
2000
ELECTRICAL SAFETY
COMMITTEE MEETING

DOE Electrical Safety Meeting

Tuesday, June 13, 2000

7:30 – 8:00	Registration
8:00 – 8:15	Welcome – Marvin Gunn – DOE Chicago Operations Deputy Manager
8:15 – 8:30	Welcome – Dr. Yoon Chang – Interim Laboratory Director, Argonne National Laboratory
8:30 – 9:30	Electrical Burn Center Virtual Tour - Dr. Mary Capelli-Schellpfeffer
9:30 – 10:00	Thermograph Imaging – Deborah Freeze - WIPP
10:00 –10:15	Break
10:15 –11:00	Electrical Design Standards For Electronics to be used in Experimental Apparatus – Keith Schuh – Fermi Laboratory
11:00 –12:00	Lunch
12:00 – 2:00	Hazardous Locations – Edward Briesch - UL
2:00 – 2:15	Break
2:15 – 3:15	High-Voltage Electrical Review - Dan Crego - Com Ed
3:15 – 5:00	Grounding Update - Mark Regan – LANL

DOE Electrical Safety Meeting

Wednesday, June 14, 2000

8:00 – 8:30	**AHJ Approval, Using the NRTLs - Chuck Monasmith – Fluor Daniel**
8:30 – 9:00	**Safety During Transformer Maintenance – Richard Croghan & Lora Flanigan – SD Myers**
9:00 – 9:30	**Hidden Design Flaws on Electrical Systems – Bill Marsh - WAPA**
9:30 – 10:00	**Difference Between Electrical Clothing and Fire Clothing – Doug Lovette - BJC**
10:00 – 10:15	**Break**
10:15 – 11:00	**R&D Topics Panel Discussion (Case Histories) – Hugh Bundy – Sandia, Keith Gershon – LLNL, Edward Henderson – LANL, Orville Paul – LLNL**
11:00 –12:00	**Lunch**
12:00 – 12:30	**R&D Topics Panel Discussion (Case Histories) - Hugh Bundy – Sandia, Keith Gershon - LLNL , Edward Henderson – LANL, Orville Paul – LLNL**
12:30 – 1:00	**NFPA 77 Static Electricity - Scott Gilmore - Honeywell FM&T/KC**
1:00 - 2:30	**OSHA Up-Date – Ron Stephens and John Grzywacz – Federal OSHA**
2:30 – 2:45	**Break**
2:45 – 3:15	**Update NFPA 70 – E - Keith Schuh – Fermi Laboratory**
3:15 – 3:45	**ISMS Application for R&D Activities – Hugh Bundy – Sandia National Laboratories**
3:45 – 4:45	**Power Line Hazard Awareness - Paul Satti - Construction Safety Council**
4:45 – 5:00	**Handbook Update and Close**

Introduction

2000 DOE ELECTRICAL SAFETY COMMITTEE
Electrical Safety Committee Meeting
Tuesday and Wednesday, June 13 and 14, 2000

Introduction

At the beginning of the meeting, a brief introduction was held, and people in attendance were asked to introduce themselves. Larry Perkins told the attendees that approximately 70 people attended last year's meeting in Orlando, Florida. The topics from the 1999 annual meeting were reviewed: Electrical Planning Meeting, Electrical Statistics, High-Voltage Practices Based on Fault Studies, Electrical Meter Safety, International Electrical Standards Update, IEC TC78 Meeting and Progress, Face and Eye Protection from Electrical Arc's, ASTM Task Force Progress, 70E/OSHA Electrical Clothing Requirements, Arc Resistant Rainwear, Underground Detection Update, Grounding of Electrical Systems and Associated Problems, Drillco Devices, Grounding of Generators Below and Above KW, Electrical Safety During D&D Activities, Intrinsically Safe Equipment, R&D Is IT Really Different, Interactive Electrical Safety Course for Researches, Electrical Inspection Program, Idaho Fatality, Alternate Methods to Meet NEC Requirements, Applied Integration Principles to Electrical Construction Safety, Approval of Unlisted Equipment, Calculations Based on the 1999 NEC, Electrical Burn Update, Ground Problems at the Y-12 Plant, and the Electrical Safety Handbook Process. In addition, a Steering Committee Meeting was held.

The topics to be discussed at this year's meeting were reviewed and the agenda follows:

DOE Electrical Safety Meeting

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<u>ELECTRICAL SAFETY COMMITTEE MEETING</u>

Tuesday, June 13

<u>Registration</u>

Participants at the meeting were registered and given names tags. Approximately 80 people attended the meeting.

Welcome

Marvin Gunn

Welcome (Marvin Gunn) DOE Chicago Operations Office

Marvin Gunn of the DOE Chicago Operations Office welcomed the participants to the annual meeting. He expressed his support of the Electrical Safety Meeting and mission to enhance electrical safety throughout DOE complex.

The U.S. Department of Energy's Chicago Operations Office plays an important role in basic research and technology development spanning a broad range of department missions. These include Science and Technology, Energy Resources, Environmental Quality, and National Security. Chicago Operations administers more than 2,500 contracts and grants in excess of $2 billion. Chicago Operations is also responsible for overseeing the operation of contractor-operated multiprogram laboratories, including the Argonne National Laboratory near Chicago and the Brookhaven National Laboratory on Long Island, New York, as well as the single purpose laboratories of Ames Laboratory, Ames Iowa; Fermi National Accelerator Laboratory, Batavia, Illinois; and Princeton Plasma Physics Laboratory, Princeton, New Jersey. Two government owned and operated laboratories are also part of Chicago Operations: the Environmental Measurements Laboratory, New York, New York, and the New Brunswick Laboratory, Argonne, Illinois.

The Department of Energy employs more than 12,000 employs at many sites throughout the country. In the two decades since it's creation, the energy, research and development and defense challenges confronting the nation and DOE have changed dramatically. The Cold War has ended and the nation's defense needs have changed. Environmental cleanup of our atomic energy legacy has increased in importance and emphasis. And, as result of DOE and predecessor R&D activities, new technologies have been perfected and are at work in our society improving our lives, generating jobs, and stimulating economic progress.

Concern over deficits and the need to balance the federal budget have led to new initiatives to "reinvent" government, including DOE. The department is conducting a Strategic Alignment Initiative to improve every aspect of its performance. Changing national demands have resulted in significant redirection and redefinition of the Department's missions and the strategies required to accomplish them. At its core, however, the Department of Energy is, as its predecessors were, a science and technology agency dedicated to carrying out research and development in pursuit of national needs.

As it has been for more than 50 years, the Chicago Operations Office seeks a leadership role as an active participant in this change, and continues in its dedication to support the department's important missions.

Office of Science - Chicago Operations Office

Office of the Manager

Manager
Robert L. San Martin

Deputy Manager
Marvin E. Gunn, Jr.

Diversity Manager
Sara J. Brunson

Communications Director
Gary L. Pitchford

Argonne Group
Group Manager
Timothy S. Crawford

Brookhaven Group
Group Manager
George J. Malosh

Fermi Group
Group Manager
Jane L. Monhart

Princeton Group
Group Manager
Jerry W. Faul

Ames Group
Group Manager
James A. Buchar

New Brunswick Laboratory
Director
Margaret E. M. Tolbert

Environmental Measurements Laboratory
Director
Mitchell D. Erickson

Acquisition and Assistance Group
Group Manager
John D. Greenwood

Environmental Programs Group
Group Manager
Anibal L. Taboas

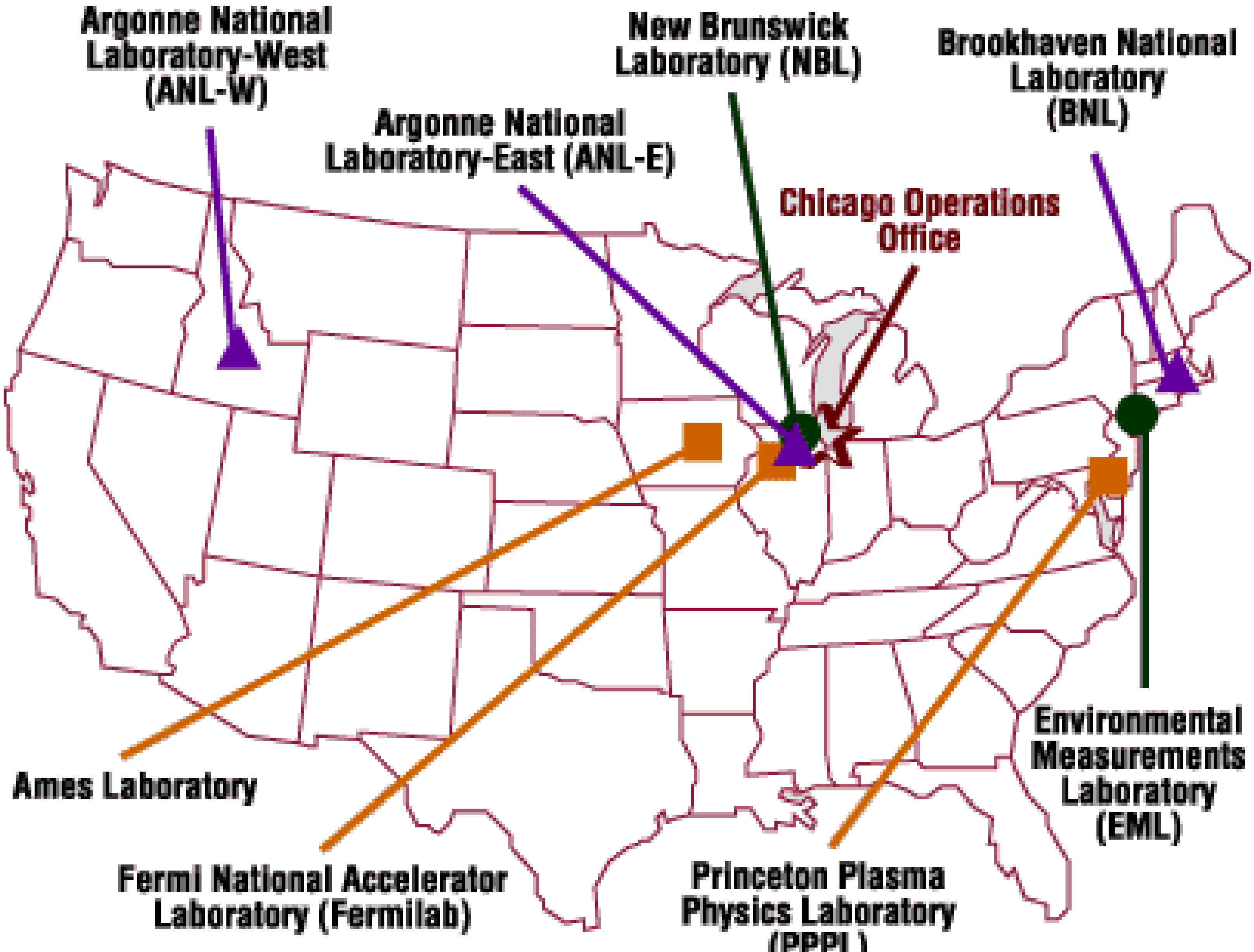
Technical and Administrative Services Group
Group Manager
John P. Kennedy

Financial Services Group
Chief Financial Officer
Larry J. Vann

Legal Services Group
Chief Counsel
Steven A. Silbergleid

Approved: ____________________
James F. Decker
(Acting)
Director of Science

February 2000


Argonne National Laboratory-West (ANL-W)
New Brunswick Laboratory (NBL)
Brookhaven National Laboratory (BNL)
Argonne National Laboratory-East (ANL-E)
Chicago Operations Office
Ames Laboratory
Fermi National Accelerator Laboratory (Fermilab)
Princeton Plasma Physics Laboratory (PPPL)
Environmental Measurements Laboratory (EML)

Welcome

Dr. Yoon Chang

Welcome (Dr. Yoon Chang)

Dr. Yoon Chang - Interim Director of Argonne National Laboratory also welcomed the participants to the annual meeting.

His remarks were the following:

Thank you, Marvin, and good morning everyone. I, too, am pleased to welcome you here today. It is a privilege for Argonne to host this year's electrical safety committee meeting. Certainly, safety - all forms of safety - are very important to us here, as they are to your organizations. And despite the challenges that remain, the safety performance of DOE contractors is - relative to workplaces at large -- quite strong. When we look at our statistics for injury and illness incidence rates, and compare them to private industry, we have room for satisfaction. Figures for both total recordable cases and lost workday cases for all the research contractors is far better than private industry's. And they are comparable to those of private colleges and universities, even though we work in environments which have the potential to be much more severe.

You are all to be commended for your role in this.

We cannot, however, be complacent.

I am sure that one of the reasons we do as well as we do is that we are always very conscious of potential dangers. We must remain alert... And we will -- at least in part -- because of efforts such as the exchange of information that you are participating in today and tomorrow. I am impressed by the range in your agenda, and with the techniques you are looking at and using. I know this will help you maintain our vigilance, and help us make the improvements we still need in our safety records.

While you are here, I hope you will find time to see at least part of our facility. As a multi-program Laboratory, Argonne supports basic and applied research across a wide spectrum of disciplines, ranging from high energy physics to climatology and biotechnology. We have cooperative programs with most of your organizations and, in the last ten years, we have worked with more than 600 companies and numerous other organizations and federal agencies to help advance DOE's mission.

Again, welcome to Argonne. I wish you a productive and enjoyable meeting.

Welcome

Pat Tran

Welcome (Pat Tran)

Pat Tran from EH-51 welcomed the participants to the annual meeting. The attendees introduced themselves and identified the locations they represented.

Electrical Burn Center Virtual Tour

Dr. Mary Capelli-Schellpferrer

Electrical Incident Scenarios With Injury & Death Consequences

Mary Capelli-Schellpfeffer

Incidents and Injuries

- Incident Definition
- Injury Definition
- Characterization of ~600 Incidents

Injuries & Death

- Who is at risk?
- What is the probability of death?
- Are fatal and survivable events fundamentally different?

Incidents + Injuries

- Reported and unreported incidents
- Treated and untreated cases
- Acute and chronic consequences

Incidents + Deaths

- Always reported
- Acutely recognized
- Action results

Clock "Conditions"

- Events: milliseconds
- Investigations: weeks to months
- Litigation: years
- Worker (i.e., survivor) reflexes: seconds
- Critical in acute medical treatment: minutes
- Rehabilitation & RTW: sometimes years

Who is a survivor?

The Survivor Experience

- Event to Hour 1.
- Hour 1 to Hour 8.
- Hour 8 to Hour 24.
- Day 2 to Day 9.
- Day 10 to Day 30
- Day 31 to Day 89.
- Day 90 to Day 119.
- Month 4 to Month 60.

Human Factors. The answer to the question, “Why should I wear PPE?”

- Limits to performance
- Limits to hazard tolerance
- Limits to responses

“Small World” Phenomena

- Incident “learning”
- Communication networking
- Changing “acceptable”

Summary

Thermograph Imaging

Deborah Freeze

Infrared Thermography

And Thermal Imaging

Infrared Thermography

Deborah Freeze
Assistant Maintenance Engineer
Westinghouse Government Services
Waste Isolation Pilot Plant

Infrared Thermography

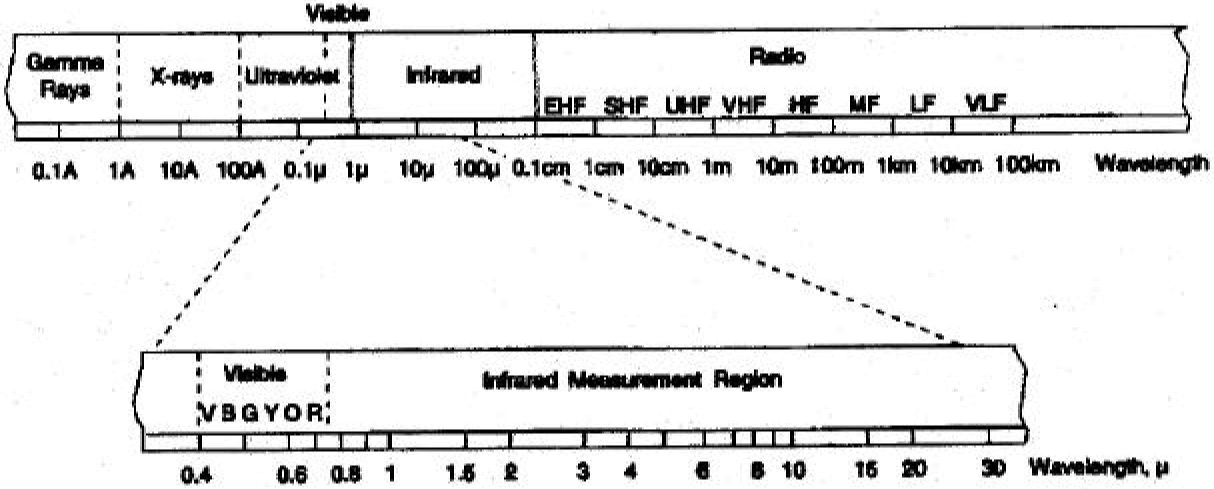
- What is Infrared Thermography?
- Advantages to using Thermography
- Thermography Applications and Thermagram Examples

Infrared Thermography

What is Infrared Thermography?

The ability to measure the electromagnetic energy (infrared radiation) that is emitted by a target to obtain the temperature without contact.

Infrared Thermography



The Electromagnetic Spectrum

Infrared Thermography

Advantages to using Infrared Thermography

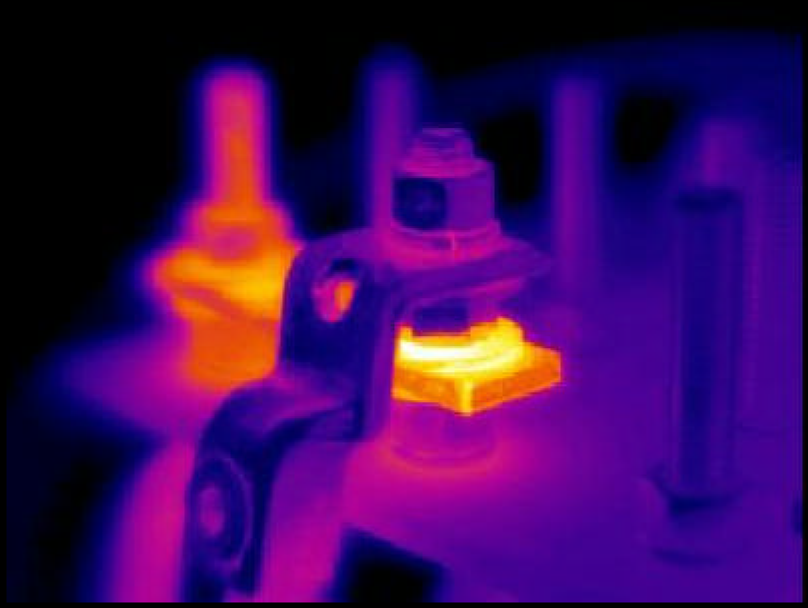
- Locate problems quickly, without interrupting service
- Drastically reduce costly, unscheduled power outages
- Minimize preventive maintenance time and maximize troubleshooting effectiveness
- Prevent premature failure and extend equipment life
- Identify potentially dangerous and hazardous conditions

Infrared Thermography

Thermography Applications

- Electrical Systems
- Mechanical Systems
- Furnaces, Boiler & Kilns
- Steam Systems
- Flat Roofs
- Fluid Levels/Flow
- NDT (Bonding, Thickness, Intrusion)
- Casting & Molding
- Concrete Integrity Inspections
- HVAC Equipment Evaluation
- Medical Injury
- Disease Evaluation
- Printed Circuit Boards
- Equine Injury
- Fire Mapping
- Search and Rescue
- Covert Surveillance

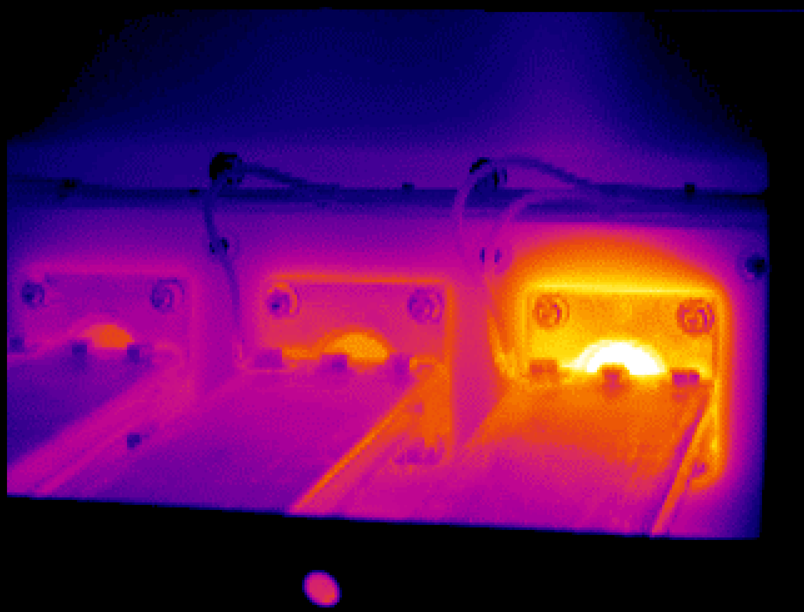
Infrared Thermography



Electrical Inspections

Poor connections, short circuits, overloads, load imbalances and faulty, mismatched or improperly-installed components can be detected.

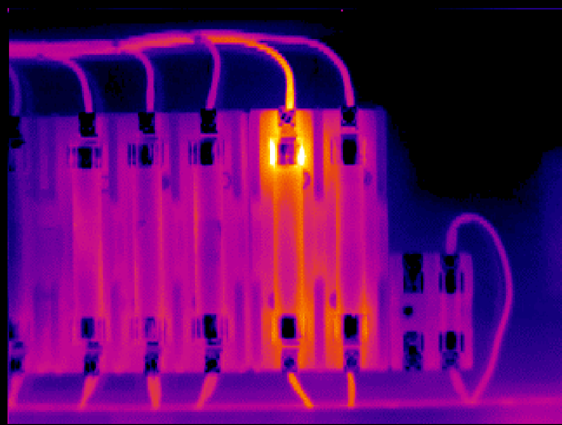
Infrared Thermography

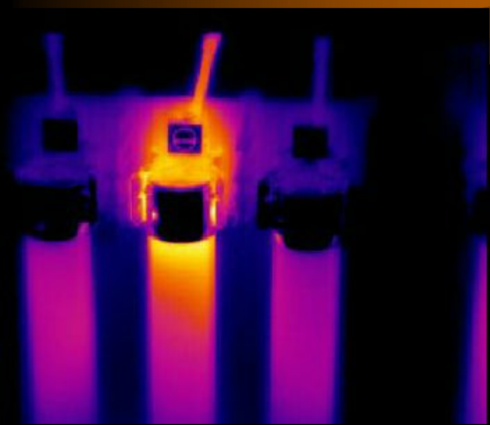


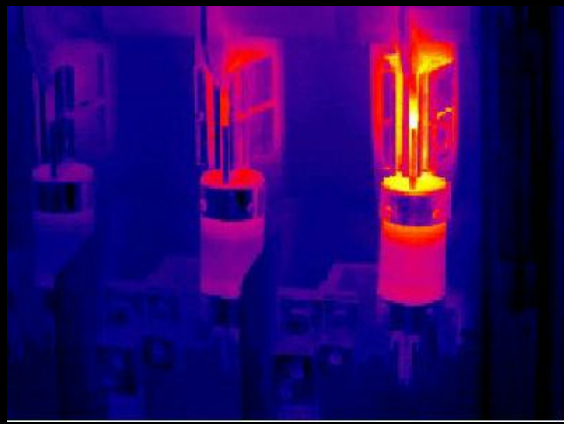
The hot bus stab to the back of this breaker represents a serious problem.

Why?

Infrared Thermography



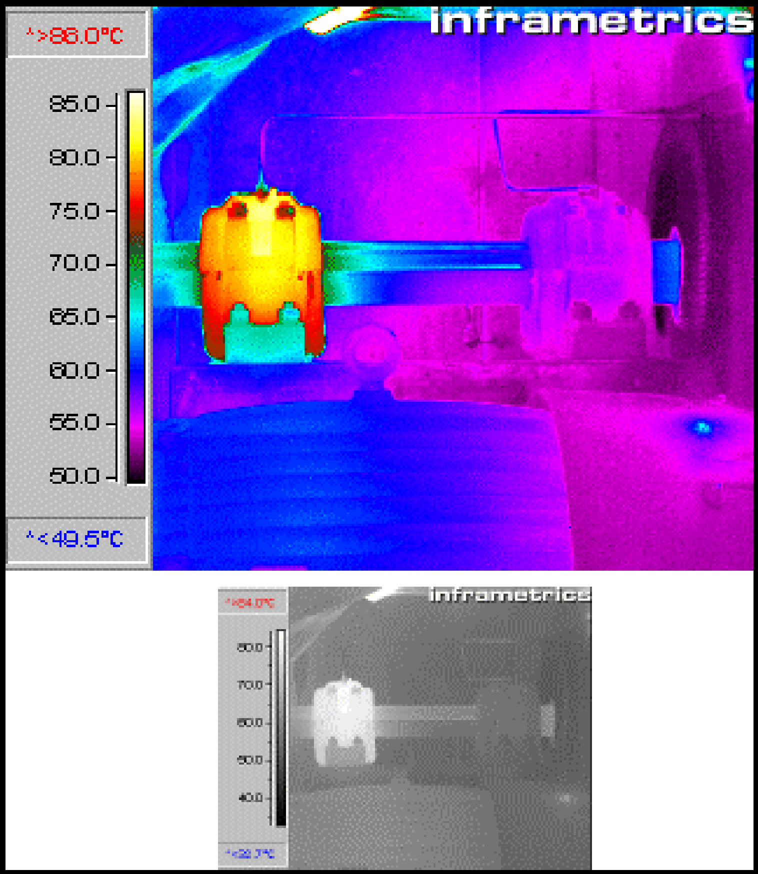




Fuse clips are vulnerable to failure because they depend on spring tension for their electrical integrity.

Infrared Thermography

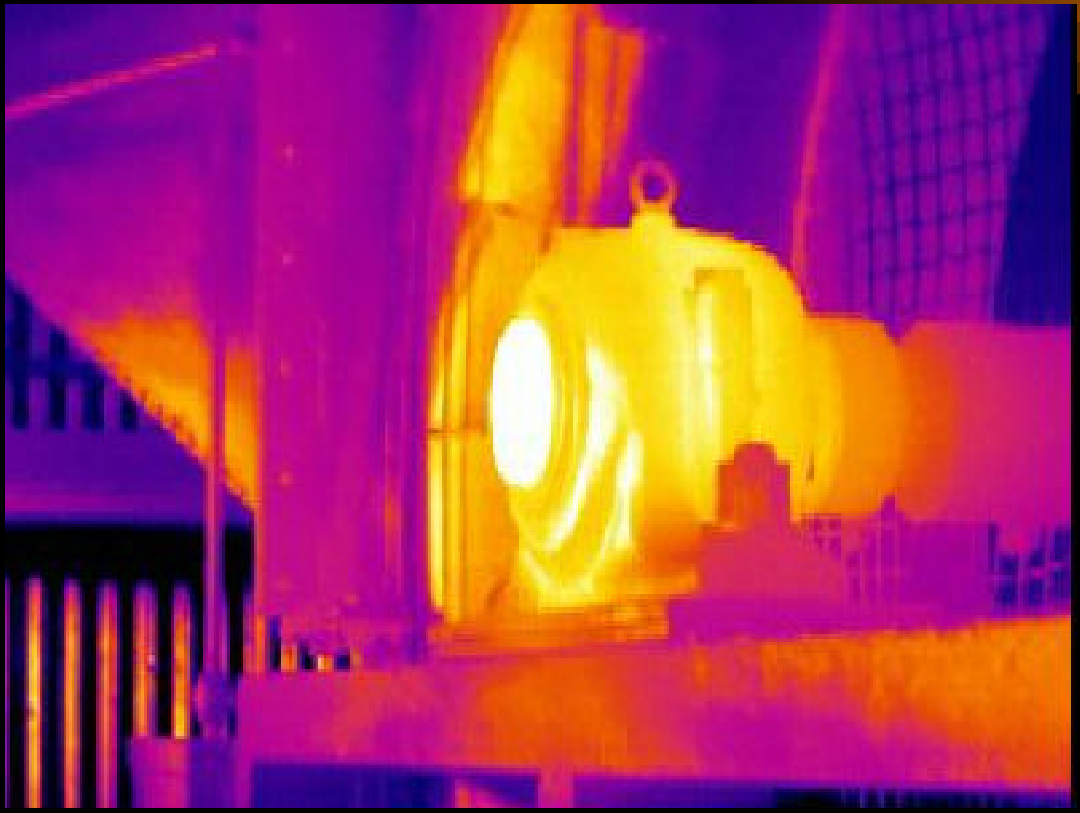
Infrared Thermography



Mechanical Inspections

The ability to detect problems in rotating equipment, such as over heated bearings and misaligned motor shafts (couplings), power transmission, improperly operating steam traps, underground water/steam leaks and MUCH more.

Infrared Thermography

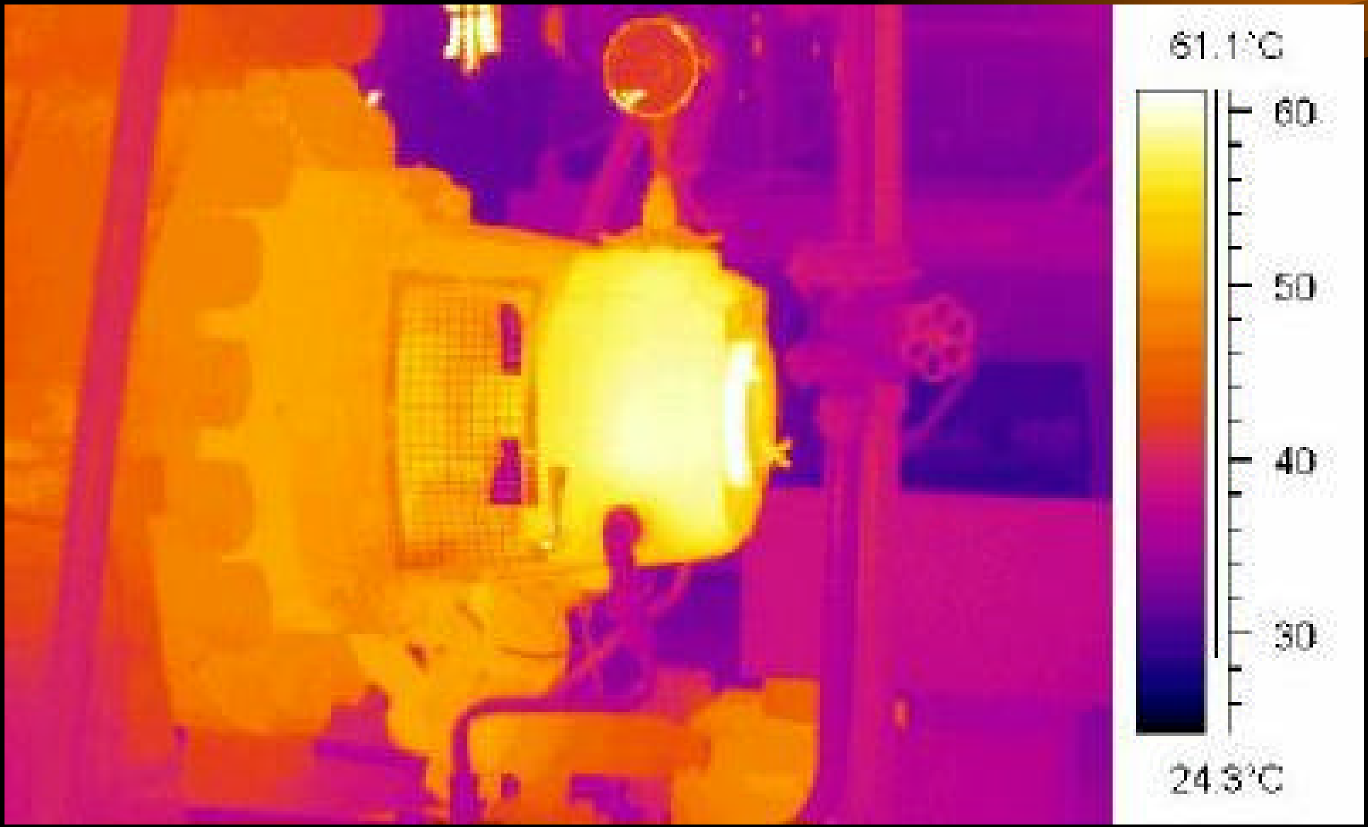


Cooling Fan Bearing

Infrared Thermography

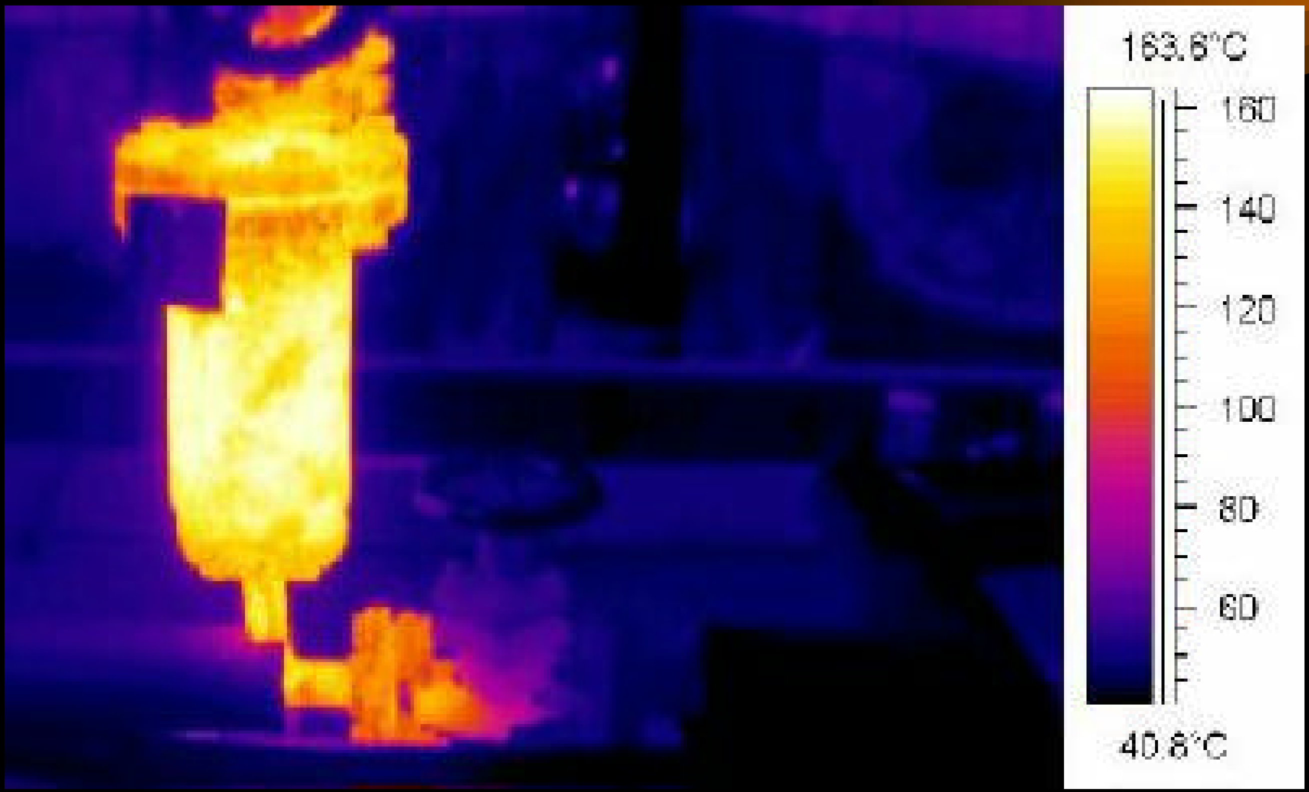
Fiber Production Rollers

Infrared Thermography



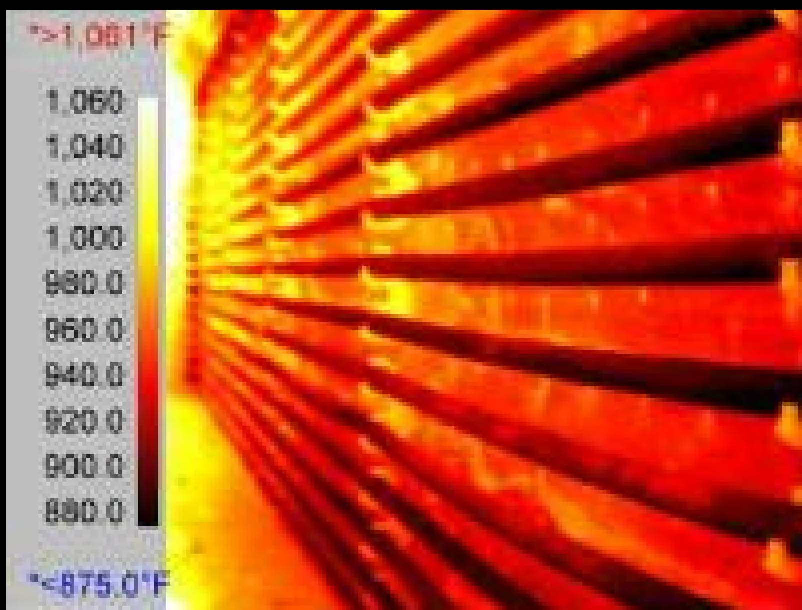
Motor End Bearing

Infrared Thermography



Steam Trap

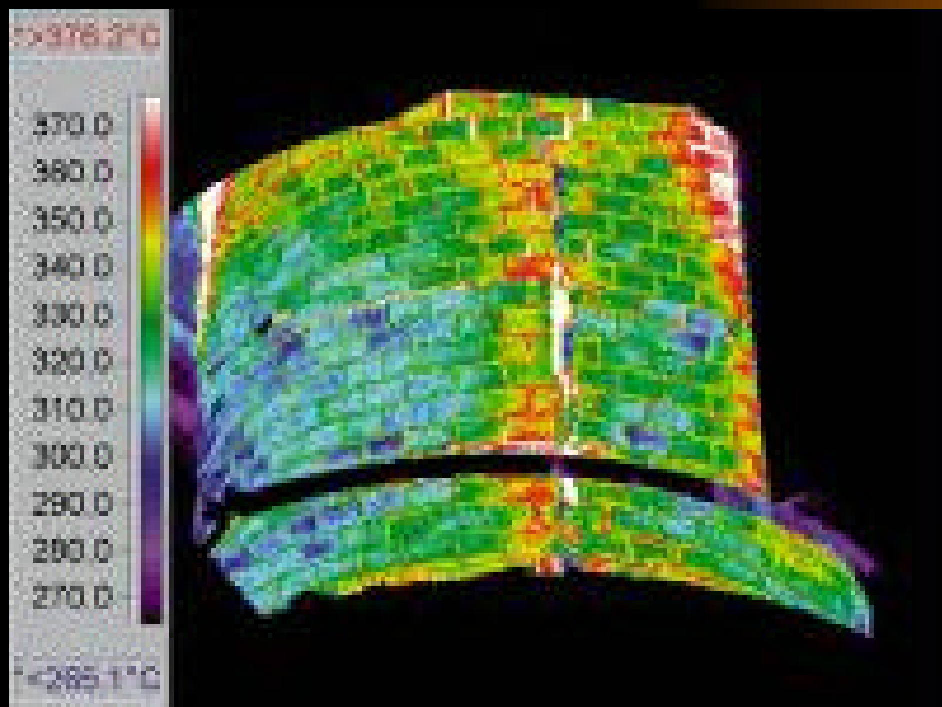
Infrared Thermography



Refractory

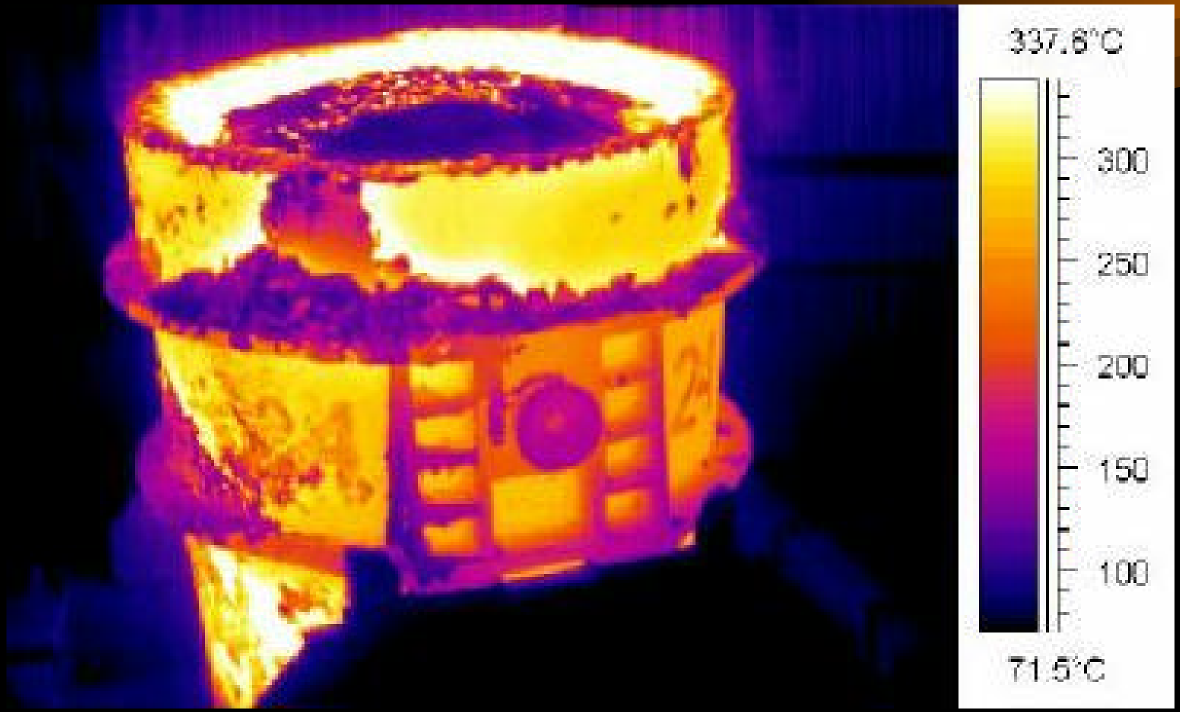
The overall condition of refractory lined vessels such as process furnaces, steel ladles, and rotary kilns can be examined.

