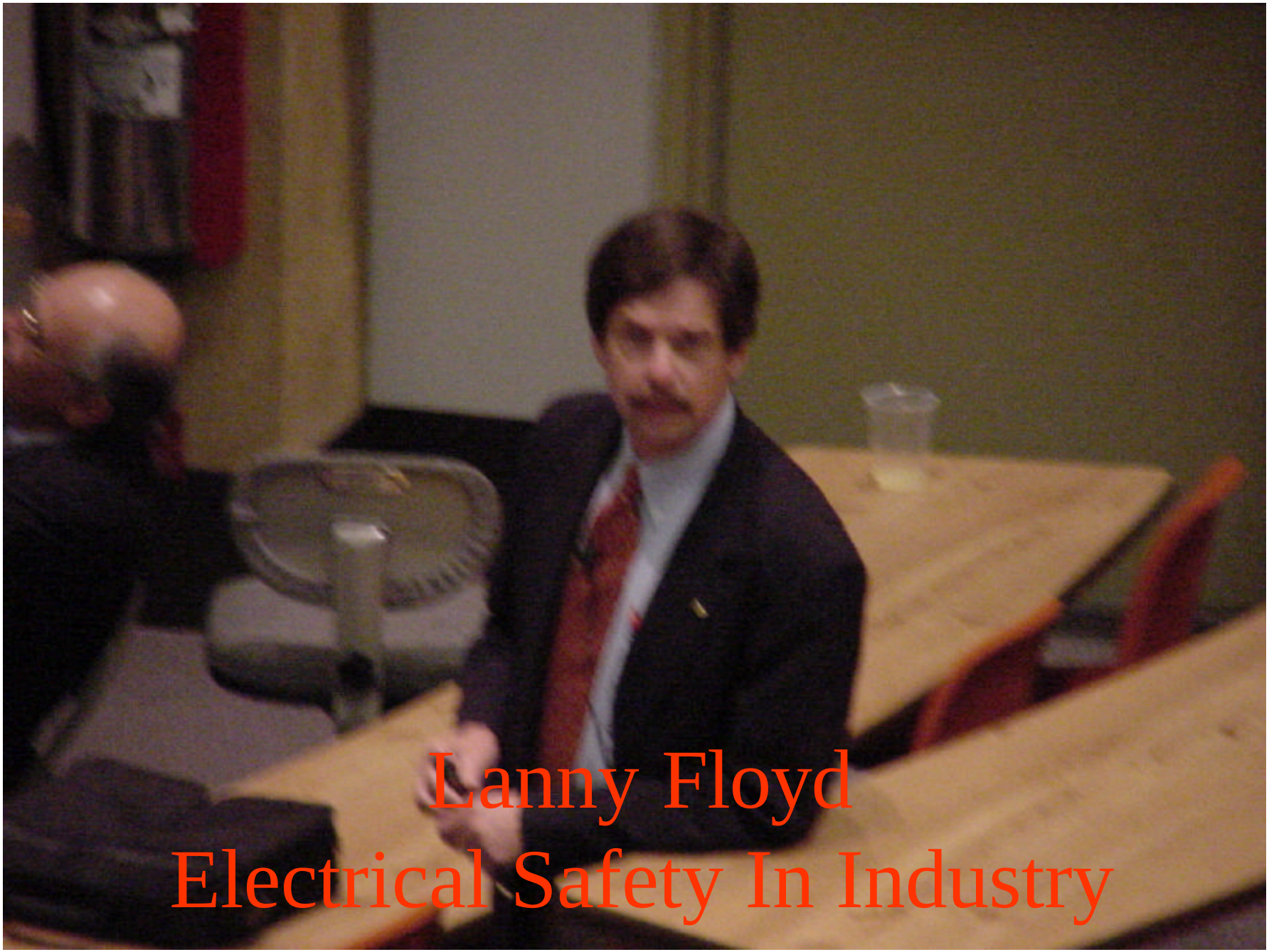
CAT III circuits - Make sure you use Cat III Leads AND Scope AND Current Clamp

What's the bottom line?

- **If you use a Scope on power circuits, you need a CAT III-600V Scope and Scope Probes.**
- **CAT II Scopes and Probes are mainly for loads that plug into a receptacle outlet.**

CAT III-600V

Electrical Safety In Industry



Lanny Floyd
Electrical Safety In Industry

Electrical Isolation is More than Lock Out/Tag Out

H. Landis Floyd
DuPont Co.
101 Beech Street
Wilmington, DE 19880
Tel: 302-695-0146
H-Landis.Floyd@usa.dupont.com

2001 DOE Electrical Safety Workshop

In DuPont Operations

- **The 6 most recent electrocution fatalities**
- **50% of the reported electrical incidents each year**

share 3 common characteristics

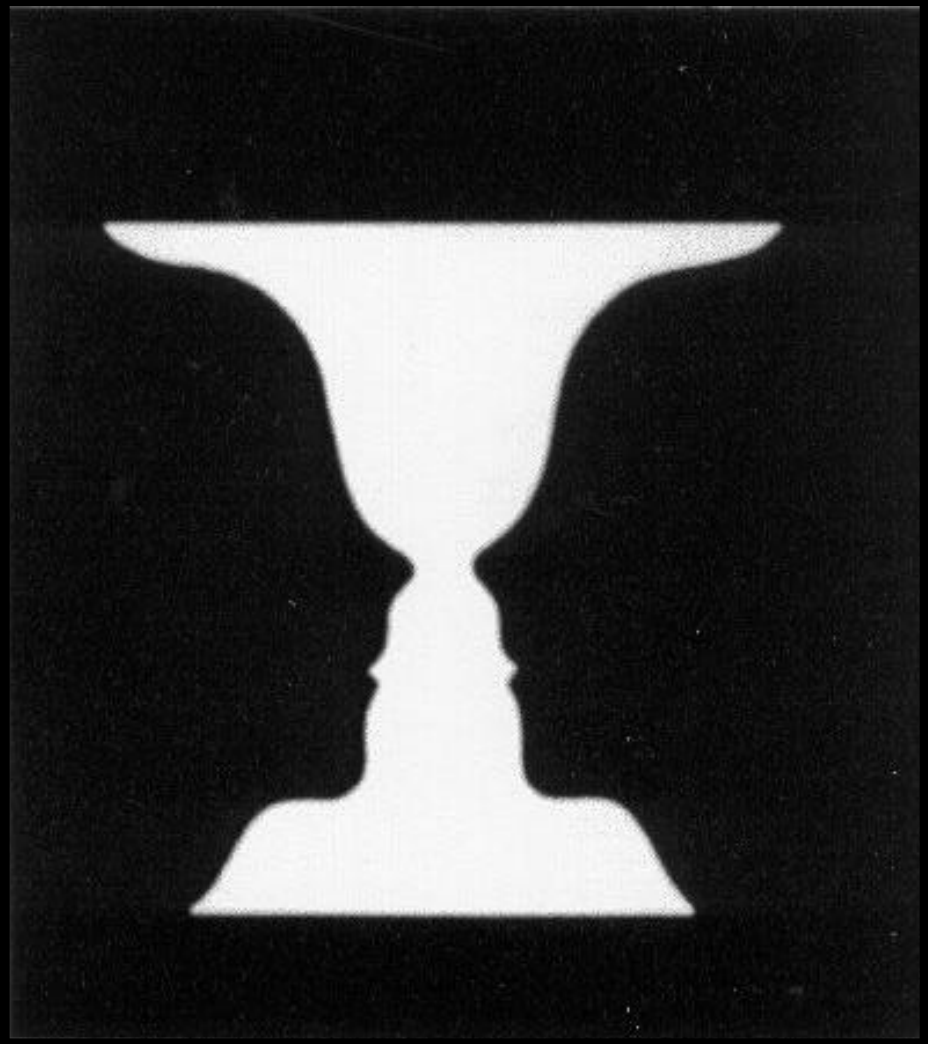
- **Work extended beyond the scope of the original job plan**
- **A door, cover, or barrier was opened or removed on electrical equipment**
- **The person was exposed to an *UNRECOGNIZED* energized conductor or hazard.**

Observations on LOTO Planning and Implementation

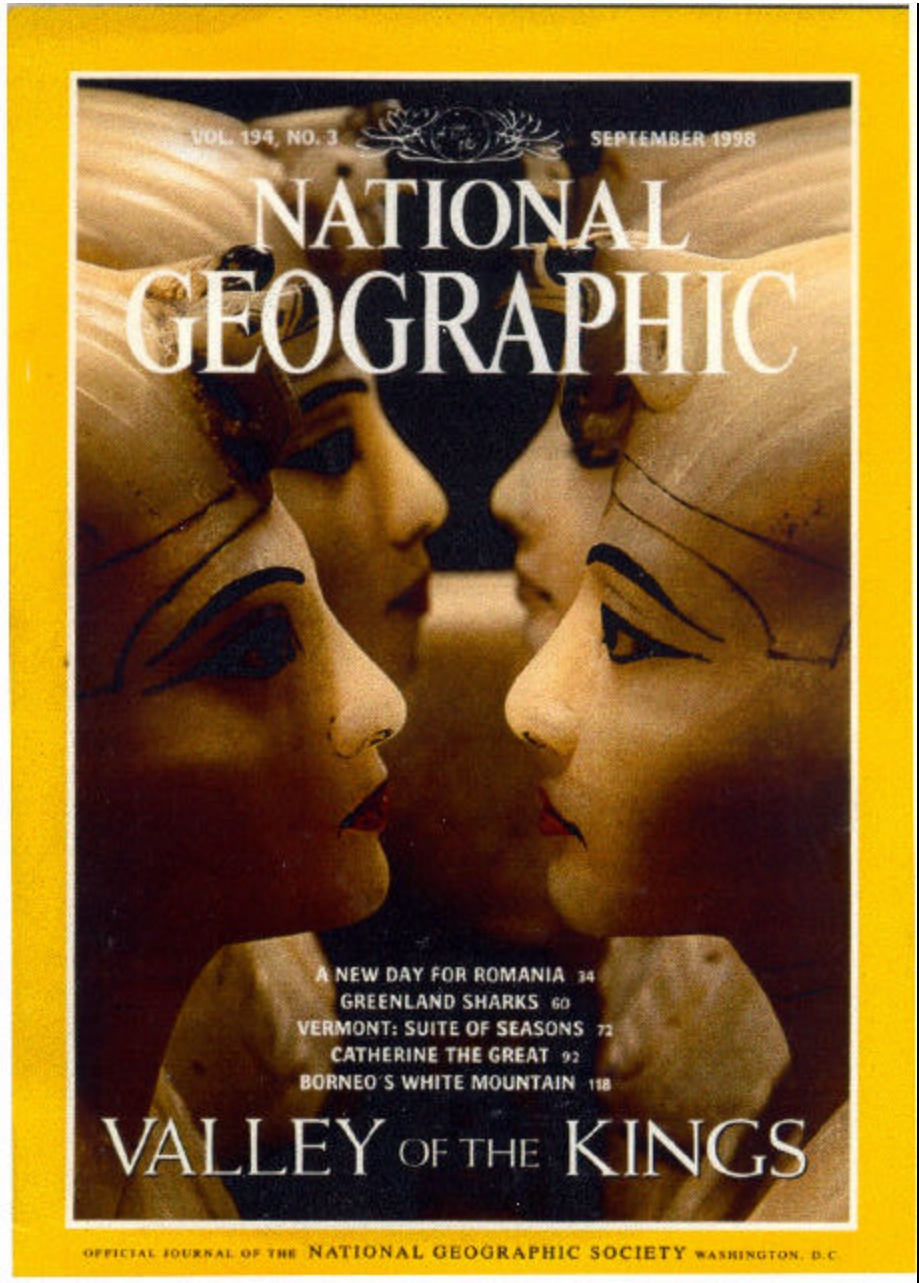
- Focused on isolating the circuit or equipment that people will contact,
- Depended on knowledgeable and competent people doing the right things

Observations on LOTO Planning and Implementation

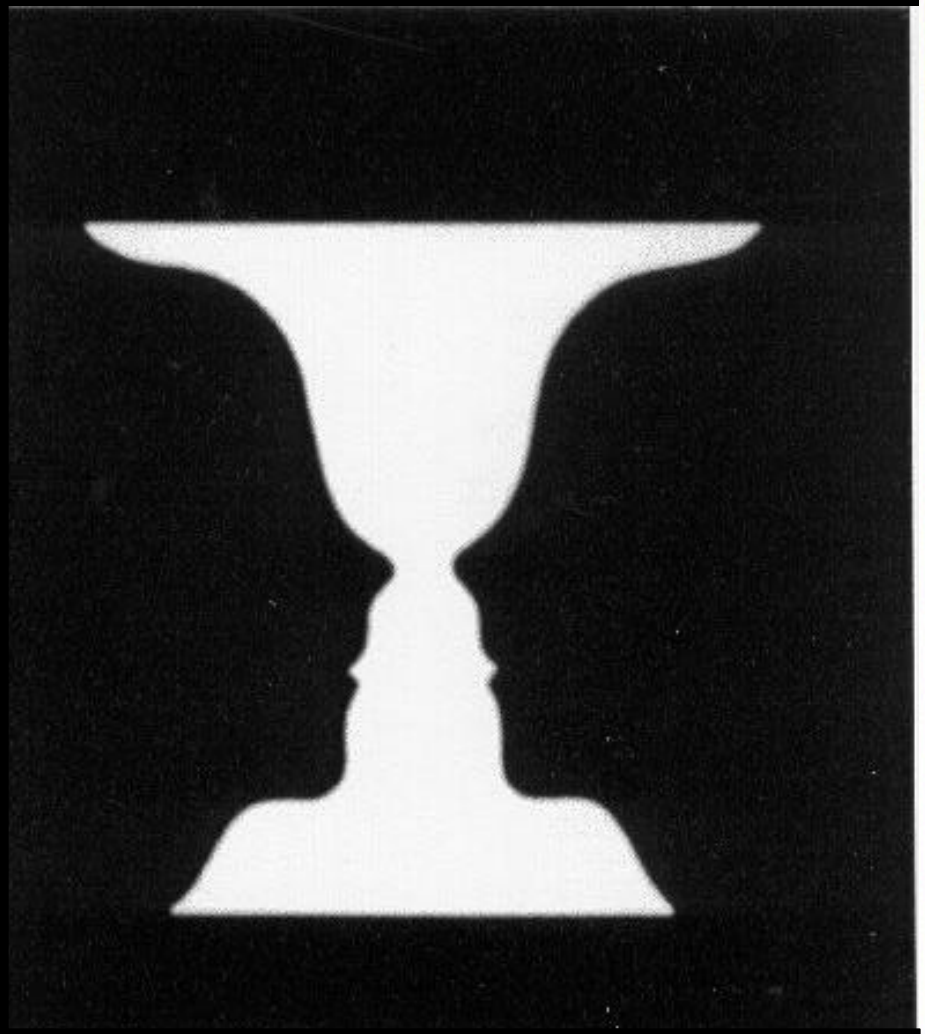
Our practice did not acknowledge that even the most competent, knowledgeable, qualified, and safest person can and will make judgement errors that could take him/her outside the safe working boundary.