Infrared Thermography



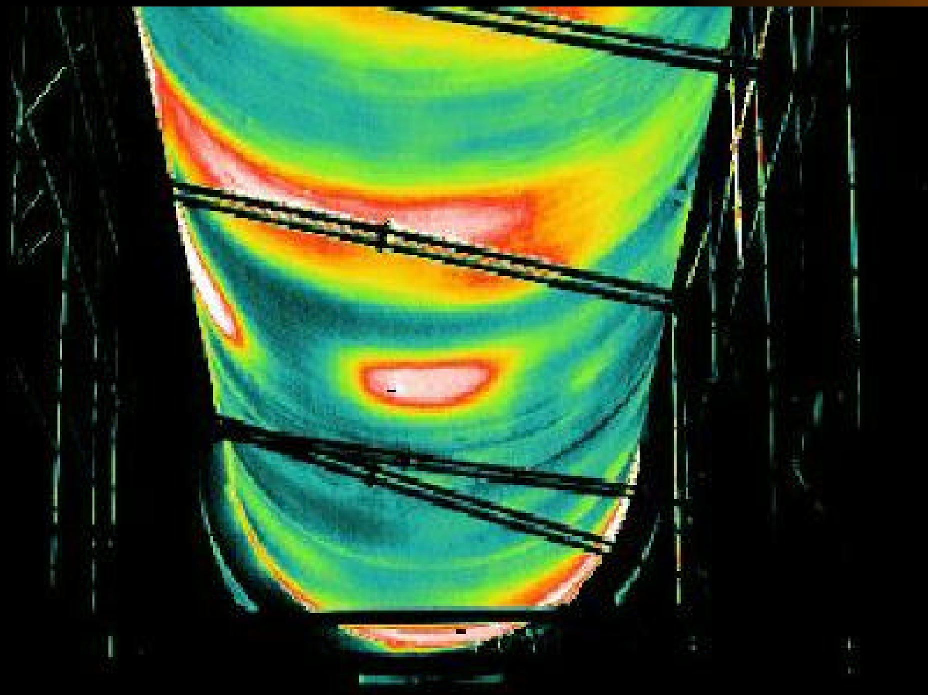
Kiln

Infrared Thermography



Steel Ladle

Infrared Thermography



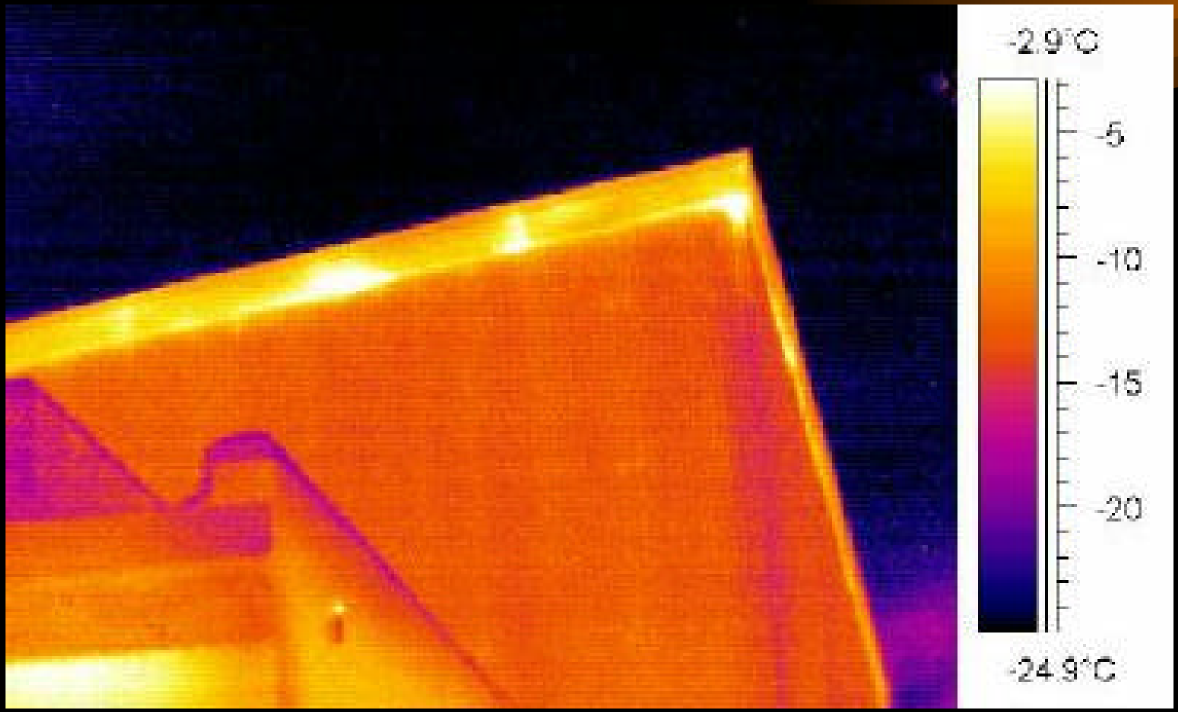
Hot Liquid Duct

Infrared Thermography

Building Diagnostics

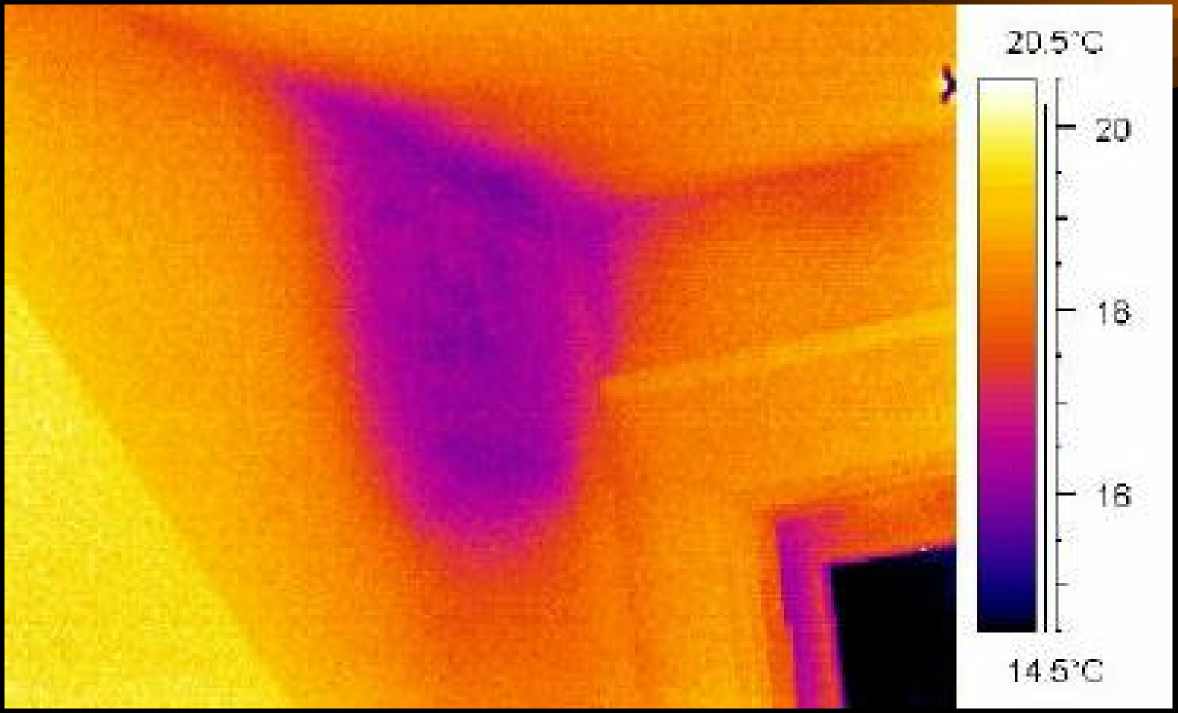
Infrared is helpful in determining missing or insufficient insulation in exterior walls, energy robbing air infiltration, and the water-damaged insulation in insulated roofs.

Infrared Thermography



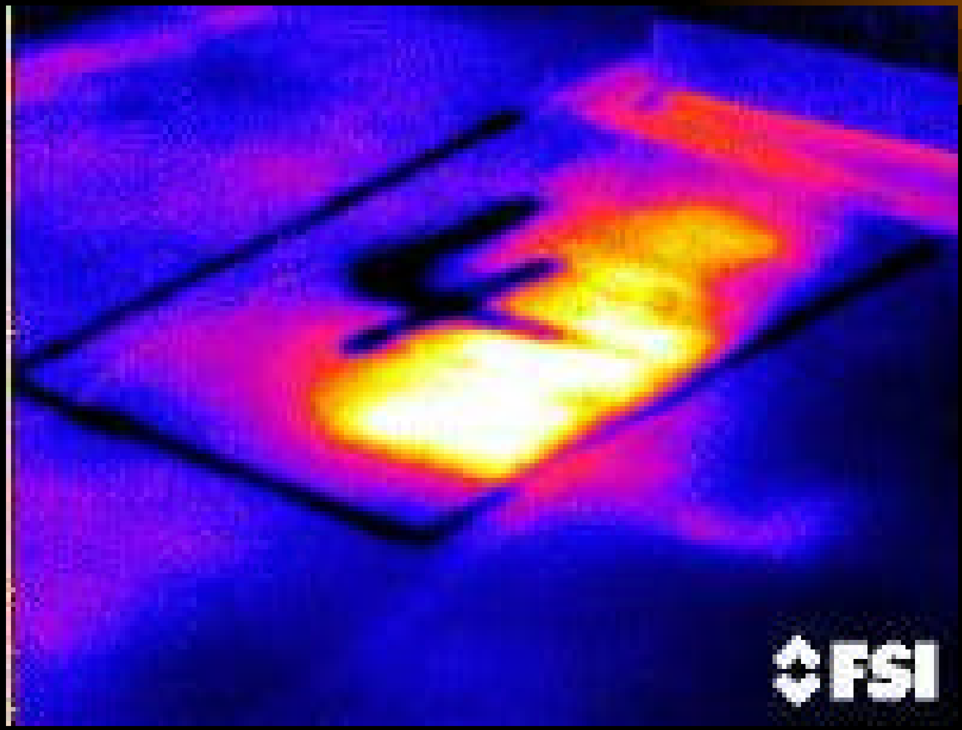
Poor Wall to Roof Joint

Infrared Thermography



Interior Room Water Seepage

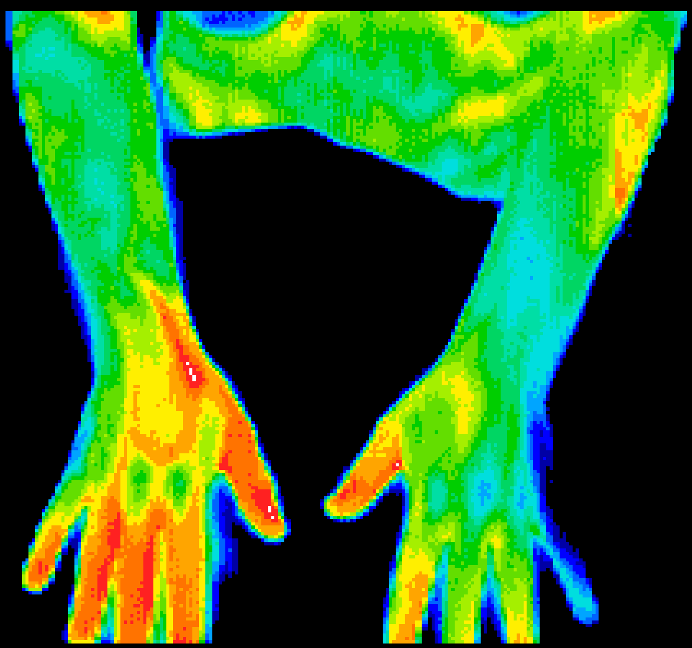
Infrared Thermography



Roof Survey

Infrared Thermography

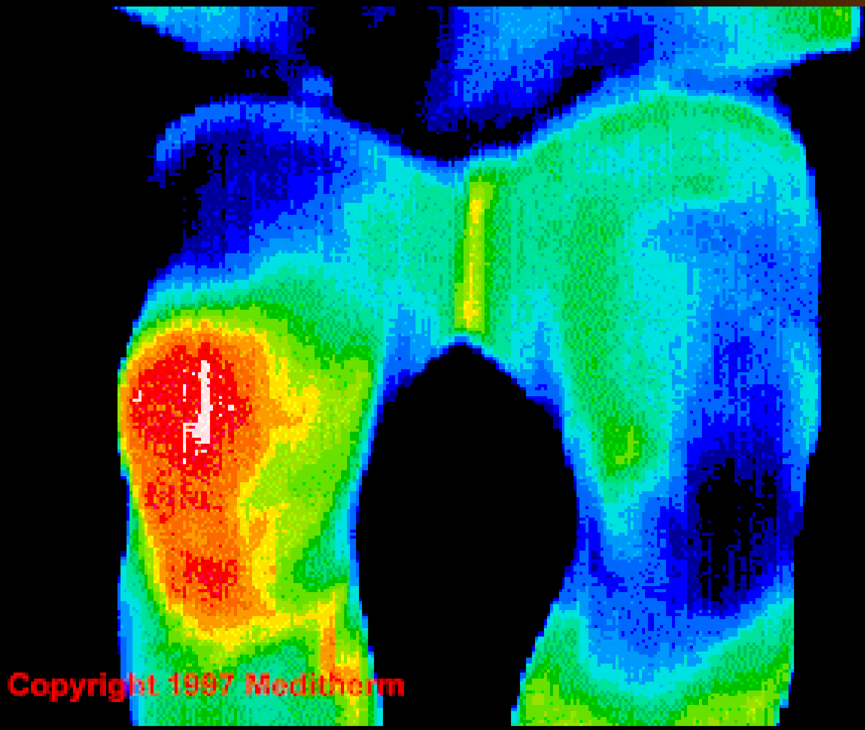
Medical Thermography



Carpal Tunnel

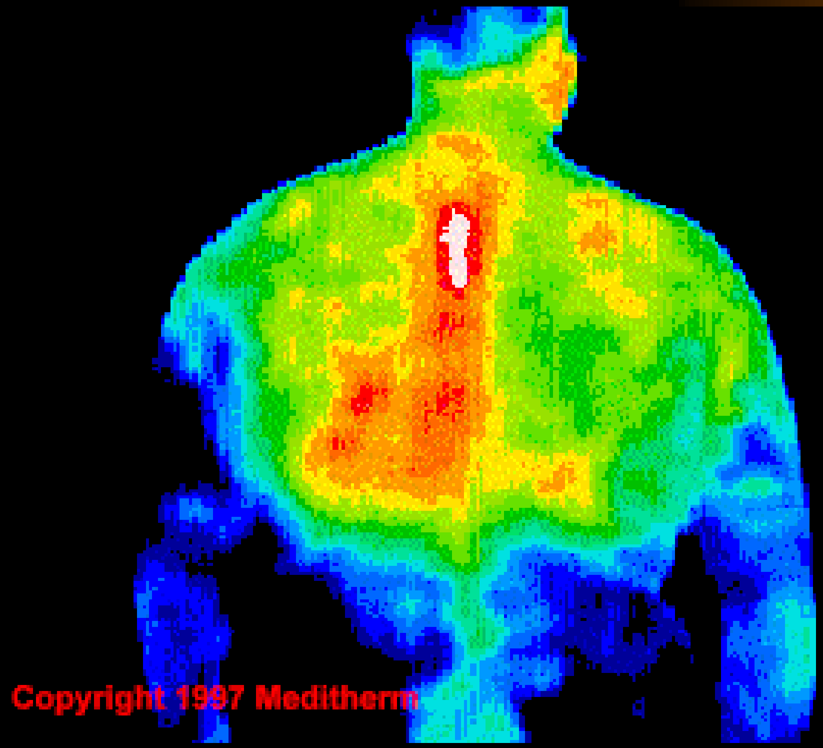
Infrared's non-radiating, non-invasive view of the body provides insights into the status of many physiological systems.

Infrared Thermography



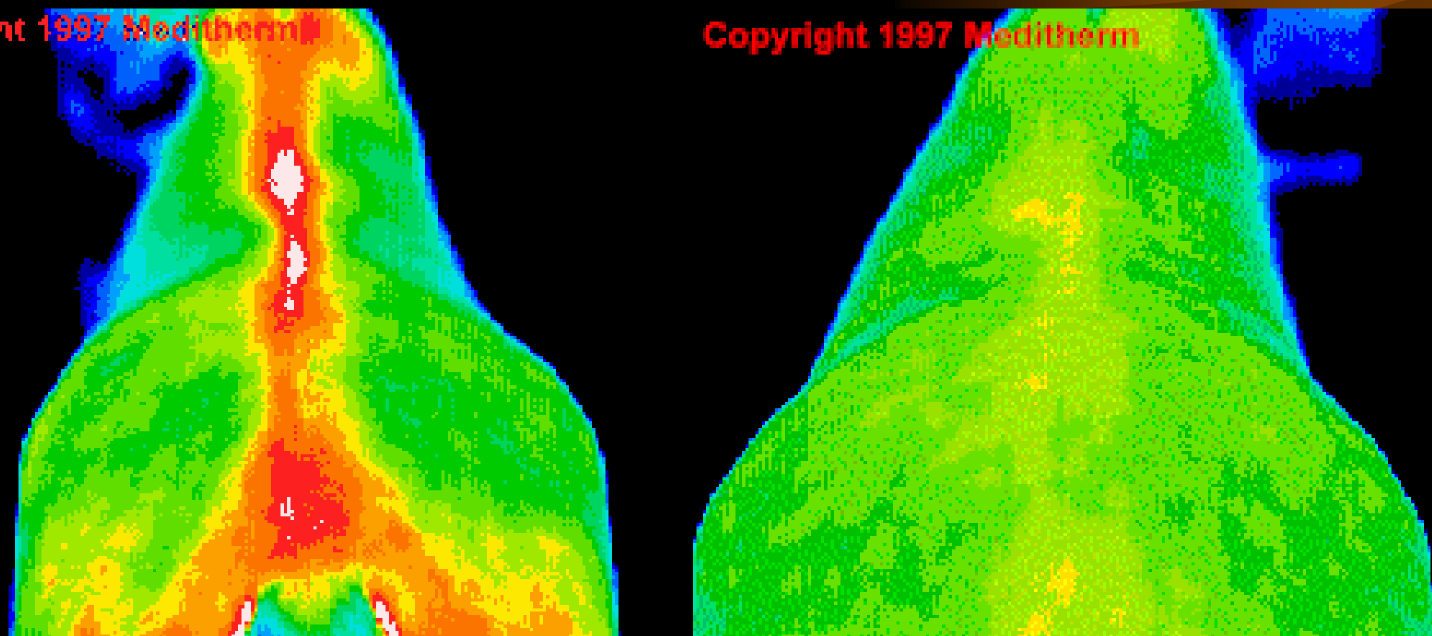
Knee Injury

Infrared Thermography



Vertebrae

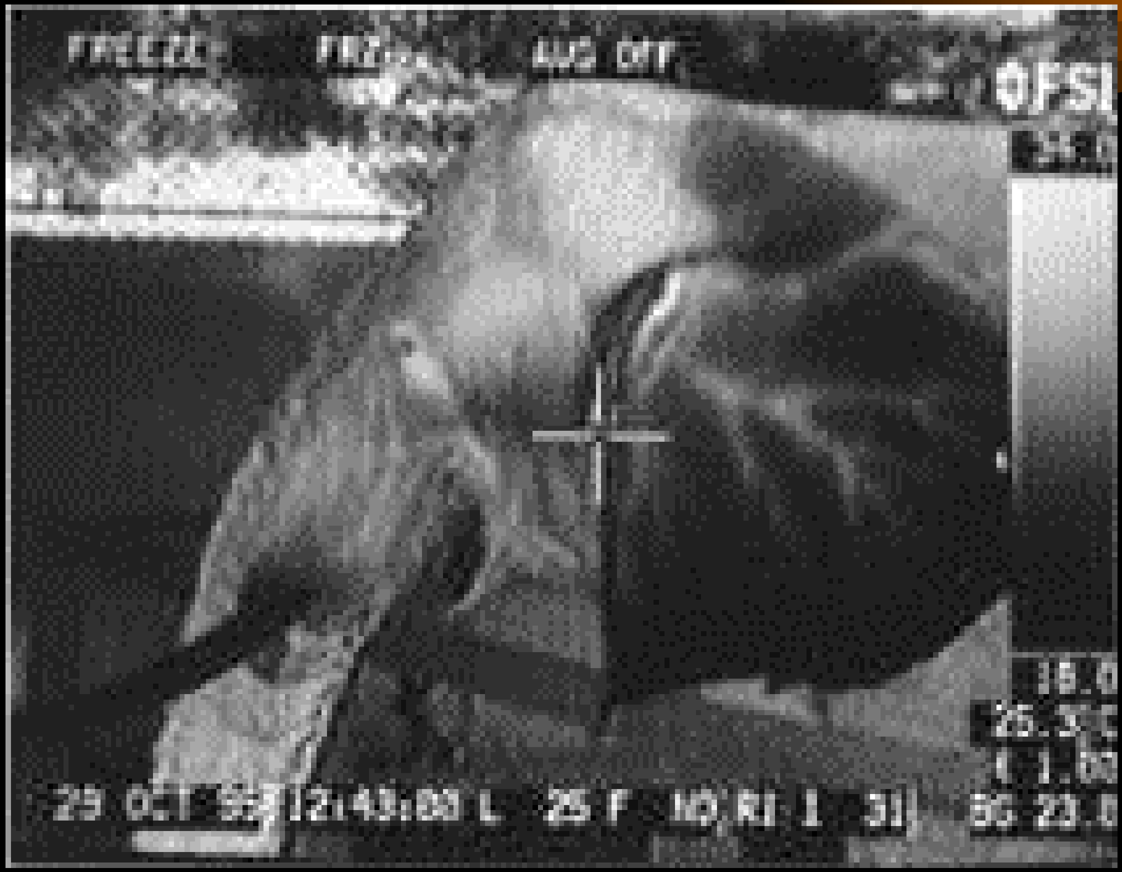
Infrared Thermography



Bad Good

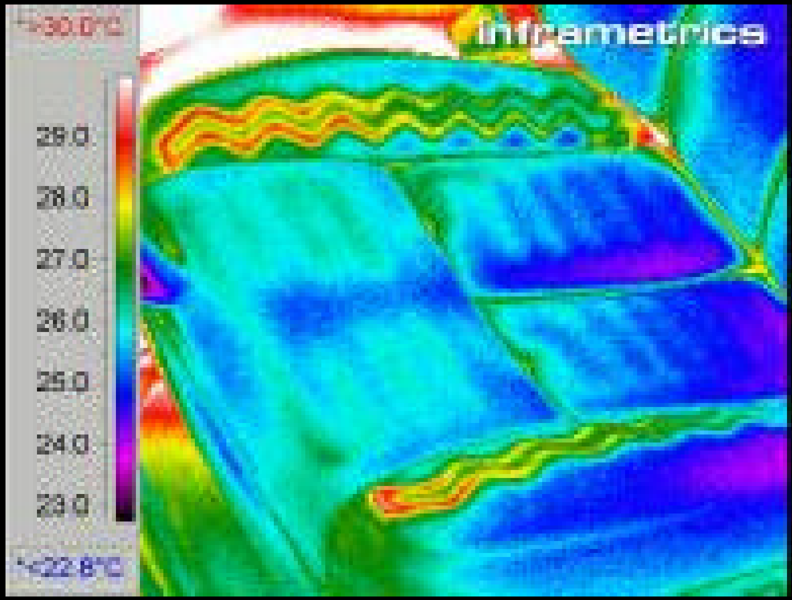
Equine Thermography

Infrared Thermography



Infrared Thermography

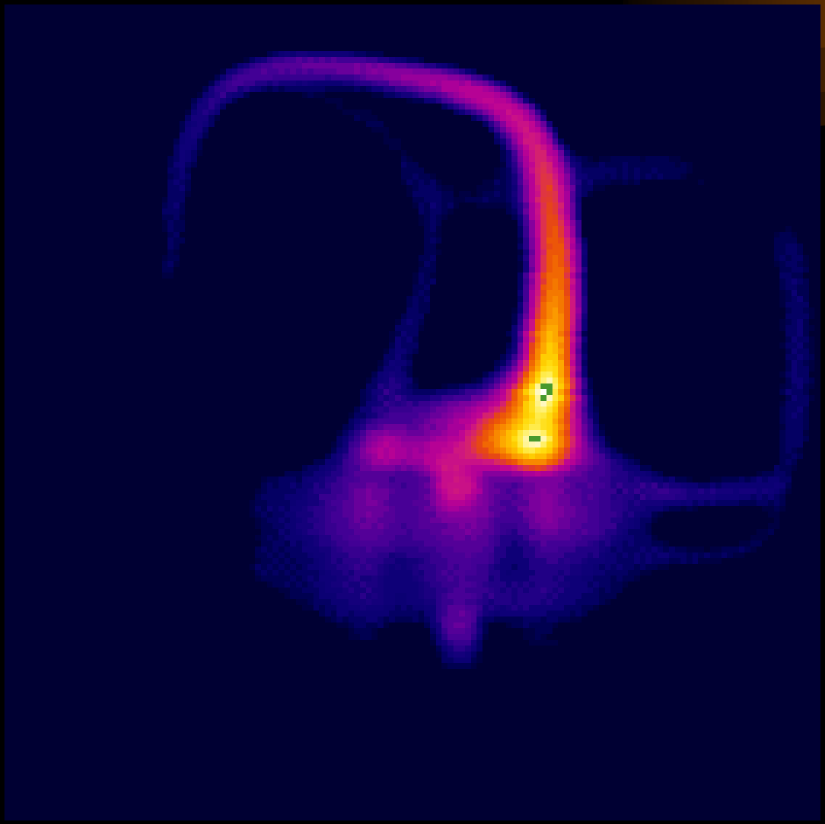
Infrared Thermography



Product Development

Thermography systems can provide valuable information at each stage of product design.

Infrared Thermography



Actual Find at WIPP

Infrared Thermography

Infrared Thermography is a powerful non-contact diagnostic technology that makes visible the heat differences in objects to determine their condition and can save time and money while increasing safety.

Electrical Design Standards for Electronics to be used in Experimental Apparatus

Keith Schuh

Electrical Design Standards For Experimental Apparatus

This document was prepared by members of the Fermilab Staff. It has been approved by the Fermilab Electrical Safety Subcommittee for inclusion into the Fermilab Standards Manual.

Presented at the US Department of Energy Electrical Safety Meeting June 13th and 14th, 2000

Keith W. Schuh

Electrical Design Standards For Experimental Apparatus

- Focus
  - Electrical Design of Experimental Apparatus
- Objectives
  - Create a Safer Work Place
  - Eliminate Accidents
  - Reduce Property Damage
  - Establish Design Criteria
  - Provide Guidance to Experimenters about the Review Process

Electrical Design Standards For Experimental Apparatus

- Source of the Problems
  - Custom Designed Equipment
- Why are these Problems Happening
  - Very few Codes or Standards
  - Frequent Trouble Shooting and Modifications
  - Very few Written Operating Instructions or Procedures
  - People Doing the Work Understand the Theory but Lack Experience

Electrical Design Standards
For Experimental Apparatus

- Identification of Hazards
  - Low Voltage & High Current
    - Printed Circuit Boards
    - Sense Leads for Power Supplies
    - Ribbon Cables
    - I/O Connectors
  - High Power & High Current Distribution
    - Connecting Power Supplies to Back Planes
    - Connecting Copper Bus Bars for Power Distribution
    - Cooling Electronic Equipment
    - Rack Protection

➢ **AC Power Distribution Causes Very Few Problems**

Electrical Design Standards For Experimental Apparatus

- **Electrical Design Standards for Electronics to be used in Experiment Apparatus at Fermilab**

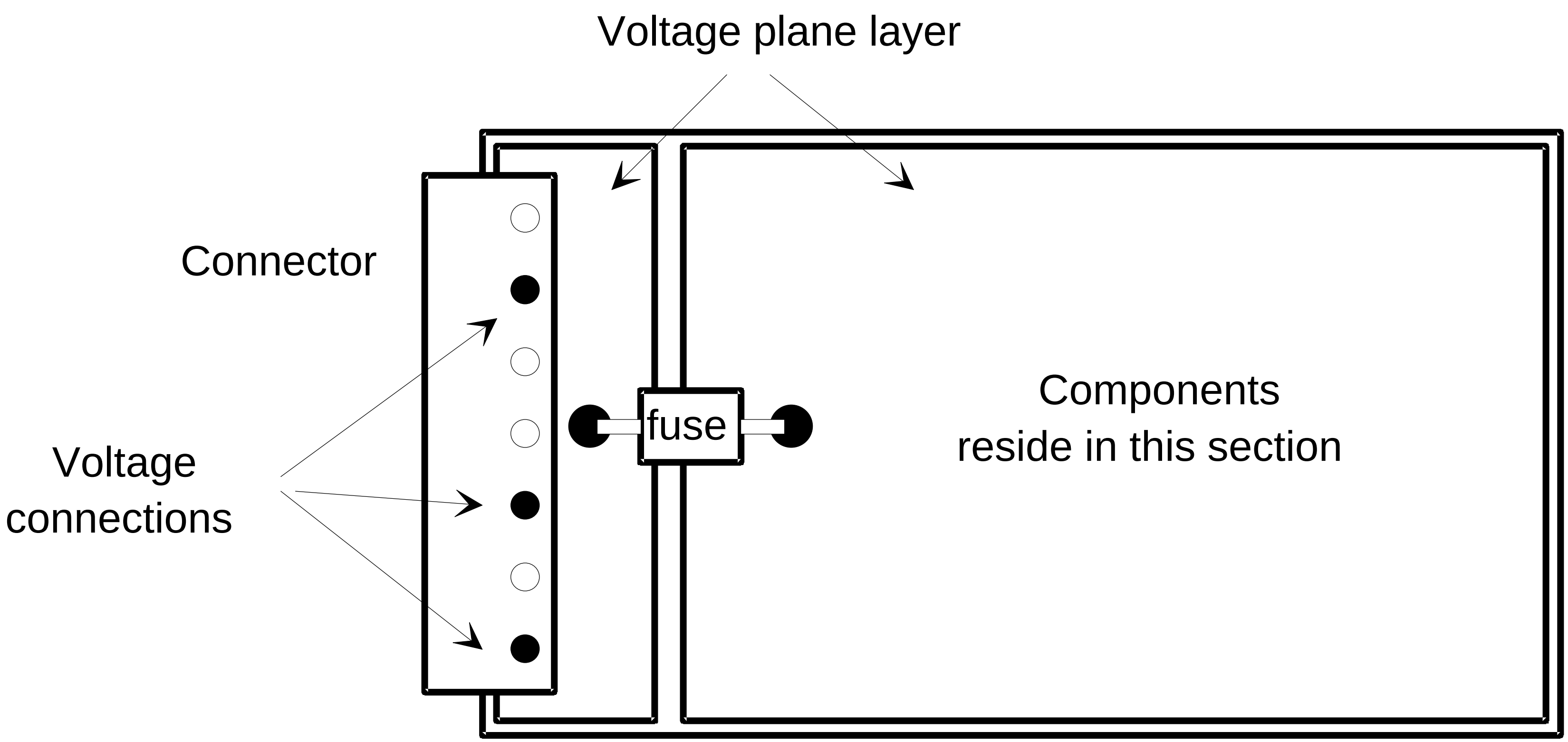
- These electrical design standards are to assist the system designer during the early stages of the experiment electronics design. In addition, they are used by Fermilab appointed reviewers during the safety inspection of experiment electronics installations. These standards have been gleaned from experience as well as from several other sources (see references). The application of these standards early in the design process can lead to simpler and safer designs. It can also speed the approval process for the Operational Readiness Clearance for Experiments which is required prior to the operation of an experiment.
- Commercially available crate-based electronics systems (CAMAC, NIM, FASTBUS, VMEbus, etc.) have been developed in accordance to available standards (IEEE, etc.) and will not, in general, be reviewed. The installations of these systems will be inspected and must meet accepted standards. It is important to note, however, that the non-standard (custom) use of these crate systems must follow these standards. All custom systems will be reviewed.
- Fermilab encourages collaborators to discuss design issues as early as possible and throughout the design cycle. We are happy to hear from you and stand ready to assist you in your design effort. Questions should be directed to your Experiment's Liaison or the Chair of the Engineering Standards Committee. Their phone numbers are available on the Fermilab Web page.

Electrical Design Standards For Experimental Apparatus

- **Over-Current Protection Devices** - Either fuses or resettable positive temperature coefficient (PTC) devices may be used for overcurrent protection of conductors and/or printed circuit boards. Whichever device is used must be sized and applied per the manufacturers recommendations and must have an interrupting current rating greater than the maximum fault current available in the circuit.
- **Over-current Protection for Printed Circuit Boards** - A fuse is required for each voltage that is capable of delivering enough power to damage the board in the event of a short circuit. The fuse should be located electrically between the power pins and the components on the card. For multilayer printed circuit cards, pins that distribute power at the same voltage level should be connected to a common section of the power plane, separate from the rest of the power plane. The fuse should then be used to connect this isolated section with the remainder of the plane. The fuse rating should be high enough to handle the inrush current at power-up yet small enough to blow before an over-current situation causes damage to the board or components on the board (beyond the cause of the over-current condition.)
- **Over-voltage Protection for Printed Circuit Boards** - A transient-voltage-suppressor (TVS) is required to address the situation where a power supply goes out of regulation or an accidental, external connection causes a voltage that is higher than the acceptable maximum to be presented to the power connections of the printed circuit board. A TVS must be wired in parallel with the load being protected, and on the load side of the fuse Each of the various voltage planes should have its own TVS installed between the voltage plane and ground. Should the power supply cause a voltage excursion above the TVS's clamp voltage, the TVS will conduct at the clamp voltage. This will cause a large current to flow through the fuse, thereby causing the fuse to blow. After the fuse blows the card is no longer in danger of being damaged by the over-voltage condition. If the transorb that is used in the design is selected carefully, by taking into account the fuse value and operating voltage, the transorb should not be damaged in an over-voltage incident. The intent is to limit the damage that results from an over-voltage condition to that of several blown fuses in a crate. This is certainly preferable to components being destroyed and, in the worst case, catching fire. However, it also means that provisions must be made to be able to replace blown fuses in an efficient manner so as to minimize the down-time of the experiment. Tests conducted at Fermilab indicate that General Semiconductor Industries, Inc., ICTE-5 transorb is a good choice for DC voltages of +5 volts and also for -5.2 volts for fuses like the Littlefuse 251000 series up to 10 amps. One must match the capability of the TVS with the fuse.

- **Powering Printed Circuit Cards**
- For multilayer printed circuit boards it is common practice to utilize a layer of copper foil for power distribution and another layer for ground return. The connector manufacturer will rate a connector pin for the maximum current that it can carry. Pins may be connected in parallel when a greater amount of current is required than one pin can carry. However, the current carrying capacity of each pin must be derated. This is to account for the fact that, due to differences in the resistance of the paths (which include the pins), an unequal amount of current will flow through the various pins. The pin that is in the lowest resistance path will carry a greater portion of the total current then a pin in a path with higher resistance. The total current will be determined by the load presented by the circuit board. If the system is implemented in a fashion that requires all pins to carry the maximum rated current then some pins will carry a greater amount of current than is allowable because some pins will carry less due to their higher resistance. A rule of thumb is to use 2/3 capacity, i.e., a single pin rated at 3 amps may be considered to handle 2 amps when multiple pins are in parallel. Boards powered in this fashion should not be plugged in “live” because the first pin making contact must handle all the current.

Electrical Design Standards
For Experimental Apparatus



Connector pins that carry the power to the circuit board are connected to the portion of the voltage plane layer that is directly under the connector. Current for the components on the circuit board flows through the fuse.

- **Ground Returns on Printed Circuit Cards (*operational problems*)**

- To keep the inductance in a signal return path down to a reasonable value it is required that the designer ensure that an adequate number of pins are reserved for return signals. When many digital signals are changing simultaneously on the data or address lines on a circuit card a great deal of instantaneous current will flow through the ground pins. (Another occurrence that causes a great deal of current to flow is the refresh cycles on a board that is heavily populated with dynamic RAM memory.) Pins and traces act as inductors in parallel. With few pins, the inductance and current can be high enough to cause a significant shift in the voltage potential of the ground pins. As more pins are used for the ground returns the magnitude of the voltage shift is reduced. Wider traces will help reduce the inductance and decrease noise. A calculation should be done to determine the magnitude of voltage shift that can be expected.

Electrical Design Standards For Experimental Apparatus

Copper is the only conductor to be used. Table 1 tabulates the minimum wire size required for a given available maximum current (ampacity). This table has been derived from several sources and the ampacities are conservatively specified taking into account: bundled conductors, limited air flow and 30°C (86°F) ambient. Insulation material must be rated for 90°C (194°F) minimum. The use of this table will result in a conservative design for the typical environments seen in experimental areas. It reduce design difficulties if used early.

Higher temperatures or other unusual conditions may require larger wire size and/or different insulation material. Special conditions that may require conductors outside of those specified in Table 1 must be reviewed by Fermilab Division Safety personnel.

Conditions				
	Copper Temperature		**75°C**	**167°F**
	Ambient Temperature		**30°C**	**86°F**
SIZE in AWQ, MCM	**AMPERES Number of conductors bundled together**			
	1 to 3	**4 to 6**	**7 to 24**	**25 to 42**
30	1.6	1.4	1.2	1.1
28	2.4	2.2	2	1.7
26	3.2	3	2.7	2.3
24	4.8	4.3	3.8	3.2
22	6.4	5.8	5	4.3
20	8	7	6	5
18	12	11	9	8
16	15	14	12	10
14	20	16	14	12
12	25	20	18	15
10	35	28	25	21
8	50	40	35	30
6	65	52	46	39
4	85	68	60	51
2	115	92	81	69
1	130	104	91	78
1/0	150	120	105	90
2/0	175	140	122	105
3/0	200	160	140	120
4/0	230	184	161	138
250	255	204	179	153
300	285	228	200	171
350	310	248	217	186
400	335	268	235	201
500	380	304	266	228

Electrical Design Standards For Experimental Apparatus

Table 2 is included since copper bus is often used for detector power distribution. Table 2 clearly shows that for any given cross-section there is a substantial temperature rise for higher currents. Consequently, the one square inch per 1000 amperes is the maximum recommended design parameter (see item “d” in the General Considerations section below). The temperature rise must be taken into account when designing the power distribution bus.

Size	Cross-sectional Area		Weight per foot, pounds	DC Resistance, Micro ohms per foot	Skin Effect Ratio	60-Cycle Current rating, Amperes	
Inches	Square inches	Cir. mils, thousands				30°C rise	65°C rise
1/8 x 7/8	0.1094	139.3	0.4226	76.46	1.00	220	360
1/8 x 1	0.125	159.2	0.483	66.9	1.00	240	400
1/8 x 1-1/2	0.1875	238.7	0.7245	44.6	1.01	340	560
1/8 x 2	0.25	318.3	0.966	33.45	1.02	440	720
1/8 x 2-1/2	0.3125	397.9	1.208	26.76	1.02	530	880
1/4 x 1/2	0.125	159.2	0.483	66.9	1.00	210	350
1/4 x 3/4	0.1875	238.7	0.7245	44.6	1.01	290	470
1/4 x 1	0.25	318.3	0.966	33.45	1.02	360	590
1/4 x 1-1/4	0.3125	397.9	1.208	26.76	1.02	430	710
1/4 x 1-1/2	0.375	477.5	1.449	22.3	1.03	500	820
1/4 x 1/3/4	0.4375	557	1.691	19.11	1.04	560	930
1/4 x 2	0.5	636.6	1.932	16.73	1.04	630	1050
1/4 x 2-1/2	0.625	795.8	2.415	13.38	1.05	750	1250
1/4 x 3	0.75	954.9	2.898	11.15	1.07	860	1450
1/4 x 3-1/2	0.875	1114	3.381	9.56	1.09	990	1650
1/4 x 4	1	1273	3.864	8.36	1.10	1100	1850
3/8 x 3/4	0.2813	358.1	1.087	29.73	1.02	370	610
3/8 x 1	0.375	477.5	1.449	22.3	1.03	460	750
3/8 x 1-1/4	0.4688	596.8	1.811	17.84	1.04	540	890
3/8 x 1-1/2	0.5625	716.2	2.174	14.87	1.05	620	1050
3/8 x 1-3/4	0.6563	835.6	2.536	12.74	1.06	700	1150
3/8 x 2	0.75	954.9	2.898	11.15	1.07	770	1300
3/8 x 2-1/2	0.9375	1194	3.623	8.92	1.10	920	1550
3/8 x 3	1.125	1432	4.347	7.43	1.12	1060	1750
1/2 x 1	0.5	636.6	1.932	16.56	1.04	550	910
1/2 x 1-1/4	0.625	795.8	2.415	13.24	1.05	650	1050
1/2 x 1-1/2	0.75	954.9	2.898	11.04	1.07	740	1200
1/2 x 2	1	1273	3.864	8.28	1.10	900	1500
1/2 x 2-1/2	1.25	1592	4.83	6.62	1.15	1070	1800
1/2 x 3	1.5	1910	5.796	5.52	1.18	1230	2050

Ribbon Cable for Power Distribution

Ribbon cables can be a special problem when they are used to carry power supply currents. They are usually small gauge (28 AWG) and generally do not have 90°C insulation as required in these standards. For example, in many experiments, ribbon cables are used to provide power to printed circuit boards as well as carry signals, e.g., multiwire proportional chamber systems that use banks of Nanometric N277-C amplifiers. It is not unusual that the ribbon cables carry several amperes of current. A short circuit in any one printed circuit board could cause excessive current flow in the ribbon cable with the potential of cable overheating, insulation failure, and fire. To minimize this possibility, the following apply:

1. The length of all 28 AWG ribbon cables used for power distribution in excess of one (1) ampere shall be less than 15 feet long.
2. The maximum current through any single conductor in the ribbon cable shall be limited to 2.4 amperes.
3. In applications where several (2 to 6) conductors in one ribbon cable are used in parallel to carry currents in excess of 3 amperes total, a maximum of 2.2 amperes per conductor is permitted. The limits of Table 1 must be applied for greater than 6 conductors.
4. Each parallel wire is to be bonded solidly together at the power supply and load connections so as to prevent one of the parallel wires from carrying more than its share of the load current.
5. In addition, misalignment of plugged in printed circuit cards could lead to excessive conductor current. Therefore, mechanisms to prevent such misalignment shall be employed. (*Keying*)

Remote Sensing for Power Supplies

In detector electronics systems, the "bulk" power supply is often located some distance from the electronics. Remote sensing is often used to minimize the deleterious effect that long power leads have on voltage regulation at the load. In most cases the sense wires are small in gauge, at least as long as the power leads and are connected from the load connection to the sense inputs on the power supply. If connected this way, and a short circuit inadvertently develops anywhere along their length, these wires will likely fail. Several methods are available to solve this problem, e.g., fuses or current limiting resistors can be installed at the load side sense connection as shown schematically in Figure 2. Sizing the sense wire to carry the total load current is a possible solution, but is not appropriate in most cases. Note that for most power supplies, shorted sense inputs results in increased output voltage and higher output current.

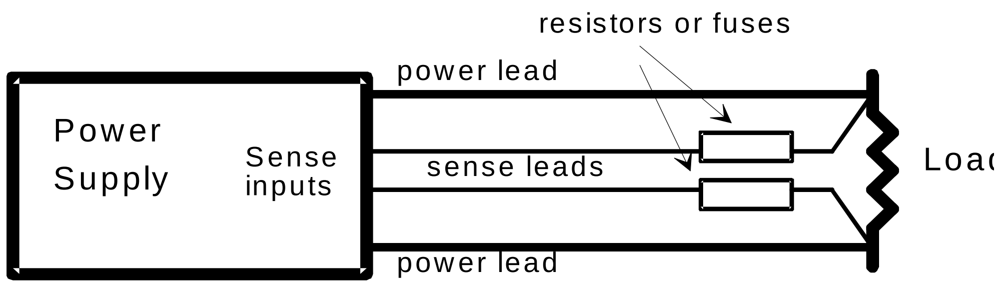


Figure 2.

General Considerations for Power Distribution

a. Splices should be kept to a minimum and preferably not used at all.

b. All connectors, lugs, terminals, etc., must be of copper. Tinned copper is preferable. Stainless steel or silicon-bronze nuts and bolts are recommended for joining copper flags or lugs. Copper or brass bolts should not be used for power connections where greater than 50 amperes is possible.

c. All wires should have strain relief at the connection points. Stud and lug connections are a special problem and should be restrained to prevent accidental rotation and a loose connection. Belleville washers can be of value with these connections.

d. All current distribution bus shall be copper and have a cross section of at least one square inch per 1000 amperes (see Table 2).

e. All bolted connections shall have a contacting bus surface area of at least one square inch per 1000 amperes.

f. Bolted connections must have a contact pressure of 2000 pounds per square inch.

g. Soldered connections should not be used for connections carrying greater than 50 amperes. Silver brazing is acceptable.

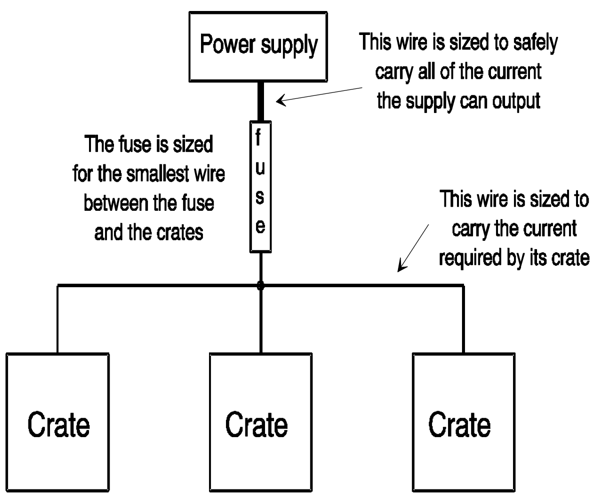
h. The operating temperature of copper bus can easily reach 100°C (212°F). The bus operating temperature must be compatible with the insulation rating of the connected load cables. Note that any fuses used should be mounted away from a bus that operates at elevated temperature. Elevated fuse temperatures will cause premature fuse failure.

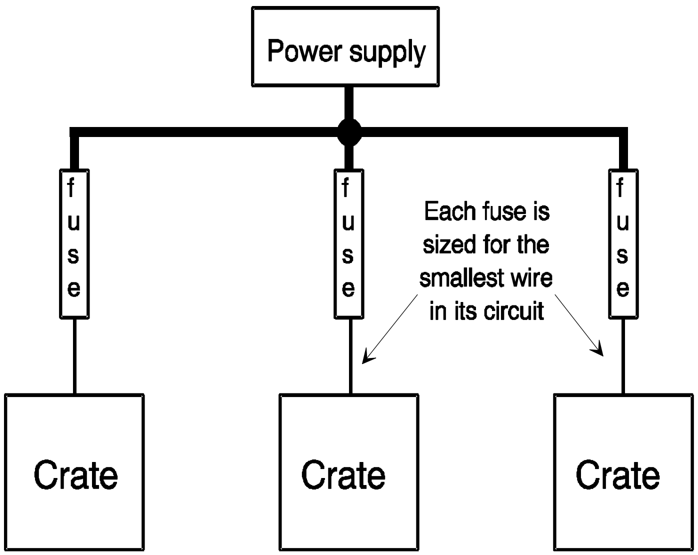
Connections From the Power Supply to the Backplane

Any connector that is used in power distribution must be rated to carry the maximum current that may be presented either from the power supply itself or, if a fuse is located between the connector and the power supply, from the fuse. Additionally, the design of the connector should be such that it would require a significant amount of effort to accidentally short two of its conductors together. Note that when power connections are secured with a bolt or screw, the connection must be designed so that surfaces other than the bolt or screw can carry the rated current.

Copper bus bar used to distribute power along the backplane should be fabricated with a cross section that is large enough to ensure that the current density is kept to under 1000 amps per square inch. Copper bus bar should be clean and flat to minimize the resistance of the connection.

When connecting a power supply to multiple crates all cables must be protected from the effects of a short. One way is to size the wire to safely carry the maximum current the power supply can output. When using wire that cannot safely carry the power supply's maximum current, a fuse is required to prevent the wire from overheating.





Power Dissipation of Printed Circuit Boards

As a "rule of thumb," the power density of a circuit card should be limited to a maximum of 1/2 watt per square inch. Areas of the board may be allowed to have a greater power density but arrangements should be made to ensure that the heat is dissipated effectively and without inducing hot spots on other parts of the board or on adjacent boards.

Cooling of Electronics Chassis

The use of natural convection to cool electronics is desirable. For greater heat loads, forced air cooling utilizing fans is the next choice. When the power density of the electronics is greater than what can reasonably cooled with fans, then water-cooled heat sinks or air/water heat exchangers are utilized. However, water cooling increases the complexity of an installation and adds another source of problems during the operation of the experiment. The design should be such that the cooling fluid, be it air, water, or some other, should not vary more than 10°C over the area of the board. This is to keep the loss in noise immunity in the electronics, which is caused by difference in temperature, to a reasonable amount.

The temperature of the cooling water can become a problem. If the temperature of the water is below the dew point of the ambient air then water will condense and drip onto the electronics. The dew point is likely to be highest during the hot summer months, precisely when one needs the most cooling performance from the system. A goal is to have the electronics operate with the coolant between 30° and 40°C. This is adequate to prevent condensation in almost all cases and minimizes the loss of noise margin due to large temperature differences between components with signal connections on the circuit boards being cooled.

Whichever system is chosen, good air flow is necessary in order to ensure that the cooling air passes over the electronic components that need to be cooled. When empty slots on the front of the crate are not covered by blank panels, the cooling air encounters a low impedance at the opening and a large percentage is forced out the front rather than up past the components on the upper portion of the cards. Install blank front panels on the front of empty card slots to alleviate this loss of cooling effectiveness.

For systems that require yet higher cooling performance one must consider that, even with blank front panels in place, the empty slots will present a lower impedance to the air flow than slots which have cards present. A greater volume of air will flow in the empty slots causing less air to flow in the occupied slots. An effective, though somewhat costly, solution is to populate the empty slots with dummy cards that present the same impedance to the flow of cooling air as the printed circuit cards do. This approach will not be required in most installations.

Rack Protection

When there is a large investment in the cost of the equipment that will be in a rack and when the equipment is custom made (as opposed to off-the-shelf commercial electronics), a device to detect faults in the system and shut the system down when a fault occurs should be considered. A rough rule of thumb is that when custom electronics can be protected for 10% or less of its cost, then a rack protection system should be considered. Parameters that can be monitored include: temperature, smoke, voltage, cooling air flow, cooling water flow, condensation/water leakage, and current. Sophisticated rack protection systems have been fabricated for approximately $2500 per rack. Systems that have a reduced set of parameters to monitor may cost less. Note that rack protection systems which monitor the voltage on high-current conductors must have the monitoring points protected from the hazard of an over-current situation caused by a short circuit on the monitoring wire.

I/O Connector Location An issue that often entails tradeoffs is the method of connecting I/O cables to the cards in a chassis. If the location of the connectors is the front panel of the cards then it is easy to get to the connector on a card in a sparsely populated chassis. However, if there are 26 cards in a chassis, with each having one or more cables running to it, the front of the chassis can become a jumble of cables. This creates a routing problem for positioning the cables themselves and additional problems with having enough room to remove the cables to a particular card, draw the card out of the chassis, replace the card, and then reconnect the cables.

If the location of the I/O connections is the back of the circuit board then provisions have to be made to make the connections. Some of the standard bus backplanes used at Fermilab do have provisions for this. Examples include VMEbus and FASTBUS which have, as part of their specifications, user-defined pins on the backplane which are not bussed but go straight through the backplane to a connector mounted on the back side of the backplane to which an I/O connector can be mated. This moves the challenge of cable routing to the back of the chassis and leaves the front open to easily remove and replace circuit boards since the I/O connector is actually mated to the back of the backplane and not to the circuit board being replaced. A combination of I/O connectors on the front and back can be employed when no other option is as attractive.

For systems that have large number cables which are densely packed together, the routing and physical support of the cables becomes a design challenge wherein the best solution is not always obvious. The location of densely packed cables impacts the flow of cooling air. Consideration for cable support and routing must be given very early in the system design cycle because of the resulting implications for printed circuit board layout and chassis configurations.

It is also possible to fabricate a custom backplane that utilizes the user-defined pins and electrically connects them from one card slot to another for the use of the boards in a specific system. Though the pins defined by the backplane specification remain unchanged, one must keep in mind that some commercial cards expect that the user-defined pins are available for their use and this could cause a conflict with the utilization of cards that were not designed specifically for the custom backplane.

Auxiliary Cards

In this context, an auxiliary card is a printed circuit board that mounts on the backside of a backplane, at 90 degrees to the backplane, and is electrically connected to a card installed on the front side of the backplane.

Cooling can become a problem if the heat generated by the electronics on the auxiliary card is greater than what can be cooled by convection with air at the temperature in the rack. Fans and heat exchangers are commonly available for the cards mounted on the front side of the backplane but it is difficult to find cooling devices for the back side which, in most cases, is left open.

Providing power to the auxiliary cards can also be a challenge. Some of the backplane specifications do not have power available on the connector to which an auxiliary card will be attached. When the power pins are available, there may not be enough current capacity available from the pins to supply both the auxiliary card and its corresponding card on the front of the crate. Designing and fabricating a custom backplane and using the user-defined pins to bus power to the auxiliary cards in one solution, albeit an expensive one. However, one drawback to this approach is that any time one would like to power up the card for testing or other purposes, the card must be in a chassis that is equipped with the custom version of the backplane as opposed to the more commonly available standard version. This can become a very significant handicap when there are more people troubleshooting parts of the system then there are fully-configured test stands available.

Yet another option for powering an auxiliary card is a power connector mounted on the card and a dedicated cable bringing power from the power supply. This solution requires that the power cable be protected against over-current situations with a fuse and also requires careful routing of the power cable.

Keying Unique Cards and Slots

When a variety of cards of the same form factor but differing functionality are used in the same backplane chassis, consider whether damage can result if one of the cards is powered up in a slot that is configured for a different card. If damage could result, then a keying system should be implemented for slots and cards to avoid inadvertently inserting a card in the wrong slot.

Design for Test

The procedure for troubleshooting electronic systems is greatly enhanced by incorporating several features on printed circuit cards. Front panel LEDs that indicate the status of various module functions help to identify which card in a crate, or which subcircuit on a card, is not working properly. A circuit that is sometimes referred to as a “heartbeat” for modules that include a microprocessor utilizes a one-shot mono-stable multivibrator and an LED. The one-shot may be triggered by a software/firmware routine that executes periodically. The implication is that the processor is not running if the heartbeat LED is not illuminated.

Status registers that can be read out via computer can be utilized to troubleshoot individual boards as well as system problems.

Test points comprise nodes in the circuit that are wired to front panel connectors to which probes from test equipment can be attached in order to quickly determine the status a portion of the circuitry.

Documentation

It is essential to have well-written documentation for the electronics system in order to ensure that the system can be reviewed, that it can be maintained, and that others can be trained to operate it in the shortest amount of time. Drawings that show the power distribution from power supplies to the crates will be required for safety reviews. Additional documentation should include accurate schematic diagrams, as-built drawings, and diagrams of interconnecting wiring. An operating manual should be written that describes how the system is to function. Well-documented source code files for programmable logic device (PLD) integrated circuits should be available.

Documentation that clearly describes the procedures for verifying the functionality of the circuit boards, and the system as a whole, should be written.

Hazardous Locations

Edward Briesch

OVERVIEW OF AREA CLASSIFICATIONS

Module 2

OBJECTIVES Module 2

- Identify the different hazardous areas
- Define the area classifications
- Define the groups for each area
- Define the temperature codes for each area

AREA CLASSIFICATIONS

- Class I
  - Flammable, gases, vapors or liquids
- Class II
  - Combustible dusts
- Class III
  - Ignitable fibers and flyings

Who Classifies Areas? Who accepts equipment?

- Authority Having Jurisdiction (AHJ)
- Approved vs. Listed

CLASS I, DIVISION 1

A Class I, Division 1 location is a location where ignitable concentrations of flammable gases, vapors or liquids:

– can exist under normal operating conditions;
– may exist frequently because of repair or maintenance operations or leakage; or
– may exist because of equipment breakdown that simultaneously causes the equipment to become a source of release

CLASS I, DIVISION 2

A Class I, Division 2 location is a location where:

- volatile flammable liquids or flammable gases or vapors exist, but are normally confined within closed containers;
- ignitable concentrations of gases, vapors or liquids are normally prevented by positive mechanical ventilation; or
- adjacent to a Class I, Division 1 location where ignitable concentrations might be occasionally communicated

CLASS I, ZONE 0

A Class I, Zone 0 location is a location where ignitable concentrations of flammable gases, vapors or liquids:

- are present continuously; or
- are present for long periods or time

CLASS I, ZONE 1

A Class I, Zone 1 location is a location where ignitable concentrations of flammable gases, vapors or liquids:

- are likely to exist under normal operating conditions;
- may exist frequently because of repair or maintenance operations or leakage;
- may exist because of equipment breakdown that simultaneously causes the equipment to become a source of ignition; or
- adjacent to a Class I, Zone 0 location from which ignitable concentrations could be communicated

CLASS I, ZONE 2

A Class I, Zone 2 location is a location where:

- ignitable concentrations of flammable gases, vapors or liquids are not likely to occur in normal operation or, if they do occur, will exist only for a short period;
- volatile flammable liquids or flammable gases or vapors exist, but are normally confined within closed containers;
- ignitable concentrations of gases, vapors or liquids are normally prevented by positive mechanical ventilation; or
- adjacent to a Class I, Zone 1 location from which ignitable concentrations could be communicated

CLASS I, DIVISION 1 & 2 GROUPS

- Group A
  – Acetylene
- Group B
  – Gases or vapors having:
    - MESG $\leq$ 0.45 mm or
    - MIC Ratio $\leq$ 0.40
  – Examples are: hydrogen, fuel and combustible process gases containing more than 30 percent hydrogen by volume, butadiene, ethylene oxide, propylene oxide, and acrolein.

CLASS I, DIVISION 1 & 2 GROUPS (cont.)

- Group C
  - Gases or vapors having:
    - $0.45 \text{ mm} < \text{MESG} \leq 0.75 \text{ mm}$ or
    - $0.40 < \text{MIC Ratio} \leq 0.80$
  - Examples are: ethyl ether and ethylene.
- Group D
  - Gases or vapors having:
    - $0.75 \text{ mm} < \text{MESG}$
    - $0.80 < \text{MIC Ratio}$
  - Examples are: acetone, ammonia, benzene, butane, cyclopropane, ethanol, gasoline, hexane, methanol, methane, naphtha, and propane.

CLASS I, DIVISION 1 AND 2 TEMPERATURE CODES

T1 (≤ 450°C)
T2 (≤ 300°C)
T2A, B, C, D (≤ 280°C, ≤ 260°C, ≤ 230°C, ≤ 215°C)
T3 (≤ 200°C)
T3A, B, C, (≤ 180°C, ≤ 165°C, ≤ 160°C)
T4 (≤ 135°C)
T4A (≤ 120°C)
T5 (≤ 100°C)
T6 (≤ 85°C)

CLASS I, ZONE 0, 1 AND 2 GROUPS

- Group IIC
  - Atmospheres containing acetylene, hydrogen, or gases or vapors having:
    - MESG $\leq$ 0.50 mm
    - MIC Ratio $\leq$ 0.45

CLASS I, ZONE 0, 1 AND 2 GROUPS (cont.)

- Group IIB
  - Atmospheres containing ethylene or acetaldehyde, or gases or vapors having:
    - 0.50 mm < MESG ≤ 0.90 mm
    - 0.45 < MIC Ratio ≤ 0.80
- Group IIA
  - Atmospheres containing acetone, ammonia, ethyl, alcohol, gasoline, methane, propane, or gases or vapors having:
    - 0.90 mm < MESG
    - 0.80 < MIC Ratio

CLASS I, ZONE 0, 1 AND 2 TEMPERATURE CODES

T1 (≤ 450 °C)
T2 (≤ 300 °C)
T3 (≤ 200 °C)
T4 (≤ 135 °C)
T5 (≤ 100 °C)
T6 (≤ 85 °C)

CLASS II, DIVISION 1

A Class II, Division 1 location is a location where:

- Ignitable concentrations of combustible dust can exist in the air under normal operating conditions;
- Ignitable concentrations of combustible dust may exist because of equipment breakdown that simultaneously causes the equipment to become a source of ignition; or
- Electrically conductive combustible dusts may be present in hazardous quantities

CLASS II, DIVISION 2

A Class II, Division 2 location is a location where:

- combustible dust is not normally in the air in ignitable concentrations;
- dust accumulations are normally insufficient to interfere with normal operation of electrical equipment;
- Dust may be in suspension in the air as the result of infrequent malfunction of equipment; or
- Dust accumulation may be sufficient to interfere with safe dissipation of heat or may be ignitable by abnormal operation

CLASS II, DIVISION 1 ONLY GROUP

- Group E
  - Atmospheres containing combustible metal dusts including aluminum, magnesium and their commercial alloys, or other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment

CLASS II, DIVISION 1 AND 2 GROUPS

- Group F
  - Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coal or dusts that have been sensitized by other materials so that they present an explosion hazard
- Group G
  - Atmospheres containing combustible dusts not included in Group E or F, including flour, grain, wood, plastic, and chemicals

CLASS II, DIVISION 1 AND 2 TEMPERATURE CODES

T1 (≤450 °C)
T2 (≤300 °C)
T2A, B, C, D ≤280 °C, ≤260 °C, ≤230 °C, ≤215 °C)
T3 (≤200 °C)
T3A, B, C (≤180 °C, ≤165 °C, ≤160 °C)
T4 (≤135 °C)
T4A (≤120 °C)
T5 (≤100 °C)
T6 (≤85 °C)

CLASS III, DIVISION 1

A location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured or used

CLASS III, DIVISION 2

A location in which easily ignitable fibers are stored or handled

CLASS III, DIVISION 1 AND 2 GROUPS

- Not divided into groups

CLASS III, DIVISION 1 AND 2 TEMPERATURE CODES

T3B, C (≤165°C, ≤160°C)
T4 (≤135°C)
T4A (≤120°C)
T5 (≤100°C)
T6 (≤85°C)

NOTE: **Article 503 of the NEC limits the maximum temperatures for Class III equipment to 165°C for equipment not subject to overloading and to 120°C for equipment that maybe overloaded**

CLASS I DIVISION VERSUS ZONE COMPARISON

Module 3

OBJECTIVES MODULE 3

- Recognize the similarities and differences between Class I, Zone and Division areas
- Recognize the similarities and differences between Class I, Zone and Division gas groupings
- Recognize the similarities and differences between Class I, Zone and Division temperature classification methods

CLASS I DIVISION/ZONE, GAS GROUP COMPARISON

Division 1 and 2	Zone 0, 1 and 2
A (acetylene)	IIC (acetylene & hydrogen)
B (hydrogen)	
C (ethylene)	IIB (ethylene)
D (propane)	IIA (propane)

CLASS I DIVISION/ZONE TEMPERATURE CODE COMPARISON

Division 1 and 2	Zone 0, 1 and 2
T1 (≤450 °C)	T1 (≤450 °C)
T2 (≤300 °C)	T2 (≤300 °C)
T2A,B,C,D (≤280 °C, ≤260 °C, ≤230 °C, ≤215 °C)	—
T3 (≤200 °C)	T3 (≤200 °C)
T3A,B,C, (≤180 °C, ≤165 °C, ≤160 °C)	—
T4 (≤135 °C)	T4 (≤135 °C)
T4A (≤120 °C)	—
T5 (≤100 °C)	T5 (≤100 °C)
T6 (≤85 °C)	T6 (≤85 °C)

COMPARISON OF PRODUCT MARKINGS

U.S.	CANADA	EUROPE	IEC
Class I, Div. 1, Group C,D Class I, Zone 1 AEx de IIB T5	Class I, Div. 1, Group C,D Class I, Zone 1 Ex de IIB T5	EEx de IIB T5 Certificate No. Additional for ATEX: 0539 II 2 G	Ex de IIB T5 Cert. Number

OVERVIEW OF PROTECTION TECHNIQUES

Module 4

OBJECTIVES MODULE 4

- Understand Class I Division 1 & 2 techniques
- Understand Class II Division 1 & 2 techniques
- Understand Class III Division 1 & 2 techniques
- Understand Class I Zone 0, 1, and 2 techniques

CLASS I, DIVISION 1 AND 2 PROTECTION TECHNIQUES

Area	Protection Techniques
Division 1	• Explosionproof • Intrinsically Safe (2 fault) • Purged/Pressurized (Type X or Y)
Division 2	• Hermetically Sealed • Nonincendive Circuits • Nonincendive Components • Nonincendive Equipment • Non-Sparking • Oil Immersion • Purged/Pressurized (Type Z) • Sealed Devices • Any Class I, Division 1 technique •Any Cl. I, Zn. 0, 1, or 2 technique

CLASS II, DIVISION 1 AND 2 PROTECTION TECHNIQUES

Area	Protection Techniques
Division 1	• Dust-Ignitionproof • Intrinsically Safe • Pressurized (Type X or Y)
Division 2	• Dusttight • Nonincendive Circuits • Nonincendive Components • Nonincendive Equipment • Pressurized (Type Z) • Any Class II, Division 1 technique

CLASS III, DIVISION 1 AND 2 PROTECTION TECHNIQUES

Area	Protection Techniques
Division 1 & 2	• Dusttight • Intrinsically Safe

CLASS I, ZONE 0 AND 1 PROTECTION TECHNIQUES

Area	Protection Techniques
Zone 0	• Intrinsically Safe (2 fault), 'ia' • Class I, Division 1 Intrinsically Safe (2 fault)
Zone 1	• Encapsulated, 'm' • Flameproof, 'd' • Increased Safety, 'e' • Intrinsically Safe (1 fault), 'ib' • Oil Immersed, 'o' • Powder Filled, 'q' • Purged/Pressurized 'p' • Any Class I, Zone 0 technique • Any Class I, Division 1 technique

CLASS I, ZONE 2 PROTECTION TECHNIQUES

Area	Protection Techniques
Zone 2	• Hermetically Sealed, 'nC' • Nonincendive,'nC' • Non-Sparking, 'nA' • Restricted Breathing, 'nR' • Sealed Device, 'nC' • Any Class I, Zone 0 or 1 technique • Any Class I, Division 1 or 2 technique

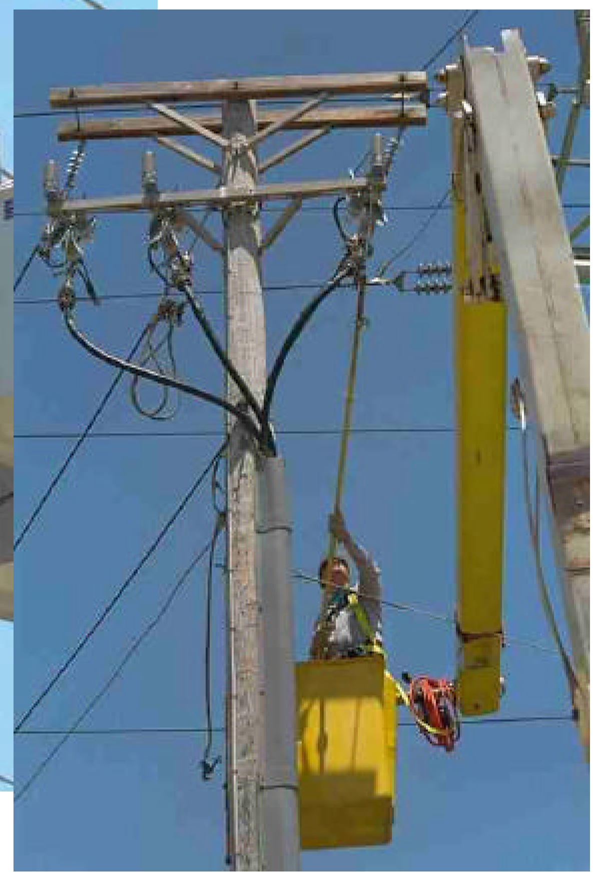
Ordinary Locations Requirements

- Some issues to be addressed include:
  - Risk of Fire
  - Risk of Electric Shock
  - Environmental Ratings

High-Voltage Electrical Review

Dan Crego

High Voltage Electrical Assessment



ANL/PFS

Introduction

ComEd Training Services

- Electrical Distribution Operations Training
- OSHA Compliance, Safety, and Industrial Hygiene
- Tool and Equipment Evaluation
- Electrical Distribution Work Practices
- Engineering Standards Training
- Personal Protective Equipment Selection and Testing

ComEd

ANL/PFS

Introduction

- Dan Crego - Training Services
- 32 years of ComEd Experience
    - Lineman
    - Safety Advisor and Field Foreman
    - High voltage Trainer and Training Designer
    - Responsible for Electrical Distribution Work Practices

ComEd

ANL/PFS

DOE 2000 Electrical Safety Meeting

- ANL/PFS Work Practices Assessment by ComEd
- Creating a Standards and Work Practices Library
- ComEd Training and Services for ANL/PFS

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Why a Work Practices Assessment?

- PFS Benchmarks Operations
  - DOE Requirements
  - Maintainance of Safety Envelope
- Local Utility the Logical Resource
- Economical Leverage
  - Utility's Experience and Processes
  - Industry Best Practices

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Establish the Plan of Action

- Establish a “Now” State
- Assess the Work Practices and Safety Procedures
- Perform a Field Observation and Familiarization
- Evaluate Work Practices and Operating Procedures
- Hazard Identification
- Control Methods
- Conduct of work between Linemen and Maintenance (480 volt) Group
- Compare ANL/PFS to Best Industry Practices

ANL/PFS

Evaluation Of Tools Used By High Voltage Linemen

- Grounding Sets
- Live Line Tools
- High Voltage Rubber Gloves
- Low Voltage Rubber Gloves
- Rubber Insulating Blankets
- Rubber Insulating Line Hose

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Review Work Activities Training

- Equipment Maintenance
- Locating facilities
- Watchman
- Patrol after Storms
- Locate and Repair Underground Cables
- Calibrate Meters and Relays
- Operate Bucket Trucks for Other Departments

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Electrical Safety, Hygiene & Skills Training

- An Ongoing Lineman Training Program ?
- Standardized Lineman Work Practice Manuals ?
- Lineman Specific Safety Rule Book ?

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What does OSHA mean "Qualified"?

- Employees are trained to identify hazards
- Employees are trained in safe work procedures to handle hazards
- Employees are trained to use the correct tools and personal protective equipment (hardhats, safety glasses & rubber gloves…)

ANL/PFS

Complying with OSHA

- Management must define the hazards
- Management must create safe work practices
- Management must create a safe work environment based on common sense and good training practices.

Review Operating Procedures and Work Practice of The Line Crew

- Electrical Distribution System Facilities Manual
- Switch Electrical Equipment
- Install Lock Out Tag Out
- Switch for Other Departments
- Install Lock Out Tag Out for Other Departments
- Connect Temporary Generating Equipment

ANL/PFS

Conclusions

- Work Place Under Complete Control of PFS
- Hi-voltage Crews Supervised and Observed
- Outside Contractors Work Under Surveillance
- Majority of Tools and PPE are OSHA Approved
- The Interaction Between Hi-voltage and Maintenance group is very Professional
- Hazard Identification is System Regularly Used

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Assessment Recommendations

- Grounding equipment comply with OSHA 1910.269
- Re-test Rubber Blankets per 1910.137
- Develop or Acquire Written Construction Standards
- Develop or Acquire Specific Work Practices

ANL/PFS

Assessment Recommendations

- Develop Written \ Mapped Switching Routines
- Develop Job Specific Safety Rule Book
- Initiate Safety Audit System
- Establish Training for the Above
- Reinforce Training Documentation

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Why Reinvent the WHEEL?

- Local Utility is an Accessible Resource
- Leverage on Existing Electrical Operations Services
  - Safety Bulletins
  - Tool and Equipment Research
  - Procedures Updates and OSHA Compliance
- *Stay Current with Utility Industry Developments*

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The ANL/PFS and ComEd Training Partnership

- Create an ANL/PFS Library of Standards and Practices
  - Adapt the ComEd Safety Rules Book
  - Select ANL/PFS Work Practices from the ComEd Database
- Adapt ComEd Electrical Safety and Skills Training to Fit ANL/PFS
- Establish Real-Time Distribution of Applicable Operating and Safety Bulletins

ComEd

ANL/PFS

The ANL/PFS and ComEd Training Partnership

- Establish Construction Engineering Standards Consultation
  - Semi-annual Standards Book Distributed
  - Hotline number to ComEd Engineering Established
- Operations Consulting Accessible
- PPE and Equipment Testing Services
- Three-year Renewable Subscription is Economical

ANL/PFS

Training Programs Underway

- Substation Electrical Safety Classes for Supervision and Linemen
- Cyclic Training Matrix Applied
- Pole-top Rescue Procedure Training
- Overhead and Underground Electrical Safety Refresher

Training Programs to Come

- Grounding and Dead-Testing High Voltage Equipment
- Transformer Connections
- Operating Error Reduction

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Operations Communications

- Tailgate Bulletins
- Near Miss Reports
- Accident Investigations
- Change and Additions to Work Practices
- Procedures and Standards Updates

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Equipment Testing and PPE

- Rubber Goods Exchange
- Hotstick Testing Procedure and Labeling
- FR Clothing Program Created
- Small Tool and Equipment Repair Services
- Test and Metering Equipment Recommendations

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Potential Services

- Create an Apprecticeship Program
- Upgrade Electrical Distribution Operating Procedures
- Safety Audits for OSHA Compliance

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Conclusion: Why Reinvent the WHEEL?