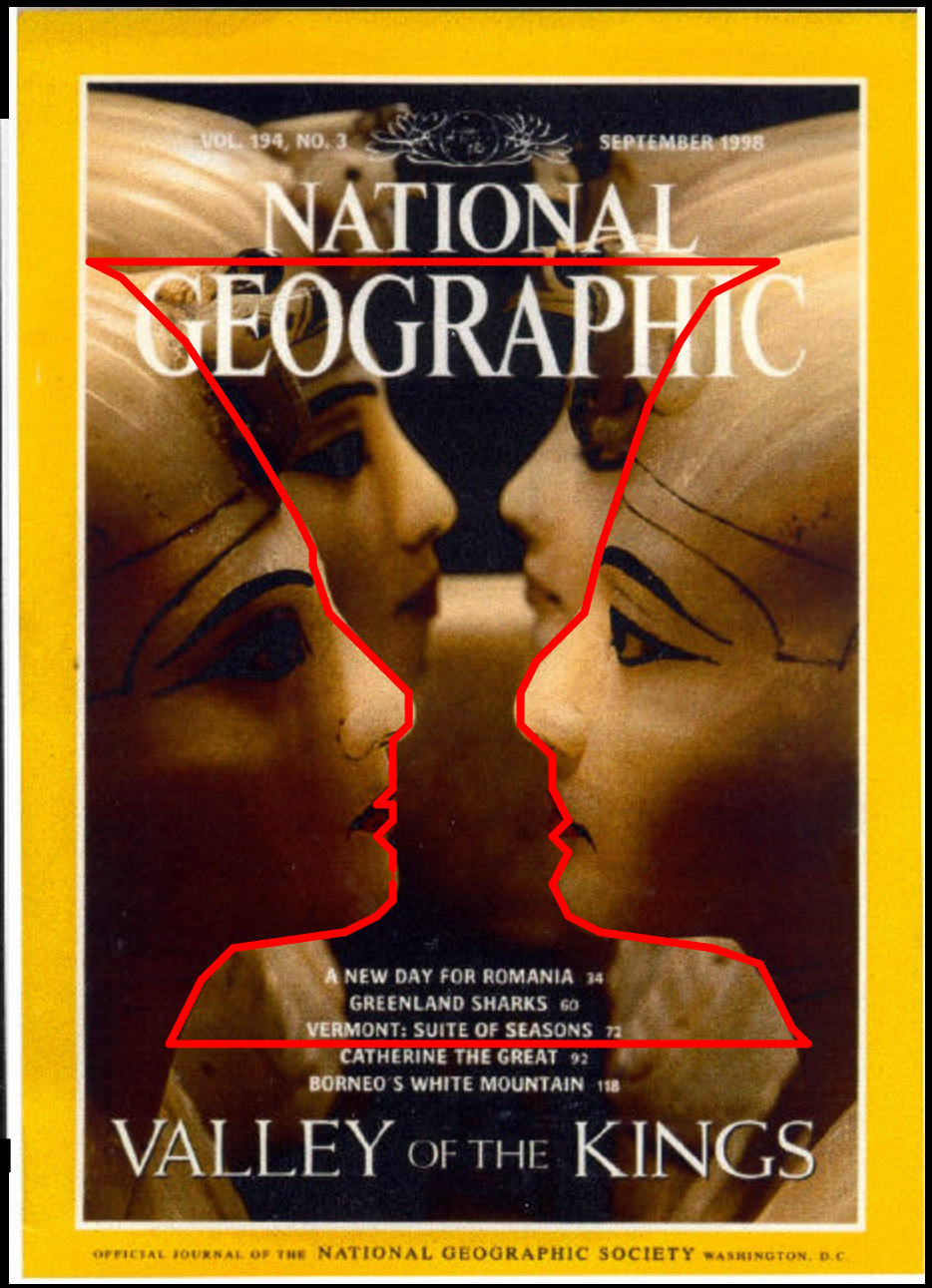


How we understand simple concepts...



...in complex environments

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OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

Techniques to Enhance LOTO Planning and Implementation

- **Verbal**
- **Written**
- **Visual**
- **Physical**
- **Testing**

To help people recognize and stay within the safe working boundary

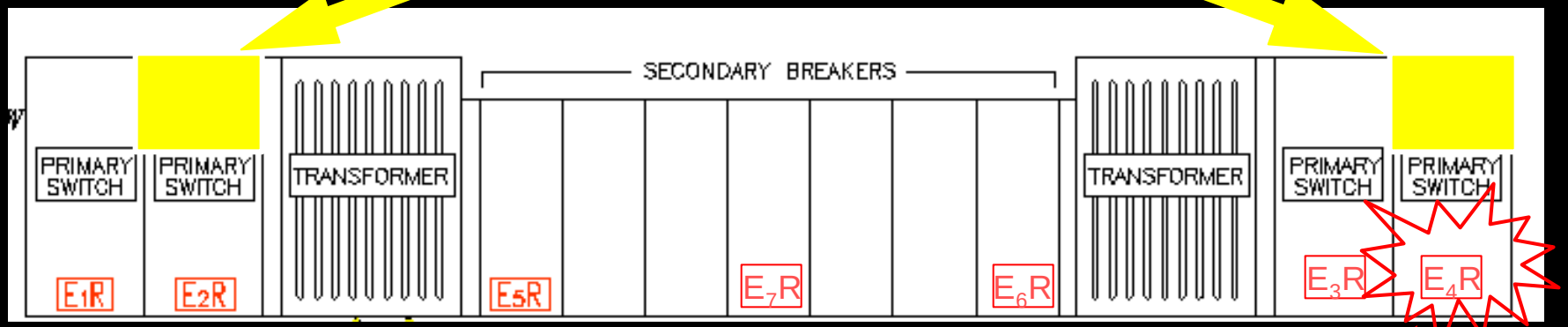
A Case History

Going Outside the Boundary of the Safe Work Zone

Employee Age: 53
He is a veteran electrician that was considered to be the "expert" in issues associated with the electrical power distribution system at the complex.
His training records indicate that he had taken a course entitled “High Voltage Certification - Level 3” on Feb. 8 ‘99

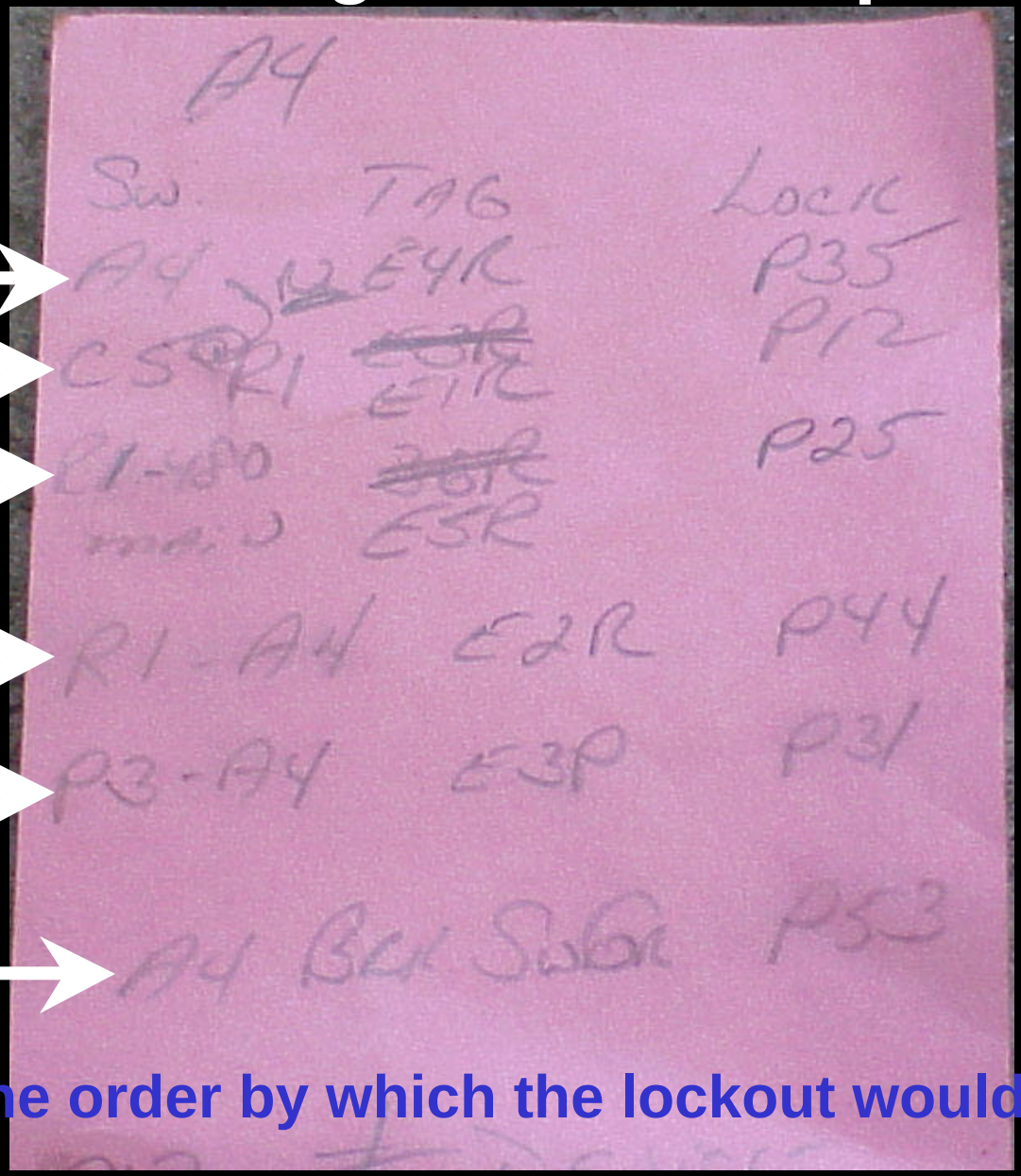
The employee received an 13.8kV electric shock that entered both hands, exited through one shoulder, and both feet, resulting in 1st and 2nd degree burns to his hands, back, forehead and feet.
He has now returned to work an appears to be heading towards a full recovery.

The week prior to the incident, a problem was detected in these two areas at the rear of the substation.



Area where the employee was injured

Switching Plan Developed



Shows the order by which the lockout would occur!

13.8 KV LOCKOUT WORKSHEET

F534.000045
Rev: 0
Impl. Date: 12-23-98
Controlled by: J534.201003

EQUIPMENT TO BE WORKED ON: ____

WORK TO BE COMPLETED: ____

____

LOCKOUT PLANNED BY: _______________________ VERIFIED BY: _______________________

13.8 KV FEEDER(S) TO BE LOCKED OUT: ___________________

BUS TIE BREAKER(S) TO BE CLOSED: ______________________

BUS MAIN BREAKER(S) TO OPEN: __________________________

FORM WAS NOT USED!

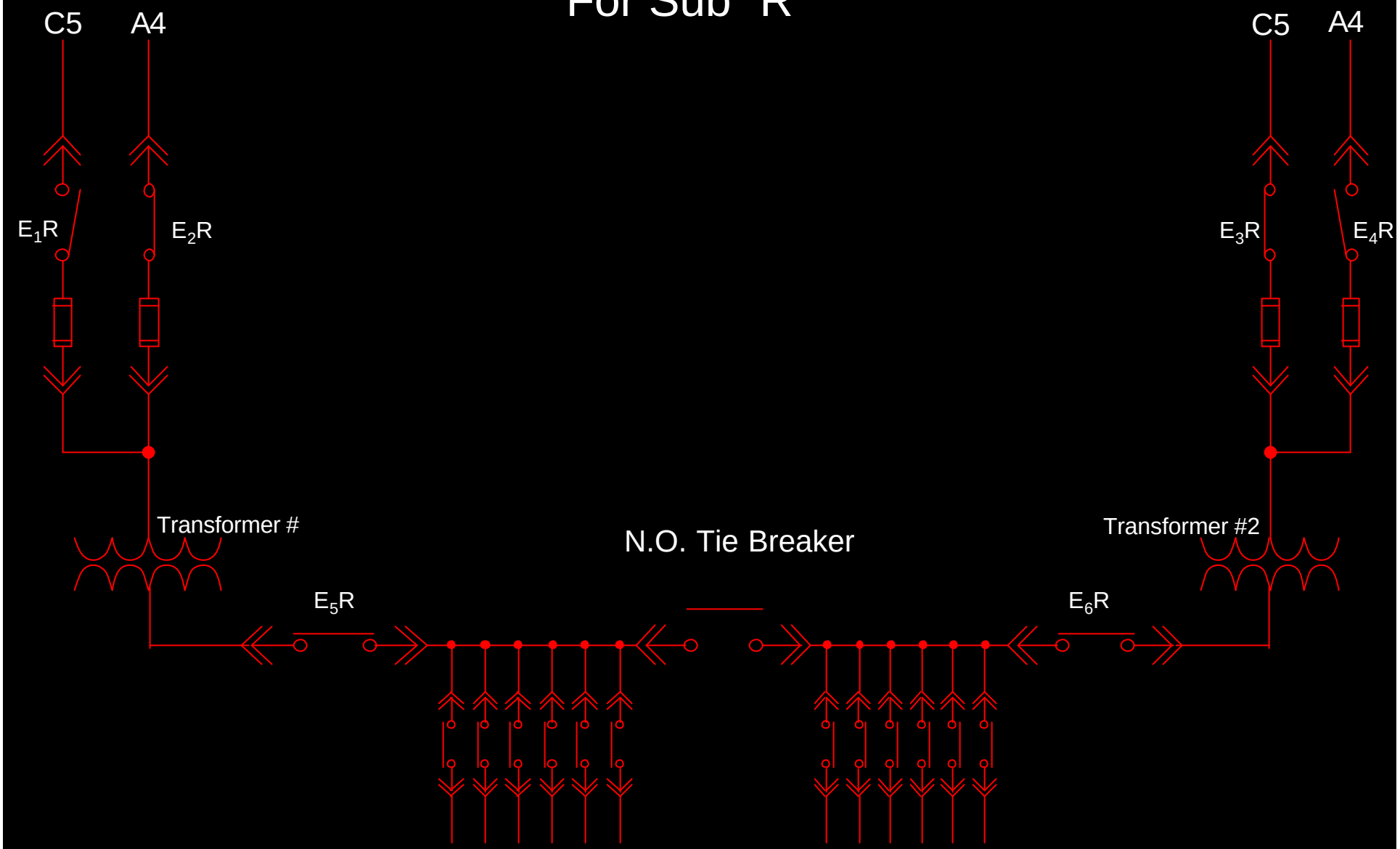
LOAD BREAK SWITCHES LOCKED OUT:

LOCATION	SWITCH I.D.	LOCK #	LOCATION	SWITCH I.D.	LOCK #

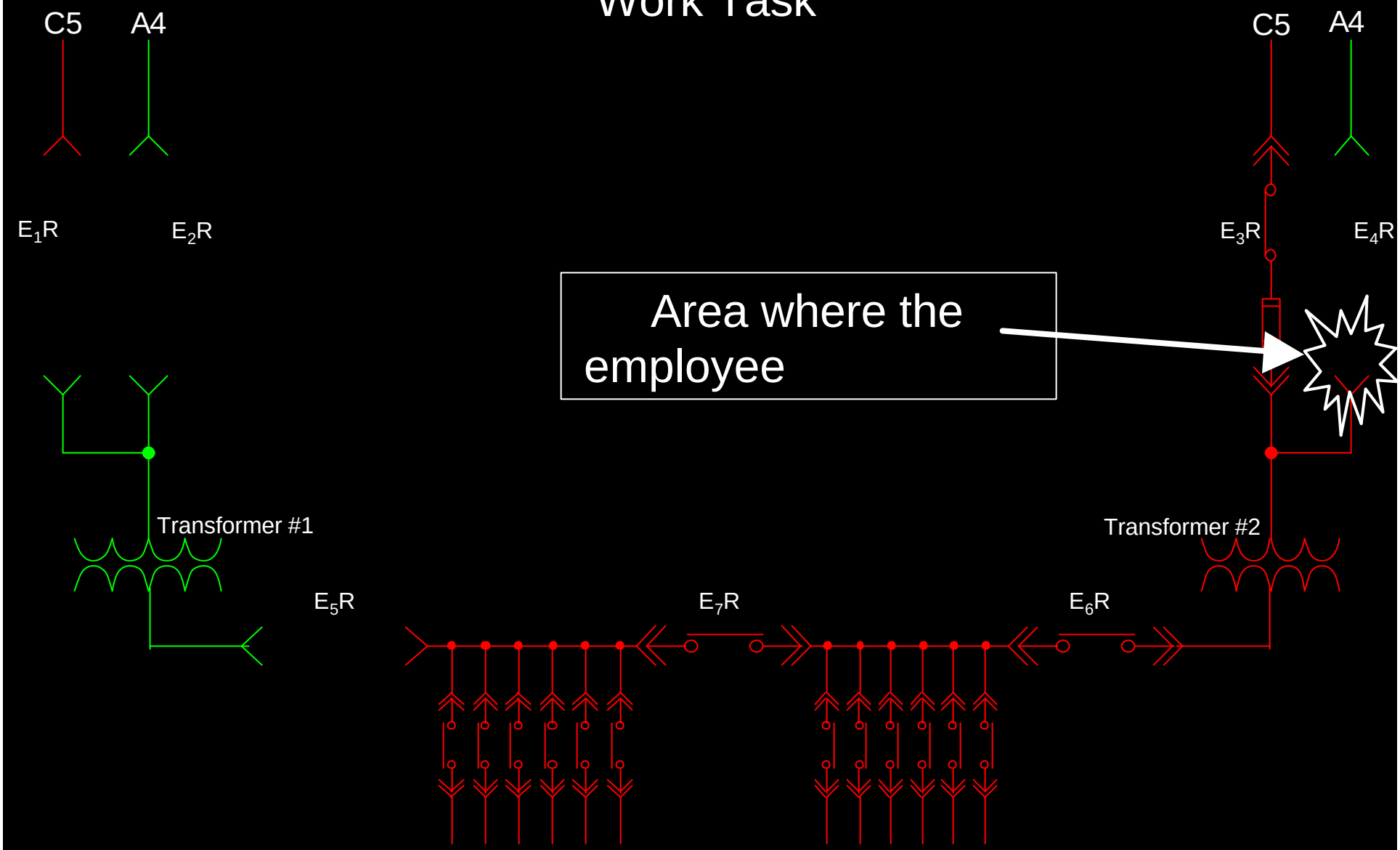
KEY BOX LOCATION: _____________________________ LOCK #: ____________________

DATE: _________________ LOCKOUT COMPLETED BY: _____________________________________

Normal Operating Mode For Sub “R”

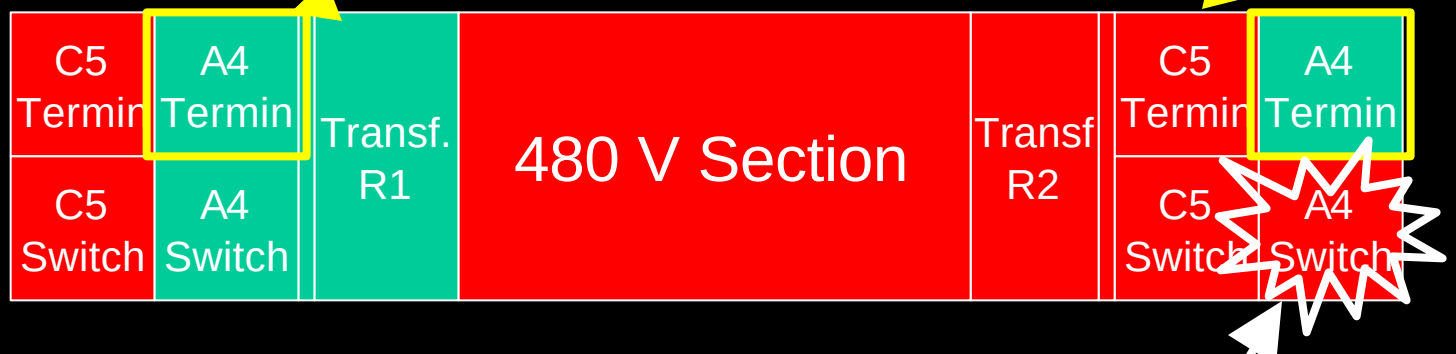


Zone Of Protection for the Work Task



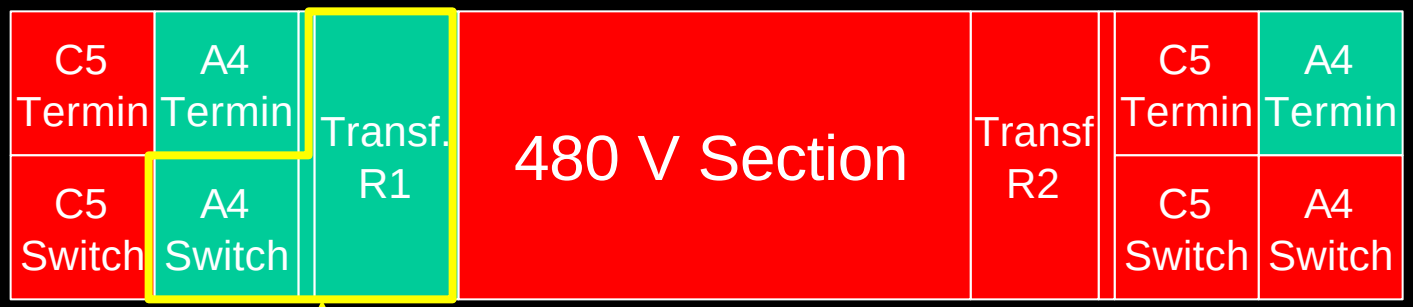
Cells within the Zone of Protection

Compartments needing access for original scope of work!



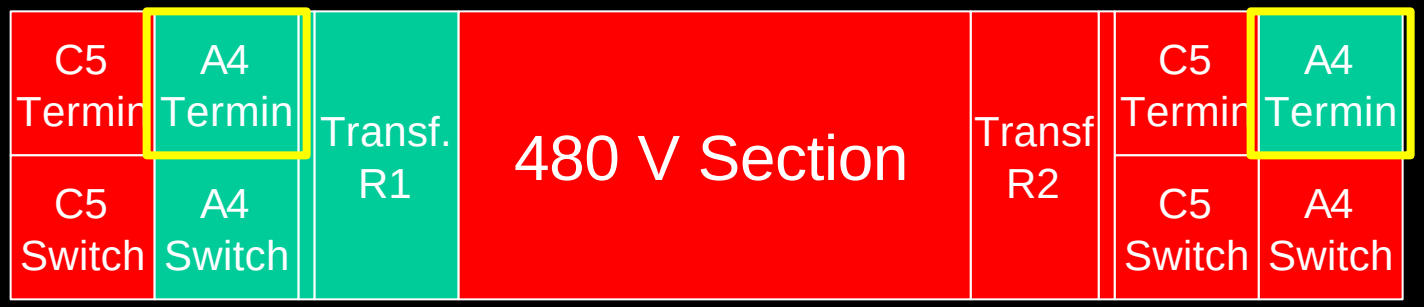
Area where the employee was injured

Cells within the Zone of Protection



Note that the established zone includes other compartments not included in the original scope of work!

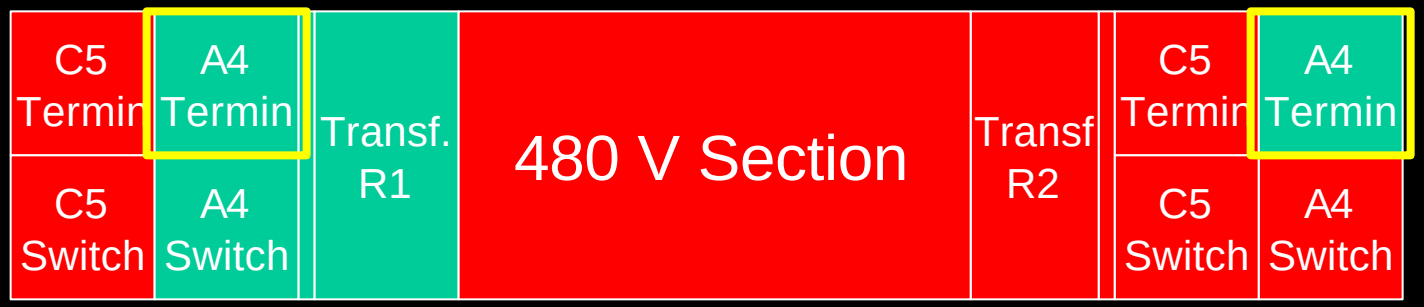
Switching / Lockout and the work in these compartments began the week prior to the injury incident.



Relevant Events Leading Up to the Incident

On Monday, Aug28

Employee reviewed progress of the work with the chief electrician.



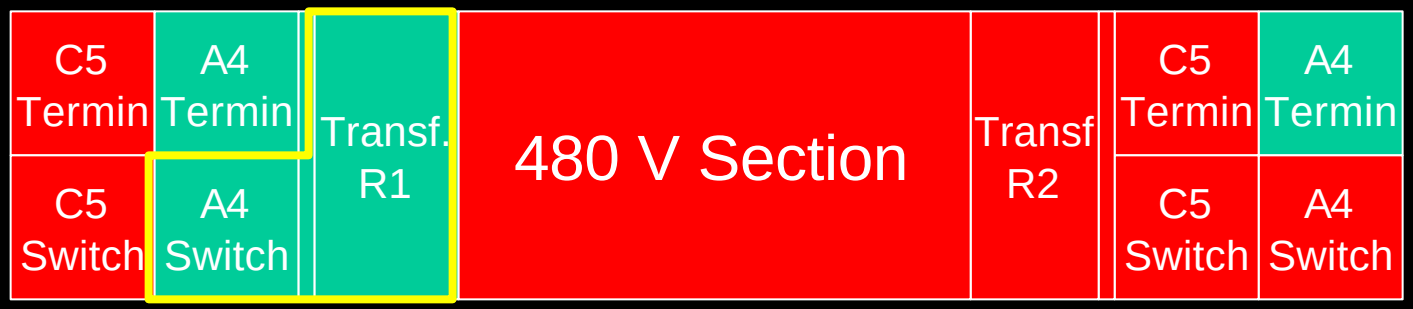
Top View)

Relevant Events Leading Up to the Incident

On Monday, Aug28

Employee reviewed progress of the work with chief electrician

After the review, it was mutually agreed that it made sense to expand the scope to include maintenance / cleaning / inspection for all of the substations in plant 2East.



(Top View)

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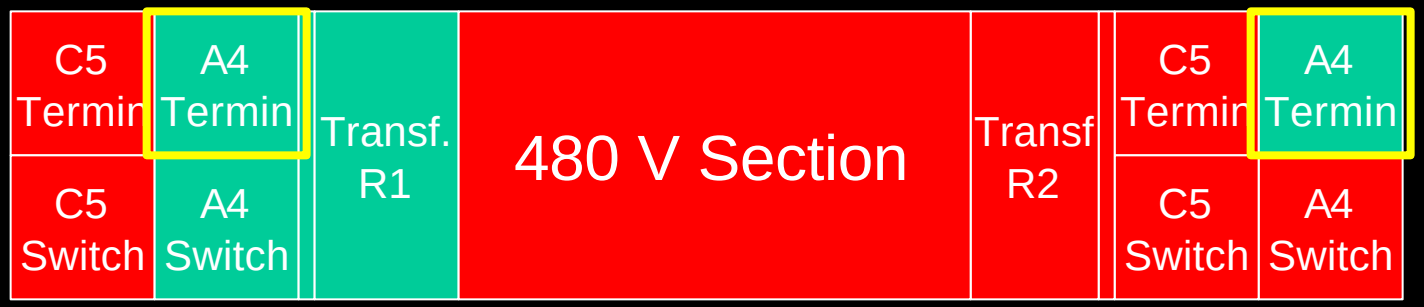


(Top View)

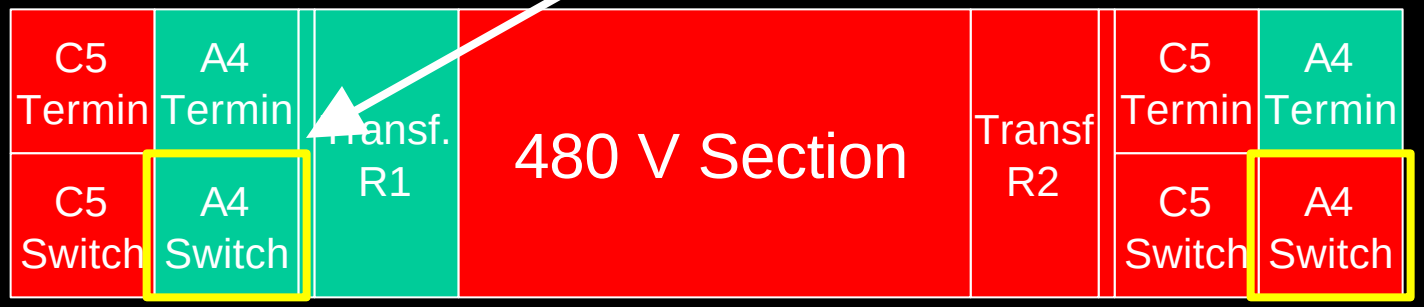
On Tuesday, Aug 29

Completed repair of the A4 terminations for R1 and R2

Relevant Events Leading Up to the Incident

On Wednesday, Aug 30

Employee assigned apprentice to work on cleaning in switch compartment A4 on the R1 side.