- Partnership for Efficient and Economical Assessment at ANL/PFS
- Local Resource for Electrical Operations Expertise
  - Tools and Equipment Recommendations
  - Work Practices
  - Engineering Standards
- Experienced Performance-Based Training Readily Available

ComEd

ANL/PFS

Grounding Update

Mark Regan

US Department of Energy Electrical Safety Conference

Argonne National Laboratory

June 13-14, 2000

US Department of Energy Electrical Safety Conference

Mark Regan   Project Leader

ESH-5

Los Alamos National Laboratory

Los Alamos National Laboratory

Environment, Safety, and Health Division

Special Thanks!

Group ESH-5	Los Alamos National Laboratory
IAEI	Richardson, TX
Mike Johnston	Plano, TX

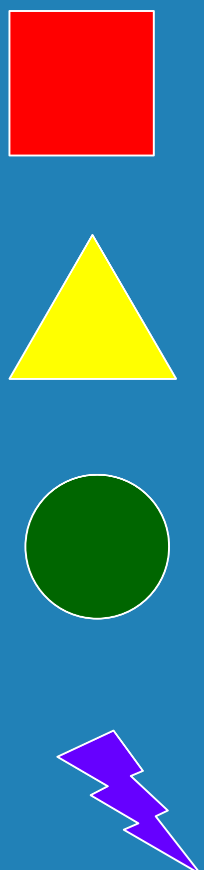
Grounding in the 21st Century

- Arc Faults
- Ground Faults
- Ground Fault Protection

Purpose

- Have FUN!!!
- Learn something new
- Work safely for a better quality of life

Personality Colors



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What We Will Cover

- Grounding Update
- Ground Faults
- Ground Fault Protection
- Arc Faults

Grounding Update

- Grounding History
- NEC Code Changes

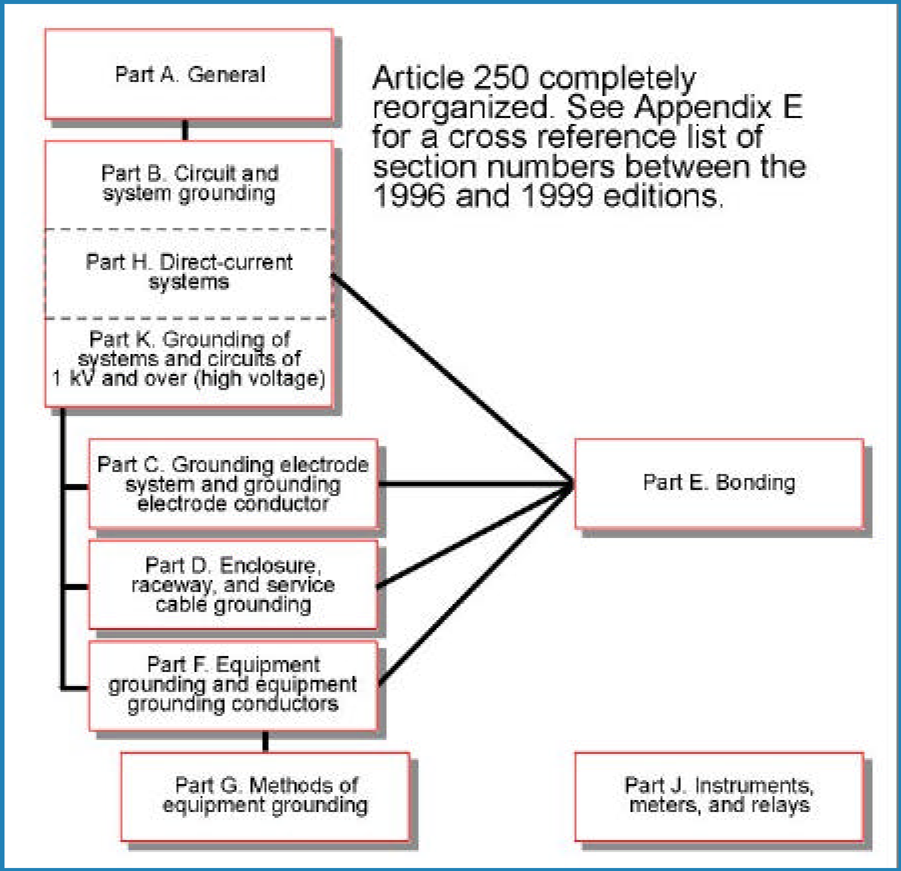
March 10, 1892

"... the Board of Fire Underwriters has condemned the practice of grounding the neutral as dangerous and orders it to be stopped."

August 31, 1897

- “ The ground wire shall be attached to a water pipe, if possible;”
- “ In the absence of other good ground, the ground shall be made of a metallic plate or <u>a bunch of wires buried in a permanently moist earth</u>.”

NEC Article 250 Revised 1999



System Grounding to...

- Stabilize and limit the voltage to ground during normal operation
- Prevent excessive voltages during lightning strikes and transients
- Create a single point equipotential plane

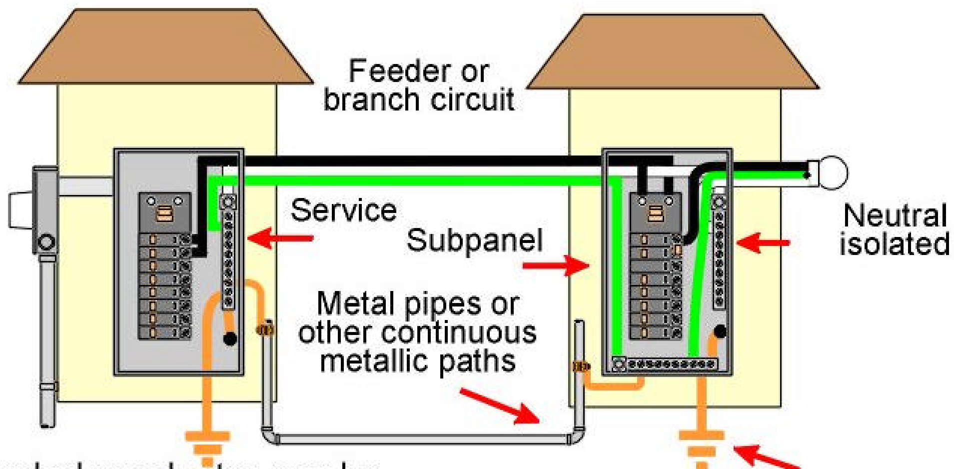
Service

Grounding Electrode Connection

Equipment Grounding

- Limit the voltage to ground on equipment
- Bonding for equipotential plane and to facilitate the operation of the overcurrent protection device
- Provide a low impedance fault return path back towards the source

2nd Building or Structure

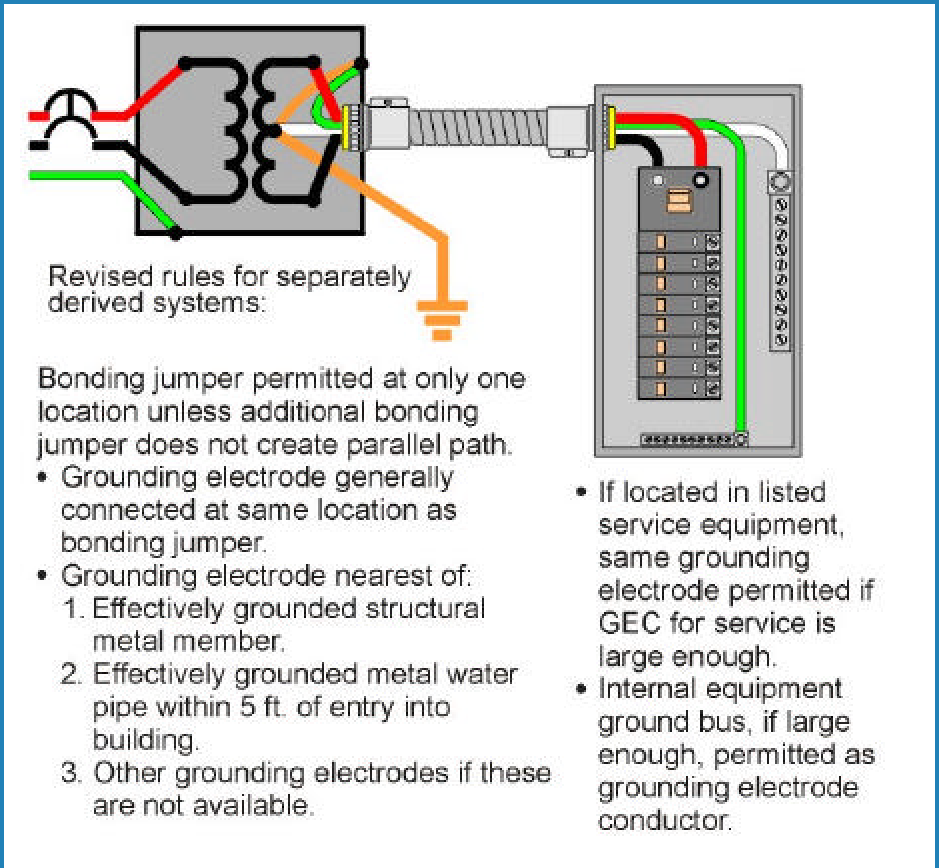


Grounded conductor can be regrounded at adnl bldg only if:

1. Equipment grounding conductor is not run to bldg or structure
2. No continuous metallic paths
3. Equipment ground fault protection not installed on service

Grounding electrode not required if bldg or structure is supplied by only one branch circuit that includes equipment grounding conductor.

XFMR Grounding



Overcurrent Protection

- Overcurrent- any current in excess of the rating of the equipment or conductors
- Overload- operation of equipment or conductors in excess of normal rating that would cause damage or overheating
- Short Circuit- phase to phase or phase to grounded conductor
- Ground Fault- phase to equipment

Ground Fault

A phase to equipment connection

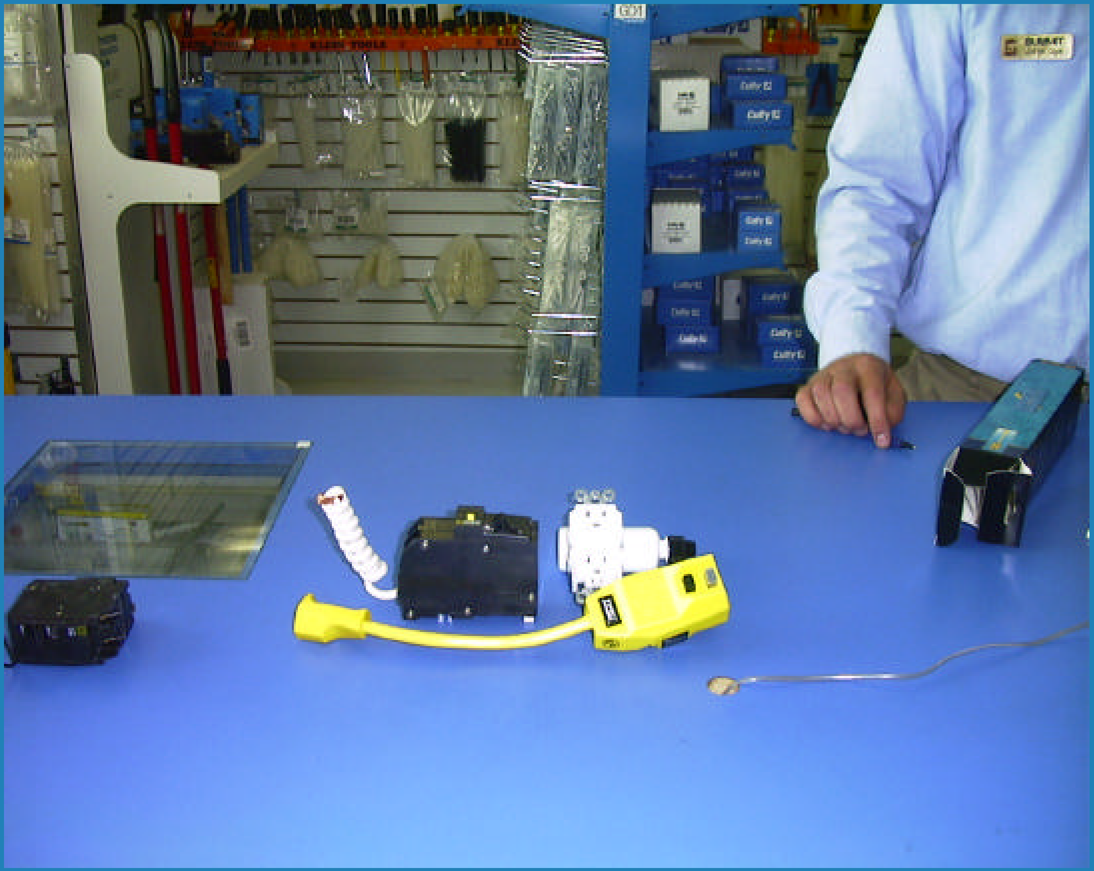
Purpose of GFCI/GFPE

- GFCI- Ground Fault Protection of People
- GFPE- Ground Fault Protection of Equipment

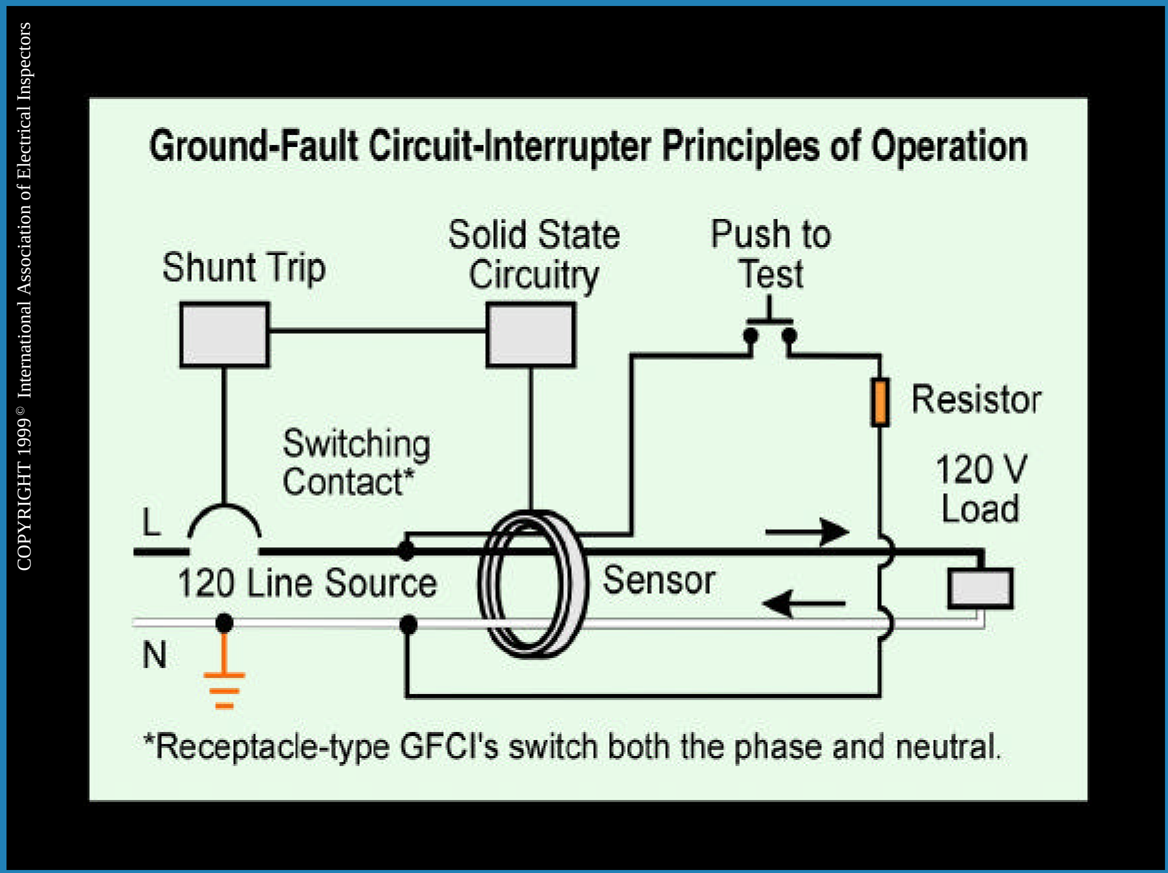
Ground Fault Circuit Interrupter

- Opens circuit when a bleed off of 5 ma (+/- 1 ma) is observed

GFCI Devices



GFCI Schematic



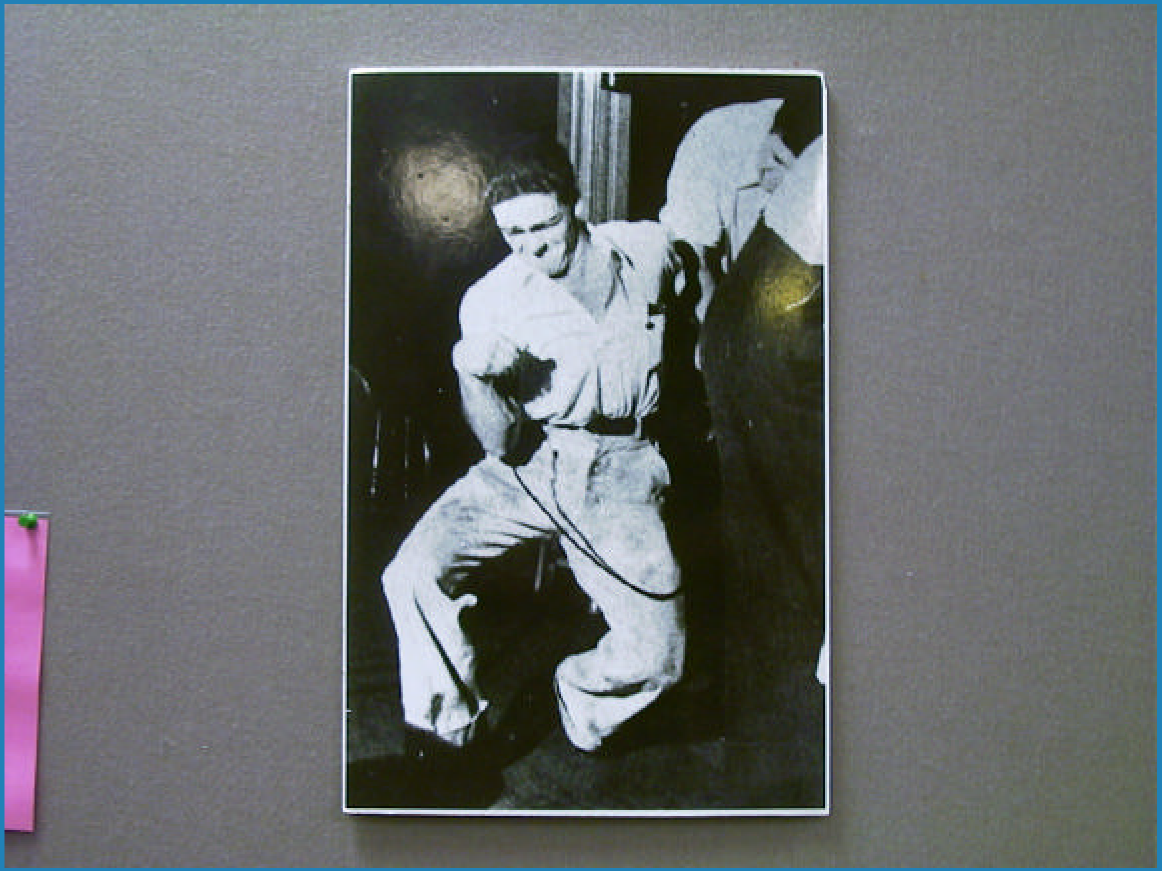
Let Go Threshold

Table 14-2
Implied Safe Voltage Based On Several Published Values of Body Resistance and Selected Body Current Safety Criteria as Published by Dalziel

Criterion	Body Resistance 300 ohms	Body Resistance 500 ohms	Body Resistance 1500 ohms	Body Resistance 3000 ohms
"Let-go" 4.5mA for children	1.35 volts	2.25 volts	6.75 volts	13.5 volts
"Let=go" 9 mA for adult males	2.7 volts	4.5 volts	13.5 volts	27 volts
Fibrilation at 23 mA 5 sec 18 kg children	6.9 volts	11.5 volts	34.5 volts	69 volts
Fibriliation at 52 mA 5 sec. 50 kg adult	15.6 volts	26 volts	78 volts	156 volts

Early Research

Involuntary Muscle Contraction



Maximum Let Go Threshold

Shock Current

Table 14-1
Percentage of the Population Estimated to Be Protected Against Inability to Let Go for Several Levels of Shock Current

Level of Shock Current	6mA(rms)	10mA (rms)	20mA (rms)	30mA (rms)
Men	100%	98.5%	7.5%	0%
Women	99.5%	60%	0%	0%
Children*	92.5%	7.5%	0%	0%

*half of let-go threshold for men

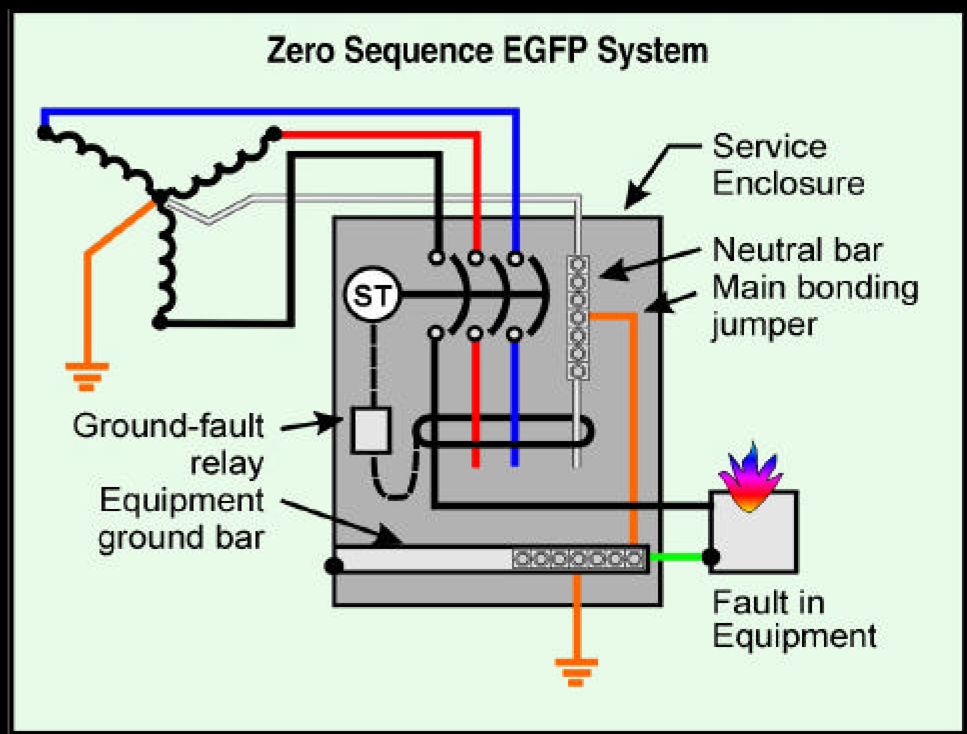
Ground Fault Protection of Equipment

A system intended to provide protection of equipment from damaging **line-to-ground fault currents** by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This **protection** is provided **at current levels less than** those required to protect conductors from damage through the operation of a supply **circuit overcurrent device**

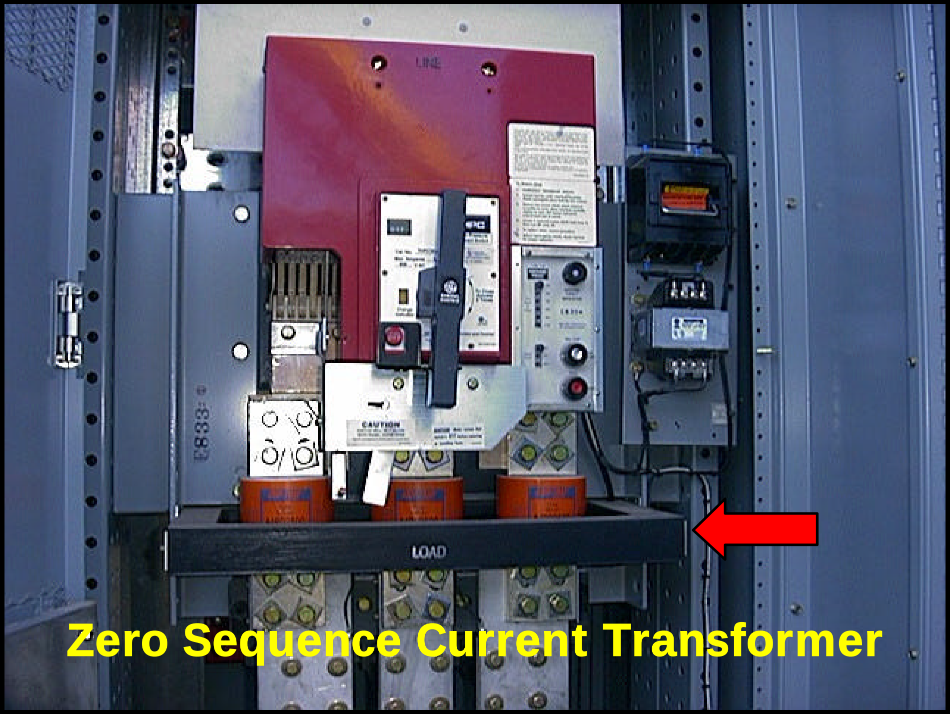
Ground Fault Protection Required…

- Solidly grounded systems more than 150 volts to ground
- Not more than 600 volts phase to phase
- Each service disconnect rated 1000 amperes or more

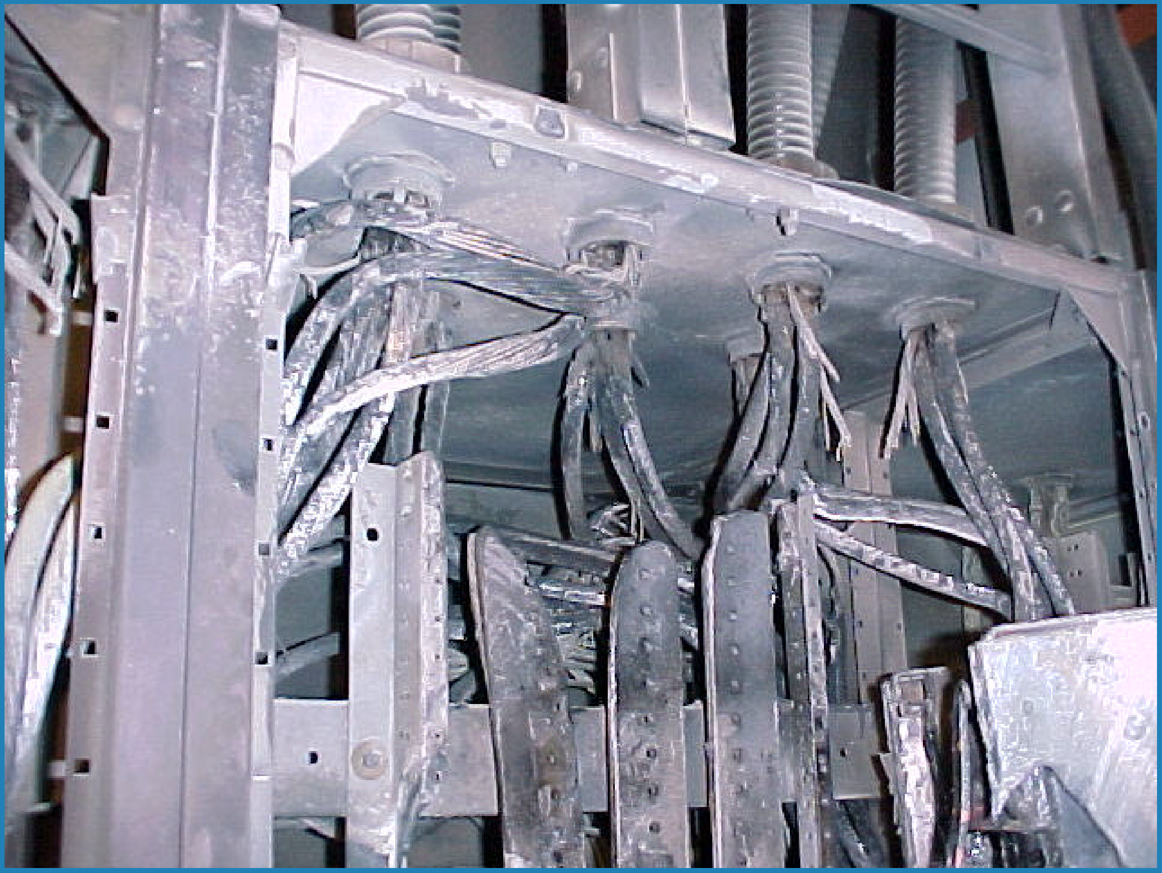
GFPE Schematic



Zero Sequence GFPE



Electrical Burndown



Arc Faults

- Arcing between conductors
- Propagation over insulation
- Several thousand degrees Celsius

Arc Fault Circuit Interrupters

- Responds to a specific electrical signature or waveform
- Must distinguish between an arc fault and normal equipment operation

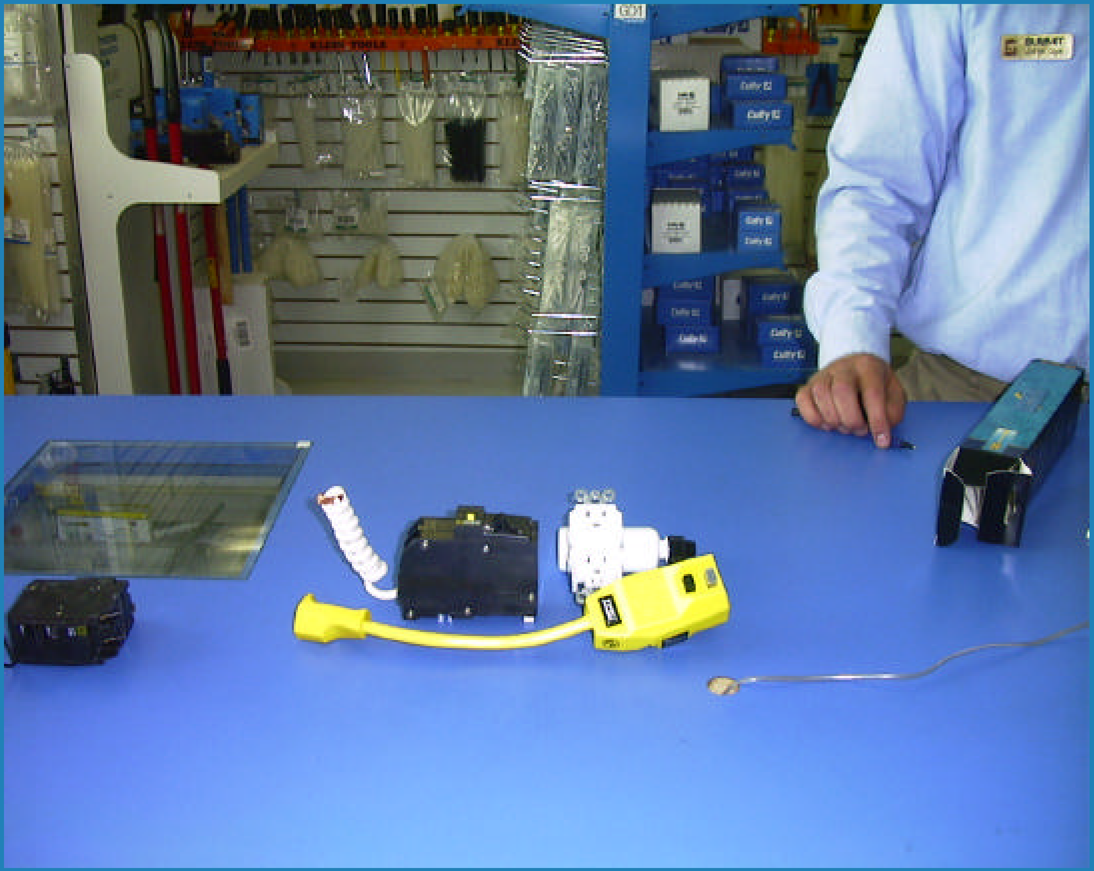
Normal Arcing Equipment

- Computers
- Motor inrush
- Switches
- Tungsten lamps

Arc Fault Circuit Devices

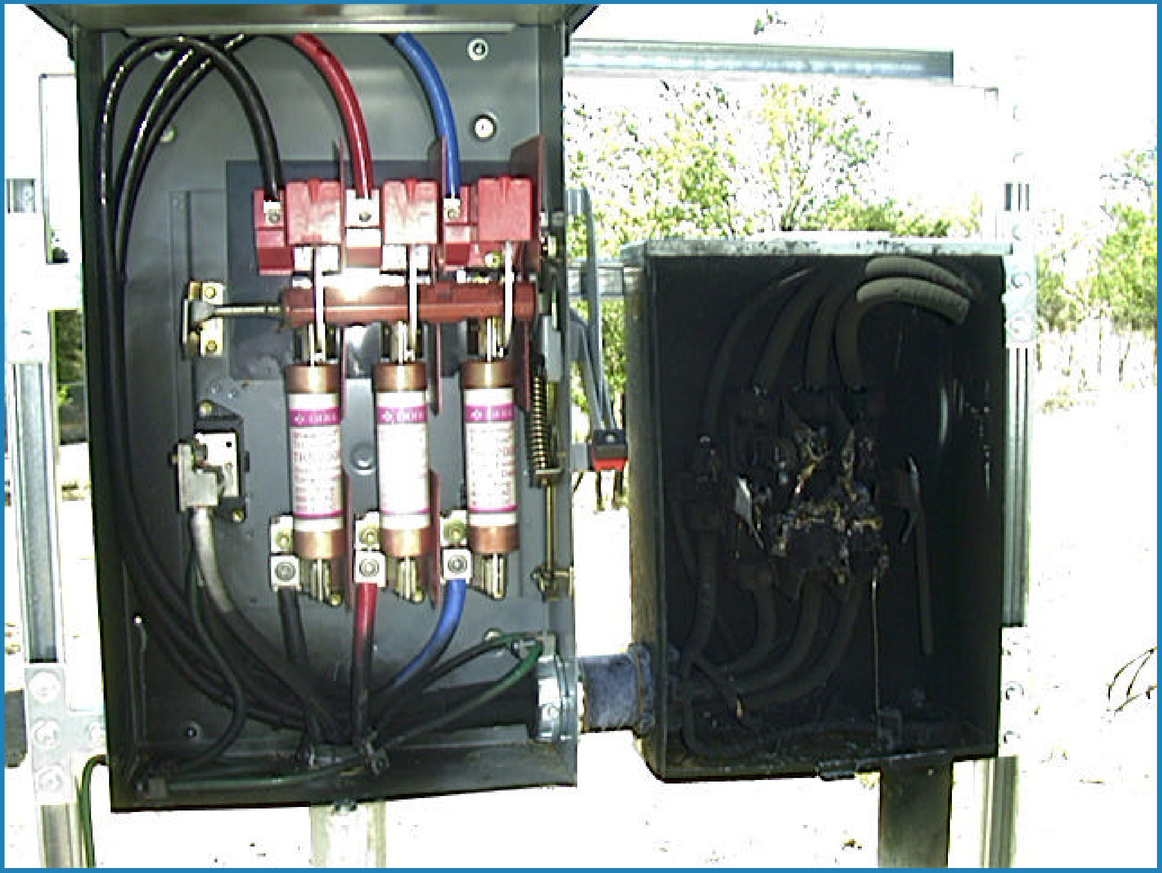
AFCI can be coupled with a circuit breaker or a CB/GFCI device

AFCI/OCPD/GFCI

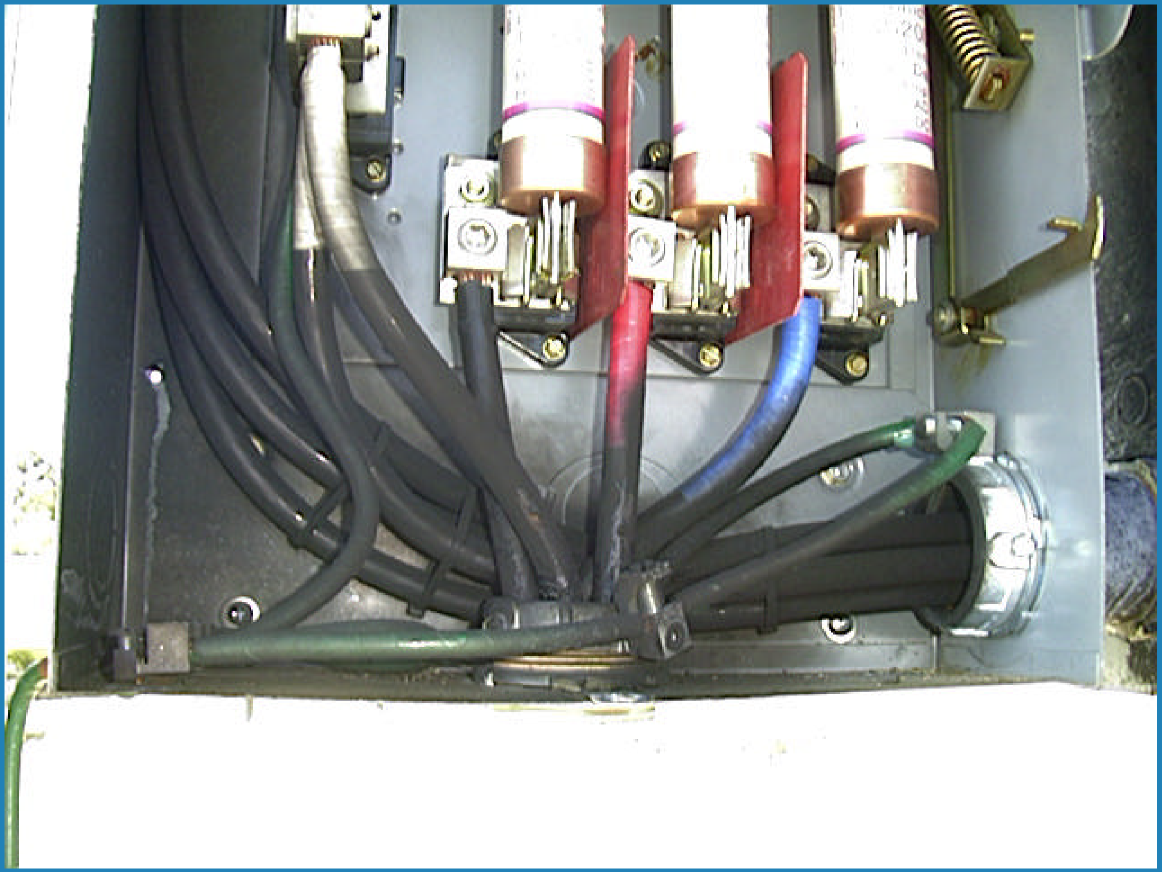


Outdoor Service

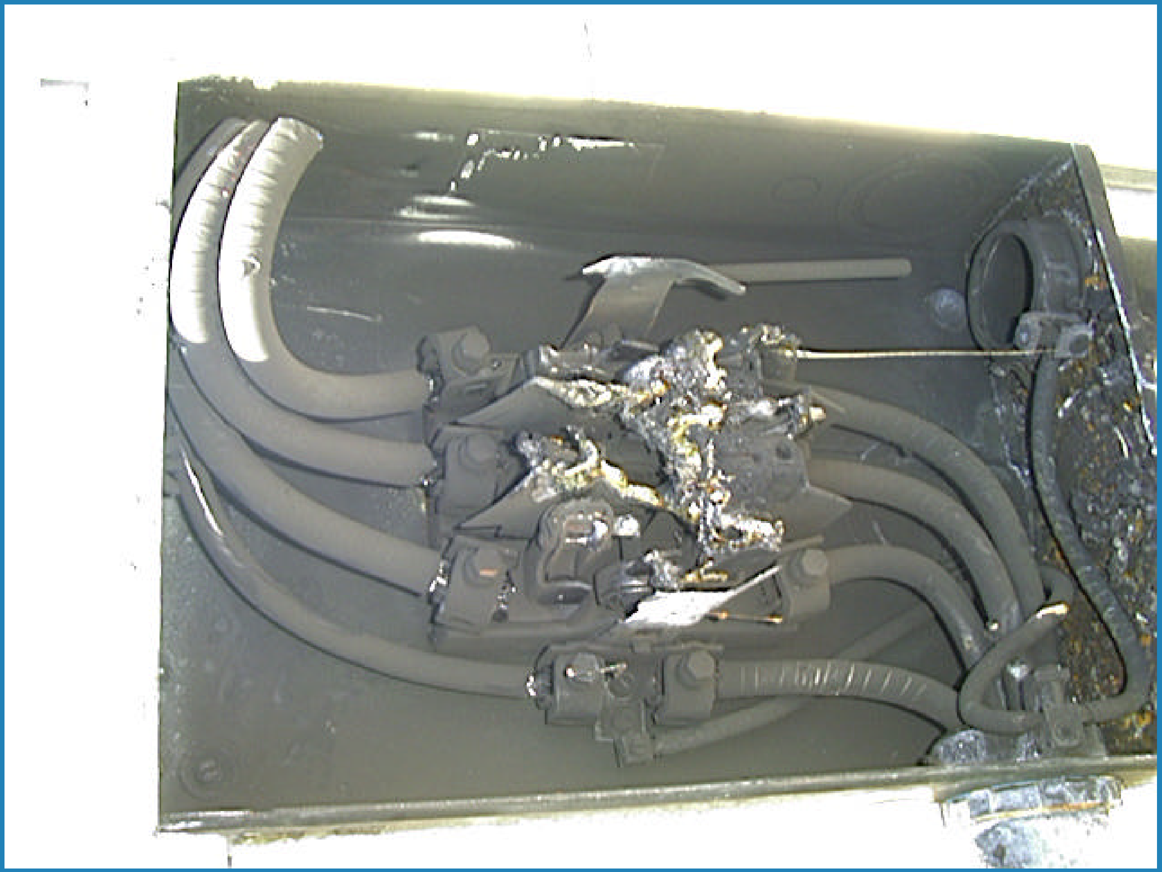
Disconnect & Meter Socket



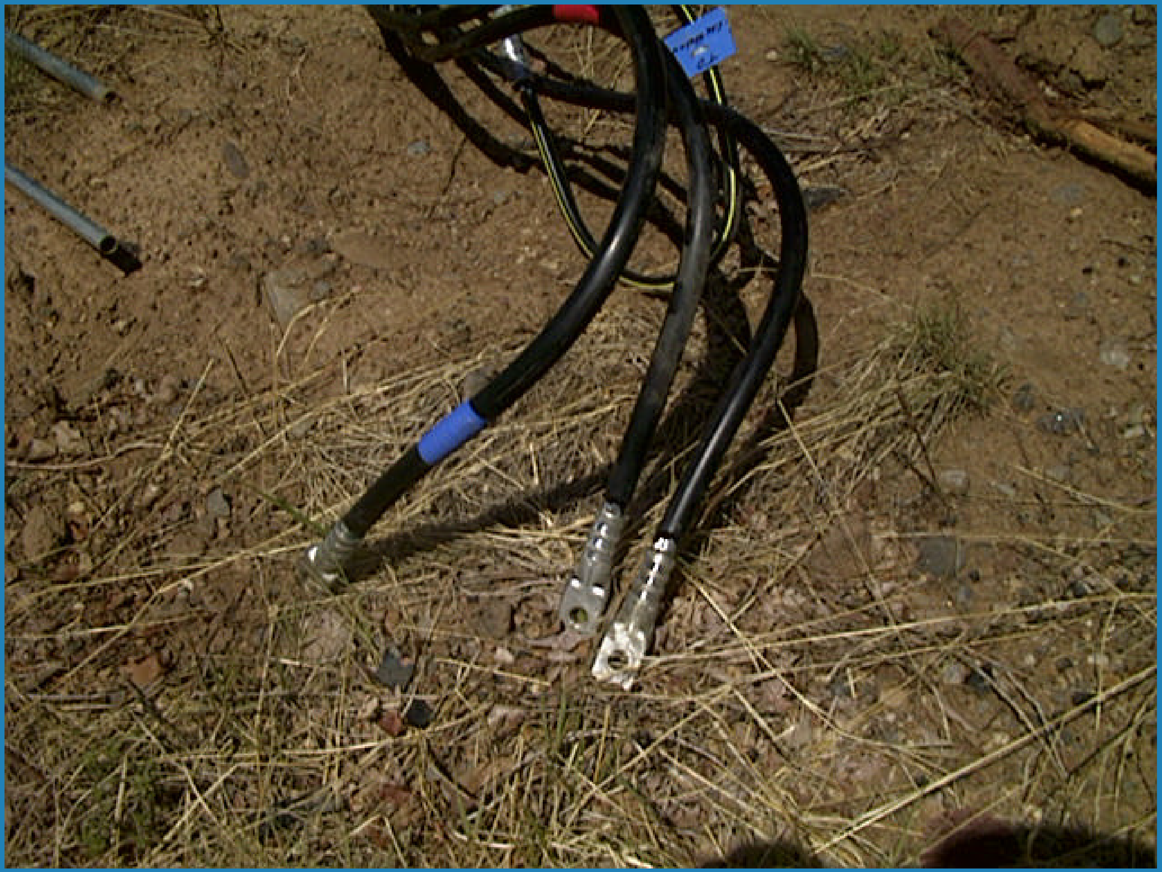
Service Equipment



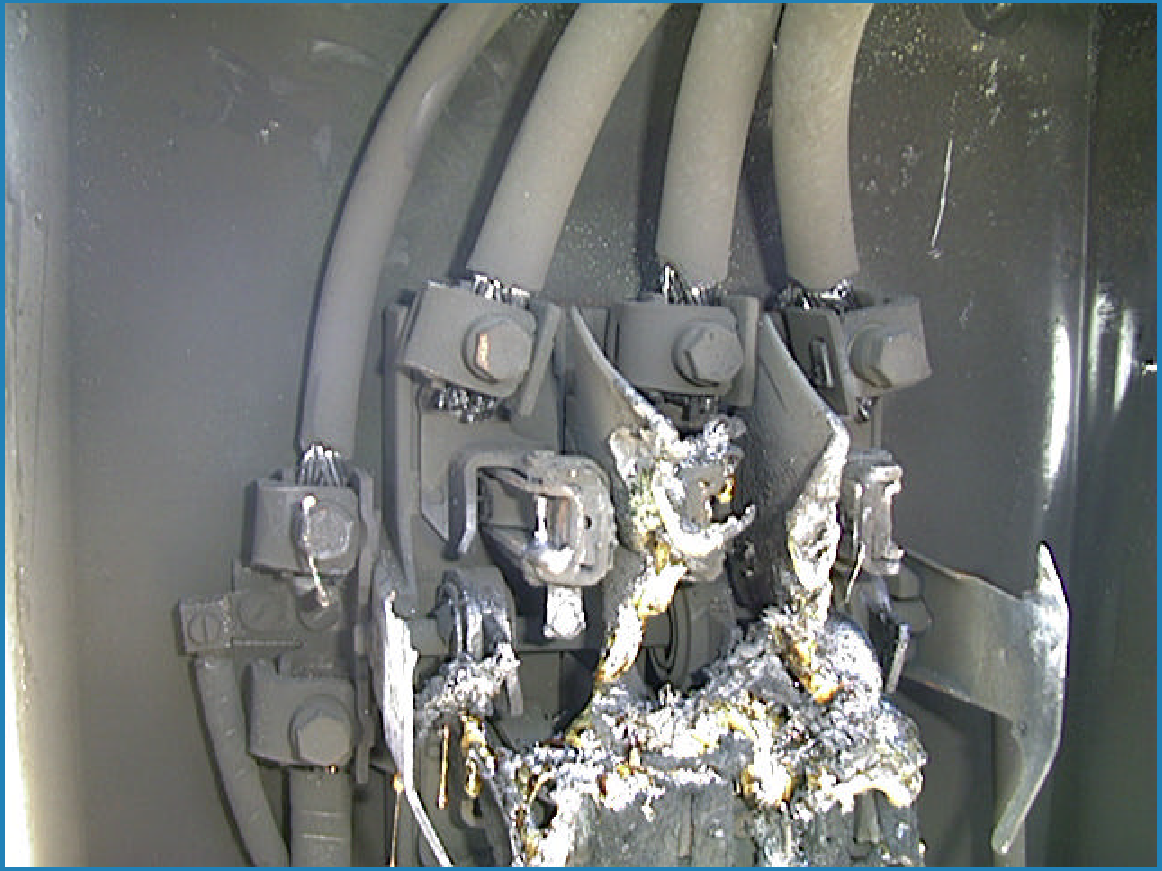
Line and Load of Meter Socket



Secondary Side of XFMR



Line Side of Meter Socket



Contacts of Meter

Back of Meter

Meter and Front Enclosure

Summary

- Proper grounding is the key to a safe and efficient electrical system
- Proper selection of fault protection is the key to protecting that system

Remember…

Those of you who are purple lightning bolts…

- WE HAVE YOUR Z NUMBERS!!!

Questions?
Thank you!

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Have a FUN DAY!

AHJ Approval, Using the NRTL's

Chuck Monasmith

Abstract

"AHJ Approval, Using the NRTL's"

By Chuck Monasmith
Fluor Federal Services,
Richland Washington

This presentation will acquaint the participant with the correct terminology and application of requirements for Nationally Recognized Testing Laboratories. A rationale for the authority having jurisdiction to use only Labeled electrical equipment will also be included. Special emphasis will be placed on the program for Labeling customized one-of-a-kind electrical equipment as Industrial Control Panels.

Why Use NRTL Listed Equipment ?

What has caused the Hanford Site to become so particular about the use and procurement of equipment that has been Listed or Labeled by a Nationally Recognized Testing Laboratory (NRTL)? When a project is designed why is it so important that only NRTL equipment be specified?

It's the easiest way to comply with the federal law. 29 CFR 1910.303. CFR ... that's Code of Federal Regulations, all federal laws are in the CFR's. But does the law say "buy only UL Listed"? Not quite. The law does say: "Electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees." This law applies and is enforced in all industries within the US. Hanford is not an exception, it is the norm.

Whenever you specify electrical equipment, whether it's a length of rigid steel conduit, a toaster, or a sophisticated hydrogen detection system, you are accepting the responsibility of complying with and satisfying the requirements of that law. You are the one who says " This equipment is free of recognized hazards." If that equipment fails and someone is shocked, are you willing to stand up and say, "I'm the person who determined that equipment was free of hazards"? Wouldn't you feel good saying that to a co-workers surviving spouse?

Compliance with the federal law is so much easier since the law allows that design responsibility to be shifted to a NRTL. If you specify and procure equipment that is Listed or Labeled by a NRTL, and it is used within the limits of that Listing, the responsibility to assure it is free of hazards is no longer yours. If it's labeled it is accepted as free of hazards.

How do you know which equipment is Listed? The NRTL's issue directories of equipment that is listed. For example Underwriters Laboratory issues several directories. The primary source for such information is the Electrical Equipment and Materials Directory.

For example: Light Fixtures are Listed in category (IETX). But what about the toaster in the first paragraph? It's Listed in the Electrical Appliances and Utilization Equipment Directory in category (KNUR). There's even a category for one of a kind custom designed and custom fabricated control panels (NIMX).

When you specify electrical equipment are you prepared to take the responsibility of proving there are no hazards? The Listed component will contain a fault within it's enclosure, that's one of UL's standard requirements. Will unlisted equipment do the same thing. It may look the same, maybe the screws for the cover are smaller. The Listed equipment has been tested to destruction to be certain those screws are the right number and right strength to provide employee safety. Will you stand up and say that an unlisted piece of equipment is just as safe. Will you say the screws are the same graded strength and are not spaced too far apart?

If you are willing to stand up and say that to all of your peers, I've got a deal on a bridge in brooklyn for you.

The bottom line here, I'm sure you've figured out a long time ago is to use Listed equipment wherever possible. Dont' stray to an unlisted and often lesser product, until you have exhausted every UL Directory or FM directory for a category that covers the equipment you are installing.

The Designated NEC Inspectors will be happy to review your equipment list to help you find Listed equipment that serves the mission and protects our friends and co-workers.

Chuck Monasmith
Secretary, Hanford Electrical Codes Board

USING THE WORDS

Is it Listed? Is it Labeled? Is it Recognized? Is it Evaluated? What is UL 508A?

Never start with a negative. Here's a second negative. A NRTL does not approve anything.
Please, never let me hear that UL has approved this receptacle. They haven't yet approved it and they never will.

Approved. NFPA standard definition: "Acceptable to the authority having jurisdiction." No mention of NRTL.

Labeled. The electrical equipment has a NRTL Label physically attached to the equipment. This word is NOT interchangeable with Listed. An example to follow. The only way to tell if a manufacturer's equipment is labeled is to look at the equipment and see the label that is attached.

Listed. The electrical equipment is listed by a NRTL in a directory. UL has several volumes of directories, (Electrical Construction Equipment / Appliances an Utilization Equipment / Hazardous Locations Equipment / etc.) Factory Mutual has its Compliance Guide. CSA has its "List of CSA Certified.....Service Equipment / Power Supplies and Transformers / Industrial Panels (9 volumes in all). ETL has its Directory of Listed products. And so on.

Listed means a specific model of the manufacturers equipment line has been independently evaluated and found to be in compliance with a UL or CSA Standard. Independently and evaluated are key words in the previous sentence.

An example of Listed and Labeled: An MCC has the vertical sections listed and labeled and four of the five compartments are listed and labeled. Because the fifth compartment has a special customer requested relay that is not Listed the fifth compartment would be listed but not labeled.
l

Evaluated. A process to determine if equipment complies with a particular standard. This may involve destructive testing or it may be a review of the design documents.

Recognized. This describes a component that may be used in an assembly. The component has been evaluated as a restricted component. A restricted component complies with the requirements of the applicable standard within its marked ratings and under certain conditions of acceptability.

UL 508A Industrial Control Panels

UL508. An Underwriters Standard. This Standard contains basic requirements for Industrial Control Equipment. This is the parent title for UL 508 C Power Conversion Equipment and UL 508A Industrial Control Panels.

UL 508A. UL does not call this a standard. It is Subject 508A. Correct Title is Outline for Investigation of Industrial Control Panels.

This presentation is intended to be the beginning of an acquaintance not a complete trainer.

Scope. The Industrial Control Panels covered by these requirements are intended for general industrial use. (sic not residential use). They are not intended for metalworking machine tools, plastic injection molding, power press controls, flame safety supervision of combustible fuel type equipment, or elevator controls. (sic there are other UL standards that apply to these types of controls)

The Industrial Control panels covered by these requirements are assemblies consisting of components such as motor controllers, overload relays, fused disconnect switches, and/or circuit breakers and related control devices such as push button stations, selector switches, timers switches, control relays and the like with associate wiring, terminal blocks, pilot lights and the like. The enclosure may be provided or the assembly may be an open construction. (sic FFS is a closed panel shop. This means we buy UL Listed enclosures from a UL Listed vendor of enclosures. open construction means the panel shop can build their own enclosures re: tin bending) (sic, we allow two active components to be built in the field)

Components. Three types of components may be used in UL Listed Industrial Control Panels.

Restricted Component – A component or device that complies with the requirements of the applicable standard within its marked ratings under certain conditions of acceptability. (sic yellow directory items reverse UR)

Unevaluated Component – A component or device for which compliance with an applicable standard has not been identified. (sic this means any other NRTL as well)

Unrestricted Component – A component or device that complies with the requirements of the applicable standard within its marked ratings.(sic this means UL Listed and Labeled)

Conclusion:

Let not one of your malicious compliance persons cite a UL Labeled panel for having components that are not evaluated. The unevaluated components can be there in a Labeled control panel.

The authority having jurisdiction has lot of responsibility and a lot of liability. Approving equipment is an engineering practice and should be done by a licensed engineer. In the commercial world this will allow a shift of liability away from the individual and to his employer. Given the number of lawyers in the world it's not a bad idea in the government sector either.

Methods to reduce the liability of the AHJ by the use of Listed and Labeled equipment are not the real issue here. Employee safety is best served by the use of NRTL Listed and Labeled equipment.

Hanford Electrical Safety Program

"Helping Keep Employees Safe from the Hazards of Electricity"

Electrical Safety Compliance Guide

ESCG-2000-01
March xx, 2000

Subject: **NRTL REQUIREMENTS FOR ELECTRICAL EQUIPMENT**

This guidance is provided by the Hanford Electrical Safety Program (HESP) to clarify requirements for approval and acceptance of electrical equipment on the Hanford Site. There have been misconceptions that the specifying engineer has the option of selecting electrical equipment that is not labeled or listed by a nationally recognized test laboratory (NRTL), then having it inspected and accepted by a designated National Electrical Code (NEC) inspector. That belief is in error. All electrical equipment must be listed or labeled by a NRTL if a listing category for such equipment exists.

NEC Article 110-2 requires electrical conductors and equipment to be approved, i.e., acceptable to the authority having jurisdiction (AHJ). OSHA Subpart S, 29 CFR 1910.303(a) also requires conductors and equipment to be approved. OSHA definitions of "acceptable" and "approved" in 29 CFR 1910.399 provide further clarification on approval requirements for electrical conductors and equipment. Simply stated, if any electrical system component is of a kind that any NRTL accepts, certifies, lists, or labels, then only NRTL accepted, certified, listed, or labeled components can be used.

There are two exceptions that apply only if NRTL-listed/labeled equipment is not available:

1. Equipment of a kind which no NRTL lists or labels may be used if it is inspected or tested by the local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with the provisions of the NEC, and
2. Custom-made equipment may be used if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection.

The PHMC includes these requirements in HNF-PRO-089, Electrical Installation Safety, Section 2.2. Other Hanford contractors may have similar procedures.

The following guidance is provided to help ensure compliance with NRTL requirements:

- The responsible design engineer is required to evaluate all electrical products specified, and when available, ensure that the product is listed or labeled by an OSHA-recognized NRTL. Design specifications will indicate traceability to the NRTL that applies to the specific product. OSHA-recognized NRTLs are listed on the internet at URL http://www.osha-slc.gov/dts/otpca/nrtl/nrtllist.html.
- If research by the design engineer indicates that there is no available NRTL listing or labeling category, the product specification and application will be determined and approved by the responsible engineer in conjunction with the Hanford Electrical Codes Board (HECB). Compliance to national codes and consensus standards (e.g., NEC, ANSI, ISA, IEEE) will be used as a basis for all product approvals in this category if applicable.
- Application of listed or labeled equipment in a use not intended by the manufacturer or not within the listing or labeling scope shall be approved by the HECB.

Particular attention should be given to custom-built control panels. Local and on-Site sources now exist for UL 508A fabrication and/or certification of industrial control panels. NEC inspectors will not approve installations of non-listed/labeled equipment if there is a NRTL category for that equipment.

For more information please contact Paul Case, Electrical Safety Program Coordinator (376-1168), or one of the designated NEC inspectors:

Bill Bresina, 376-5265 Randy Dykeman, 372-3701 Debbie Wallace, 372-2290

Safety During Transformer Maintenance

Richard Croghan and Lora Flanigan

SDMYERS THE TRANSFORMER CONSULTANTS ACTS 4:12

Safety During Transformer Maintenance

Authority:

- OSHA, 29 CFR 1910.269 (Subpart R), Power Generation, Transmission & Distribution

Liaison Person

- CPR & First Aid
- Site Specific Training (MSHA, etc.)

Minimum Safety Equipment

- Clothing
- Hard Hat
- Safety Glasses
- Rubber Goods
- Safety Toe Shoes
- Lock-out / Tag-out Kit

Preliminary Substation Inspection:

- Prior to entering a substation
  - Tall weeds, uneven footing, lighting, position of conductors
- Entering the substation / unit(s) to be serviced
  - Snakes, bees, etc.
  - Bushings
  - PRD's
  - Condition of bushings & insulators
  - Sudden pressure relays
  - Ground Cable

Working on units

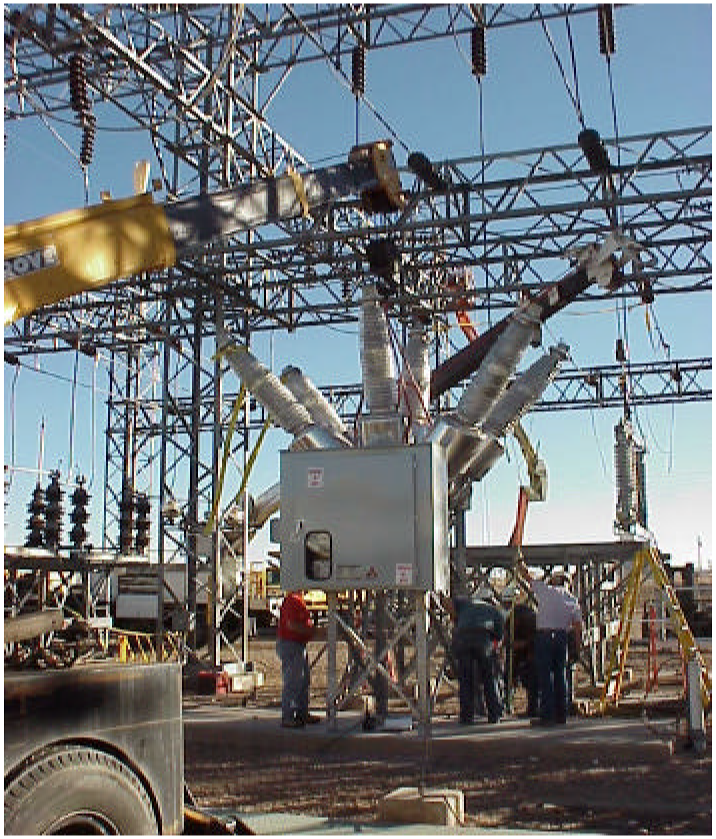
- Ground Cables
- Touching Unit(s)
- Gauge Inspection
- Vacuum
- Spill Prevention
- Equipment Grounding

Hidden Design Flaws on Electrical Systems

Bill Marsh

It Looked good on Paper!

A quick look at design/installation flaws on the high voltage transmission system



National Electrical Safety Code (IEEE C2) gives clear guidance on HV installations, what goes wrong?

- Installations not closely monitored by competent personnel
- Installations done without review by Design Engineers. (maintenance modifications)
- Design Engineers not taking currently installed structures and equipment into design criteria.

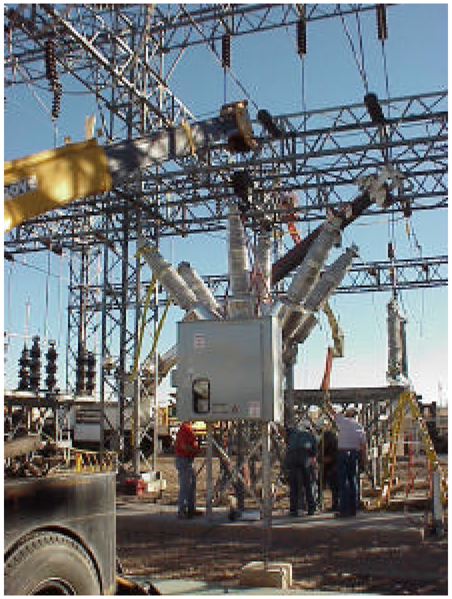
National Electrical Safety Code (IEEE C2) gives clear guidance on HV installations, what goes wrong?

- Design Engineers using “generic” symbols on drawings, causing field modifications.
- Infringement on power line right-of-ways.
- Design Engineers using proper electrical clearance but not enough clearance for maintenance activities (see next slides)
- Equipment installed by customers maintained by WAPA

Power system Design/installation issues

- Replacement equipment does not match existing location.

Old OCB being removed



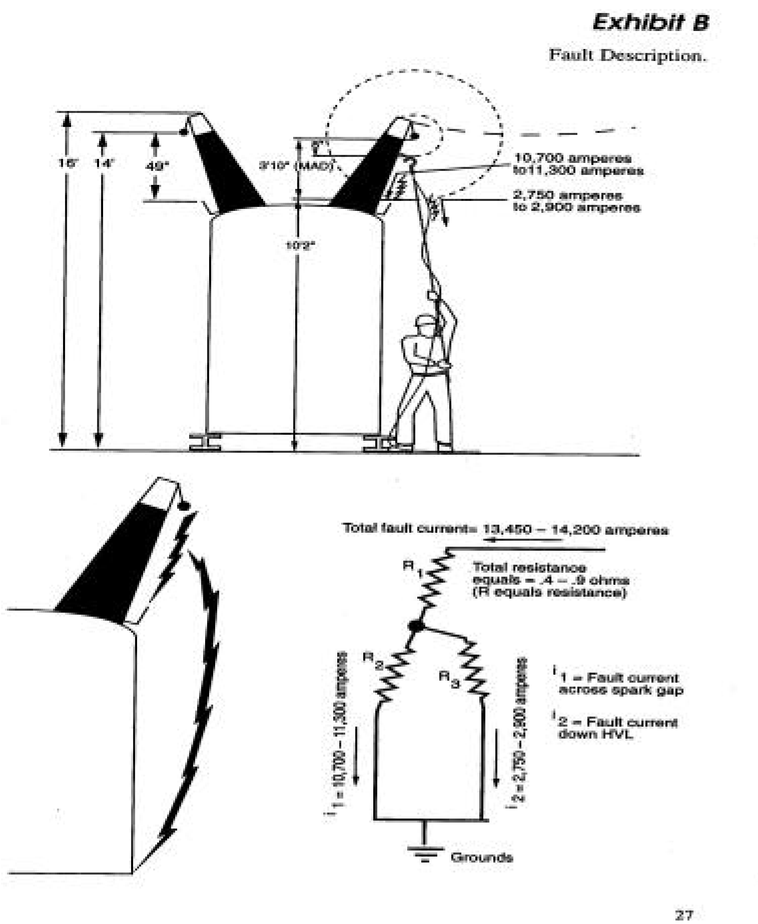
New SF6 Breaker same area-doesn't fit!

Power system Design/installation issues

- Attached protective devices lowering HV ground clearance

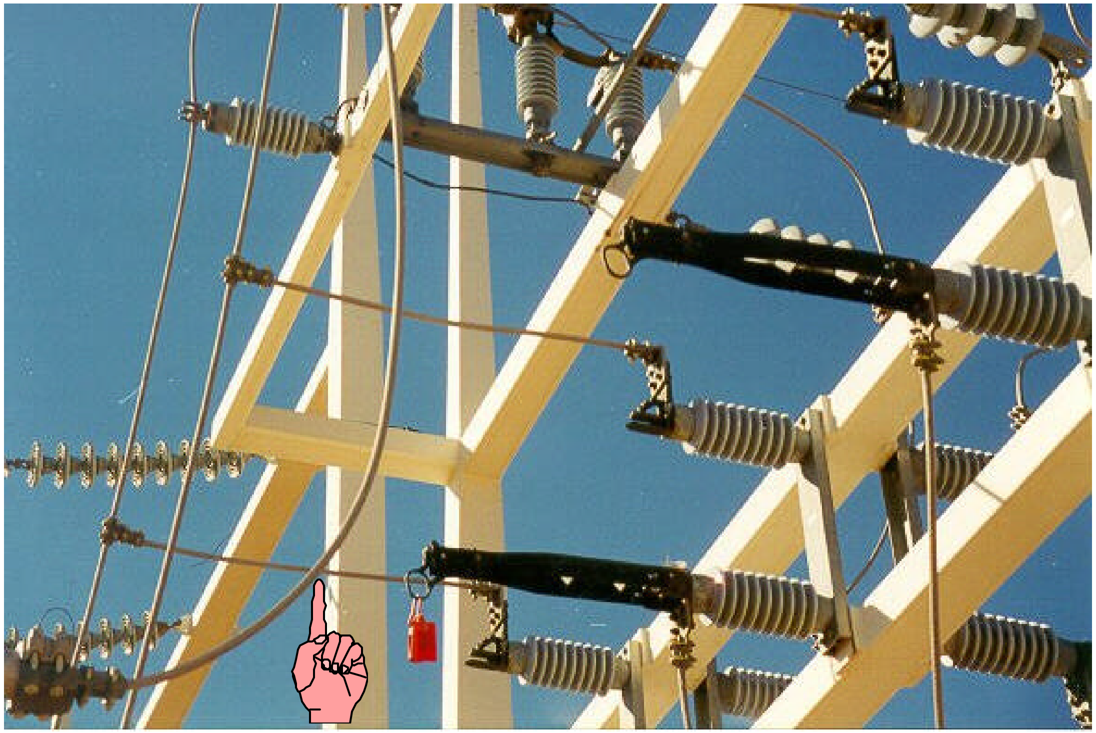
Spark gap attachment on 138kv bushing effectively lowers electrical clearance to ground 2feet. Does it matter?

Does it matter? You Bet!



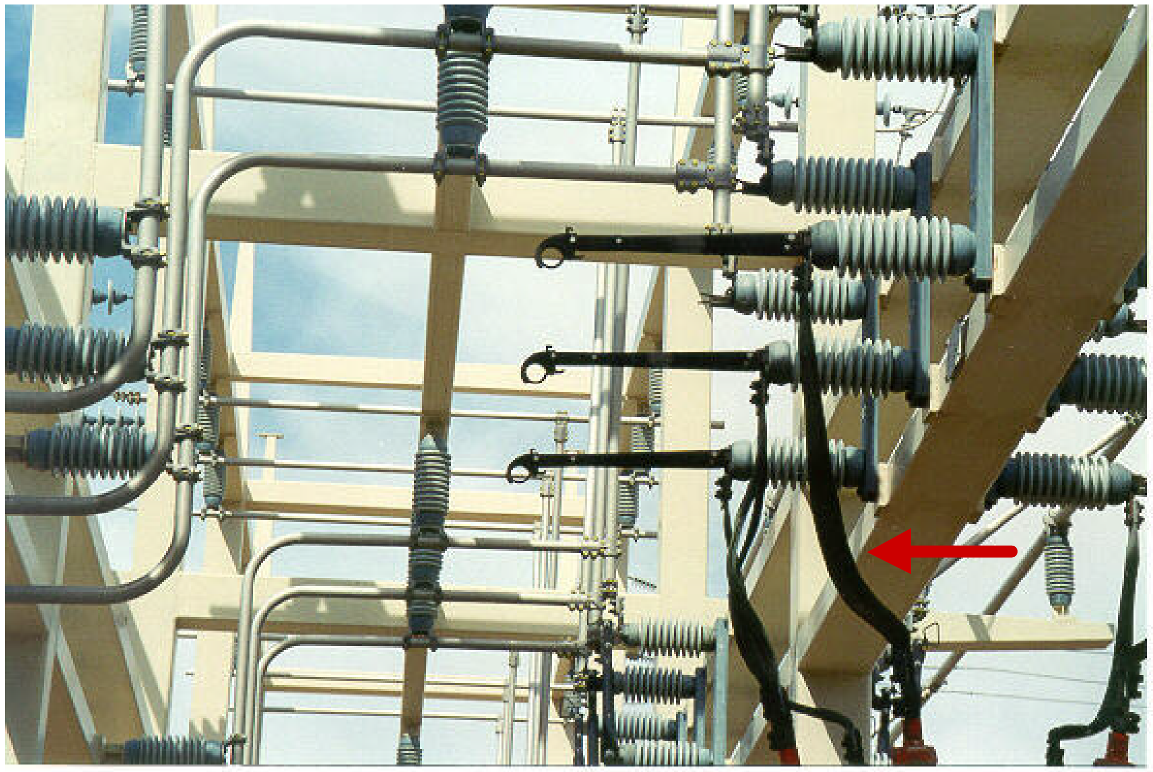
Power system Design/installation issues

Improperly installed equipment



Note distance of conductor/jumper

Power system Design/installation issues



Flat woven conductors- PPG's don't properly fit/ Electrical workers must use portable ladder to install grounds close to breaking M.A.D

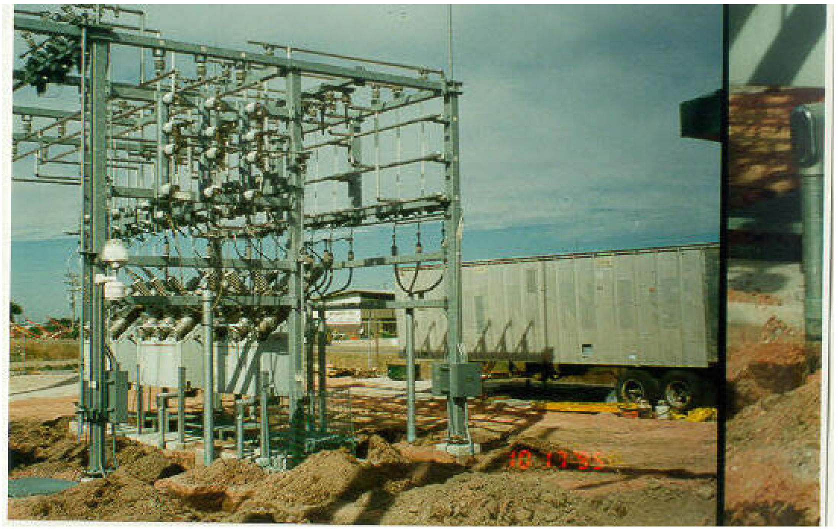
Right of Way Problems 115kv line was built in the 1950's before ski town was developed

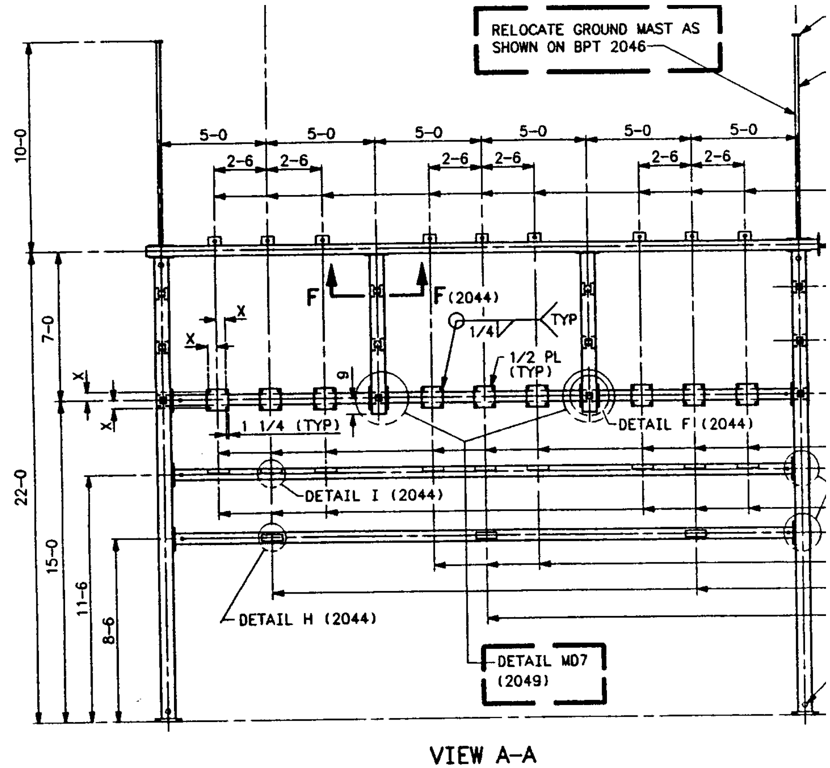
How would you like to change those light bulbs!

City fueling station, could have static problems

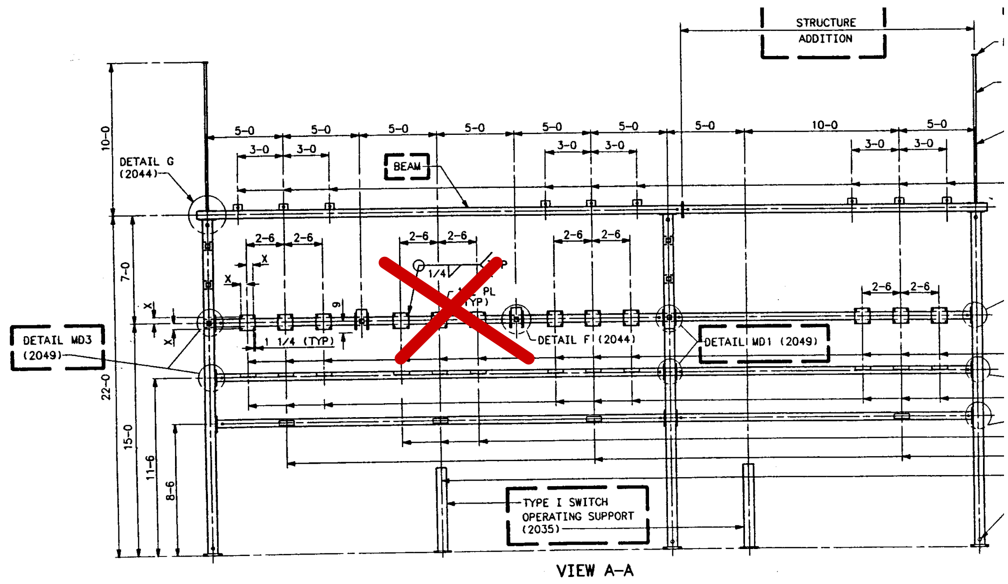
Apartment complex

This installation meets electrical clearance requirements





Electrical clearance meets code, Maintenance cannot perform maintenance on center breaker without taking all 3 out of service



Spacing modified by adding new bay, removing center circuit breaker, distance increased from 10’ centers to 20’. This allows bypass of circuit breaker.

What is WAPA doing to correct these issues?

- Safety Office reviews all specs for substation and transmission line design and modifications
- Maintenance division brought in at the planning stage for construction on the power system
- Project Manager assigned to all major projects
- Design Engineers required to make site visits for modification of existing facilities.
- Aggressive Right of Way (ROW) policy for infringements on the Transmission system.