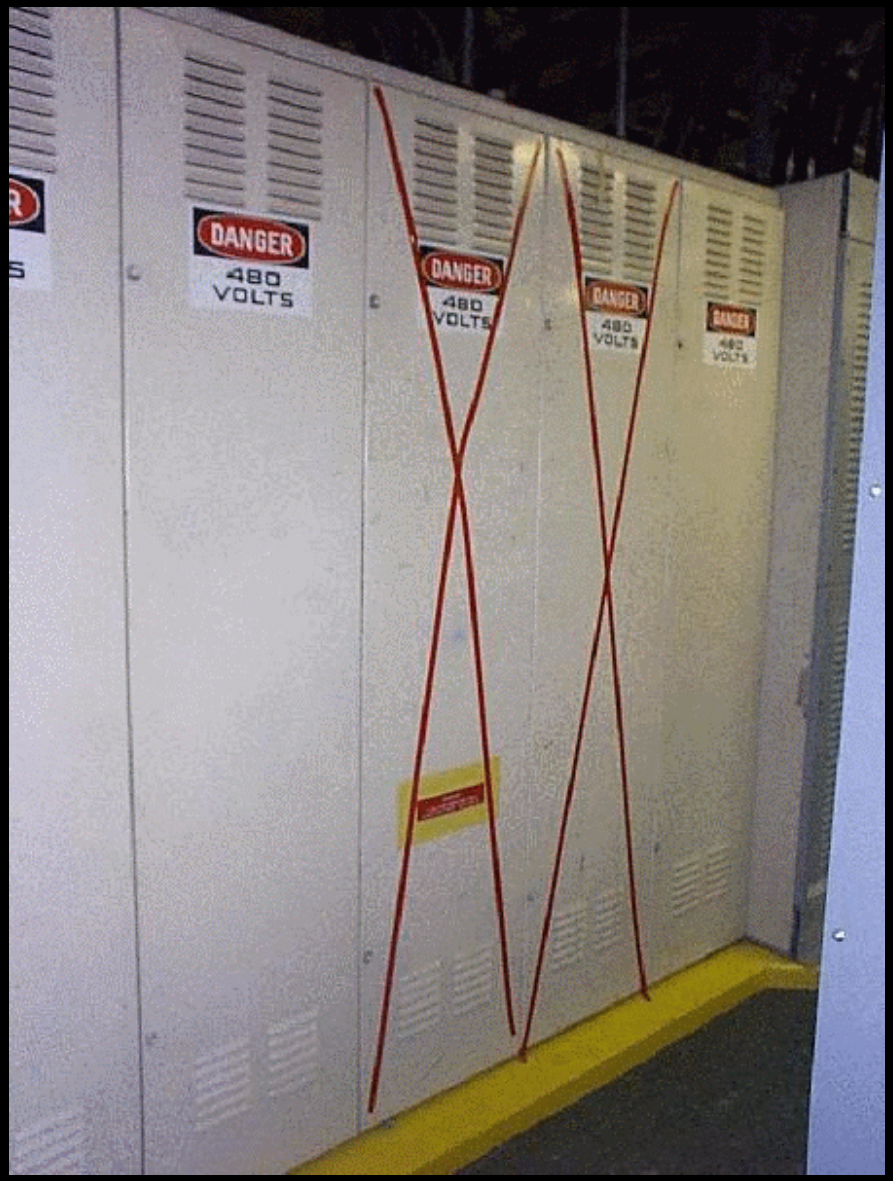
(Top View)

Then, the employee entered switch compartment A4 on the R2 side.

-CAUTION-

Barrier must NOT be removed or raised until both sources of voltage are removed. Test for voltage with barrier in place.

-CAUTION-
Barrier must NOT be removed or raised until both sources of voltage are removed. Test for voltage with barrier in place.



Sometimes the right tool is a roll of red tape.

A procedure to aid selection of PPE is posted on the switchgear

Making the Safe Working Zone *More* Visible

Temporary Visual Aides

Enhancing Electrical LOTO

- Verbal verify understanding
- Written clear, concise, standard
- Visual temporary warnings
- Physical lock/secure adjacent compartments
- Test

TEST

Every Circuit, Every Conductor, Every Time

BEFORE

You

TOUCH

AMERICAN ELECTRICIANS' HANDBOOK

7th Edition 1953 McGraw-Hill

MEASURING, TESTING, AND INSTRUMENTS

154. Electricians often test circuits for the presence of voltage by touching the conductors with the fingers. This method is safe where the voltage does not exceed 250 and is often very convenient for locating a blown-out fuse or for ascertaining whether or not a circuit is alive. Some men can endure the electric shock that results without discomfort whereas others cannot. Therefore, the method is not feasible in some cases. Which are the outside wires and which is the neutral wire of a 115/230-volt, three-wire system can be determined in this way by noting the intensity of the shock that results by touching different pairs of wires with fingers. Use the method with caution and be certain that the voltage of the circuit does not exceed 250 before touching the conductors.

155. The presence of low voltages can be determined by tasting. The method is feasible only where the pressure is but a few volts and hence is used only in bell and signal work. Where the voltage is very low, the bared ends of the conductors constituting the two sides of the circuit are held a short distance apart on the tongue. If voltage is present a peculiar mildly burning sensation results, which will never be forgotten after one has experienced it. The taste is due to the electrolytic decomposition of the liquids on the tongue which produces a salt having a taste. With voltages of 4 or 5 volts, due to as many cells of a battery, it is best to test for the presence of voltage by holding one of the bared conductors in the hand and touching the other to the tongue. Where a terminal of the battery is grounded, often a taste can be detected by standing on moist ground and touching a conductor from the other battery terminal to the tongue. Care should be exercised to prevent the two conductor ends from touching each other at the tongue, for if they do a spark can result that may burn.

You Can Make a Difference

- Change the Culture
- Instill New Habits
- Challenge “the way we’ve always done it”

You Can Make a Difference

- **Change the Culture**
- **Instill New Habits**
- **Challenge "the way we've always done it"**

Electrical accidents and injuries don't have to happen!

Mark Earley

NFPA 70-E Committee – Path Forward

Electrical Safety Requirements for Employee Workplaces

The Future for NFPA 70E

Ken Mastrullo

NFPA® INTERNATIONAL

Today's agenda

- NFPA 70E–2000
- OSHA adoption
- Supporting material and information
- NFPA 70E – 2003

NFPA 70E–2000

- Is compatible with the NEC
- Focuses on *flash protection*
- Includes lookup tables for PPE
- Includes new Part IV—“Safety Requirements for Special Equipment”

NFPA Path Forward

- Pursue OSHA adoption of 70E
- Provide supportive materials and information for 70E
- Initiate revision cycle for the 2003 edition of 70E

OSHA Adoption Process

- NFPA officially requested that OSHA adopt 70E by reference.
- OSHA placed 29 CFR 1910 Subpart S on the Fall 2000 Regulatory Agenda.
- Ad hoc group met with OSHA three times to discuss adoption of 70E.

The NFPA 70E Ad Hoc Group

- Compared 29 CFR 1910 Subpart S and 29 CFR 1926 Subpart K with NFPA 70E.
- Submitted incident data to support OSHA adoption of 70E.
- Provided letters of support from diversified interests.

Future of OSHA Subpart S

- OSHA will update Subpart S to meet the requirements of NFPA 70E.
- Subpart S revision will be phased in over 5 years.
- Will include the latest technology.

NFPA® INTERNATIONAL

Supporting Material and Information

- *Working Safely with Electricity* video
- The textbook *Electrical Safety in the Workplace*
- Seminars on NFPA 70E content
- Additional books and reference material
- A worldwide web board to provide public information on 70E and electrical safety

NFPA 70E–2003

- The committee initiated a revision cycle for 70E.
- The committee will address several key issues:
  - ✓ Evaluate public proposals that will be submitted
  - ✓ Update 70E to the 2002 NEC
  - ✓ Provide enhanced information based on latest technology for incident energy calculations

Committee Task Groups

- Part I Task Group
- PPE Task Group
- Construction Relevancy Task Group
- Arc Flash Task Group

Proposed Style Changes

Use the NEC *Manual of Style*

- **“Parts” become “Chapters”**
- **“Chapters” become “Articles”**
- **“Appendices” become “Annexes” and are relocated to the back of the document**

Advantages of Style Changes

- Format compatible with the NEC
- Information in chronological order
- All annex material in the back
- Search feature works very well

Timetable for NFPA 70E-2003

Notification of intent to enter cycle	8/10/01
Proposal closing date	12/28/01
ROP meeting	2/18-20/02
ROP issued	8/01/02
Comment closing date	10/02/02

Timetable for NFPA 70E-2003
(cont'd)

Final date for ROC meeting	11/15/02
Association meeting	5/18-22/03
Council appeal closing date	6/13/03
Council issuance	7/18/03

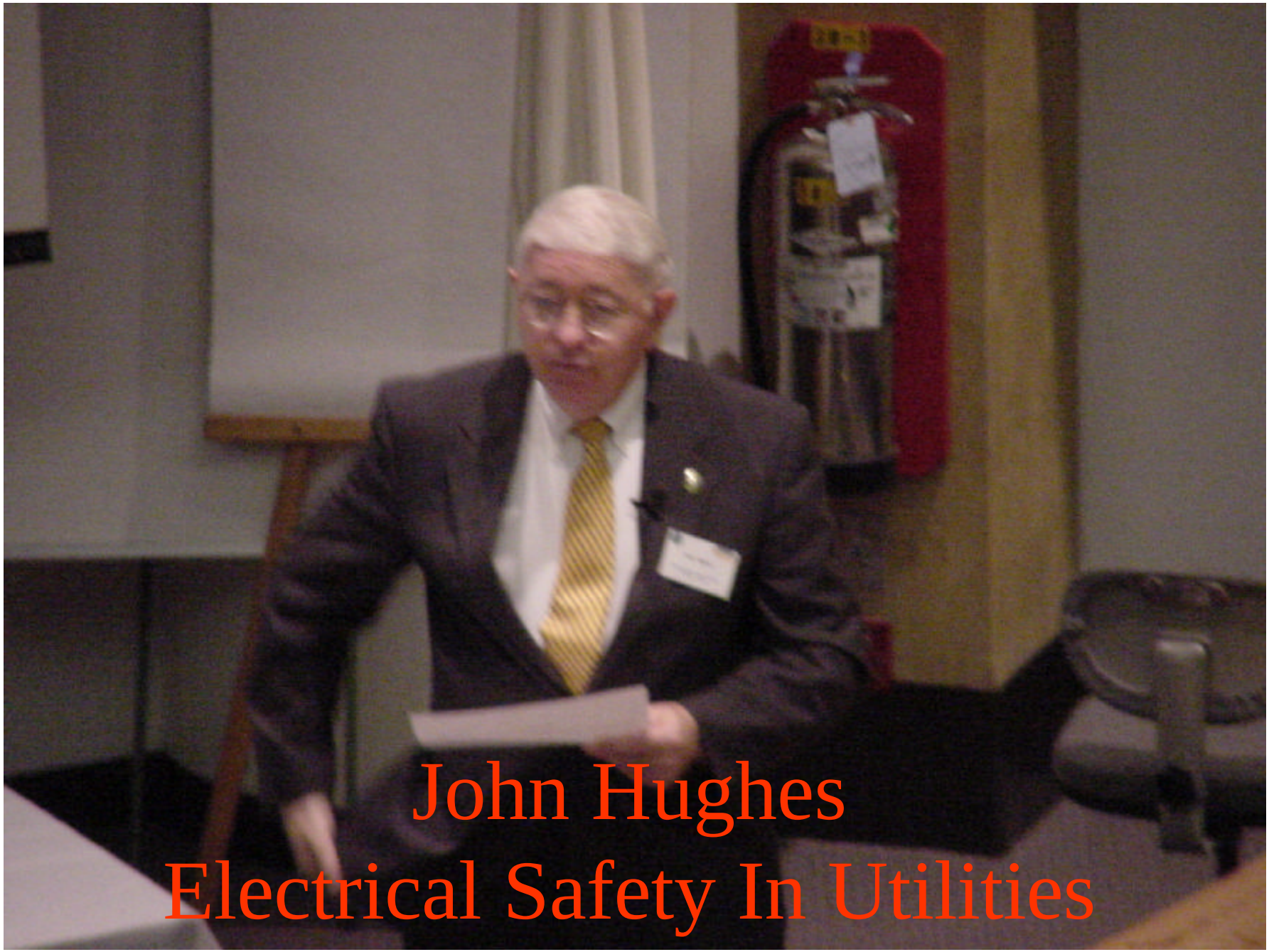
Open Process

- Meetings are open to the public, and participation is invited.
- Anyone can submit a proposal or comment.
- Input from broad experience makes 70E a better document.

Questions on NFPA 70E

Ken Mastrullo

- **Phone (617) 770-3000**
- **E-Mail nec@nfpa.org**



John Hughes
Electrical Safety In Utilities

DOE ELECTRICAL SAFETY MEETING

PRINCETON, NJ

AUGUST 2, 2001

JOHN V. HUGHES CUSA
PUBLIC SERVICE ELECTRIC & GAS COMPANY
DISTRIBUTION DEPARTMENT
ADMINISTRATOR, SAFETY/& INDUSTRIAL HEALTH

PUBLIC SERVICE ELECTRIC & GAS COMPANY

(PSE&G)

IS THE LARGEST UTILITY IN NEW JERSEY

PSE&G
DISTRIBUTION DEPARTMENT EMPLOYS

- 3,301 EMPLOYEES
- 1,799 IN ELECTRIC OPERATIONS
- 1,034 IN GAS OPERATIONS
- 468 IN MANAGEMENT

PSE&G, DISTRIBUTION DEPARTMENT EMPLOYEES ARE REPRESENTED BY:

- LOCAL 94 IBEW
- LOCAL 855 PIPE FITTERS
- OPEIU

PSE&G

DISTRIBUTION DEPARTMENT SERVES

1.9 MILLION ELECTRIC CUSTOMERS

1.6 MILLION GAS CUSTOMERS

AT PSE&G

HEALTH & SAFETY

MUST NEVER BE

COMPROMISED

HEALTH, SAFETY AND WELL BEING IS OUR #1 PRIORITY – MORE IMPORTANT THAN

- **PRODUCTION**
- **PROFITS**
- **SERVING THE CUSTOMER**

AT PSE&G EVERYONE HAS THE ABSOLUTE RIGHT AND OBLIGATION TO:

- QUESTION A JOB PROCEDURE
- STOP AND CORRECT ANY UNSAFE ACT OR CONDITION

THE FOUNDATION OF THE PSE&G SAFETY PROGRAM IS:

- THE SAFETY TAGGING SYSTEM
- PERSONAL PROTECTIVE EQUIPMENT (PPE)
- PRACTICES AND PROCEDURES

THE SAFETY TAGGING SYSTEM IS BASED ON THE FOLLOWING CRITERIA:

- SAFETY
- PERSONNEL PROTECTION
- EQUIPMENT PROTECTION
- CUSTOMER SERVICE AND RELIABILITY
- SYSTEM USAGE BY AFFECTED PERSONNEL
- TAGGING COMMITTEE REVIEW AND RECOMMENDATIONS
- OPERATIONAL HISTORY OF THE SYSTEM
- GOVERNMENT REGULATIONS

PSE&G SAFETY TAGGING SYSTEM MANAGEMENT

- MANUAL PAPER OUTAGE REQUESTS
- ELECTRONIC OUTAGE REQUEST SYSTEMS
  - TRIS
  - SAP
  - OMS

PSE&G SAFETY
TAGGING SYSTEM CONTROLS

OUTAGE REQUESTS ARE SUBMITTED TO THE TAGGING AUTHORITY FOR APPROVAL.