Difference Between Electrical Clothing and Fire Clothing

Doug Lovette

Electrical Worker Protective Apparel

Versus

Structural Fire Fighting Protective Clothing

A Comparison

Presented to the DOE Electrical Safety Committee

June 2000 – Chicago, Illinois

Electrical Worker Protective Apparel
ASTM Standards

ASTM F1506 - "Performance Specification for Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards"

- Adopted in 1994
- FTMS191A, Method 5903.1
- March 2000, Requires Arc Testing

ASTM F1958 (formerly PS-57), "Test Method for Determining Ignitability of Clothing by Electric Arc Exposure Method Using a Mannequin"

- PS-57 – Adopted in 1997
- F1958 – Adopted in 1999
- Evaluate and determine ignitability of untreated fabrics

- ASTM F1959- (formerly PS-58), "Test Method for Determining Arc Thermal Performance (Value) of Textile Materials for Clothing by Electric Arc Exposure Method Using Instrumented Sensor Panels".
    - PS-58 – Adopted in 1997
    - F1959 – Adopted in 1999
    - standard test method FR clothing
    - provides the test method to determine:

- Arc Thermal Performance Value (ATPV) - the incident energy, in calories/cm^2, that results in sufficient heat transfer through the fabric to cause the onset of a second degree burn based on the Stoll curve
- Heat Attenuation Factor (HAF) - The percentage of incident energy which is blocked by a protective material at an incident energy level equal to ATPV
- Breakopen Threshold (E_{BT}) - The average of the five highest incident energy levels which did not cause FR fabric breakopen and did not exceed the second degree burn criteria).

Structural Fire Fighting Protective Clothing
NFPA Standards

- NFPA 1971 – “Protective Ensemble for Structural Fire Fighting”

- Development in 1973 – Adopted in 1975 – Protective Clothing
- 1986 Edition – More Performance Requirements, Less Specifications
- 1991 Edition – Third Party Certifications, Listing and Labeling
  Protective Hoods, Wristlets, Heat Stress, Cleaning
- 1997 Edition – Combines NFPA 1971 (Protective Clothing)
  NFPA 1972 (Helmets)
  NFPA 1973 (Gloves)
  NFPA 1974 (Footwear)

- Thermal Protective Performance – (TPP)
  - Heat Flux Exposure of 2.0 cal/cm^{2}s (F)
  - TPP = F x t where t is time to 2nd degree burn
- Flame Resistance Test One
  - Federal Test Method Standard (FTMS) 191A
  - Method 5903.1, Flame Resistance of Cloth – Vertical

- NFPA 1975 – "Station/Work Uniforms for Fire Fighters"

- Development in 1982 – Adopted in 1985
- Established requirements for FR Station Uniform Clothing
- 1994 Edition – Revised Scope/Purpose
  Not Primary Protective Garment (Exceptions)
  Not Cause or Contribute to Injury
  Pre-Test Conditions – Washing/Dry Cleaning

- NFPA 1976 – “Standard for Protective Clothing for Proximity Fire Fighting”
- NFPA 1977 – “Standard on Protective Clothing and Equipment for Wildland Fire Fighting”
- NFPA 1999 – “Standard on Protective Clothing for Emergency Medical Operations”
- Two draft standards – NFPA 2112 and 2113 – flash fire exposures

OSHA References

- 29CFR 1910.132(d) – Personal Protective Equipment, Hazard assessment and equipment selection
- 29CFR 1910.156(e) – Fire Brigades, protective clothing
- 29CFR 1910.269(l)(6)(iii) – Working on or near exposed energized parts, Apparel

Comparative Heat Flux

• .2 cal/cm^2/sec.	Red Hot Stove Element
• 2 cal/cm^2/sec.	TPP – NFPA 1971
• 30 cal/cm^2/sec.	S. E. U. S. Utility Accident

Cost and Weight

- Clothing to protect from the hazards of electrical arcs:
  - 1/3 the weight
  - 1/5 the cost

Conclusions

- There are many similarities
  - Use same FTMS 191 Test Method
  - Some NFPA philosophies used in ASTM documents
- There are many differences
  - Clothing in presence of arc reacts differently than in flame
  - Short term versus long term exposure
  - Breakopen and HAF
- Electrical Arc protection apparel is not apprpriate for fire brigade use
- Fire brigade coat could be used as electrical apparel IF
  - Wanted to test the garment to the ASTM standards
  - Wanted to use a heavier, more expensive garment

R&D Topics Panel Discussion

Hugh Bundy, Keith Gershon, Edward Henderson, Orville Paul

R&D PANEL DISCUSSION

- 1. What is a "light" electrical shock?
- 2. Is there a requirement for an AHJ at DOE R&D sites?
- 3. Is there a need for having an AHJ in an R&D environment?

R&D PANEL DISCUSSION

- 4. Does the NEC apply to R&D facilities? We've been living without an AHJ for years. Why do we need one now?

- 5. What does the NEC say an AHJ is permitted to do?

R&D PANEL DISCUSSION

- 6. Can the AHJ make interpretations of the rules or permit alternate
- methods? Under what conditions?

- 7. What equipment should be examined by an AHJ?

R&D PANEL DISCUSSION

- 8. Have we ever found vendor furnished equipment un-safely wired? Have you ever found it with a UL label?

R&D PANEL DISCUSSION

- 9. We either buy or build the R&D equipment we need. Sometimes we buy
- equipment that is manufactured outside the USA. We're the experts. We
- know what we want and how we're going to use it than anyone else. Why do
- we need an AHJ to 'approve' equipment?

R&D PANEL DISCUSSION

- 10. Did anyone ever get shocked or hurt from non-NRTL equipment?
- 11. The equipment is listed by an NRTL (e.g., UL), so why did it fail?

R&D PANEL DISCUSSION

- 12. It has a UL label, can we use it wherever we want?

- 13. What is the AHJ looking for when examining equipment?

R&D PANEL DISCUSSION

- 14. It has an "EC" sticker. Isn't that the European version of 'UL'?

- 15. Should the AHJ be involved during design or only show up when the equipment arrives?

R&D PANEL DISCUSSION

- 16. What does an AHJ look at when examining non-NRTL listed equipment?

- 17. What are some of the possible problems that an AHJ might be faced with when asked to examine some equipment?

R&D PANEL DISCUSSION

- 18. Is it important to keep records of AHJ approvals (and why)? AHJ rejections (and Why)?

- 19. How will one person (the AHJ) examine all non-NRTL equipment?

R&D PANEL DISCUSSION

- 20. What are some of the qualifications of an AHJ? What are the criteria to be used to select an AHJ?

- 21. "How does an AHJ get trained?" ...certified?" Are commercial training sessions available?

R&D PANEL DISCUSSION

- 22. The diversity of Approving non-listed equipment:
- Why are different contractors using different criteria?
- What is the backlash from affected workers? Is this a foolish waste of time?

R&D PANEL DISCUSSION

- How many accidents are strictly the result of using non-listed equipment?
- How far do you go to assure the equipment "isn't likely to cause serious physical harm or death" (OSHA's requirement)?

R&D PANEL DISCUSSION

- Is a 110VAC shock considered 'likely to cause serious physical harm'?
- Are electrical measurements really necessary?
- Are permanent records required if the equipment has an 'approved' sticker? Do you use bar coded stickers related to a computer data base?

R&D PANEL DISCUSSION

- 22. When are interlocks required on R&D equipment?

- 23. How do you apply OSHA and the NEC for 'temporary' activities (experiments)?

R&D PANEL DISCUSSION

- 24. Are R&D workers forced to use unsafe equipment because they can't buy what they need (no one makes such equipment)?

- 25. Permanently mounted cable trays in permanent R&D labs

R&D PANEL DISCUSSION

- 26. Why does the R&D world think it does not have to comply with OSHA?
- 27. What standards does the R&D world think they should follow?
- 28. Why do the R&D people think they should not perform LO/TO on equipment?

R&D PANEL DISCUSSION

- 29. What does the R&D people think they should not have to use electrical PPE?

- 30. What makes the R&D world different?

FIRE AT LOS ALAMOS

MARK REGAN


STOP

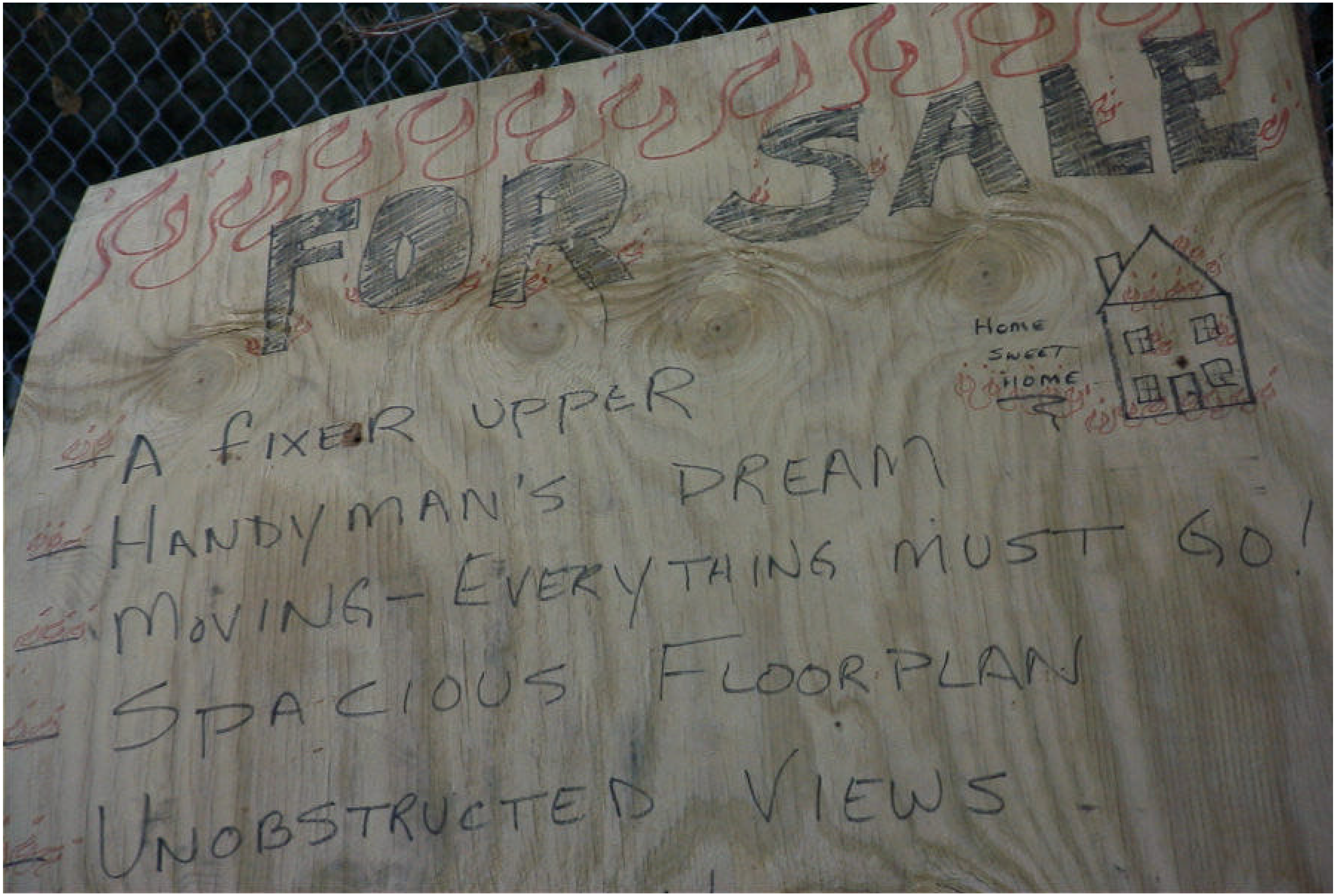

42

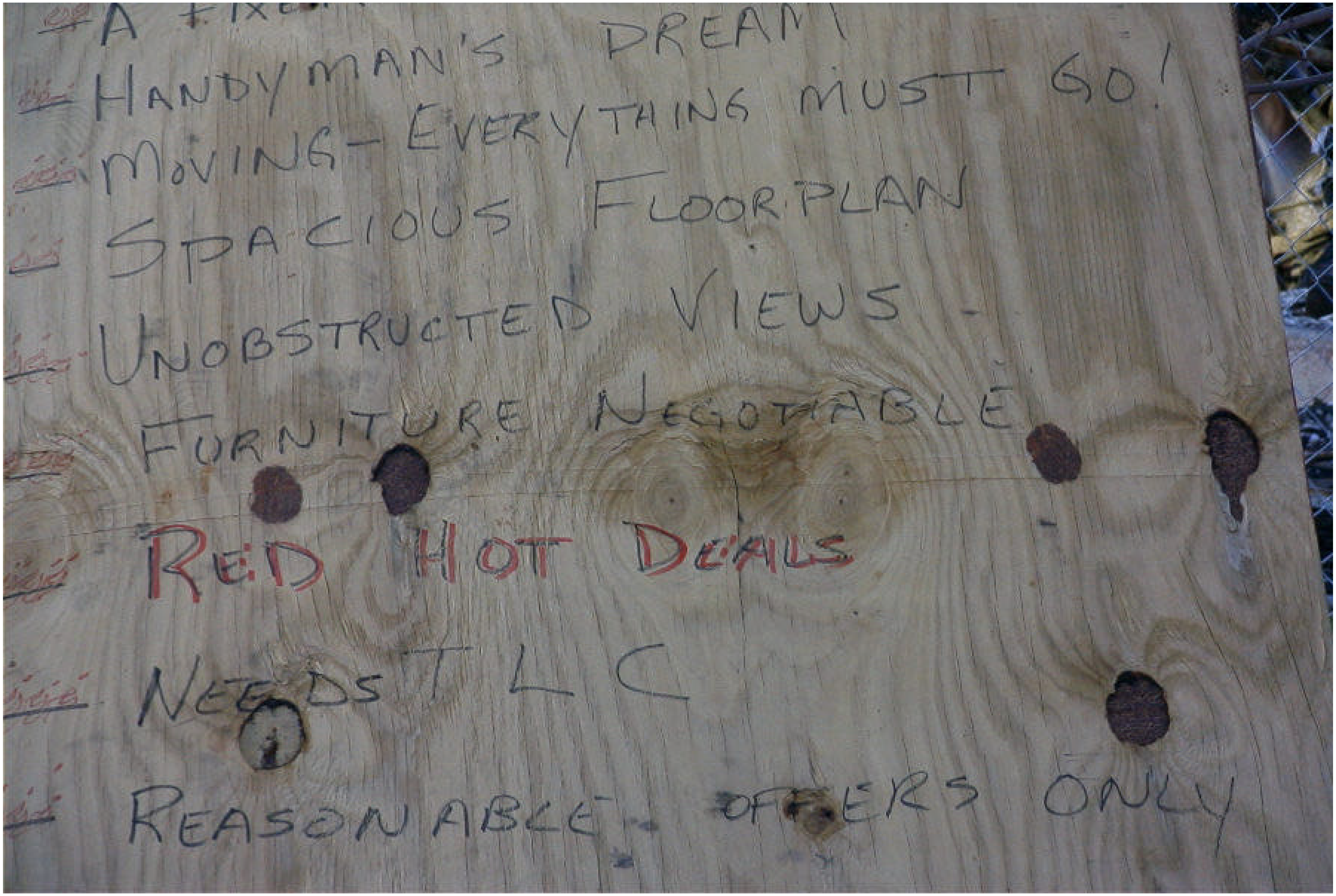

ALL PRIVATE
PARKING

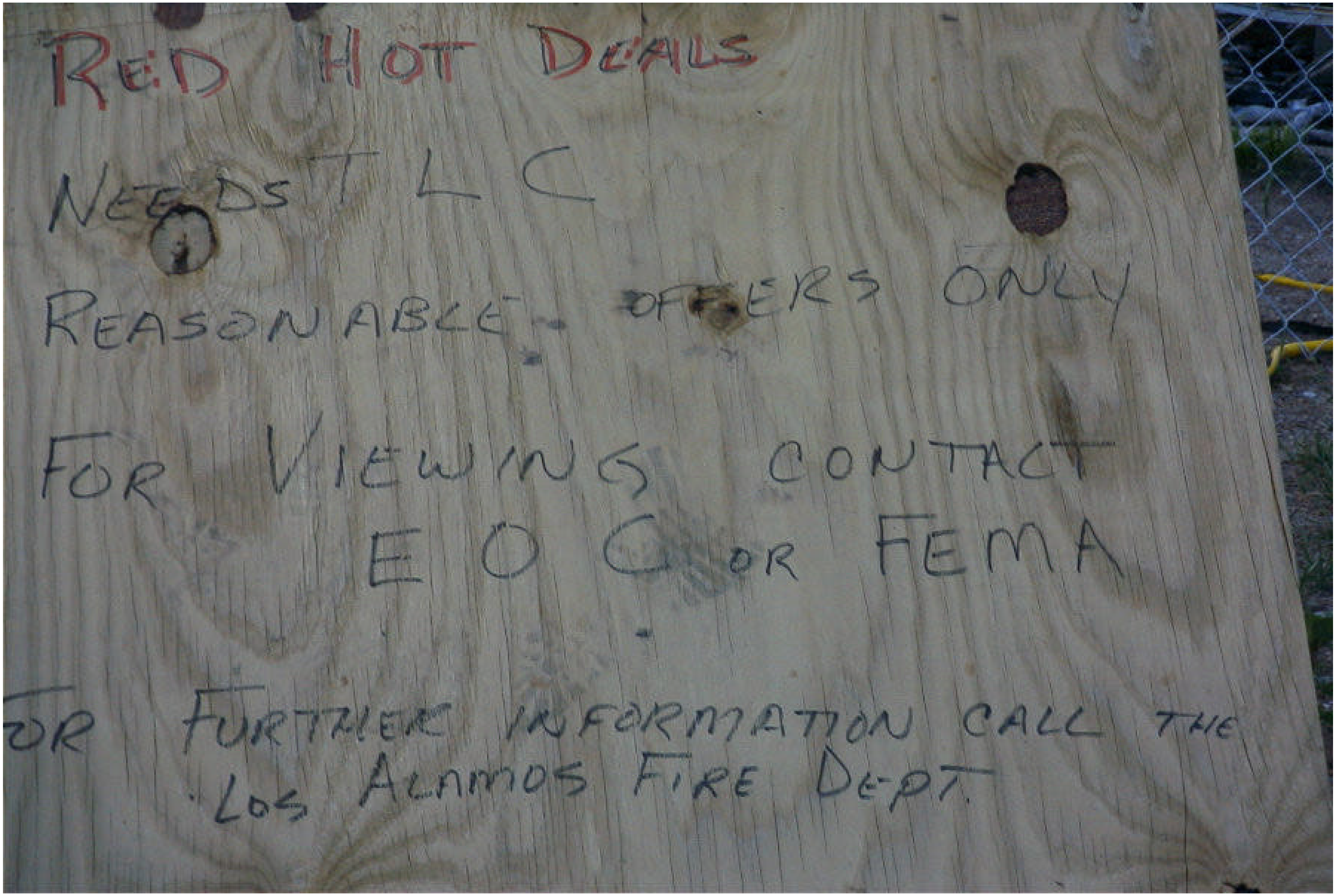

LOT 171
1800
CORONA


4214 B


NO MORE USW


FOR SALE
Home
Sweet
Home
A fixer upper
Handyman's dream
Moving - everything must go!
Spacious floor plan
Unobstructed views


HANDYMAN'S DREAM
MOVING - EVERYTHING MUST GO!
SPACIOUS FLOORPLAN
UNOBSTRUCTED VIEWS -
FURNITURE NEGOTIABLE
RED HOT DEALS
NEEDS TLC
REASONABLE OFFERS ONLY


RED HOT DEALS
NEEDS T L C
REASONABLE OFFERS ONLY
FOR VIEWING CONTACT
E O C OR FEMA
FOR FURTHER INFORMATION CALL THE
LOS ALAMOS FIRE DEPT.


FOR VIEWING CONTACT
E O C OR FEMA
FOR FURTHER INFORMATION CALL THE
LOS ALAMOS FIRE DEPT.
REMODELING DONE BY NAT'L PARK
SERVICE

NFPA 77 Static Electricity

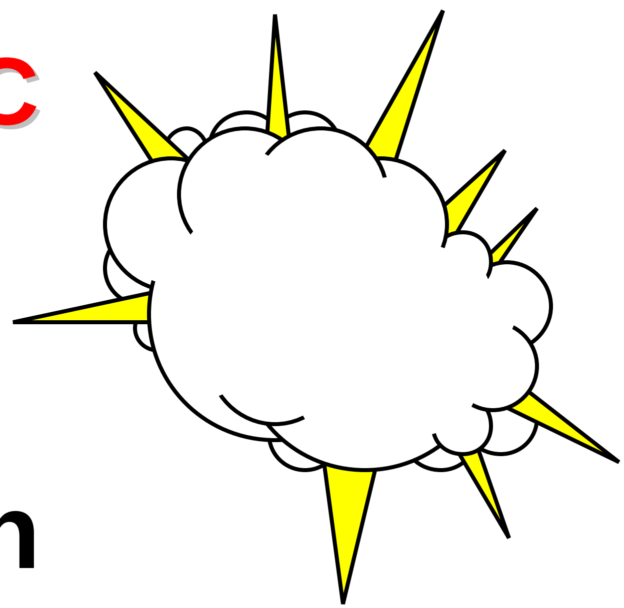
Scott Gilmore

Static Electricity

Scott Gilmore

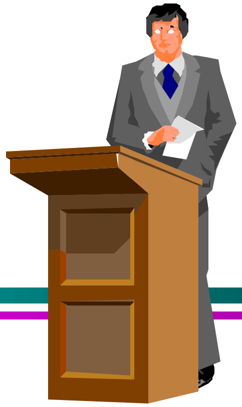
Honeywell FM&T/KC

(816) 997-4043



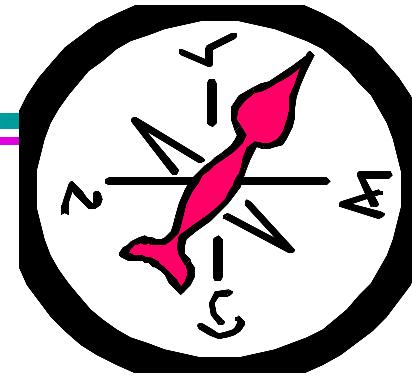
- **General Overview**
- **General Discussion**
- **Safety Perspective**

OBJECTIVES



- To enhance general knowledge and understanding about static electricity (electrostatics)
- To enhance understanding of natural static generation and static dissipation
- To understand safety measures taken to minimize risks from electrostatic discharge (ESD)

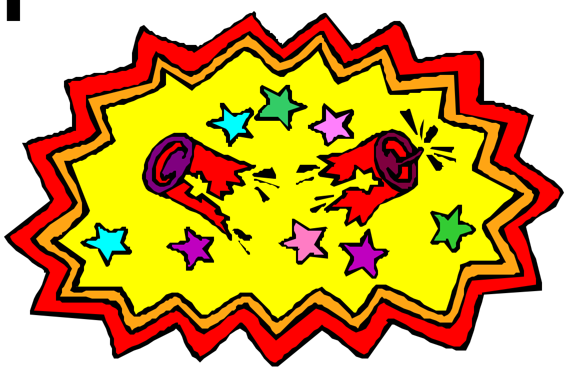
OUTLINE



- **Introduction** **(Module "1")**
- **Basics -- Static Electricity** **(Module "2")**
- **Typical Control Measures** **(Module "3")**
- **Actions/Recommendations** **(Module"4")**
- **Conclusion + Q&A** **(Module "5")**

Static Electricity Quiz

When you fill your car with gasoline, the greatest hazard of gasoline vapor ignition (explosion) is:



A. Cigarettes / cigars
B. Automobile backfire
C. Other heat source (mufflers)
D. Static discharge

Static Electricity Quiz

When you fill your car with gasoline, static electricity is generated from the filling process itself.

A. TRUE

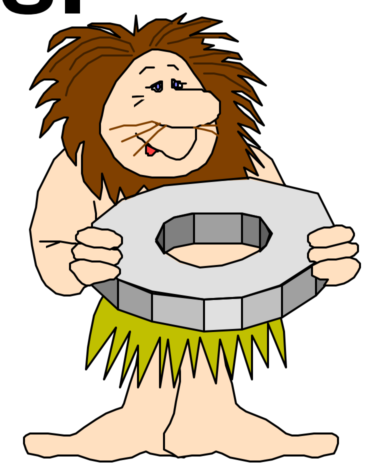
B. FALSE

Static Electricity Quiz

When static electricity is generated filling your gas tank, your car is effectively isolated on rubber tires to eliminate static hazards.

A. TRUE

B. FALSE

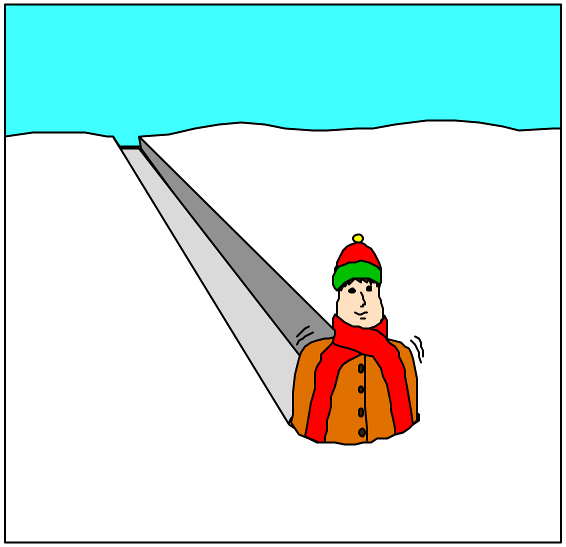


Static Electricity Quiz

The generation of static electricity is worst in the Fall and Winter.

A. TRUE

B. FALSE

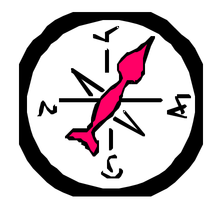


Static Electricity Quiz

The most common natural electrostatic phenomena is:

A. The northern lights

B. A lightning bolt

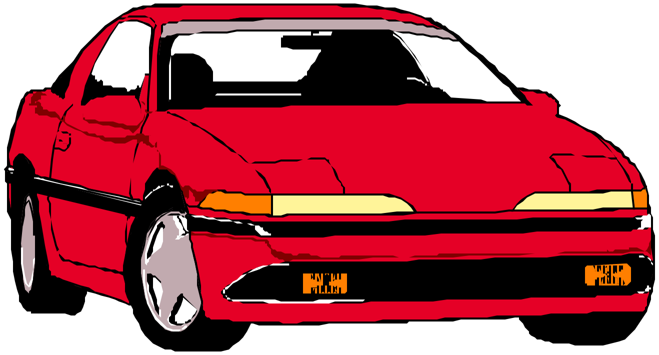


C. A compass needle pointing north

D. The sparkle of flowing water

Static Electricity Quiz

At a gasoline station, gasoline vapor ignition hazards exist anywhere within the station's property lines:



A. True

B. False

Static Examples

- FM&T/KC

  -- Laborers

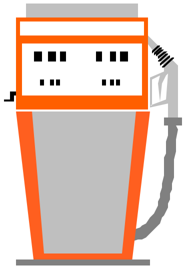
- External Investigations

  -- Production Worker

- Pick-up Bed liners

  -- Warnings

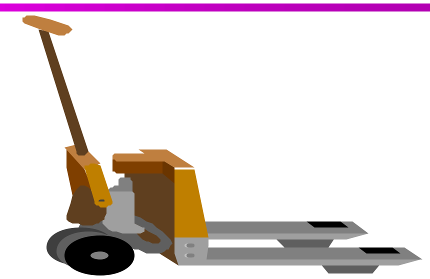
- Refueling of Vehicles

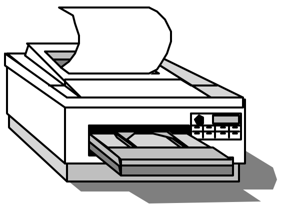


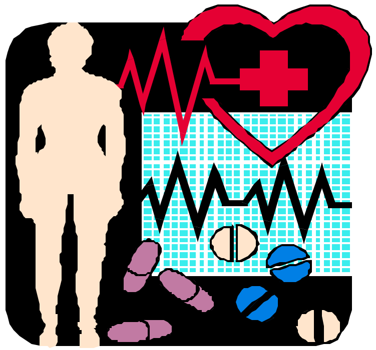
  -- Recent News

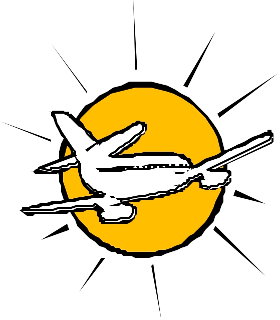
Static Examples

- Pallet Wrap Machine
  - -- Plastic wrap
- Copiers / Printers
  - -- Static brushes
- Medical Capsules
  - -- Polonium 210
- Tanker / Jet Fueling
  - -- Bonding



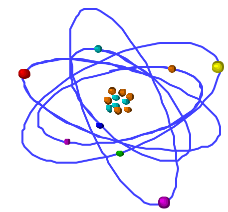






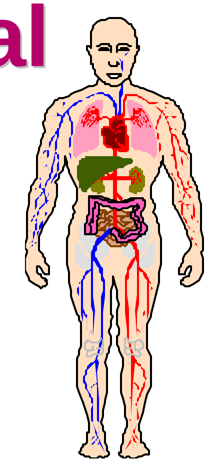
Basics of Electricity

- Electrons ALWAYS in Motion in Nature



  -- Separating (Imbalance)

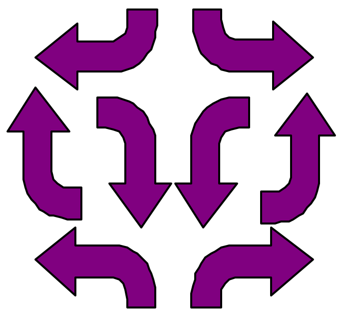
  -- Re-uniting (Balance)
- Objects Either Conductor / Insulator
- Form of Energy / Energy Potential



  -- Senses Not Detect
- Static vs. Dynamic

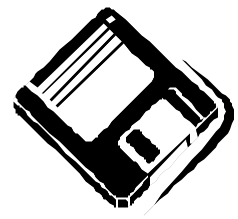
Static Terminology

- **Voltage** (normally kilo, mega)
- **Amperage** (normally milli, micro, nano, pico)
- **Capacitance** (storage ability)
- **Resistance** (opposition)
- **Joules** (energy level)
- **Relaxation** (dissipation)



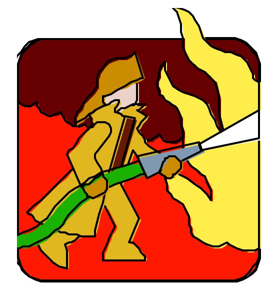
Hazards of Static Electricity

Direct Property Damage



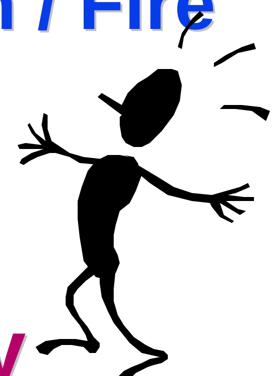
» Electronics / Magnetics

Indirect Property Damage



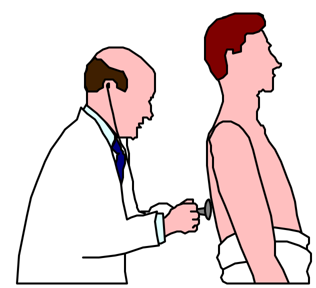
» Overpressures / Flash / Fire

Direct Personal Injury



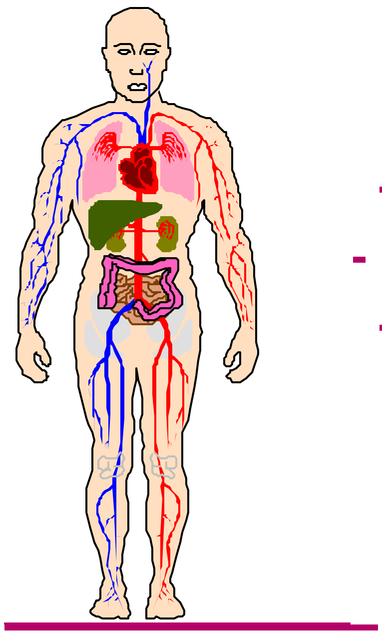
» Startle Reflex

Indirect Personal Injury



» Burn / Flash / Concussion

Illustration of Static Electricity



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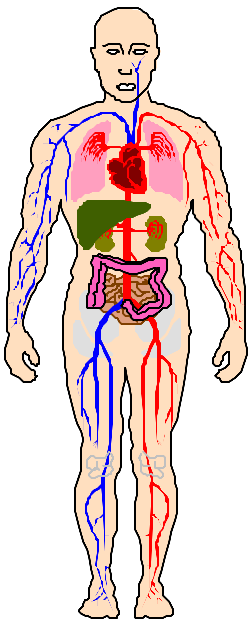
STATIC CHARGED

BLEEDING

STATIC DEPLETED

EQUALIZE TO NEUTRAL STATE

Illustration of Static Electricity



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EXCESSIVE STATIC
CHARGE ISOLATED
(CAPACITOR)

NO BLEEDING

AIR INSULATOR

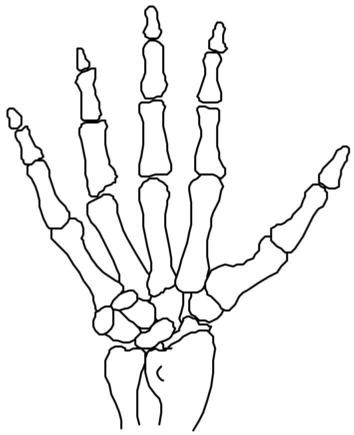
\+ + +

\+ + + + + + + +

UNABLE TO EQUALIZE

Elements of Static Ignition

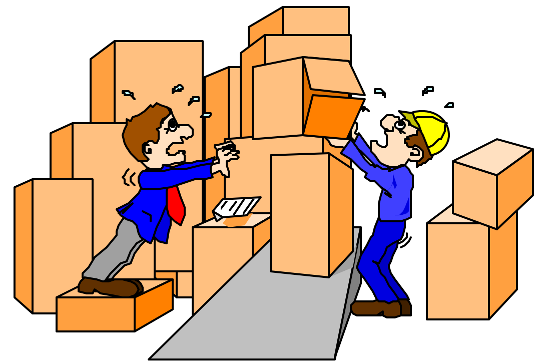
1. Static Charge Generated
2. Isolated Accumulation of Charge
3. Static Spark Discharge Across Gap
4. Spark Occurs in Ignitable Mixture
5. Spark of Sufficient Energy to Trigger Ignition of Mixture



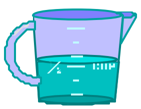
All 5 are Essential

Typical Static Control Measures

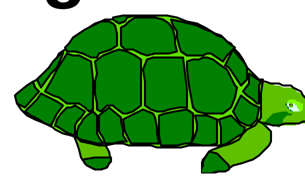
STATIC GENERATION



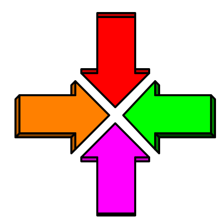
1. Modify the Work Process



- » Change materials
- » Change equipment (metal)
- » Slow process (flow / mixing / agitation)

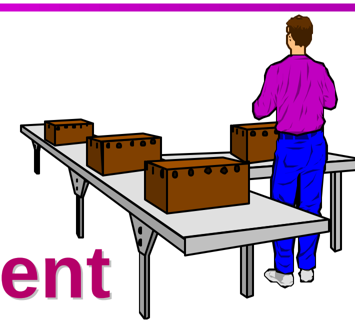


- » Add surfactants
- » Bottom fill (liquids)
- » Humidification / Ionization of air

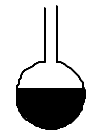


Typical Static Control Measures

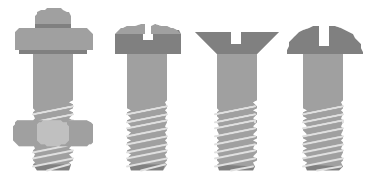
STATIC ISOLATION



2. Modify the Work Process / Equipment



- » Conductive additive
- » Change equipment (metal)
- » Bonding
- » Grounding
- » Humidification / Ionization