THE TAGGING AUTHORITY GRANTS WORK PERMISSION TO FIELD PERSONNEL IN PERSON, VIA RADIO, TELEPHONE OR BY WRITTEN COMMUNICATION.

TYPES OF PSE&G SAFETY TAGS

- CARDBOARD AND PLASTIC
- STANDARDIZED BY SIZE, COLOR AND SHAPE

PSE&G APPLIANCE SERVICES BUSINESS UNIT UTILIZES A LOCKOUT/TAGOUT PROCEDURE TO ISOLATE ENERGY SOURCES AT CUSTOMERS' PREMISES.

PSE&G PROVIDES THE FOLLOWING PERSONAL PROTECTIVE EQUIPMENT TO PERSONNEL WORKING ON OR NEAR ENERGIZED LINES OR EQUIPMENT:

- **HARD HAT**
- **SAFETY GLASSES**
- **FR CLOTHING**
- **RUBBER GLOVES – CLASS 2**
- **RUBBER SLEEVES**
- **DIELECTRIC FOOT WEAR**
- **FALL PROTECTION HARNESS & LANYARD**

PSE&G, LINE PERSONNEL “GLOVE” 4 & 13 KV OVERHEAD CONSTRUCTION

PSE&G, SUBSTATION MECHANICS, METER AND RELAY TECHS USE CLASS 0 RUBBER GLOVES TO WORK ON CIRCUITS OF 50 TO 600 VOLTS.

BARRIERS TO ZERO INCIDENTS ARE FAILURES TO:

COMMUNICATE	-	PRE & POST JOB BRIEFS
FOLLOW	-	WORK PROCEDURES
WEAR	-	PPE
PERFORM	-	TESTING & GROUNDING

Electric Shock Accident Grounding and Induced Voltage

George V. Causer, CUSA
Safety Manager

Western Area Power Administration

Lakewood, Colorado

Accident Introduction

- On October 2, 2001, a journeyman lineman experienced an electrical shock when he bridged two separate grounded systems. (established grounding system and un-bonded guy wire connection at the structure)
- The voltage difference was caused by the induced voltage condition at the work site.

Accident Introduction Cont..

- The victim was working out of an non-insulated platform. He contacted the structure guy wire connected to the structure, the guy wires were not bonded to the established grounded system
- In bridging the grounded systems, the accident victim placed himself in series with the grounded circuits

Accident Introduction Cont.

- The accident victim bridged a voltage difference of approximately 1,000 volts

Accident Victim

- The victim lost consciousness, the journeyman lineman who was on the same platform, pulled the victim away from the structure and quickly lowered him to the ground
- Emergency medical assistance was requested immediately
- The victim had a pulse but was not breathing on his own. After administering two deep breaths the victim began breathing on his own

Accident Victim (Cont.)

- The accident victim was quickly transported by ambulance to the local hospital
- He suffered a small burn, sore muscles, and some chipped teeth
- After a few weeks of recuperation, he returned to work.

Accident Background

- On the morning of the accident, the Redding and Elverta line crews gathered at the work site to remove a HSWT structure. Prior to dismantling the structure, all of the trucks and the de- energized line conductors were grounded to the established grounding system (a copper rod driven into earth/ground -

Accident Background (Cont.)

– The Telelect line truck used to support the structure was grounded to a separate ground rod. The grounded line conductors were isolated from the structure and suspended by the insulated boom of the REACH ALL truck to facilitate the removal of the structure.

Accident Background(Cont.)

- The Tracy-Ygnacio 69-kV transmission line had a history of induced voltage incidents due to the paralleling of other adjacent energized transmission lines. The Tracy-Ygnacio 69-kV line and Tracy-Los Vaqueros 69-kV line are double-circuited for approximately 12 miles. At the time of the accident, the Tracy-Los Vaqueros 69-kV line was energized.

Accident Background(Cont.)

- The Olinda-Tracy 500-kV line, which was carrying a load of approximately 688 megawatts at the time of the accident, 2:00 p.m., closely parallels the Tracy-Ygnacio 69-kV line for approximately 17 miles. Also two other energized 500 kV lines closely parallel the 69 kV line for approximately 12 miles. These conditions significantly contributed to the induced voltages at the work site.

Accident Description (Cont.)

- Prior to the accident, the accident victim and another journeyman lineman were on the elevated work platform dismantling the switch, which was mounted on top of the HSWT structure. The accident victim, leaning over the metal work platform, came in contact with the guy wire bracket at the pole.

Accident Description

- Since the guy wires were not bonded to the established grounding system, the accident victim bridged two separate grounded systems that were at different voltage levels.
- This voltage difference was caused by the induced voltage.

Accident Description

- In bridging the grounded systems, the accident victim placed himself in series with the grounded circuits, which subjected him to a hazardous current.

Root and Contributing Causes

- The Investigation Team determined that the root cause of the accident was attributed to the lack of understanding for the need to establish an equi-potential zone at the work site.

Root and Contributing Causes

The Investigation Team also identified three contributing causes that if they had been adequately addressed could have prevented the electric shock accident.

Root and Contributing Causes

- The need to establish an equi-potential zone at the work site is not clearly defined in Western's safety documents.
- Not recognizing the induced voltages that may exist on unbonded circuits.
- If hazardous step and touch voltages had been suspected at the work site, measurements could have been taken to assess and mitigate the hazards.

Conclusions

- The induced voltage hazards that can exist on de-energized lines that closely parallel other energized lines are not generally well understood by electrical workers. Western has conducted induced voltage measurements during staged-fault tests to evaluate and assess the induced voltage hazards that working personnel may be exposed to at the work site.

Conclusions (Cont.)

- There have been some recent incidents involving induced voltage conditions, which indicates that these hazards are still not being fully recognized by the utility industry.The findings and recommended steps to alleviate these kinds of hazards were presented to maintenance personnel.

Judgements of Need

- Two judgements of need from the conclusions and causal factors were developed. They are as follows:

Judgements of Need (Cont.)

- **Management needs to ensure that Western employees adequately understand the induced voltage effects and the hazards that may be imposed, if the hazards are not mitigated.**

- **Western needs to include language in its safety documents to clearly address the need of establishing an equi-potential zone at. the work site.**

Corrective Action Plan

- Western's Electrical Power Training Center has developed and are conducting grounding training to all the craftsmen.
- Changes were implemented to the Power System Safety Manual.
- The grounding chapter of the Power System Maintenance Manual is currently being revised.

Doug Lovette
Electrical Safety In Utilities

Public Utility versus DOE Electrical Utility Philosophies

Doug Lovette

- Protective Relay Settings
- Line Design/Construction
- Energized Work
- Rate Payers/Deregulation
- National Electrical Safety Code/ National Electrical Code/NFPA 70E

Electrical Work Permits

- 29CFR 1910.147/.269(d)/.333 versus 29CFR 1910.269(m)

Lessons Learned

- Regulations versus real world – Hand-held voltmeters
- Wire Rope – more than meets the eye
- Power Operations versus maintenance thinking

Electrical Incidents

- Utility versus DOE requirements
- Modifications cause incident

Keith Gershon

Non-NRTL Equipment Inspection Training Program

LLNL Non-NRTL Equipment Inspection

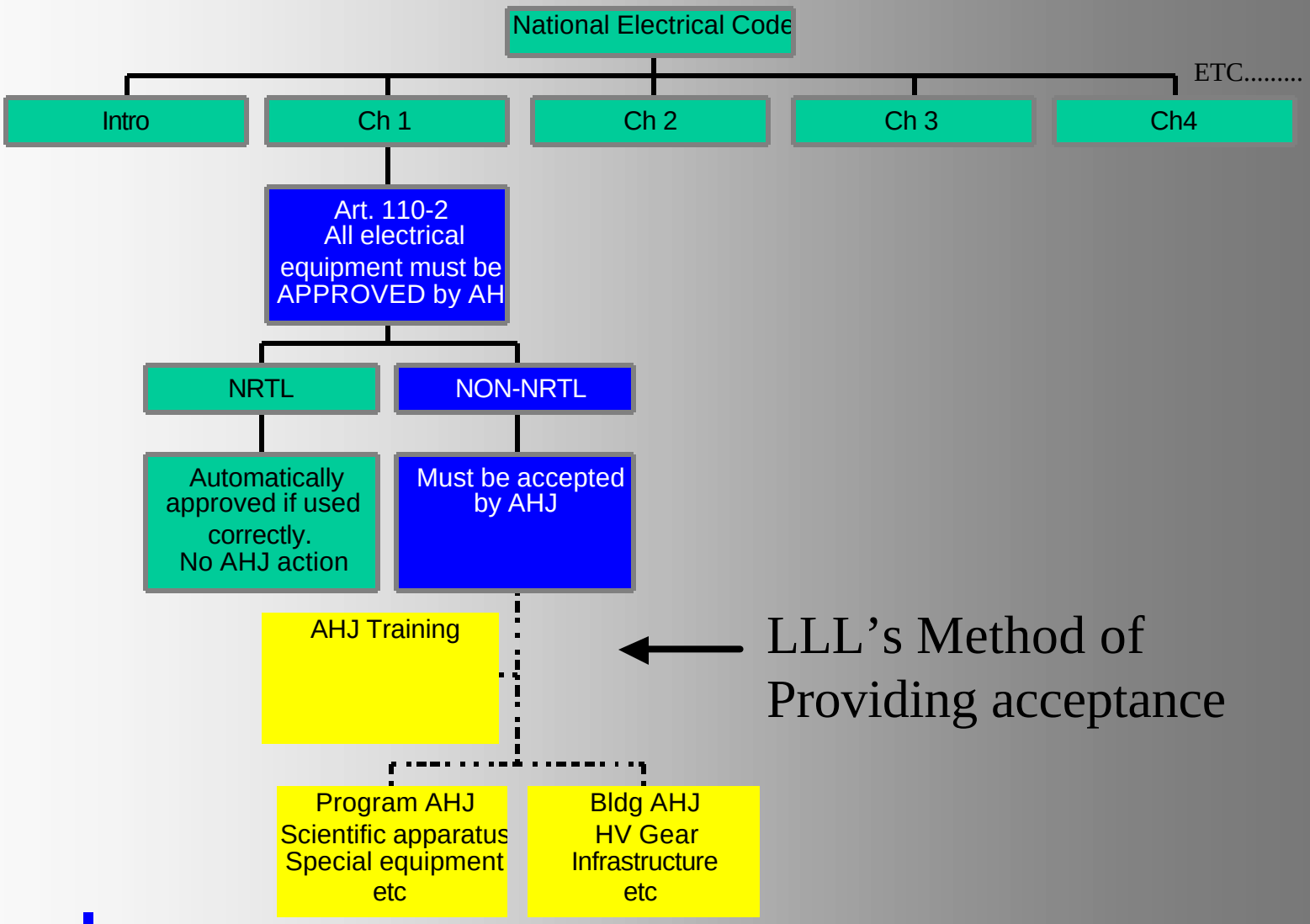
Inspector Training and Certification

Keith Gershon, LLNL Electrical Safety Engineer

LLNL Field AHJ Training

- How LLNL distinguishes Building v. Program AHJ functions
- What an AHJ equipment inspection does and does not mean
- Basic Elements of LLNL's training program
- Current Status

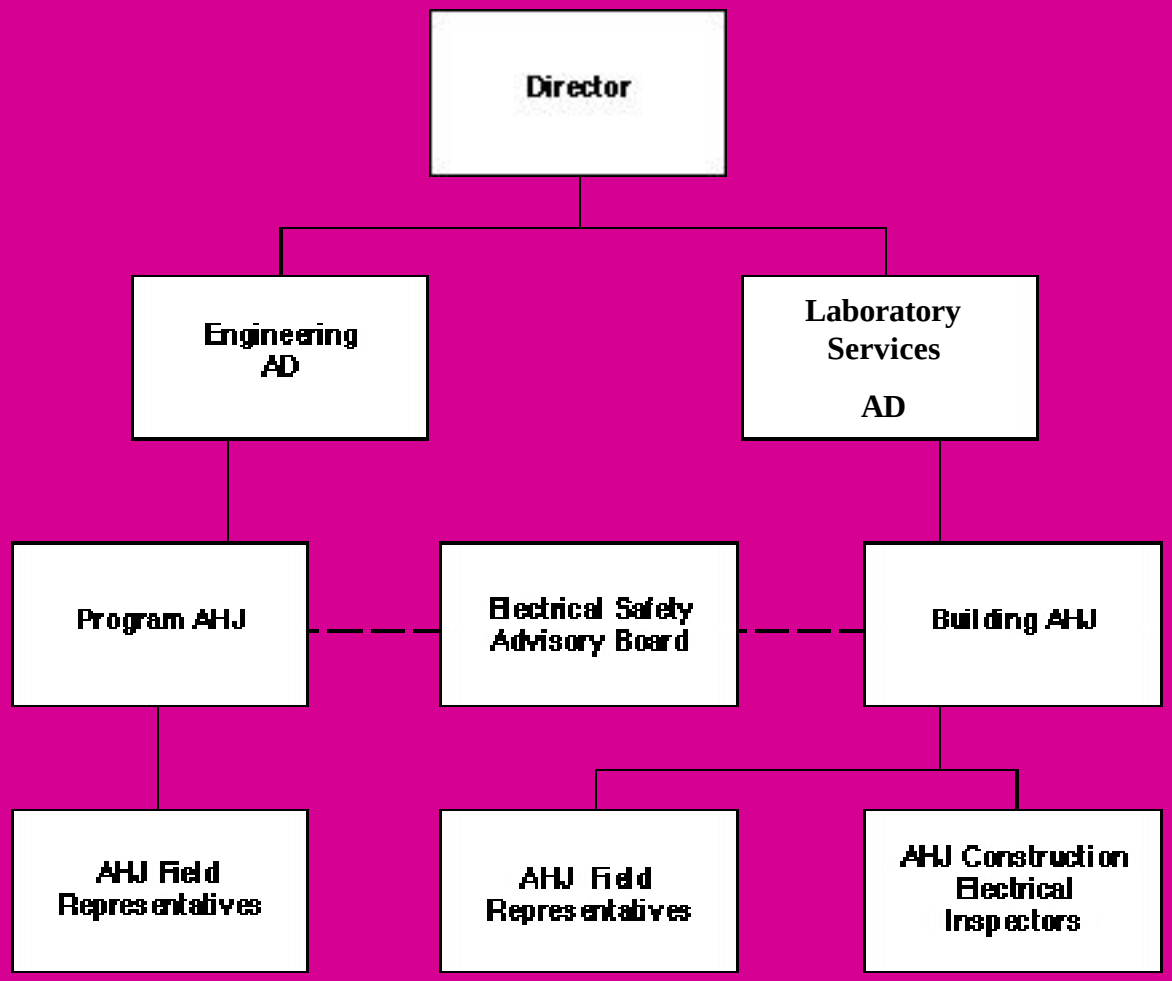
BUILDING AHJ



LLL's Method of Providing acceptance

PROGRAM AHJ

LLNL AHJ Structure



Program AHJ
Building AHJ
R&D Gear
Non-NRTL
Commercial
Equip.
Foreign born
equipment
Exp. power supplies
Grounding
Distribution
Wiring Methods
Non-NRTL
Commercial
Equip.
New constr.

Level 1 Inspection

- Primarily Visual
- Limited to observation of finished product
  - no disassembly / reverse engineering
- No destructive testing
- No hazardous exposures to inspector
- The owner is responsible!

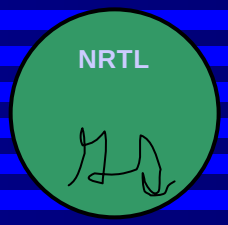
Equipment Labels

Bar Code: Equipment has been identified as requiring inspection.

Also, used for tracking

AHJ Approved / Rejected (mandatory)

Yellow Pending, Green NRTL (Optional)



What does FAHJ Acceptance Indicate?

- The equipment appears to meet minimum safety criteria.
- The equipment should not cause a shock, burn, or fire if used properly.
- The equipment has been examined to the extent indicated on the inspection form.
- The equipment is permitted be connected to the LLNL electrical system.

What does FAHJ Acceptance NOT indicate?

- Quality
- Reliability, functionality
- Total conformance with all applicable Standards
  - Inspections are very limited in scope
    - Relatively brief
    - No destructive testing
    - No hazardous exposures to inspector
    - No re-engineering

Responsibility

- Line management is responsible for safety – REMEMBER ISM!
- FAHJ assumes no responsibility for the ultimate safety of the equipment/product.
- This is the same as the outside world (e.g., UL).
- This is the same as with municipal AHJs.

Program AHJ Training Overview

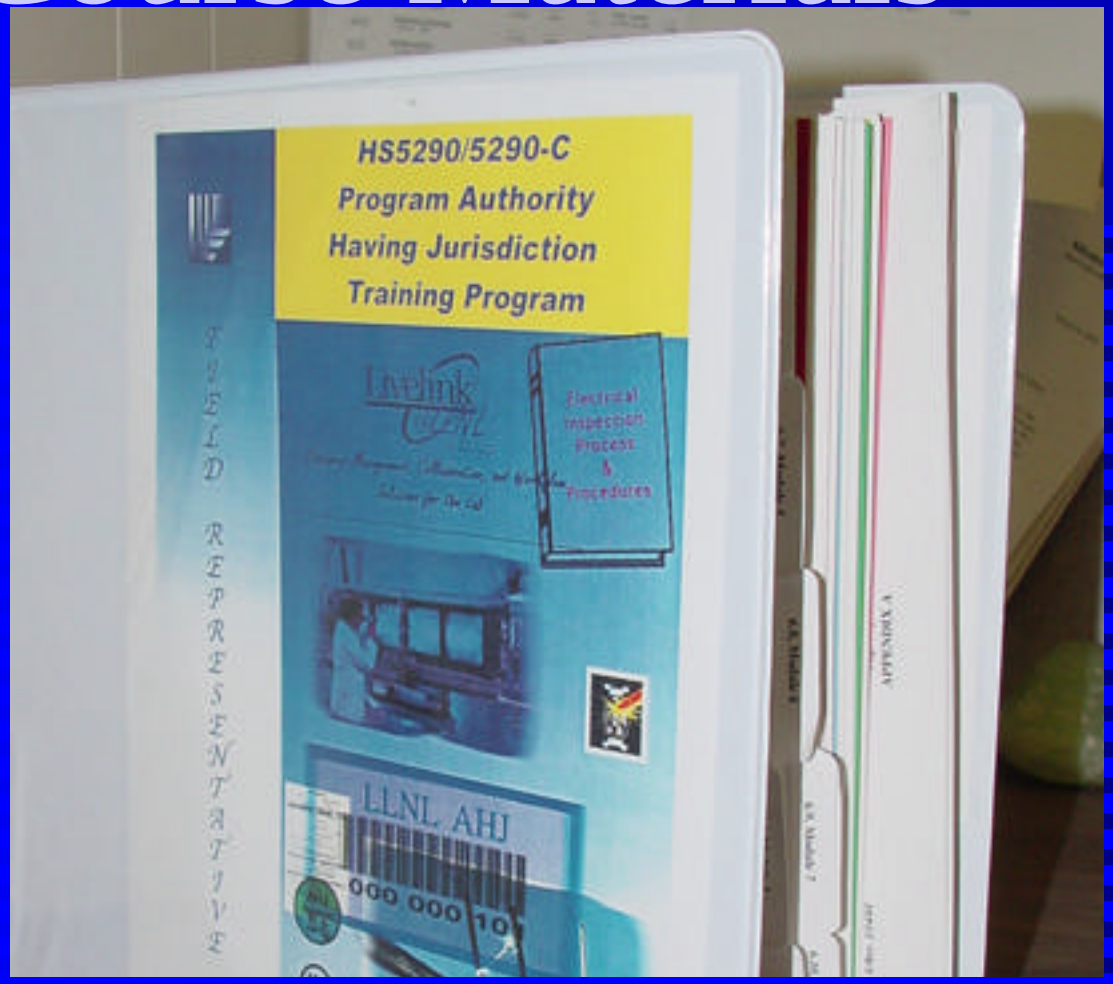
Note: This is considered to be an Advanced Class

- Day 1:
  - Electrical Safety; General and R&D Topics: 4 hours
  - Roles & Responsibilities of AHJ: 4 hours
- Day 2:
  - Business process; How the system works, documentation, using Livelink database: 4 hours
  - Checklist Overview: 2 hours
  - NEC: 2 hours

Program AHJ Training Overview (cont'd)

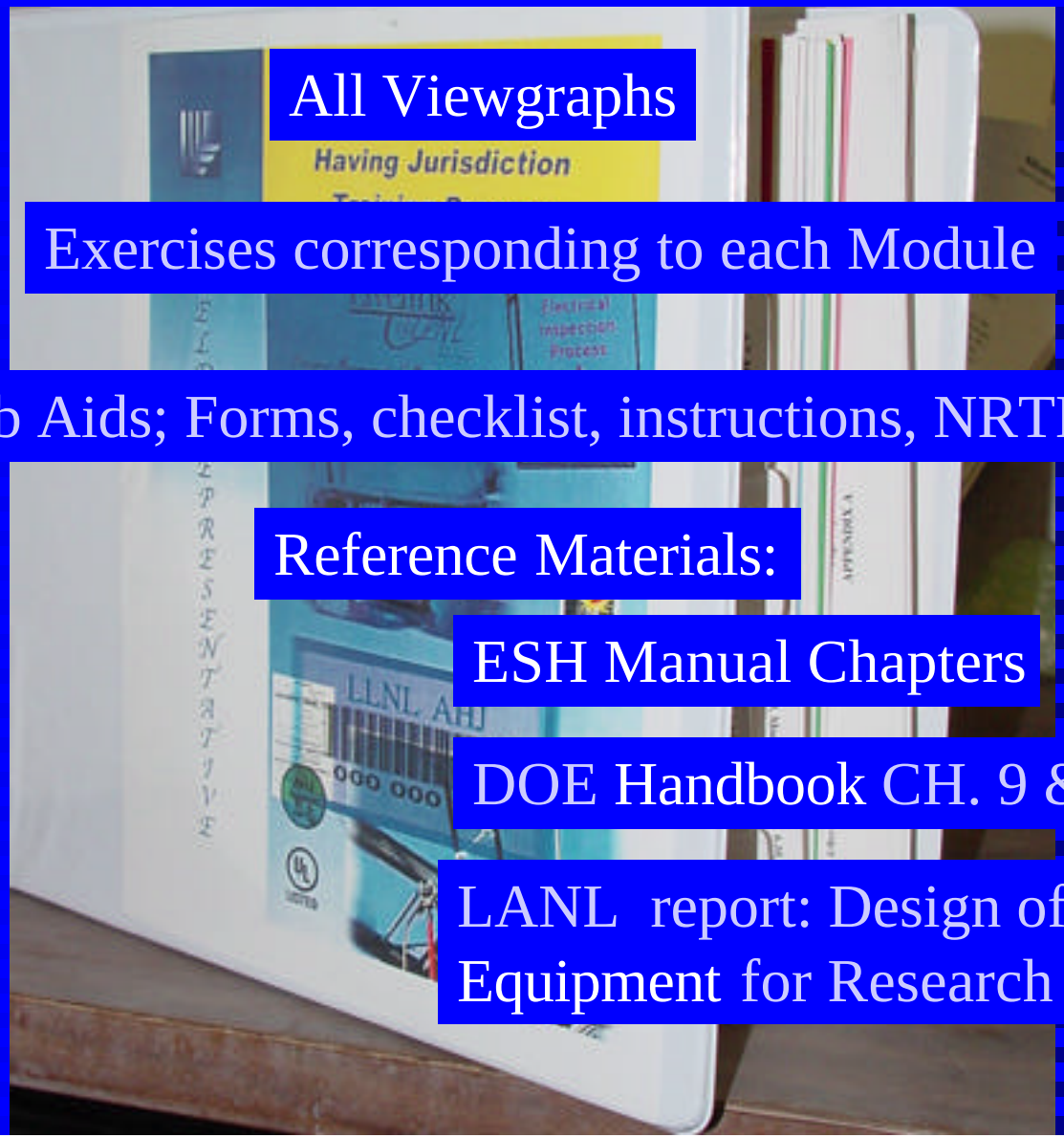
- Day 3:
  - NEC, continued: 4 hours
  - References & Standards; UL, ANSI, DOE Handbook: 4 hours
- Day 4: UL Engineers
  - Overview of 508, 508A, 3101: 4 hours
  - Demonstration Evaluations: 4 hours
- Day 5: UL Engineers
  - Student-performed hands-on inspections: 8 hours

Course Materials



Participant's Guide

Participant's Guide



All Viewgraphs

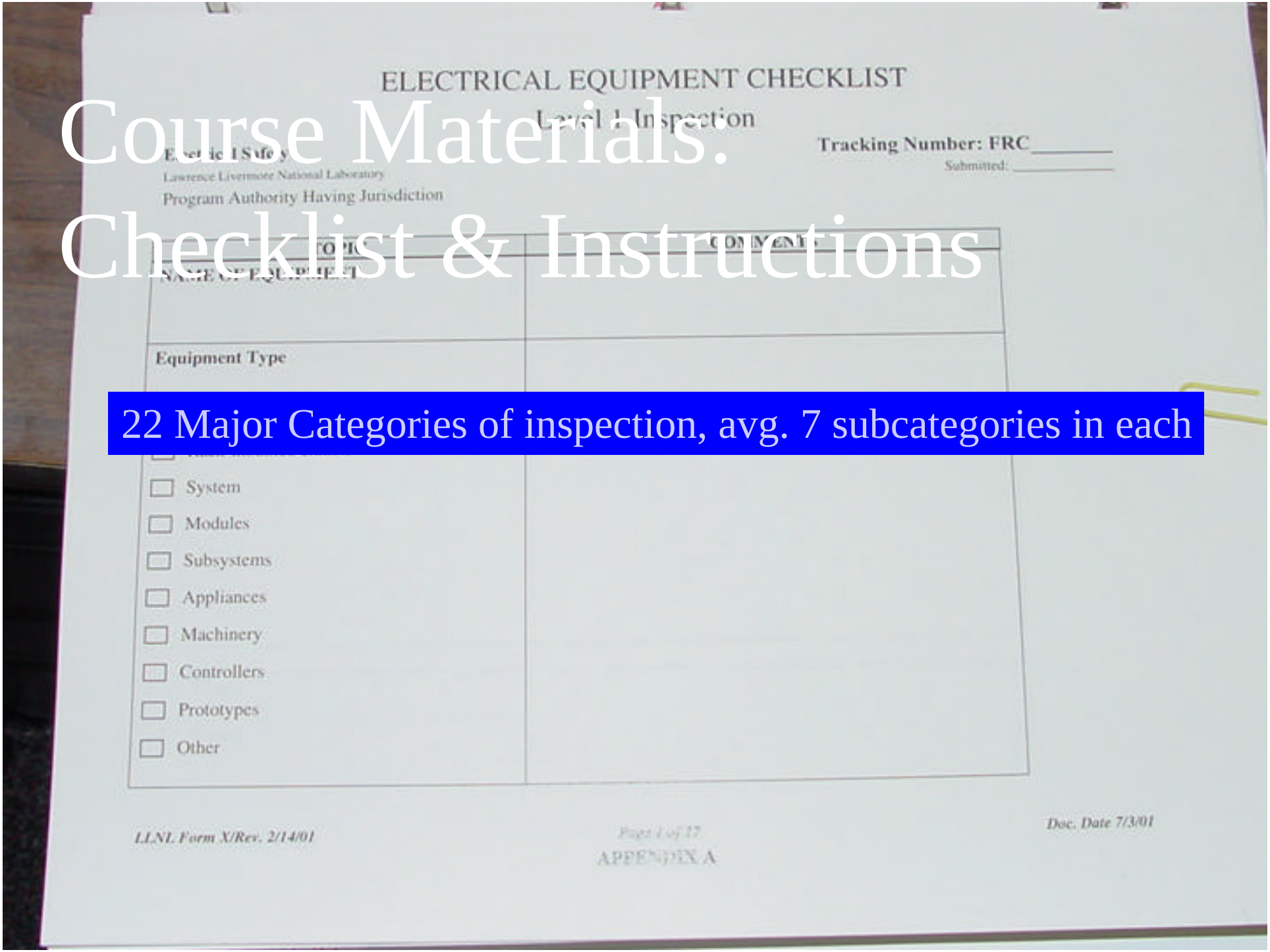
Exercises corresponding to each Module

Job Aids; Forms, checklist, instructions, NRTLs, etc

Reference Materials:

- ESH Manual Chapters
- DOE Handbook CH. 9 & 10
- LANL report: Design of Safe Equipment for Research

Course Materials: Checklist & Instructions



ELECTRICAL EQUIPMENT CHECKLIST

Level 1 Inspection

Electric Safety

Lawrence Livermore National Laboratory

Program Authority Having Jurisdiction

Tracking Number: FRC_____

Submitted: _____

TOPIC	COMMENT
NAME OF EQUIPMENT	
Equipment Type	
☐ System	
☐ Modules	
☐ Subsystems	
☐ Appliances	
☐ Machinery	
☐ Controllers	
☐ Prototypes	
☐ Other	

LLNL Form X/Rev. 2/14/01

Page 1 of 17

APPENDIX A

Doc. Date 7/3/01

22 Major Categories of inspection, avg. 7 subcategories in each

Course Materials:

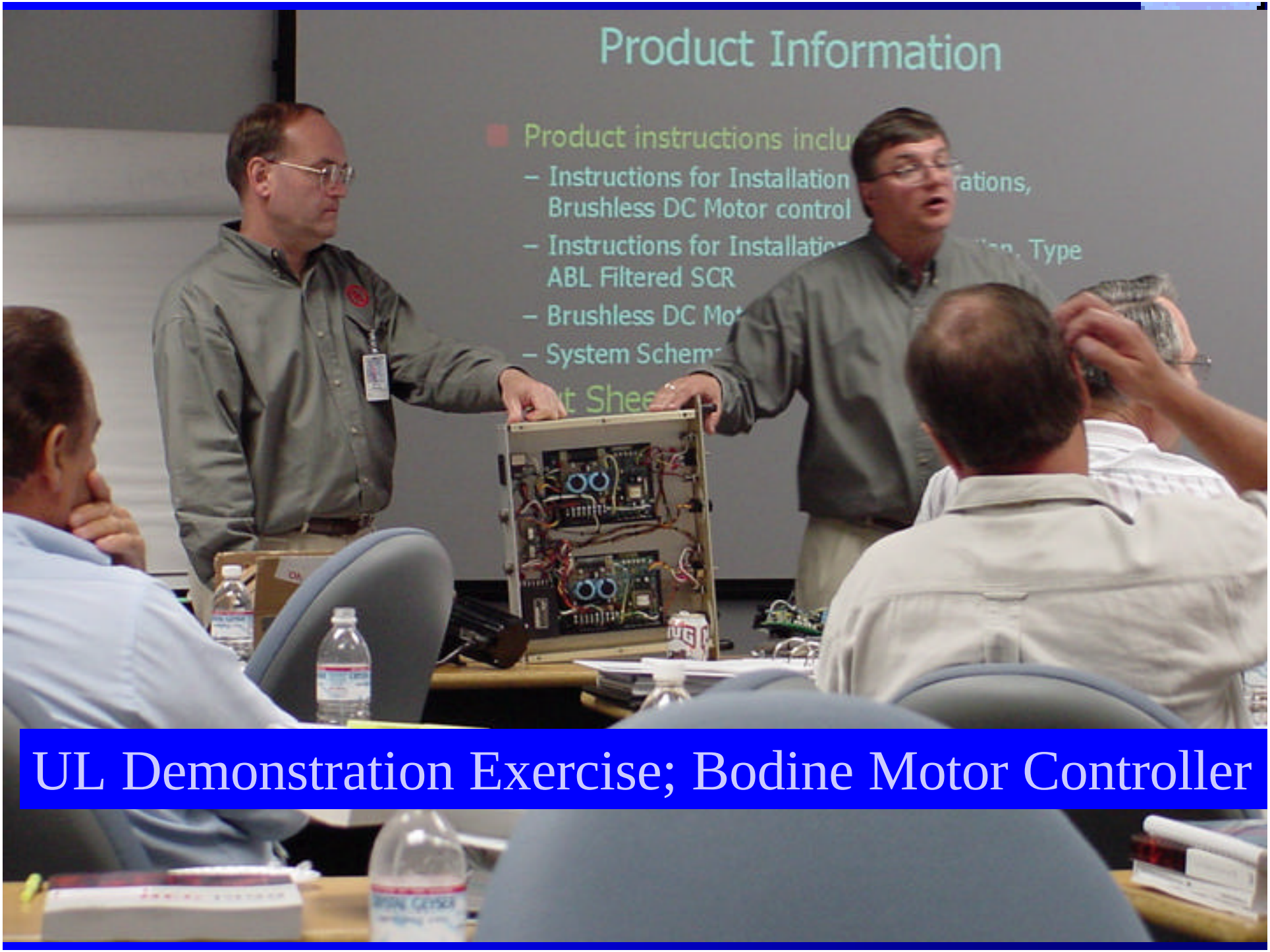
NEC

UL Wire & Cable Marking Guide

Course Materials:
UL Standards 508, 508A, 3101-1
UL Classroom Handouts

Field Inspection Exercise; X-ray training simulator

Field
Inspection
Exercise; Pulse Power Generato



UL Demonstration Exercise; Bodine Motor Controller

Field
Inspection
Exercise; Control Logic Chassis

Current Status / Lessons Learned

- Approx. 55 employees trained
- 20 more expected in August
- Checklist needs continuous improvement
- Need comprehensive EE Standards so designers will know their stuff will pass
- Need ongoing seminars & info sharing between field AHJ representatives

Questions/Answers

Keith Schuh

ISMS and Electrical Safety

Integrated Safety Management

This document describes the Fermilab

Particle Physics Division

Implementation of ISM.

Keith W. Schuh

Schuh@Fnal.gov

DOE ISMS

DOE Guideline

DOE G 450.4-1B Vol. 1 **135 pg.**

DOE G 450.4-1B Vol. 2 **109pg. app**

DOE G 450.3-3 **33pg. guide**

PPD ISM Functions &Responsibility

The core functions are:

- Define the work
- Analyze the hazards associated with the task(s)
- Take action to mitigate those hazards
- Perform the work within the hazard controls
- Provide feedback to allow improvements

In your daily work, you should use these five core functions as your work guide.

"Line Management Responsibility for Safety" includes **everyone**. We are all part of the "line". It is expected that individuals will follow the ISM core functions for **every** task.

PPD ISM

Within PPD our focus is work planning. A hazard analysis and mitigation of the hazards is a natural part of this planning. Approval of the work and notification of supervisors about work plans is the standard procedure, and review of completed work to improve future work should be a part of our standard practice.

This implementation is not intended to challenge the competence of trained and experienced people. We are working towards safety performance at a new level where more eyes on the hazards and mitigation of the hazards are needed to find and avoid the more exotic problems.

Where to Apply ISM ?

Safety of Daily Work Activities

Safety of New Experiments

When

A plan has been developed within the Particle Physics Division. Tables can be used as a roadmap to help supervisors and individuals determine:

- When is a written Work Plan/Hazard Analysis required and who writes it?
- When must a written Work Plan/Hazard Analysis be reviewed and who reviews it?
- When should line management be notified about Work Plans/Hazard Analyses?

Why

We need to be alert for accident situations stemming from several ordinary hazards working in concert.

"More eyes" includes writing a Work Plan/Hazard Analysis, having the written plan reviewed by experts in some cases, having every individual on a work team read and sign the written plan, and having the approved written plan distributed to the next level in line management.

It gets people plan for safety before they start a task.

Why do I Need it to be Written

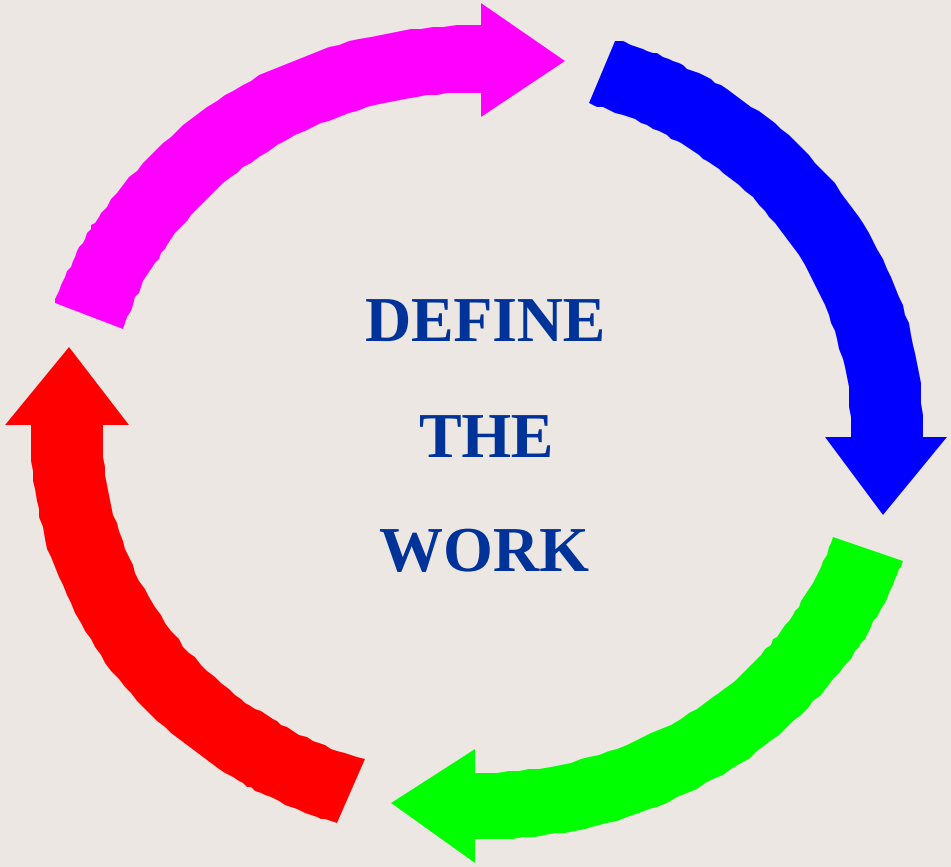
Employees and contractors need to know what the safety requirements are for the job or area they are working in.

This provides the ground work so several employees and contractors can work together safely.

We have more the 25 different work permits.

One or more may be required.

Experts have tunnel vision.


DEFINE
THE
WORK

Who Develops the Work Plan

Developers of Work Plans/Hazard Analyses, including:

· Individual workers,

recognizing that we all act in this capacity each day.

· Supervisors, Group Leaders, Task Managers for T&M work, and Detector Sub-project Managers.

Usually a team of individuals and supervisors will collaborate to write a Work Plan/Hazard Analysis.

Supervisors have a special responsibility to ensure that Work Plans/Hazard Analyses are written when required by this document.

Supervisors Responsibility

You are required to have a written Work Plan/Job Hazard Analysis for tasks done by your employees if their work passes any of the following thresholds (Note your judgment is required):

- **The task involves two or more of the hazards in Table 1.**
- **The task involves one hazard at the "high level" defined in Table 1.**
- **The task involves at least one hazard from Table 1 with a work crew where individual responsibilities of each crew member should be clearly spelled out.**
- **The task is outside of the normal duties and responsibilities for your group and involves one or more hazards from Table 1.**

(e.g., your group is called to a new area to "help out", or your group is assigned a new permanent and continuing task)

Supervisors Responsibility cont.

- **The task involves complex activities of more than one day duration and at least one hazard from Table 1.**

(You should consider having daily toolbox meetings to review the complexities each day.

But this is not required if a simple task is just being repeated every day.)

· **If in your judgment the task is complicated and would be done more safely using a written Work Plan/Hazard analysis, then write one!**

Supervisors Responsibility cont.

You are required to have Work Plans/Hazard Analyses reviewed if the work passes any of the thresholds in Table 2.

Table 2 indicates who should do the review, either a designated PPD Approver, a PPD Department Head, a PPD ES&H Review Committee, or the Division Head. If an obvious reviewer cannot be identified, contact the Division Office.

Supervisors Responsibility cont.

Once you have a written plan, **you have the following additional responsibilities:**

Discuss the work plan with all involved employees, and get each employee to sign the Work Plan/Hazard Analysis as a record that the job was understood. Post a copy near the work area if possible.

Keep the Work Plan/Hazard Analysis for your employees on file for one year.

Provide a copy of the Work Plan/Hazard Analysis up the line in the PPD Line Management. (If required)

Recurring Tasks

For tasks that recur often, it is permissible to write a generic Work Plan /Hazard Analysis good for one calendar year. All such generic plans expire on December 31 every year and must be reviewed, amended as needed, and re-approved.

CDF Supervised Access

Information Needed

- **Job name and location**
- **Job start and end date**
- **A description of the work**
- **A list of hazards associated with the work**
- **Details on planned mitigation of each hazard**
- **The name of the task manager or task supervisor**
- **A list of individuals in the work party with each person's role clearly defined**
- **The name of the Work Plan/Hazard Analysis author**
- **A place for approval by a reviewer if applicable**
- **A place for individuals in the work party to sign that they have read and understood the plan**
- **Details on notification to other divisions if applicable**

Forms Frequently Serve the Purpose

Electrical Work Permit

Pressure Vessel Testing permit

Radiation Work Permit

Confined Space Entry Permit

Written Lockout/Tagout Procedure Form

Fire Detection/Protection System Disablement Request

Welding and Burning Permit

Toxic Material Handling Permit

Work Permit and Notification Form (FESHM 2020)

FESHM 2060 Hazard Analysis form

Other PPD written Procedures.

Who Reviews Work Plans

Reviewers of Work Plans/ Hazard Analyses, including:

- Task Managers for Fixed Price work, Service Contract Managers
- PPD Approvers (defined in Table 2)
- PPD Department Heads
- PPD Project Managers
- PPD ES&H Review Committees
- PPD Division Head or Designee

ANALYZE
THE
HAZARDS

Hazards

- Radiation
- Electrical Work
- Electronics Work
- Confined Space Work
- Fall Hazard
- Mechanical Hazard
- Moving Mechanical
- First Time Use
- Crane,Host & Forklift Use
- Hydraulic Systems
- Excavation & Digging
- Flammable Gas
- Pressure / Vacuum Systems
- Cryogenics
- Oxygen Deficiency
- Chemicals
- Hazardous Substances
- Work with regulated Pollutants
- Machining and Grinding
- Repetitive Tasks
- Noise Hazards
- Other Environment Hazards
- Magnetic Fields
- Lasers
- Welding,brazing,open flame work
- Spaces controlled by other divisions

Hazards
Radiation

Hazard

- Radiation areas at Fermilab are labeled --work in a Controlled Area or in a Radiation Area is a hazard. However, work in a Controlled Area by people already specifically trained for the radiation hazards in that area is NOT a hazard.
- Known radioactive objects at Fermilab are labeled with a "Class“ sticker -- work on such objects is a hazard.
- Work with radioactive sources is a hazard.

High

- Work on Class 2-5 radioactive objects.
- Work with contaminated objects.
- Work with radioactive liquids.
- Work with depleted Uranium.
- Moving sources between buildings.

Electrical & Electronics

Hazard

- Hazards are electrocution and injuries associated with arc blast
  (burns, hearing loss, flying debris).

- A hazard if a worker is likely to be exposed to voltages, currents, or stored electrical energy of sufficient magnitude and duration to startle or injure if shocking, arcing, sparking, or heating should occur.
- Workers must have Basic Electrical Safety training.

High

- Work activities near or on exposed electrical conductors, circuits, or equipment that are or may be energized and where there is a significant potential for arcing, flash burns, electrical burns, or arc blast.
- Any work on an AC electrical power distribution system.

- Work activities near or on exposed electrical conductors, circuits, or equipment that are or may be energized and where there is a significant potential for arcing, flash burns, electrical burns, or arc blast.
- Any work with non-commercial electronics or with electronics modified at Fermilab has a greater hazard potential, particularly in the prototype stage.

Confined Space

Hazard

High

Work in a space that:

1. Is large enough and so configured that you can bodily enter and perform assigned work; and
2. Has limited or restricted means for entry or exit; and
3. Is not designed for continuous occupancy.

Entry into a "Permit Required Confined Space" -- these are labeled and indicate a potential hazardous atmosphere or other safety hazard in the confined space.

Falls

Hazard

- Work from a ladder at 6 feet or more above the floor.
- Work from a scissors lift.
- Work on low slope roofs (less than 4" rise in 12" horizontal).
- For clarification, work from previously approved scaffolding is NOT a hazard.