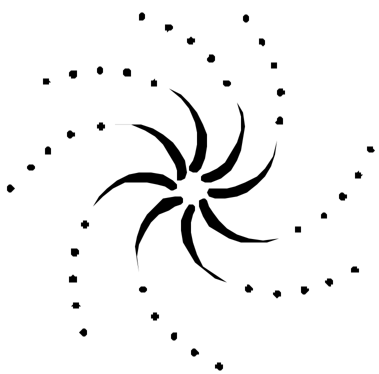


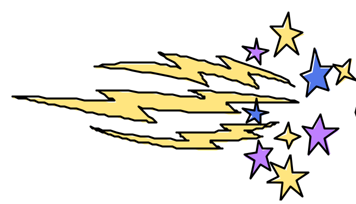
Typical Static Control Measures

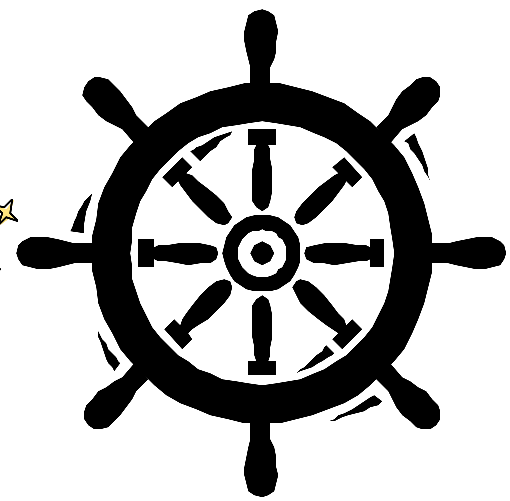
STATIC SPARKING

3. Modify the Work Process

- » Spark promoters





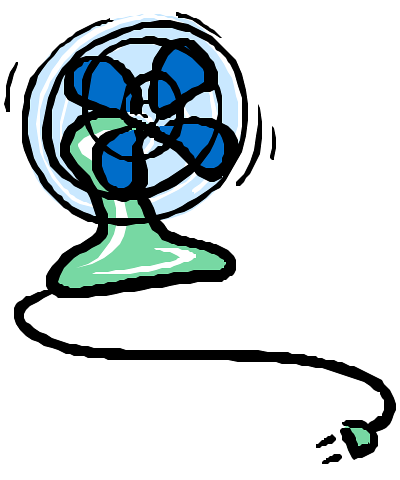


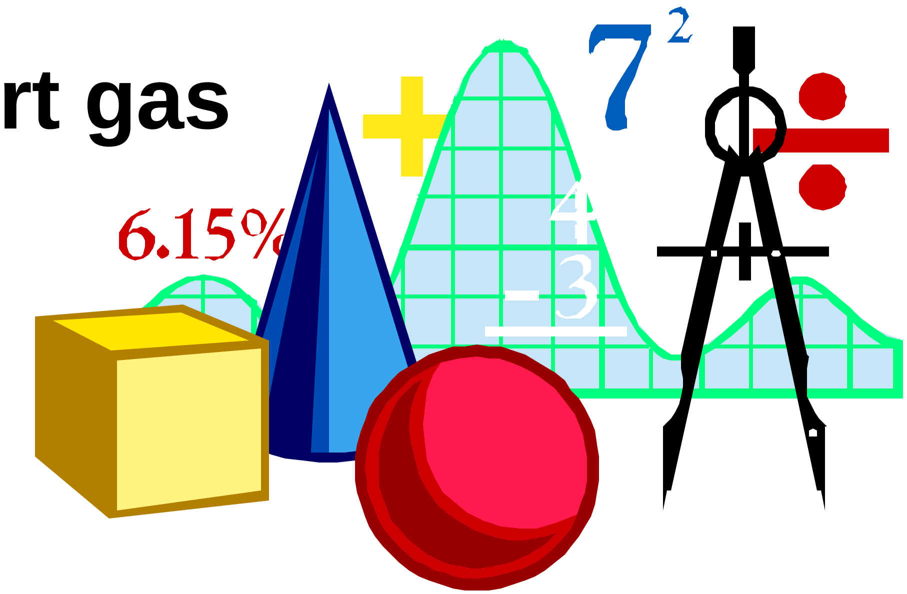
Typical Static Control Measures

STATIC IN IGNITIBLE MIXTURE

4. Modify the Environment

- Dilution
- Purge with Inert gas





Typical Static Control Measures

STATIC SPARK ENERGY LEVEL

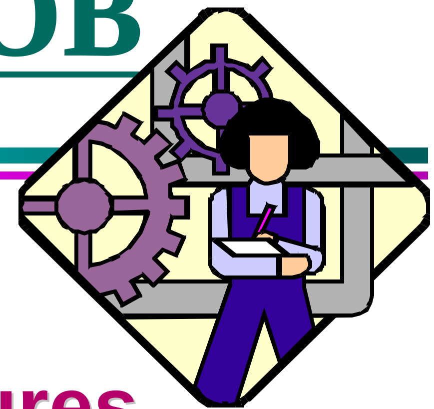
5. Modify the Spark

- » **None**

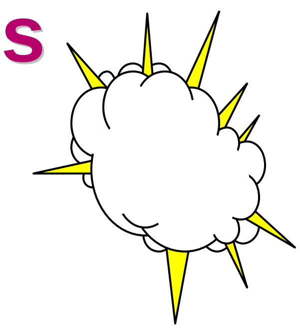
ACTIONS TO TAKE

- Understand Static
- Respond on Case-by-Case Basis
  - » Equipment Modifications
  - » Process Modifications
  - » Facility Modifications
  - » Engineering Controls
  - » Administrative Controls
- Share Information

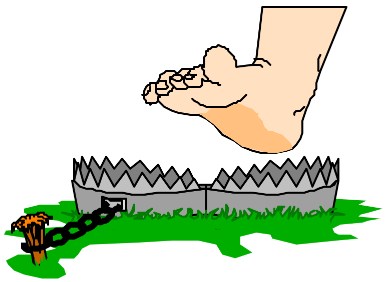
DURING YOUR JOB



- Appreciate nature of static
- Appreciate nature of ignitible mixtures
- Appreciate nature of susceptible equipment
- Wear PPE / Clothing
- Be observant of equipment / conditions
- Follow work practices
- Report static events to management
- Maintain vigilance / Maintain perspective

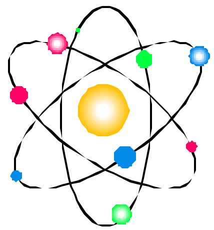


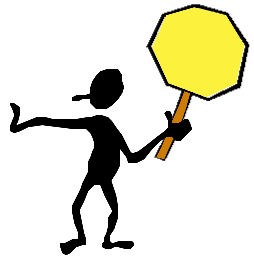
CONCLUSION



Static Risks

- Static is **ALWAYS** present
- **EVERY** activity generates static
- We can **NEVER** eliminate static
- We **CAN** understand and control it





OSHA Up-Date

Ron Stephens and John Grzywacz

1926 - Subpart K Electrical 1910 Subpart S Electrical

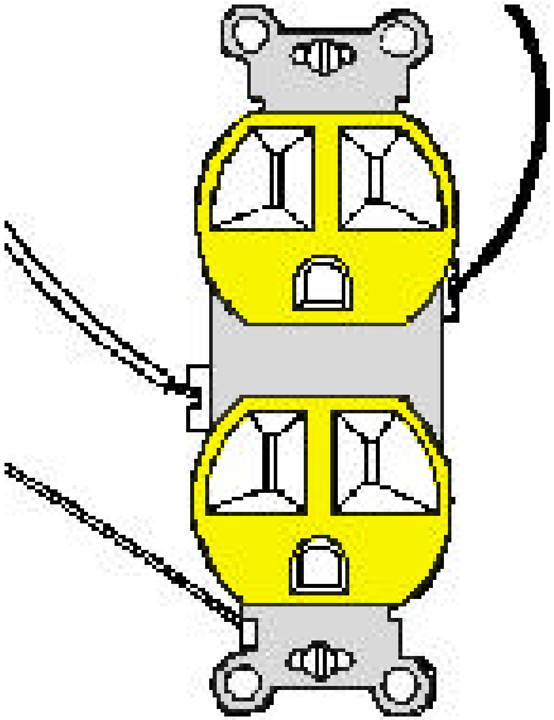
Ron Stephens, Assistant Area Director/Team Leader

John Grzywacz, Senior Instructor/OTI

An Enlightened Construction Worker

Subparts K & S Electrical - Installation Safety Requirements

- 1926.402(a) Covered. Sections 1926.402 through 1926.408 contain installation safety requirements for electrical equipment and installations used to provide electric power and light at the jobsite.
- 1910.302(a)(1) Covered. The provisions pf 1910.302 through 1910.308 of this sub-part cover electrical installations and utilization equipment installed or used within or on buildings, structures, and other premises.



- **[1910.303(a) Approval]** **[1926.403(a) Approval]**

All electrical conductors and equipment shall be approved.

NRTL'S (Nationally Recognized Testing Laboratories)

Applied Research Laboratories, Inc. (ARL)

Canadian Standards Association (CSA) (also uses initials "US" instead of "NRTL" in its markings)

Canadian Standards Association (CSA) (time limited use of mark formerly used by the American Gas Association (AGA))

Communication Certification Laboratory, Inc. (CCL)

Detroit Testing Laboratory, Inc. (DTL)

Electro-Test, Inc. (ETI)

Entela, Inc. (ENT)

Factory Mutual Research Corporation (FMRC)

Intertek Testing Services NA, Inc. (ITSNA) (formerly ETL Testing Laboratories, Inc.)

Intertek Testing Services NA, Inc. (ITSNA) (formerly ETL Testing Laboratories, Inc.)

MET Laboratories, Inc. (MET)

NSF International (NSF)

National Technical Systems,Inc. (NTS)

SGS U. S. Testing Company, Inc. (SGSUS) (formerly U.S. Testing Company, Inc.)

Southwest Research Institute (SWRI)

TUV Rheinland of North America, Inc. (TUV)

Wyle Laboratories (WL)

Underwriters Laboratories Inc. UL)

1910.303(b)(1) 1926.403(b)(1) NEC 110-3(a)

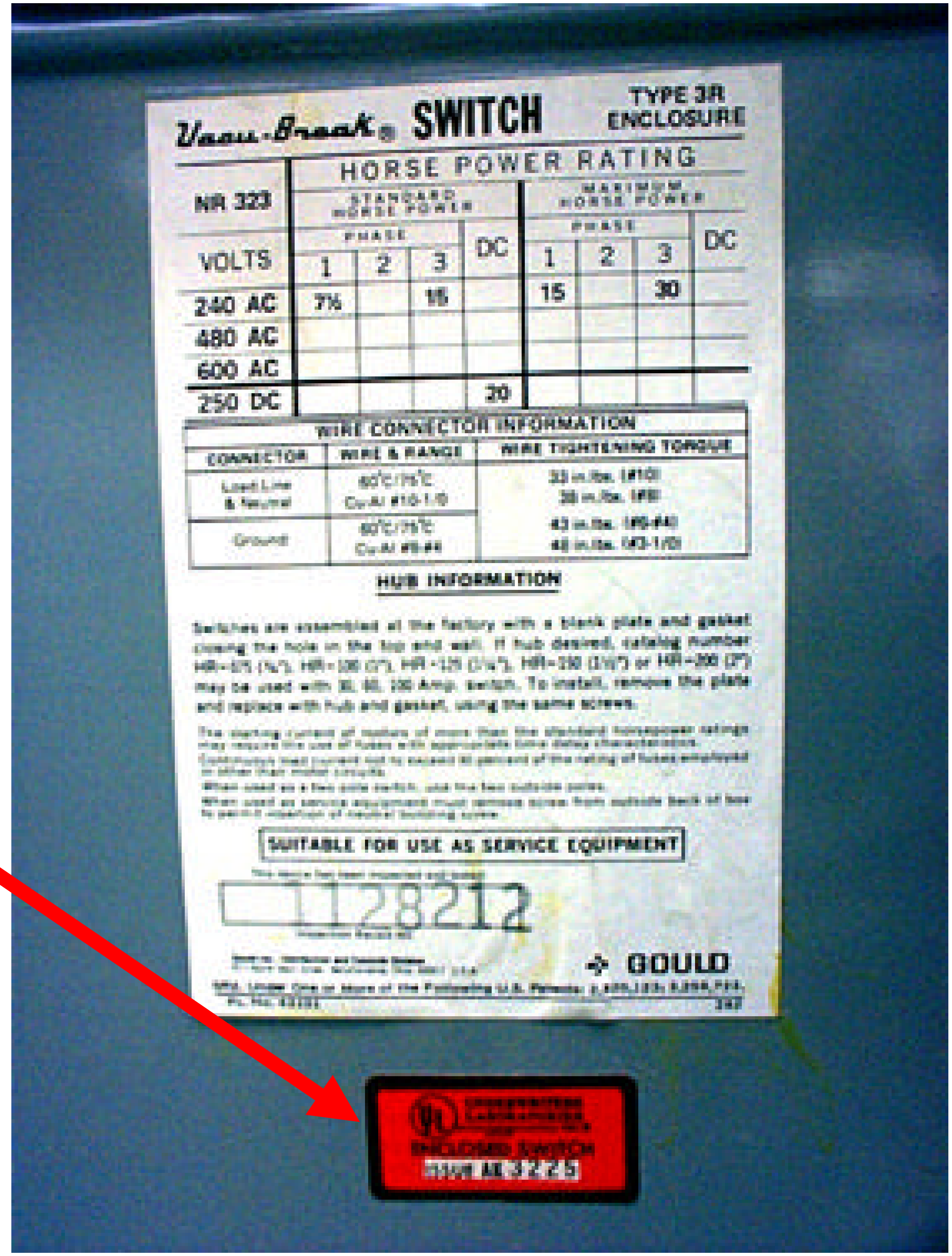
EXAMINATION: The employer shall ensure that electrical equipment is free from recognized hazards that are likely to cause death or serious physical harm to employees.

- **(b)(1)(i) Suitability for installation and use in conformity with the provisions of this subpart - evidenced by listing, labeling, or certification for that identified purpose.**
- **(b)(1)(ii) Mechanical strength and durability.**
- **(b)(1)(iii) Electrical insulation.**
- **(b)(1)(iv) Heating effects under conditions of use.**
- **(b)(1)(v) Arcing effects.**
- **(b)(1)(vi) Classification by type, size, voltage, current capacity, specific use.**
- **(b)(1)(vii) Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.**

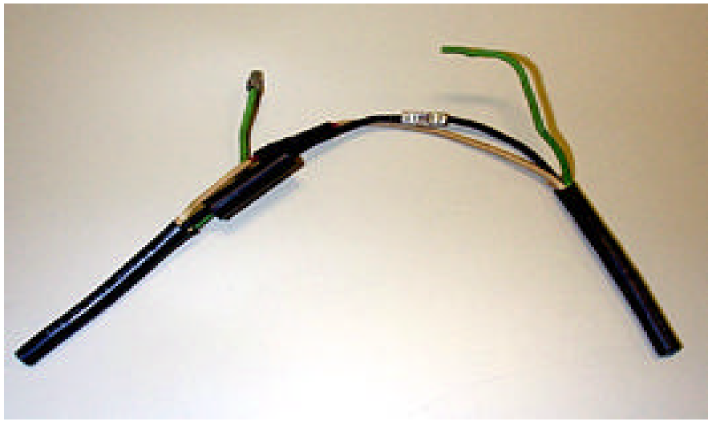
[1910.303(b)(2)](#) [1926.403(b)(2)](#) [NEC 110.3(b) - Installation and use.](#)

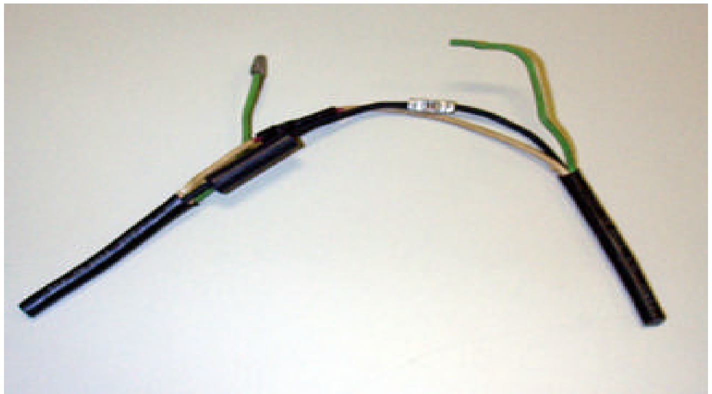
Listed, labeled, or certified equipment shall be installed and used in accordance with instructions included in the listing, labeling, or certification.

UL Label

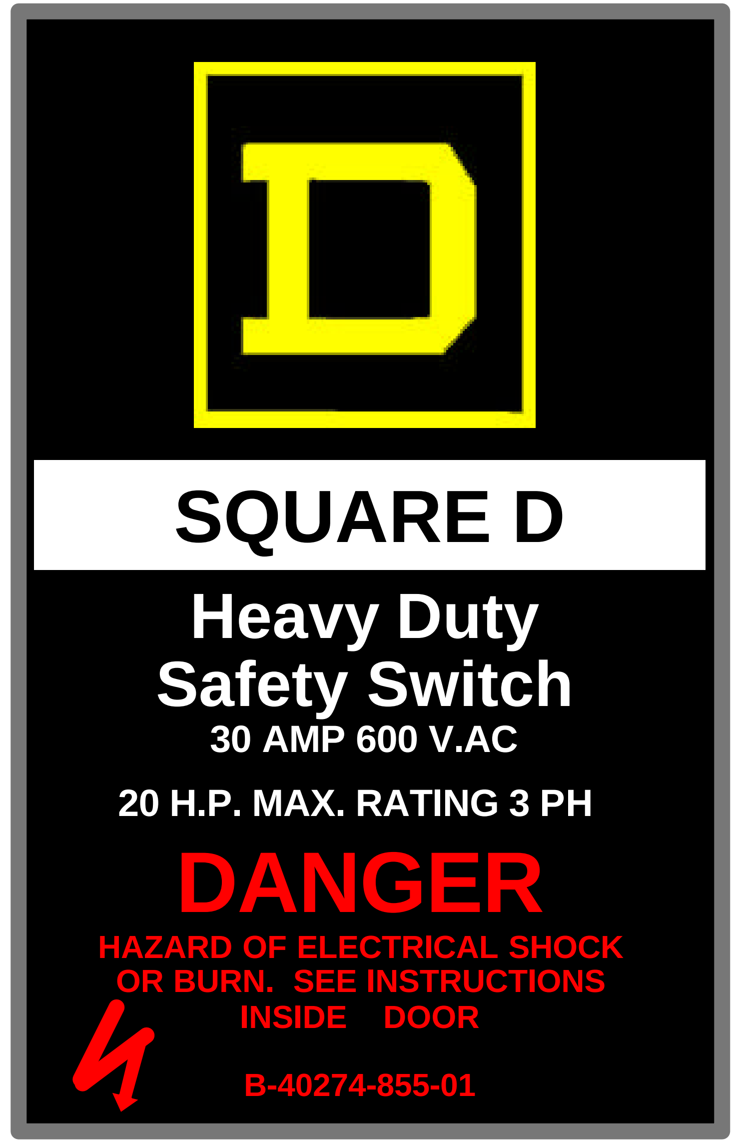


- **1910.303(c) Splices**
  1926.403(e)
  NEC 110.14(b)
  - Conductors shall be spliced or joined with splicing devices designed for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered.
  - All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device designed for the purpose.





- **[1910.303(e) Marking](#)**
  [1926.403(g)](#)
  [NEC 110.21](#)
  - **Electrical equipment shall not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment and unless other markings are provided giving voltage, current, wattage, or other ratings as necessary. The marking shall be of sufficient durability to withstand the environment involved.**



- **[1910.303(f) Identification of disconnecting means and circuits.](#)**

  [1926.403](#)

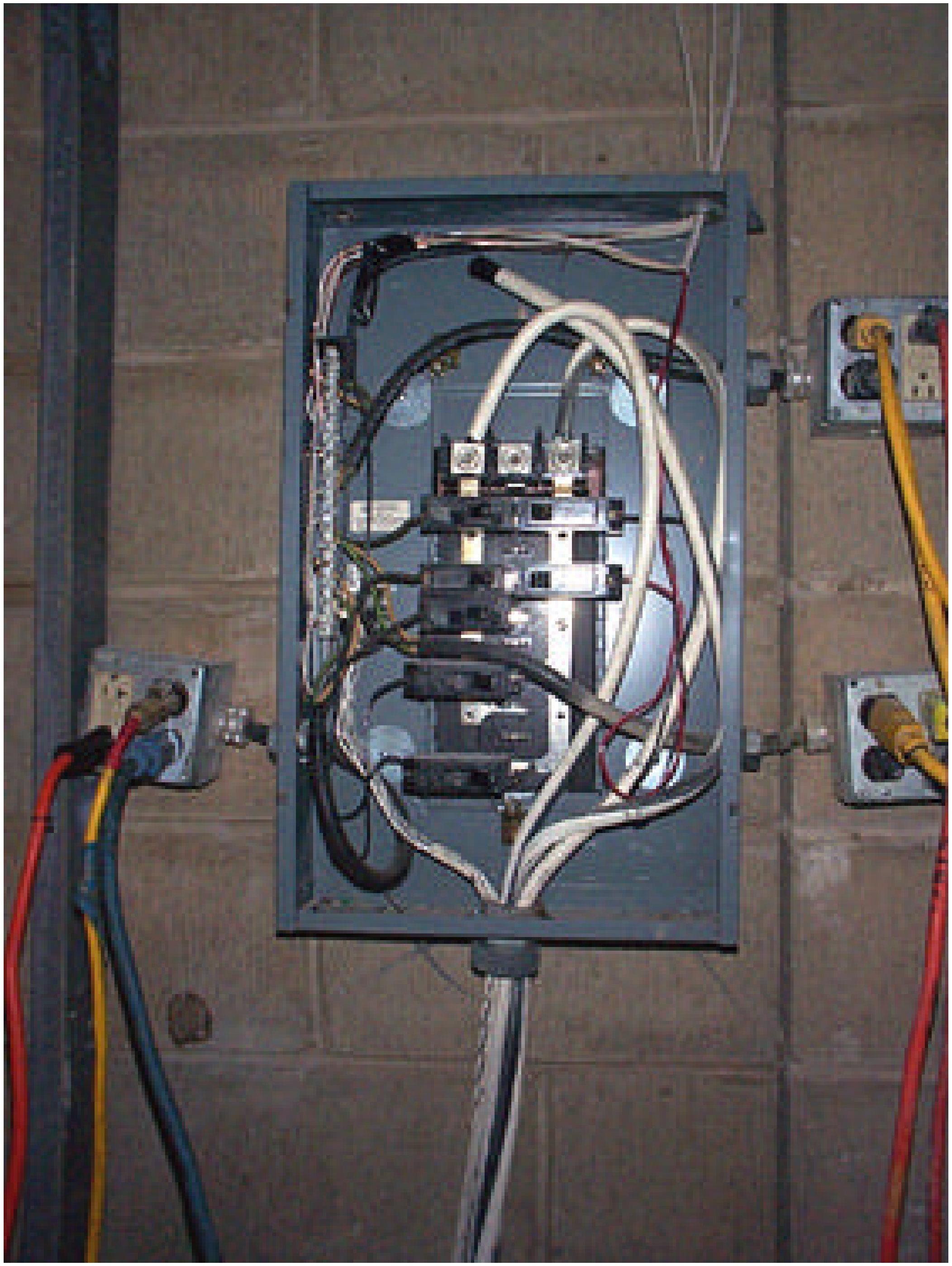
  [NEC 110.22](#)

  - **Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These markings shall be of sufficient durability to withstand the environment involved.**

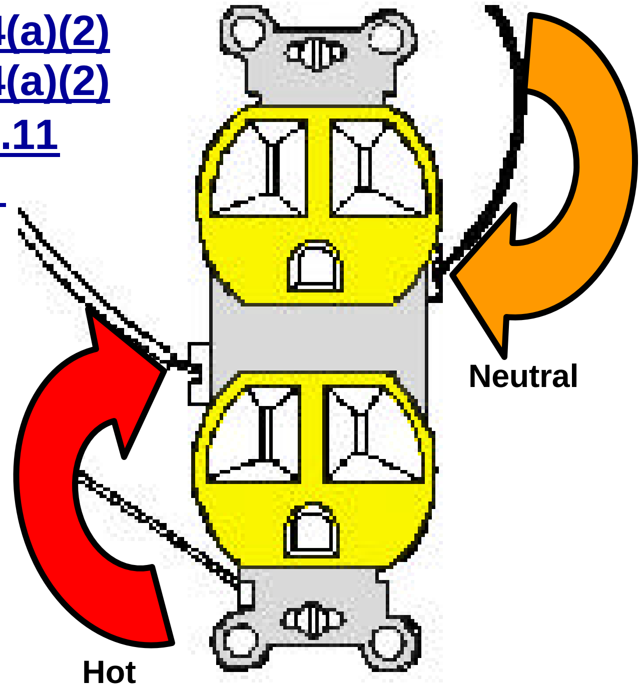
MARKINGS

- **1910.303(g)(2)**
  1926.403(i)(2)
  NEC 110.17(a)
  Guarding of live parts.

(i)(2)(i) Except as required or permitted elsewhere in this subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by cabinets or other forms of enclosures, or by any of the following means:

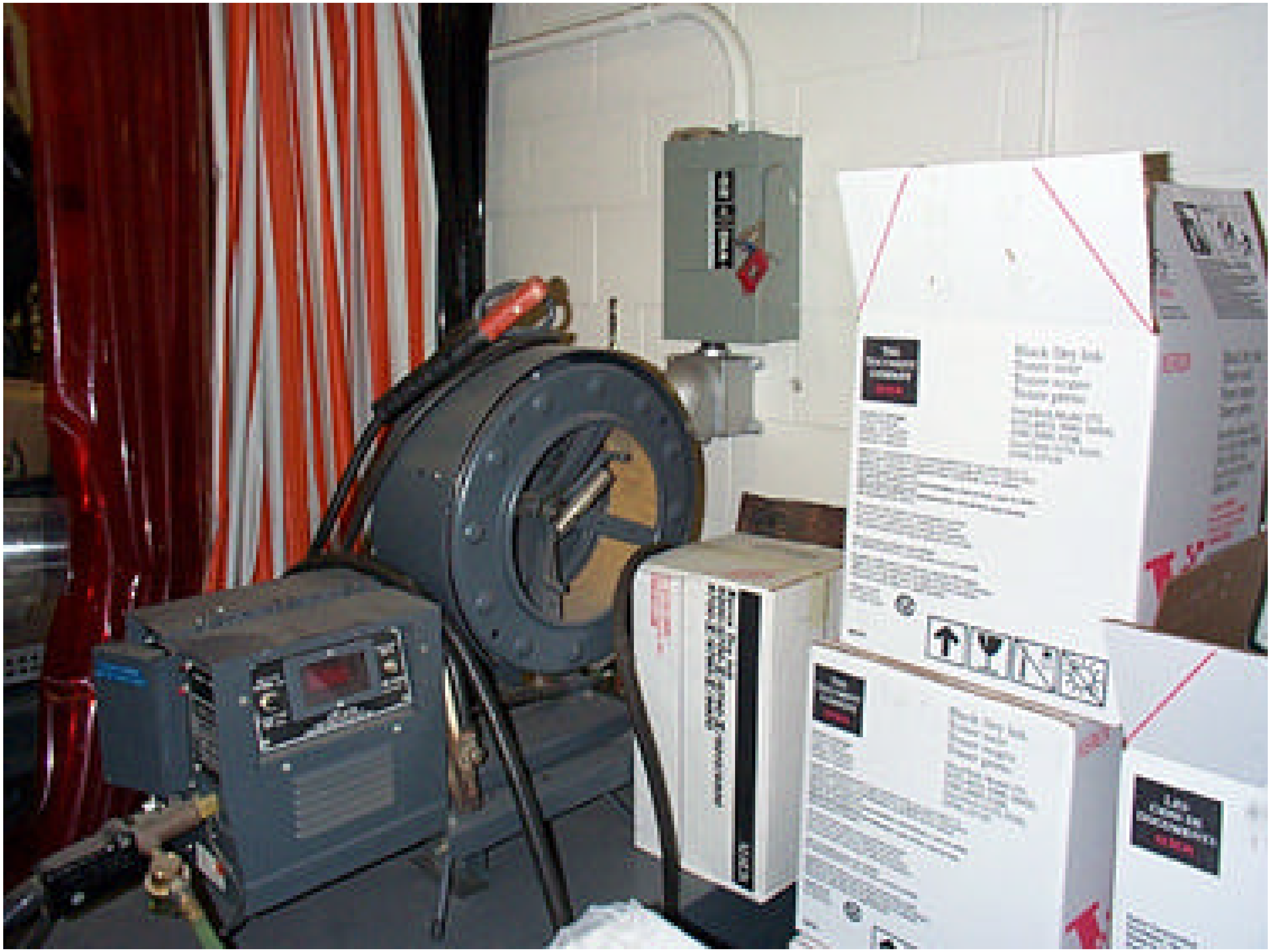


1910.304(a)(2)
1926.404(a)(2)
NEC 200.11
Reverse Polarity

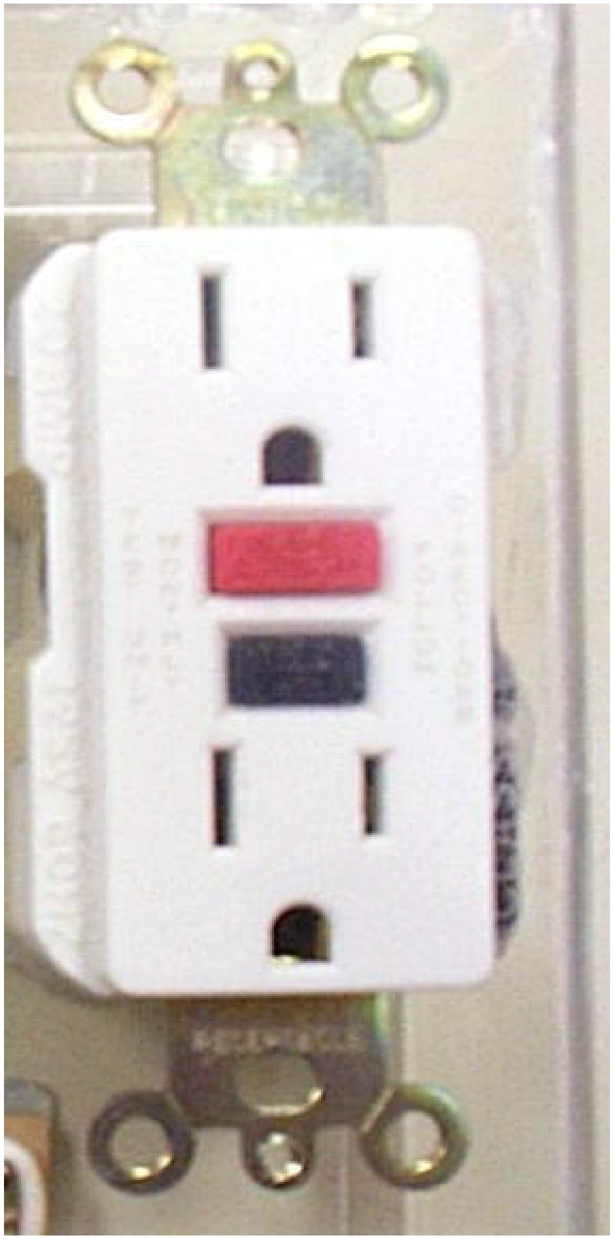


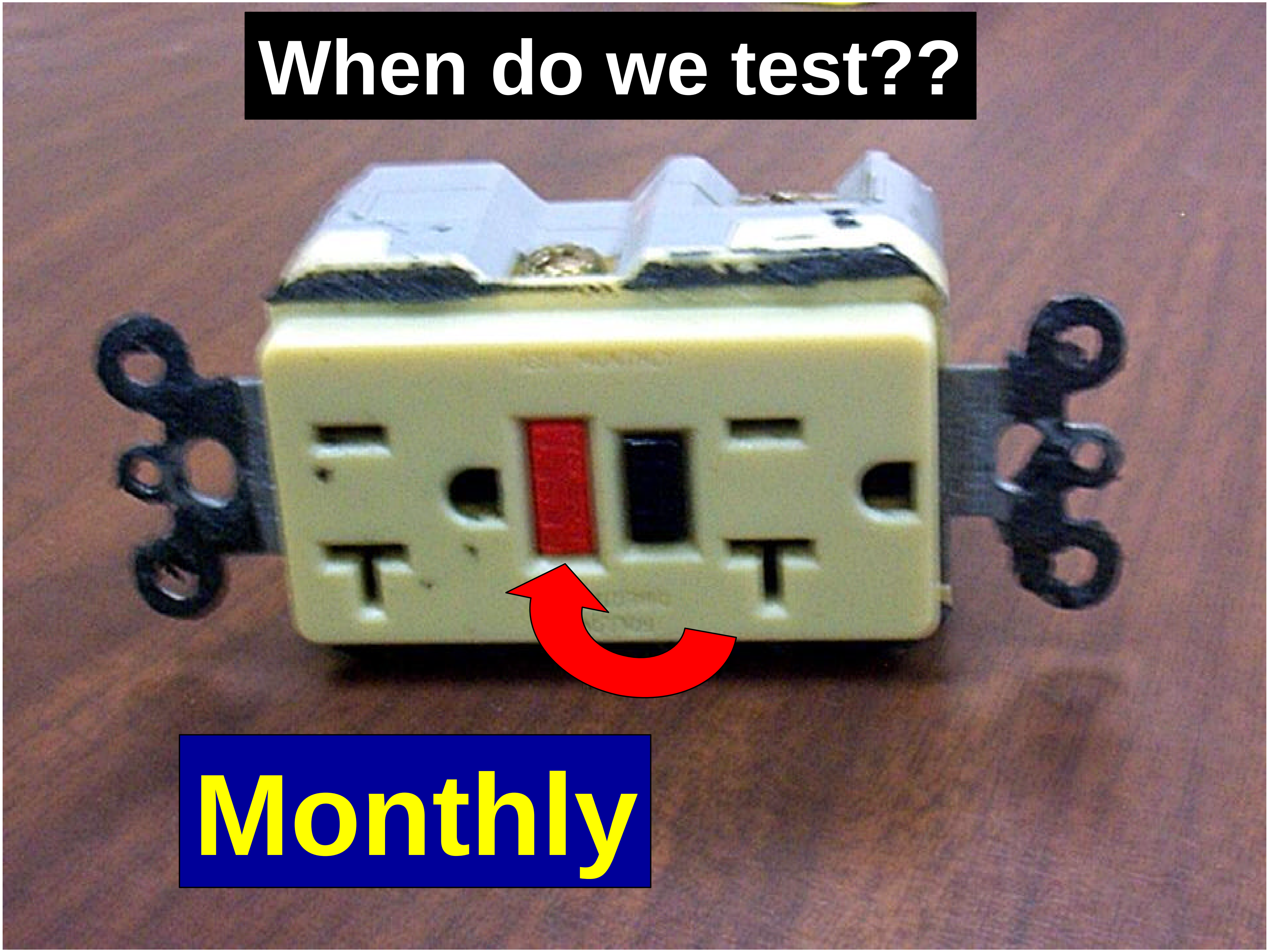
Blocked Electrical Panel

1910.303 (g)(1)(ii)   1926.403(h)(l)(1)(ii)   NEC 110.16(b)



- **[1926.404 (b)(1)(i) General.]**
  - **The employer shall use either ground fault circuit interrupters as specified in paragraph (b)(1)(ii) of this section or an assured equipment grounding conductor program as specified in paragraph (b)(1)(iii) of this section to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.**




When do we test??
Monthly

- **[1926.404(b)(1)(ii) Ground-fault circuit interrupters.]()**
  - **All 120-volt, single-phase 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection.**

- **[1926.404(b)(1)(iii) Assured equipment grounding conductor program.]**
  - **The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees.**

1926.404(b)(1)(iii) Assured equipment grounding conductor program shall comply with the following minimum requirements:

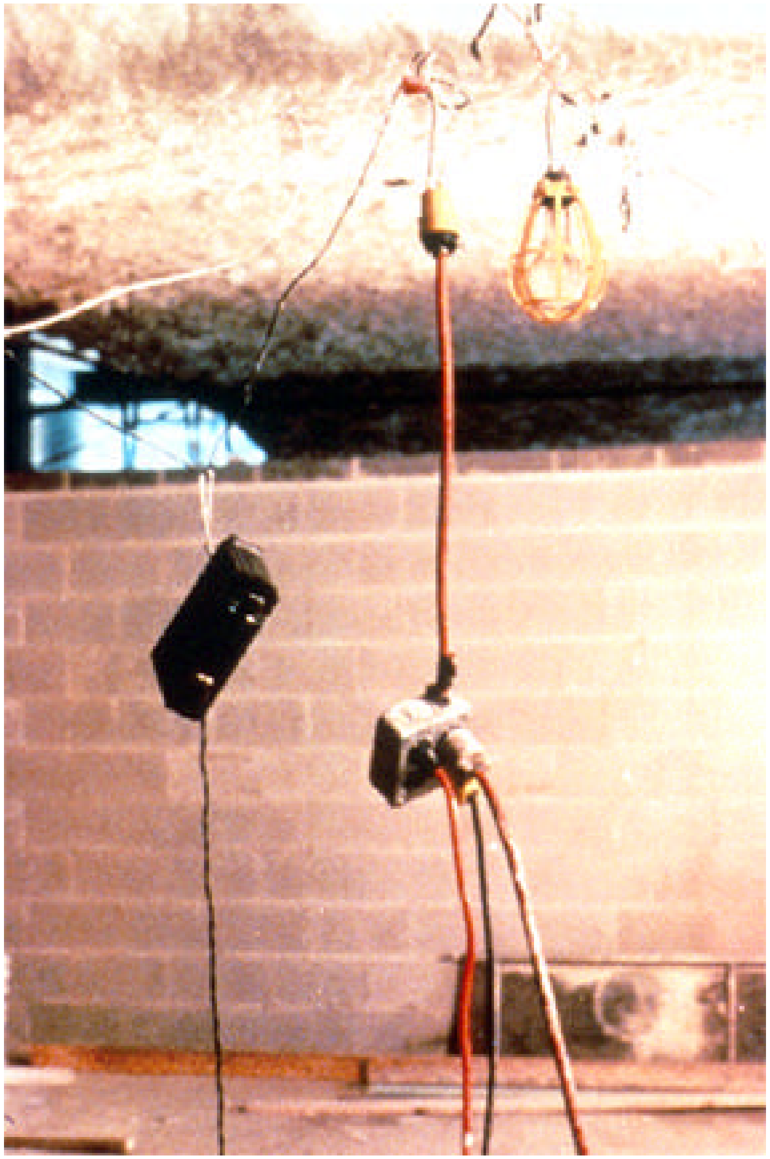
- (b)(1)(iii)(A) A written description of the program
- (b)(1)(iii)(B) designate one or more competent persons
- (b)(1)(iii)(C) visually inspected before each day's use
- (b)(1)(iii)(D) Perform tests on all cord sets
  - for continuity and shall be electrically continuous
  - for correct attachment of the equipment grounding conductor

1926.404(b)(1)(iii) Assured equipment grounding conductor program shall comply with the following minimum requirements: (Cont'd)

- (b)(1)(iii)(E) All required tests shall be performed:
  - (b)(1)(iii)(E)(1) Before first use;
  - (b)(1)(iii)(E)(2) Before equipment is returned to service following any repairs;
  - (b)(1)(iii)(E)(3) Before equipment and after any incident
  - (b)(1)(iii)(E)(4) At intervals not to exceed 3 months - 6 months
  - (b)(1)(iii)(F) Shall not use equipment which has not met the requirements of this paragraph (b)(1)(iii) of this section.
  - (b)(1)(iii)(G) Tests performed as required in this paragraph shall be recorded.
    - Identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test.
    - Indicate the last date it was tested or the interval for which it was tested.
    - Record shall be kept by means of logs, color coding, or other effective means
    - Maintained until replaced by a more current record.
    - Record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

- 1910.304(f)(4) Grounding path
  1926.404(f)(6) NEC 250.51
  - The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