High

- Work from a ladder if 3 of 4 limbs cannot maintain contact with the ladder.
- Work from a ladder set on uneven or slippery ground.
- Work from an articulating lift device (e.g. a "cherry picker" or other such single arm device).
- Work at 6 feet above floor without guardrails.
- Work on high slope roofs.
- Any new use of scaffolding, including erection of the scaffolding.

Mechanical

Hazard

Potential for release of stored energy through falling, rotating, or other unplanned movement.

Note that standard moves of objects with Crane, Hoists, and Forklifts are covered below.

High

Work with a mechanical system that has the potential to release stored energy in excess of 60,000 foot-pounds.

Examples are: 30 tons at 1 foot off the floor, 3 tons at 10 feet off the floor.

Any unusual arrangement of heavy objects, even if below 60,000 ft-lb. energy.

Other mechanical stored energy hazards (e.g. springs) require calculation.

Moving Mechanical

Hazard	High
Potential for injury from computer controlled moving objects.	Work in an area where an employee can be caught between objects. Work near unguarded rotating shafts.

First Time Use

Hazard	HIGH
• Potential hazard with any first time use of mechanical or electrical Equipment if a significant injury could occur.	• First time production work with new equipment designed or modified at Fermilab if a significant injury potential exists. • Examples: start of production with a large new mechanical machine is a high hazard, but starting use of a small low-power printed circuit board is not.

Crane, Hoist, Forklift Use

Hazard

Material handling with this equipment can have a significant potential for injury if done improperly.

Below-the-hook lifting devices must be approved fixtures.

Employees must be trained and qualified to operate the device.

High

If exceptional care is required due to size, shape, or close installation tolerance of a particular load.

For clarification, it is not usually a high hazard to perform a "standard lift", e.g. a lift within the crane weight limit of a standard shield block using the lift eye or to lift other loads with an approved lifting fixture.

Hydraulic Systems

Hazard	High
These systems can run at several thousand pounds per square inch, so small leaks can be a hazard without eye protection.	Any work where a sudden uncontrolled release (failure) of pressure could result in injury (e.g. people working around a heavy object supported hydraulically could get "caught between"). Work with modified hydraulic systems.

Excavation and Digging

Hazard	High
Any digging or soil boring with motorized equipment. Any digging (even by hand) where utilities or unsanitary conditions may be encountered. Any digging where on-lookers are present and could be injured.	Digging deeper than 4 feet. Digging into a radiation shield berm. Any excavation that could become a confined space -- for example within or under a building.

Flammable Gas

Hazard

Flammable gas areas are classified by fire risk and must be reviewed to determine the risk class (unreviewed areas are Class 2).

Work in a Risk Class 0 area (risk of small local flash fire) is a hazard.

High

Work in a Flammable Gas Risk Class 1Area (risk of local fire) or in a Risk Class 2 Area (risk of a general fire).

Cryogenic

Hazard	High
Working with solids, liquids, or gases colder than -150 C.	Working with more than 200 liters of cryogenic material.

Oxygen Deficiency (ODH)

Hazard

Working in areas that can have large releases of gases to reduce the oxygen concentration below 19.5%.

Work in an ODH-1 area is a hazard.

High

Working in an area classified as ODH-2 or above is a high hazard.

Chemicals

Hazard

Use of materials that are flammable, combustible, corrosive, reactive, toxic, caustic, or poisonous.

Use of any material that because of the quantity and/or manner it is being used is hazardous to the health of the worker.

MSDS are always required and every employee must have HazCom training in how to read an MSDS.

Containers must always be properly labeled.

High

Work with solvents, reactive or corrosive chemicals in large amounts or in a poorly ventilated area.

Work with poisonous chemicals (e.g. plating solutions containing cyanide).

Work with highly reactive chemicals (e.g. battery acids, metal cleaning solutions containing a high % of hydrofluoric acid).

Work with known carcinogens or cancer-suspect agents (e.g. benzene or methylene chloride or chloroform).

Any work with explosive chemicals.

Any work with new chemicals synthesized at Fermilab.

Occasional use of small amounts (500 ml) of consumer products or other chemicals available from the stockroom is not a high hazard.

Hazardous Substances

Hazard	High
Chemical Carcinogens, Lead, Asbestos, Beryllium and Beryllium Alloys are hazards to workers.	Direct handling of Lead, Asbestos, Beryllium (even when passivated), and Beryllium alloys is always considered a high hazard, but packaged or encapsulated objects are low hazards. Work with known carcinogens or cancer-suspect agents. Clean-up (abatement) work is always a high hazard.

Work with Regulated Pollutants

Hazard

Work that will generate a WASTE product with a chemical that has a flash point below 140 degrees F, a pH below 2 , a pH greater than 12.5, or which contains any toxic substance (see MSDS).

High

Any work that will generate more than 5 gallons of regulated waste.

Any work with chemicals where a significant spill is possible and likely to get into the environment (e.g. drain or ditch nearby). The "significant" level will depend on the chemical.

Work that will generate a mixed (radioactive + regulated) waste.

Machining and Grinding

Hazard	High
Moving machinery operated without appropriate guards. Work with the employee in an unusual or awkward position (e.g. overhead grinding is an eye hazard). Sparks from these operations must be controlled.	Machining or grinding hazardous materials such as lead, magnesium, beryllium Removal of structural welds on large weldments (fall hazard may result).

Repetitive Tasks

Hazard	High
Work at an inappropriately designed computer setup. Assembly work with repetitive tasks.	Four consecutive hours of repetitive assembly work. Jobs that may aggravate a pre-existing medical condition. Assembly jobs that have caused previous repetitive injuries.

Noise

Hazard	High
Eight hours of work in an environment where you must raise your voice (but not shout) to be heard.	Two hours of work per day in an environment where it is necessary to shout in order to be heard. Work that exceeds a posted noise hazard limitation. (Typically 8 hrs @ 85 dbA).

Other Work Environment

Hazard	High
Respiratory hazards from dust, animal waste, …	Continuous work in temperatures above 86 degrees F or below -25 degrees F must be evaluated.
Work in areas of excessive heat or cold.	
Work from awkward positions.	

Magnetic Field

Hazard

Iron objects in a magnetic field can move.

Cardiac pacemakers, metallic implants, and other medical devices can function improperly in magnetic fields as low as 2.5 gauss.

High

Work near any area with a fringe field of more than 1 kilogauss in air over an accessible region more than 1 foot long in all directions.

Any time averaged exposure of people to 300 gauss or more.

Any situation were ferrous objects can be subject to magnetic forces causing sudden unexpected movement.

Lasers

Hazard

Laser systems can present electrical, chemical, and eye or skin hazards from intense visible light.

Lasers are classified on a scale of 1 (safe) to 4 (dangerous).

High

Work with a Class 3b or higher laser (training is required).

Pressure/ Vacuum Systems

Hazard

- Potential for rupture or implosion.
- Modification of a pressure system is a hazard.
- Unusual or rare operation of a pressure or vacuum system is a hazard.

High

- Work on systems with a pressure greater than 150 psi.
- Work with a vacuum chamber larger than 35 cubic feet and larger than 12 inches in diameter.
- Work with thin vacuum windows greater than 12 inches in diameter.

Welding, Flame Cutting, Brazing, Open Flame

Hazard	High
Hazards are fire, eye injury, thermal and ultra violet burns, noise, ventilation, toxic fumes. Welding work in an area where passers-by can see the arc. .	Any flame cutting on an existing structure

Spaces Controlled by Other Divisions

Hazard	High
Potential for unknown hazards.	Always considered a high hazard until analyzed. This includes all Collision Halls.

Review Matrix

Hazard	Designated PPD Reviewer	Department Head	PPD ES&H Department	Division Head	Experiment ES&H Review
Radiation	Permit Req. PPD RSO	Notify	Notify	Notify prior to moving	For any source use
Electrical	Permit Req. Elect. Coord.	Notify		Notify Must approve hot	
Electronics	Supervisors	Notify			Non-commer stored energy
Confined Space		Notify	If permit required	Notify	
Fall	Scaffolding PPD reviewer	Notify	Notify		
Mechanical	PPD Eng. Approver	Notify		Notify – approve > 500k ft-lbs.	> 3 tons above floor or >10T
Moving Mechanical	PPD Eng. Approver	Notify	Notify	Notify	> 5 ft/sec

Review Matrix

Hazard	Designated PPD Reviewer	Department Head	PPD ES&H Department	Division Head	Experiment ES&H Review
First time use	PPD Eng. Approver	Notify		Notify	
Crane, hoist,forklift	PPD Eng. Approver		Notify	Approves unusual use	
Hydraulic	PPD Eng. Approver	Notify			
Excavation Digging	Permit Req. TM or CC		Notify		
Flammable Gas		App. All Class 1&2	Notify	Approves All	Reviews All
Cryogenic	PPD Eng. Approver			Approval for >200L	>200 liter
ODH	ODH-1 Supervisor	ODH-2 or higher	Notify		All use
Chemical	Supervisor	Notify	Notify	Notify	

Review Matrix

Hazard	Designated PPD Reviewer	Department Head	PPD ES&H Department	Division Head	Experiment ES&H Review
Haz. Sub		App. Proc	App. Abatem	Notify	All Use
Pollutants	PPD Env. Officer	Notify	Notify		
Mach.&Grin			App. Haz Mat	Notify if Haz.	
Rep. Task	Supervisor	Notify	Notify		
Noise			App > 8hr.>85db	Notify	
Environment	Supervisor >86F or <25F	Notify			
Magnetic	PPD Eng. Approver	Notify	App. >300 G		
Laser	Laser Saf. Off	Notify	Notify	Notify	All Use

Review Matrix

Hazard	Designated PPD Reviewer	Department Head	PPD ES&H Department	Division Head	Experiment ES&H Review
Pressure& Vacuum	PPD Eng. Approver	Notify	Notify	Approves Operation	All Use
Open Flame	Fire Dept. PPD SSO				

OPERATIONAL
READINESS
NEW
EXPERIMENTS

New Experiments Review Criteria

Mechanical Hazards: Devices which meet any of the following criteria:

- Weighs over 3 tons and is supported above the floor
- Exceeds 10 tons in total weight
- Moves at a speed greater than 5 ft/sec
- Costs more than $100,000 to replace
- Includes pressure/vacuum vessels

Electrical Hazards: Electrical systems which meet any of the following criteria:

- Uses non-commercial or modified commercial equipment.
- Uses non-PREP or modified PREP equipment.
- Any non-commercial low voltage high current or high voltage distribution systems.
- Any equipment with large capacitor banks.

New Experiments Review Criteria cont.

Fire Hazards: Any large combustible items such as large quantities of plastic scintillator, large numbers of cables requiring cable trays

Oxygen Deficiency Hazards: Use of any oxygen displacing gases such as chamber gas systems, helium bag systems, dry nitrogen, cryogenic magnets or targets

Cryogenic Hazards: Cryogenic systems for magnets, hydrogen targets, calorimeters, or any cryogenic system with inventory exceeding 200 liters.

New Experiments Review Criteria cont.

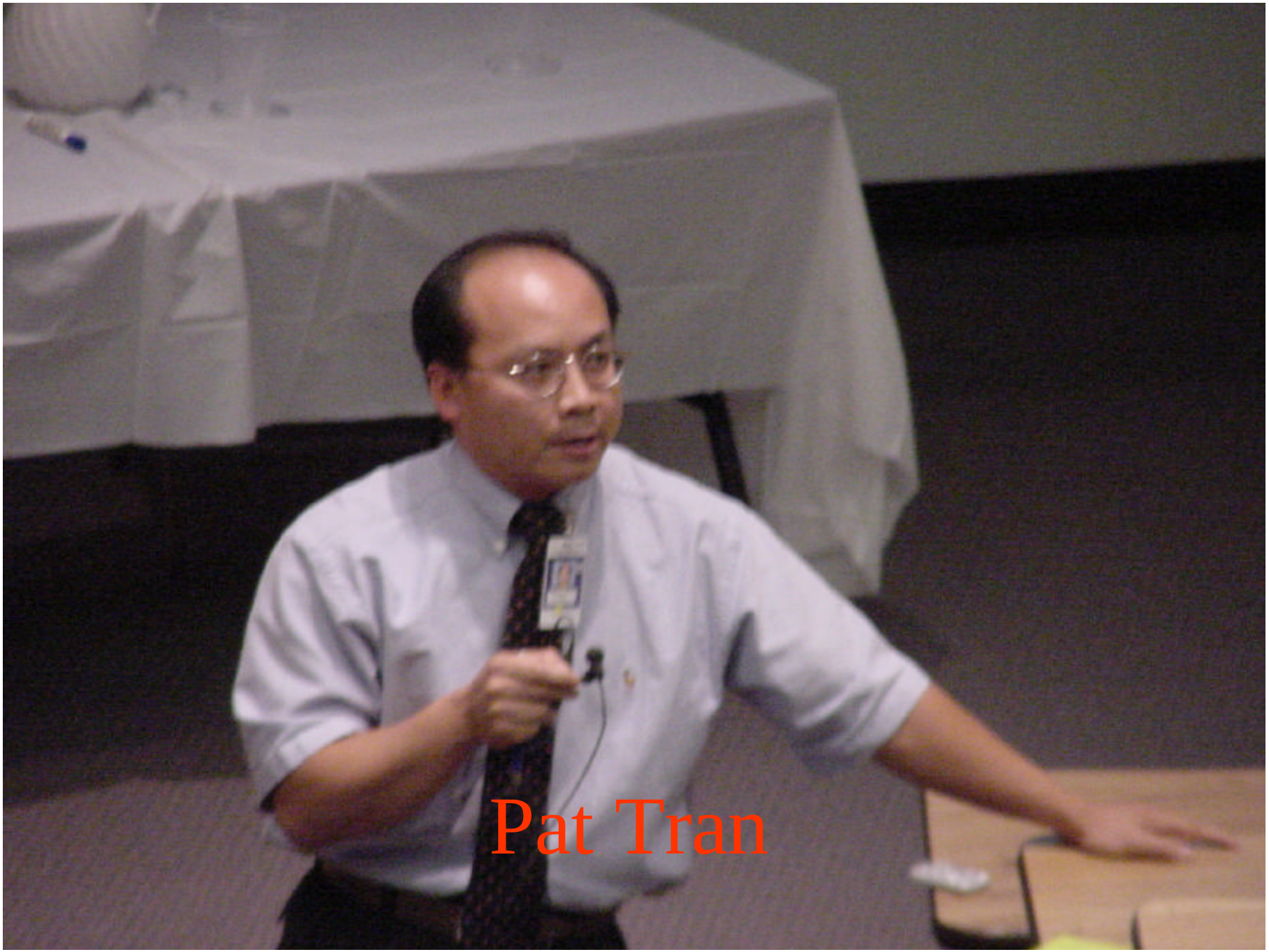
Laser Hazards: Lasers of any class.

Flammable Gas Systems: Any use of flammable gas and flammable gas mixtures.

Radiation Hazards: Radioactive sources/materials which will be used. Specify if embedded in detectors.

Toxic Materials: Toxic/hazardous materials planned or used, if the amount exceeds few gallon/pound quantities.

Examples include: lithium, beryllium, mercury, lead, uranium, cyanide, etc.


Pat Tran