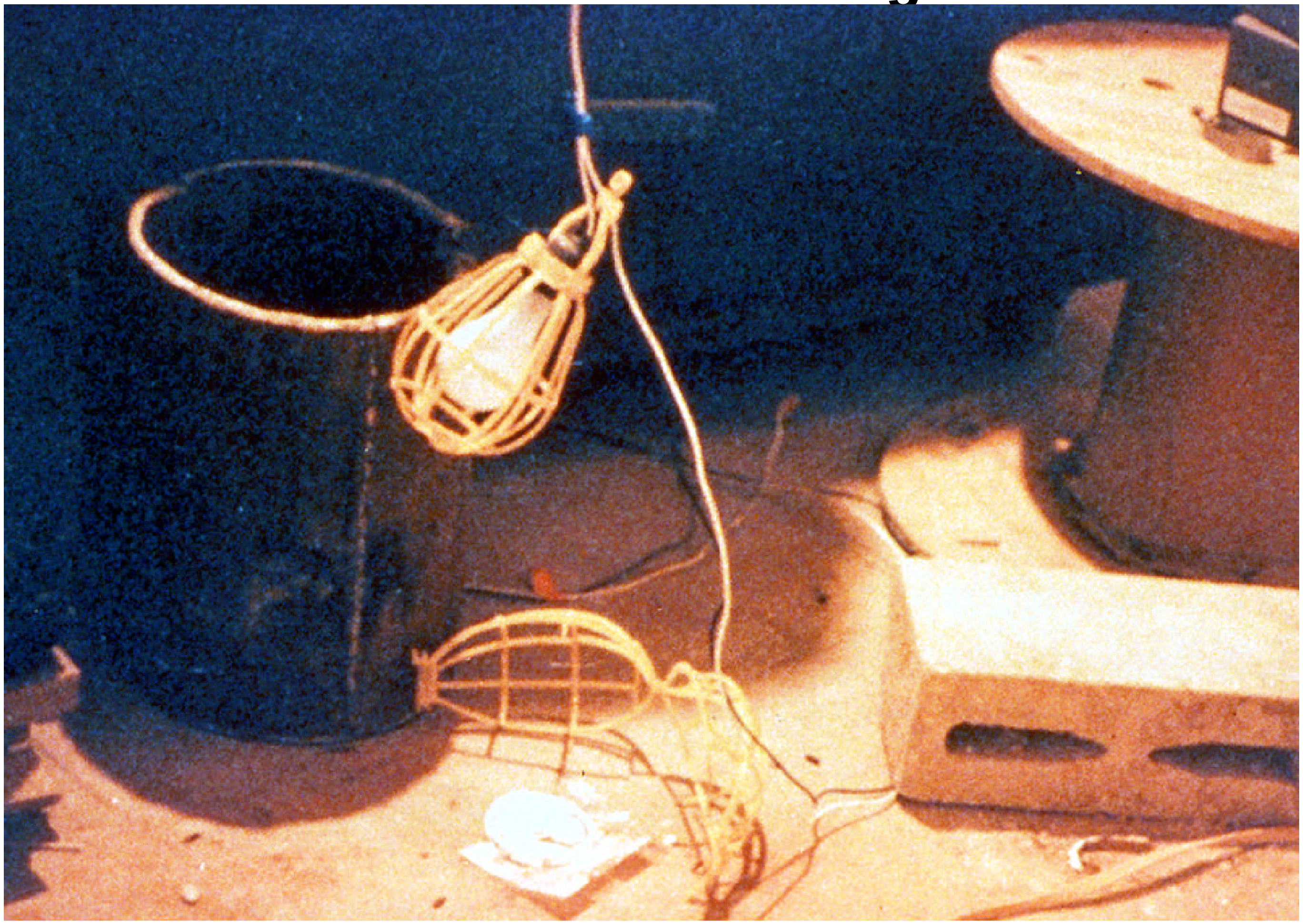
- **1926.405(a)(2)(ii) General requirements for temporary wiring -**
  - **(C)Receptacles for uses other than temporary lighting shall not be installed on branch circuits which supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits which supply temporary lighting.**



- **1910.305(a)(2)(iii)(F)**

  1926.405(a)(2)(ii)(E) **NEC 305**

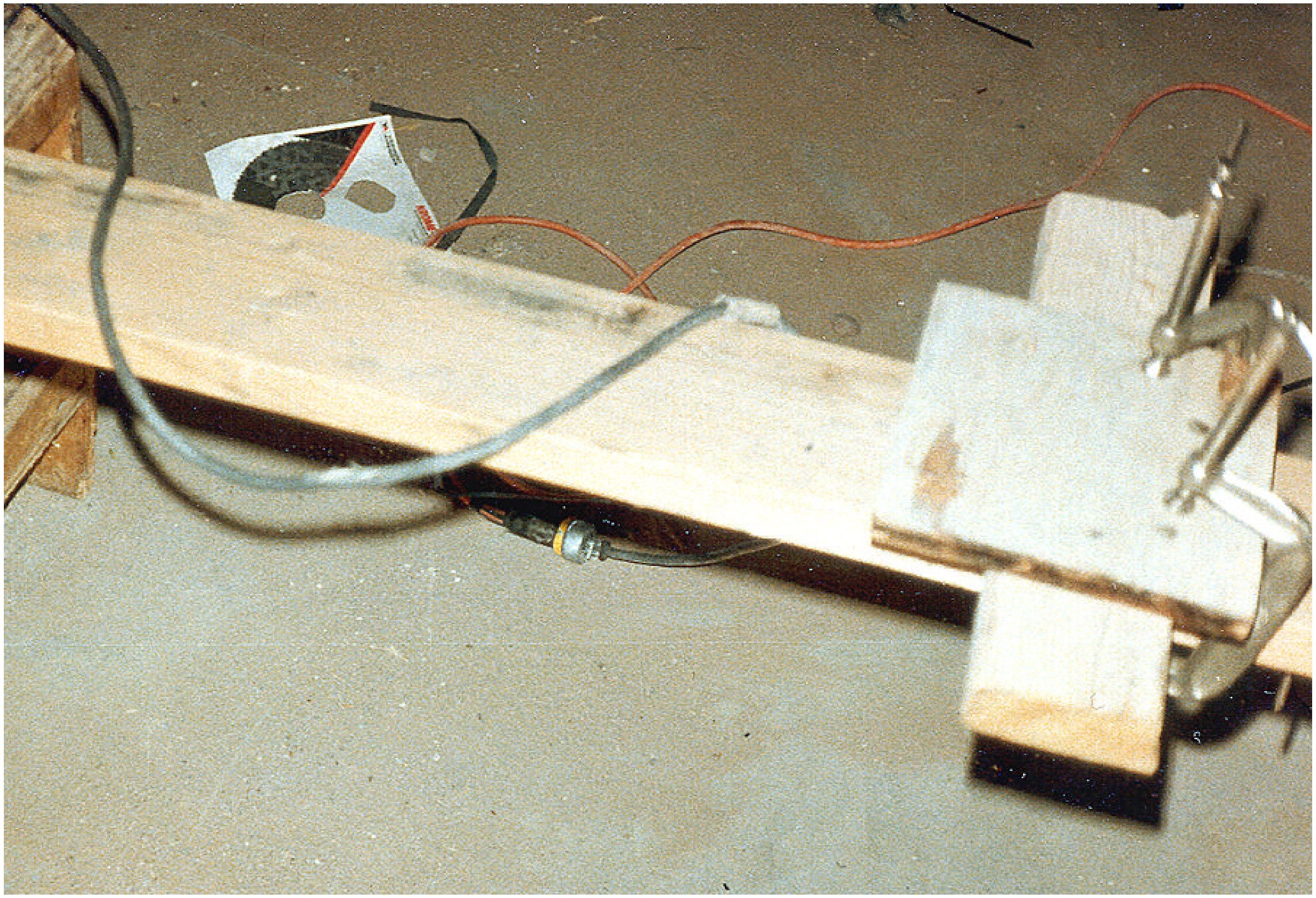
  All lamps for general illumination shall be protected from accidental contact or breakage.



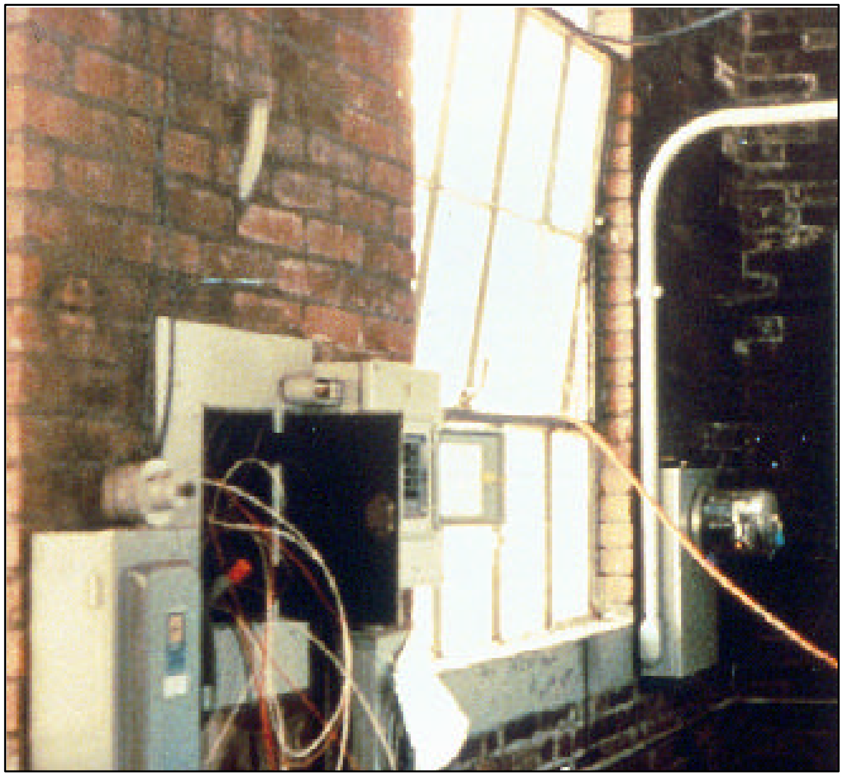
- **[1910.305(a)(2)(iii)(G)](#)**

  [1926.405(a)(2)(ii)(I)](#)

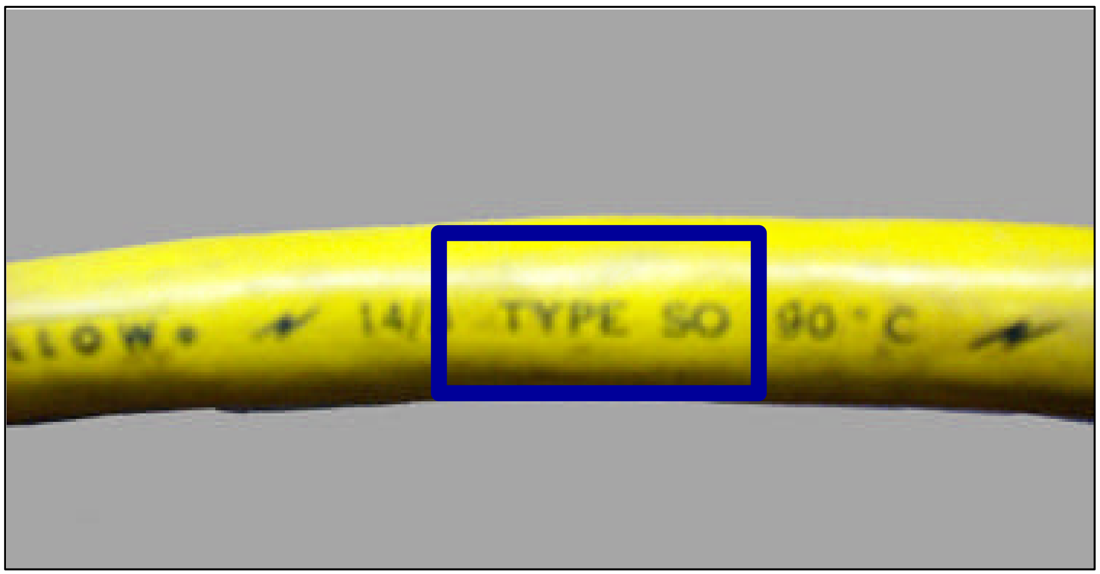
  - **Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided.**



- **1910.305(a)(2)(iii)(G)**
  1926.405(a)(2)(ii)(I)
  - **Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided. Flexible cords and cables may pass through doorways or other pinch points, if protection is provided to avoid damage.**



- **1926.405(a)(2)(ii)(J)**
  NEC 305.6(b)
  - Extension cord sets used with portable electric tools and appliances shall be of three-wire type and shall be designed for hard or extra-hard usage. Flexible cords used with temporary and portable lights shall be designed for hard or extra-hard usage.



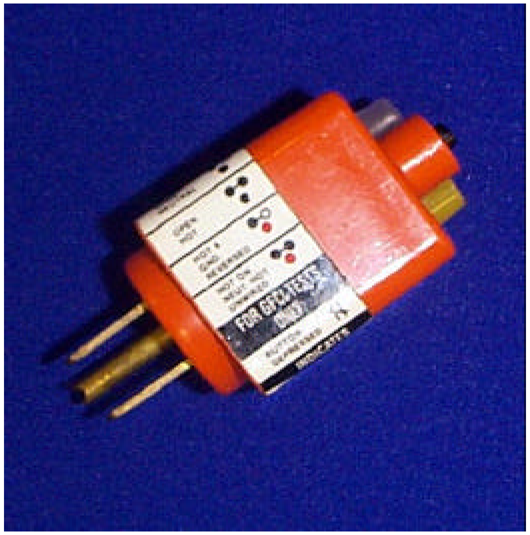
NOTE: The National Electrical Code, ANSI/NFPA 70, in Article 400, Table 400-4, lists various types of flexible cords, some of which are noted as being designed for hard or extra-hard usage. Examples of these types of flexible cords include hard service cord (types S, ST, SO, STO) and junior hard service cord (types SJ, SJO, SJT, SJTO).

- **1910.306(b)(1) 1926.405(b) NEC 370-7(a)**

Cabinets, boxes, and fittings.

- **(b)(1) Conductors entering boxes, cabinets, or fittings. Conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed.**
- **Unused openings in cabinets, boxes, and fittings shall also be effectively closed.**

TESTERS



ELECTRICAL HAZARD RECOGNITION

Work-Practice Considerations

1. Safety Planning
2. Personnel Qualifications
3. Guarding Electric Equipment
4. Work “On”, “Near”, or “in the area” of Energized Equipment
5. Isolating Equipment for Work
6. Labeling, Marking, and Identification of Equipment

Work-Practice Considerations (Cont'd)

7. Prints and Drawings
8. Work Clothes
9. Personal Protective Equipment
10. Tools and Test Equipment
11. General Precautions
12. Other Considerations

FY99 Frequently Cited Serious Violations
Subpart S - Electrical (1910.301-399)

1. ***303(g)(2)(I)*** Live parts
2. ***305(b)(1)*** Conductors entering cabinets/boxes/fittings protected from abrasion.
3. ***304(f)(4)*** Grounding path
4. ***305(b)(2)*** Electrical box covers
5. ***305(g)(1)(iii)*** Use of flexible cords and cables

FY99 Frequently Cited Serious Violations
Subpart K - Electrical (1926.400 - 449)

1. ***404(b)(1)(i)*** Branch circuits - ground fault protection/assured equipment grounding program
2. ***404(f)(6)*** Grounding path
3. ***404(b)(1)(ii)*** GFCI's
4. ***403(i)(2)(i)*** Guarding live parts
5. ***403(b)(2)*** Equipment installation/use

NFPA 70 - E

Keith Schuh

NFPA 70E Update

STANDARD FOR
ELECTRICAL SAFETY
REQUIREMENTS
FOR EMPLOYEE WORKPLACES
2000 Edition

By

Keith W. Schuh

Schuh@fnal.gov

For DOE Electrical Safety Meeting

NFPA 70

Purpose: “the practical safeguarding of persons and property from hazards arising from the use of electricity”

Scope: Installations

NFPA 70E

Purpose: ….a document that was applicable for electrical safety-related work practices….

Scope: “ This standard addresses those electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees in there pursuit of gainful employment.”

NFPA Meeting November , 1999

152 Proposals Submitted

Results :

106	**Accepted**
17	**Accepted in Principal or in Part**
29	**Rejected**

Proposal 70E-1

This proposal upgrade the wording in Part I to match 1999 National Electrical Code (NEC). This brought along with it the Zone classification system and listing and marking requirements for hazardous locations.

All are associated with Class 1

Zone 0 - A location in which an explosive gas or vapor/air atmosphere is present continuously or is present for long periods. (Normally this is considered to be 1,000 hours per year.

Zone 1 - A location in which an explosive gas or vapor/air atmosphere is likely to occur in normal operation.

Zone 2 - A location in which an explosive gas or vapor/air atmosphere is **NOT** likely to occur in normal operation.

From- "Guide for the Design, Testing, Construction, and Installation of Equipment in Explosive Atmospheres"; John A Bossert; CSA

Proposal 70E-3

Gives definition for the terms:

Limited Approach Boundary. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which is not to be crossed by unqualified persons unless escorted by a qualified person.

Prohibited Approach Boundary. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part.

Restricted Approach Boundary. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.

Proposals 70E-4

Definition of “Live Parts” revised to read:

“Electric conductors, buses, terminals, or components that are uninsulated or exposed and (**WHERE)** a shock hazard exists.”

P70E-48 Committee Statement. The concept of live parts requires two conditions to be present before a part is considered live. Condition # 1 is uninsulated or exposed. The second condition is where a shock hazard exists.

Proposal 70E-35

All definitions previously in Part II were moved to the Introduction section of Part I with the other definitions.

The wording of many definitions and sections have been revised "to harmonize NFPA 70E and Future OSHA standard requirements"

I counted 64 of these

Proposal 70E-71

This proposal put into words how to determine the Flash Protection Boundary.
It along with 72 & 76 & 77removed Column 2 (flash protection boundary) of the old Table 2-3.3.5
The new Table is 2-1.3.4 the distances have changed in some cases.
New data was made available that validated calculations for less the 600 volts.

Proposal 70E-73

Added the requirement,

Under Flash Hazard Analysis 2-1.3.3, to determine the "incident energy exposure" also flame resistant clothing and personal protective equipment shall be used based on the incident energy exposure.
Page 71 (App. B-5 II)

As an alternative, the PPE requirements of 3-3.9 of Part II shall be permitted in lieu of a detailed flash hazard analysis.

Proposal 70E-79

This proposal was rejected, it recommended replacing the words "avoid contact" in Table 1.3.4 and replacing it with some number.

Proposal 70E-80 was getting there but the committee felt it needed more work to be complete.

Proposal 70E-116

A new Section 3-3.9 “Selection of Personal Protective Equipment”

Introduces the
“Hazard Risk Category Classification”
for a number of common work tasks
and defines what FR clothing and
PPE is required

“Category 0” Tasks:

- CB operation with covers off <240 V
- Opening hinged covers on 240 V panels to expose
- Operating >240 V CB with cover on
- Operating (600 V) MCC starter with door closed
- Operating NEMA E2 starter with door closed
- Work on control circuits with energized parts <120v

“Category 0”PPE

- Untreated Natural Fiber Long-Sleeve Shirt and Pants
- Safety Glasses

PPE "Category 1" Tasks:

- Work on energized <240 V parts
- Work on energized parts or voltage testing, voltages > 120 V
- Removal of covers on 240 V> panels
- MCC starter operation with door open
- Opening hinged covers on MCCs to expose
- Cable tray or cable trough cover removal or installation (600 V and<)

PPE “Category 1”

- Flame-resistant shirt
- Regular untreated blue jeans (see notes)
- Hard Hat
- Safety Glasses

PPE "Category 2" Tasks:

- Work on energized parts or voltage testing, voltages > 240 V
- Application of safety grounds to 600V*

* Double-Layer Flash Hood required

PPE “Category 2”

- Flame-resistant Coveralls over untreated natural fiber clothing
- *or*

  Flame-resistant shirt over cotton T-shirt with flame-resistant pants
- Hard hat, safety glasses, leather work shoes, leather gloves
- Double-Layer flash hood with hearing protection, As required for task

PPE "Category 3" Tasks:

- 600 V Motor Control Center - Insertion or removal of starter "bucket"
- 600 V Switchgear - Insertion or removal of circuit breaker with open door
- Removal of bolted covers from 600 V switchgear
- Outdoor, hookstick operated, disconnect switch operation

PPE "Category 3"

- Two sets of FR Coveralls over untreated natural fiber street clothing
- Hard hat, FR hard hat liner ,
- Safety glasses
- Leather work shoes, leather gloves
- Double-Layer flash hood and hearing protection

PPE “Category 4” Tasks:

- Removal of bolted covers on NEMA E2 starters or switchgear 1kv>
- Operating circuit breaker, or racking circuit breakers in or out, on 1kv> switchgear with door open
- Application of safety grounds at 1kv >
- 1kv > insulated cable examination, in manhole or other confined space

PPE “Category 4”

- FR Coveralls over untreated natural fiber street clothing
- Hard hat, safety glasses
- Leather work shoes, leather gloves
- FR hard hat liner
- Double-Layer flash suit, flash hood, and hearing protection

Proposal 70E-147

Added new Appendix B, Section 5
Explains calculations to estimate incident energy

Proposal 70E-149

Added new Appendix F to Part II

“Simplified, Two-Category,Flame-Resistant (FR) Clothing System”

CLOTHING - **<u>Everyday Work Clothing:</u>**

FR long-sleeve shirt (minimum ATPV of 5) worn over an untreated cotton T-shirt with FR pants (minimum ATPV of 8)

or

FR coveralls (minimum ATPV of 5) worn over an untreated cotton T-shirt (or an untreated natural fiber long-sleeve shirt) with untreated natural fiber pants.

APPLICABLE TASKS: All Hazard/Risk Category 1 and 2 tasks listed in Table 3-3.9.1.

* ATPV- Arc Thermal Performance Value

CLOTHING-- **Electrical "Switching" Clothing:**

Double-layer FR flash jacket and FR bib overalls worn over either FR coveralls (minimum ATPV of 5) or FR long-sleeve shirt and FR pants (minimum ATPV of 5), worn over untreated natural fiber long-sleeve shirt and pants, worn over an untreated cotton T-shirt

or

Insulated FR coveralls (with a minimum ATPV of 25, independent of other layers) worn over untreated natural fiber long-sleeve shirt with untreated denim cotton blue jeans ("regular weight," minimum 12 oz./yd.^{2} fabric weight), worn over an untreated cotton T-shirt.

APPLICABLE TASKS: All Hazard/Risk Category 3 and 4 tasks listed in Table 3-3.9.1.

Proposal 70E-152

Added a new Part IV to provide guidance for safe work practices and installations of Electrolytic Cell Lines, Storage Batteries, Lasers, and other specialized power electronic equipment

Copies of the Report on Proposals for NFPA 70E and others can be obtained by contacting

1-800-593-6372

1-800-344-3555

1-617-770-3000

http://www.nfpa.org

www.nfpa.org/Codes/Current_Codes_and_Standards/Proposals_Comments/proposals_comments.html

ISMS Application for R&D Activities

Hugh Bundy

Department of Energy
Electrical Safety Advisory Committee
June 13-14, 2000

ISMS APPLICATION FOR R&D ACTIVITIES

Hugh R. Bundy
Sandia National Laboratories

What's different about R&D workers?

Education - taught theory, not hand work

Curriculum - safety is seldom included

Training - hands-on work to verify theory

Career - is safety a priority?

Employer - provides some safety training

SAFETY GUIDANCE

OSHA & NEC

Power Generation

Power Distribution

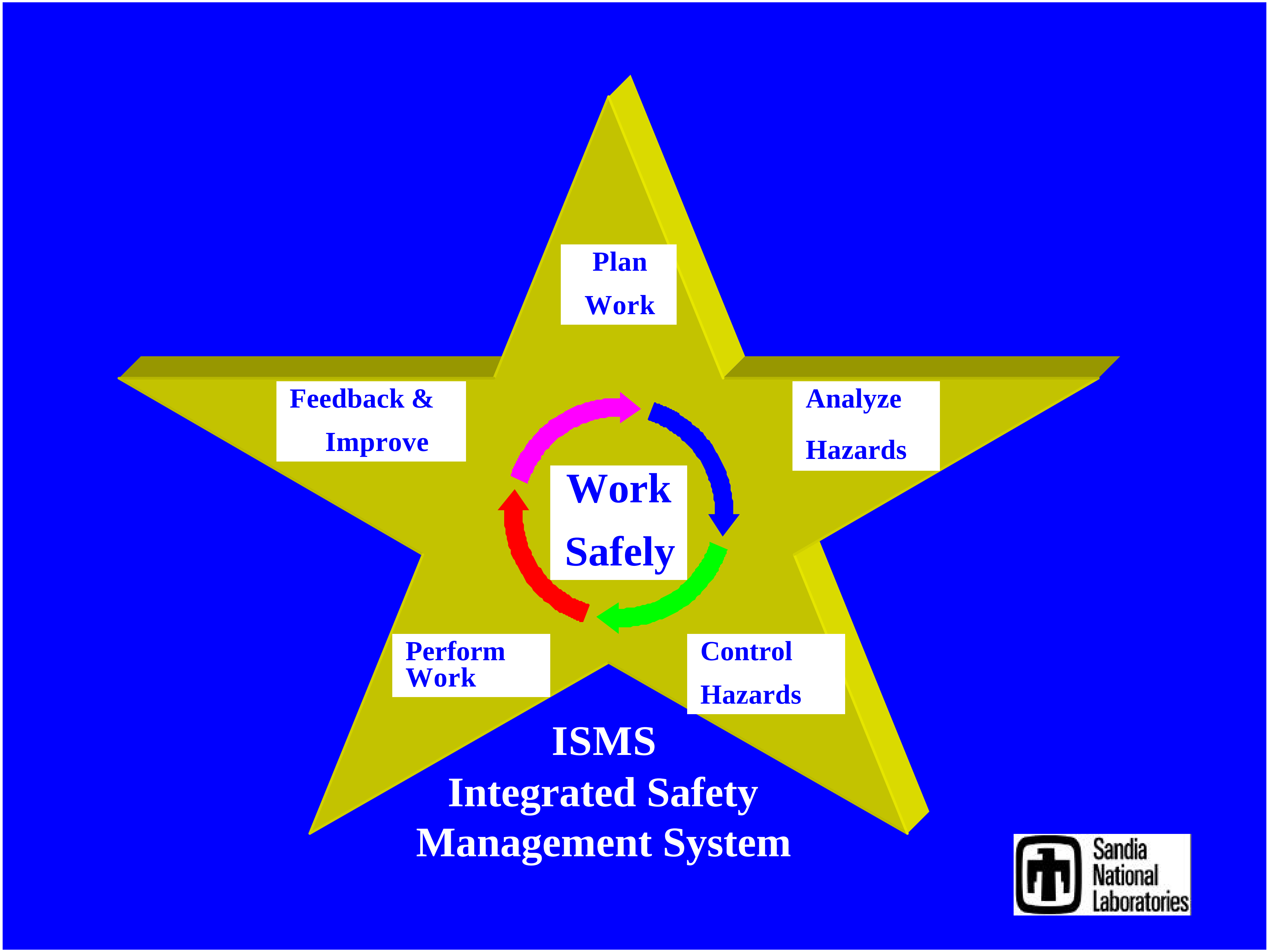
R&D - Temporary - How much?

A Class Less

Attitude

"I have a Ph.D. in Electrical Engineering, I can teach that course blindfolded"

"Our folks don't need safety training. They all have graduate degrees and have been doing this work for 20 years."


Plan
Work
Analyze
Hazards
Control
Hazards
Perform
Work
Feedback &
Improve
Work
Safely
ISMS
Integrated Safety
Management System
Sandia
National
Laboratories

DIFFICULTY OF PLANNING WORK

- Clearly the hardest part of ISMS
- New experiments aren't fully defined
- Changes occur daily
- New hazards 'pop' up
- Early data lead to more changes

Sandia National Laboratories

ASK THE IMPOSSIBLE!

In your procedures include:

"Every possible troubleshooting scenario you may encounter during the life of the project"

Observe the blank, quizzical, and other looks

"You've got to be kidding!"

Sandia National Laboratories

HIGH RISK AREAS

Developing new experiments

- **Procedures incomplete or not developed**

Modifying experiments

- **New hazards not identified**

Troubleshooting

- **Hazards uncovered without procedures**

Sandia National Laboratories

EXAMPLES OF ADDED HAZARDS

No guarding or isolation of HV circuits

- Lexan covers added later

Capacitors added without bleed resistors

- add resistors later if test is successful

Set up trials without interlocks

- add interlocks if trials work

Sandia National Laboratories

Personnel Qualifications

- Knowledgeable of Equipment & Hazards
- Unique Equipment & Configurations
- Special efforts to identify hazards
- Develop mitigation plan
- Involve workers in plan development

Sandia National Laboratories

Work & Training Issues

- No jewelry, metal watches, necklaces, earrings
- Troubleshoot - look-over equipment before starting
- Buddy system for energized work
- Canes handy, Know nearest disconnecting means
- Formalize OJT training - Qualified, Trained
- Document OJT training information
- Pass-down training dilutes information
  - all go back to same source for info.

General Safety Design Criteria

- UL Listed or Recognized components/equipment
- Fuse power supplies @ 125% of full load or less
- Segregate power source & measurement wiring
- Enclosures and interlocks for high energy circuits
- Covers over exposed energized parts
- Danger/warning signs indicating hazards
- Ample access space to internal components

General Safety Design Criteria

- Circuits fail to SAFE condition
- Red emergency OFF mushroom switches
- Automatic discharge circuits
- Integral, easily accessible safety ground hooks
- Easily accessible capacitor discharge points
- Solid single point STAR equipment grounding
- Easily accessible, lockable disconnect switches

Shorting Sticks & Straps

- Don’t assume automatic device works
- UL listed device - Integral part of equipment
- Rated for max impulse current (fully charged cap)
- Short between terminal and cap case
- Don’t hold on to conductor
- Clip-on shorting strap while shorting stick on terminal Clip grounded side first
- Visually inspect for cracks, broken strands, insulation Clear insulation over braid helps

Parallel Cap Banks

- Parallel banks no resistance like in series banks
- Fuse H V end of each cap in bank
- If one cap shorts, energy from other caps doesn't blow apart shorted cap - shrapnel
- Design-in redundant (manual) discharge in case of automatic system failure
- Shorting sticks > resistor in cable to limit current

Equipment Grounding

- Power/earth ground - return path, trip breaker for fault conditions
- Star ground reduces control/meas ckt noise
- Connect to building ground at only one place
- Parallel grounds (loops) - ΔV circulating currents causing radiated noise signals
- Separate ground rod creates problems

Examples Not Covered By NEC, OSHA

- Capacitors are NOT automatically discharged (460-6)
- High Voltage can be very low energy, energized work OK
- Ratings can far exceed NEC for pulsed applications
- Clearances may not be followed, e.g., PFN design (384-36)
- It may be acceptable to BLOW UP the equipment (to meet requirements)
- Grounding requirements are vast and complex
- No color codes

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PFN Safety Issues

- If wires, resistors or inductors open-up:
  - ▲ Dump relays don't discharge
  - ▲ Shorting one side of cap to gnd may not discharge
  - ▲ "Jumper" or "Alligator Clip" one end to ground does not hold-off cap recharge
- <u>Following procedure - false sense of security</u>
- Want to assure discharge across capacitors
  - ▲ Double "sticking" both sides of capacitors
  - ▲ While "double sticking" attach jumper across capacitors

HIGH VOLTAGE R&D LAB - 5/14/98

- Old rack mount equipment - door interlocks
- Current user did not design equipment
- Substitute for 'usual' HV Power Supply
- Makeshift HV cable connection
- Time was of the essence

- Door interlock did not shut off HV Power Supply
- Pointed to problem area (~ 3 inches)
- 27,500 volt DC shock

Sandia National Laboratories

TECHNICIAN PERFORMING LEAK TEST ON VACUUM SYSTEM - June 1999

- **System modified to add additional capability**
- **New configuration required leak testing**
- **Introduce helium at potential leak points**
- **System energized to allow helium detection**
- **Ion gage operating 145 to 600 VDC**
- **145 VDC shock**
- **Leak testing procedure does not exist**

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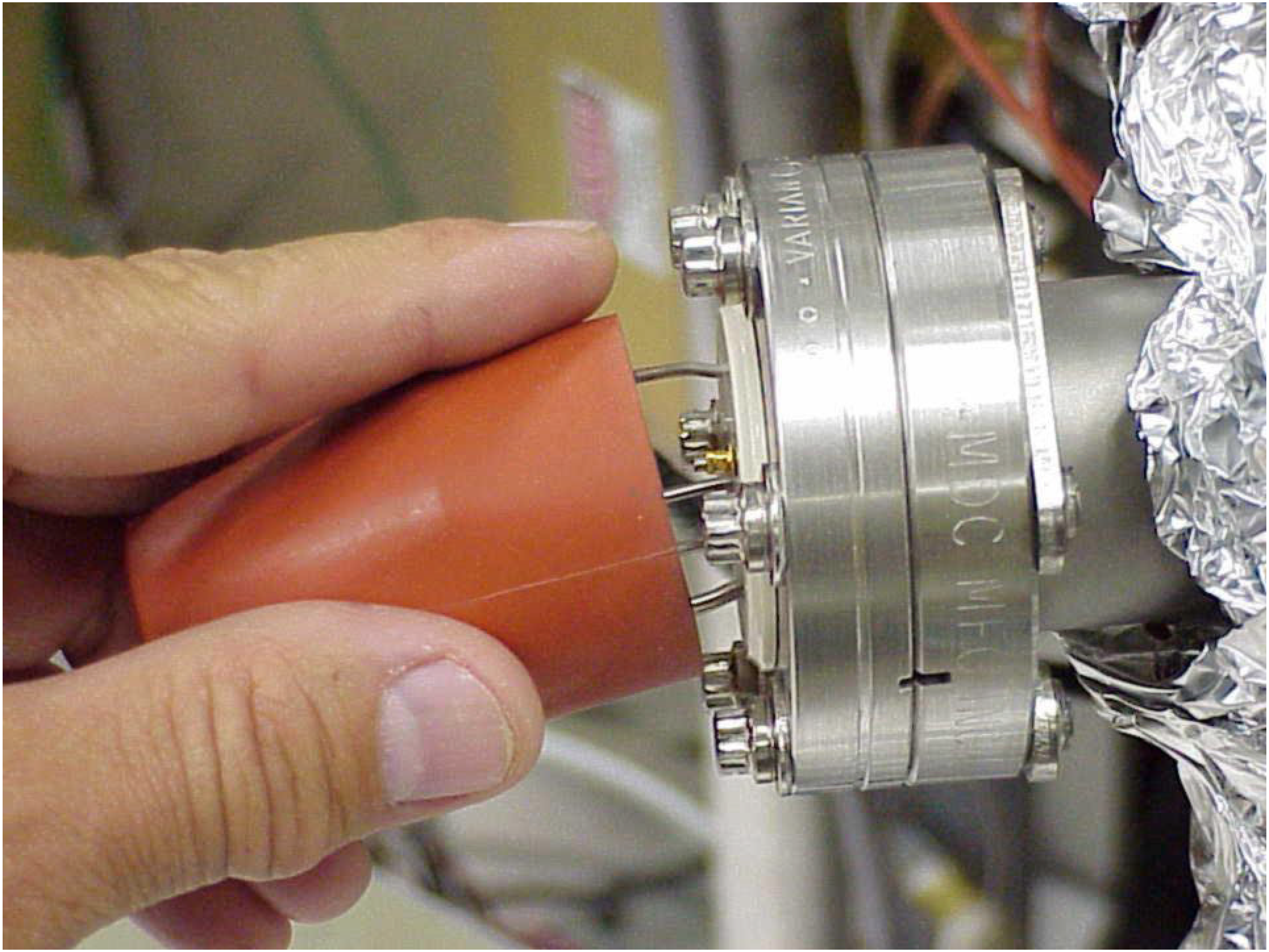
VARIAN
MDC

CERAMICS HYSTERESIS TESTING

Shock - March 1999

- Set up and check out new testing apparatus
- Shocked while moving test sample under probe
- Computer monitor indicated Standby mode
- Voltmeter check showed 550VDC present
- Condition could not be duplicated
- System is software controlled

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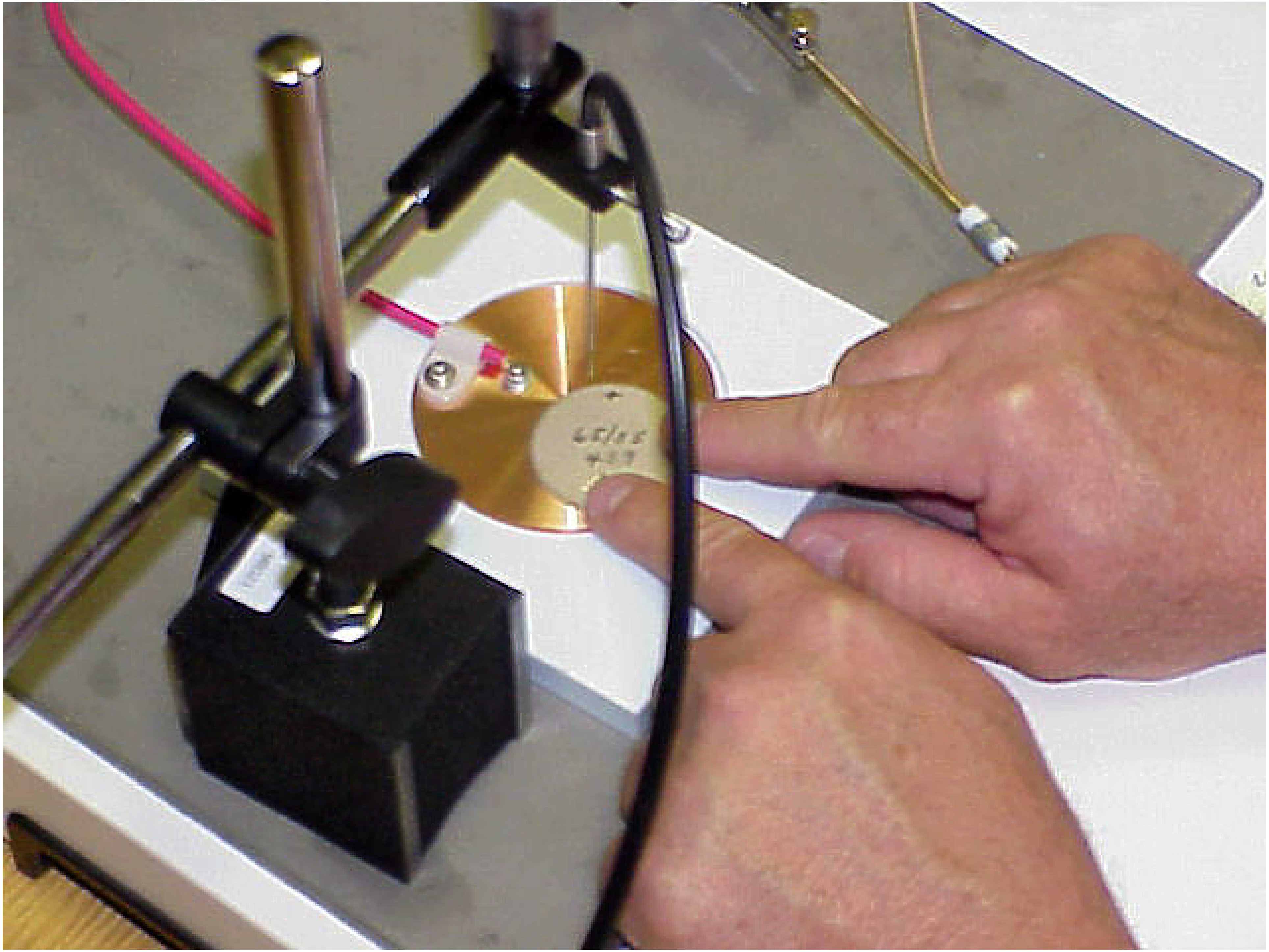

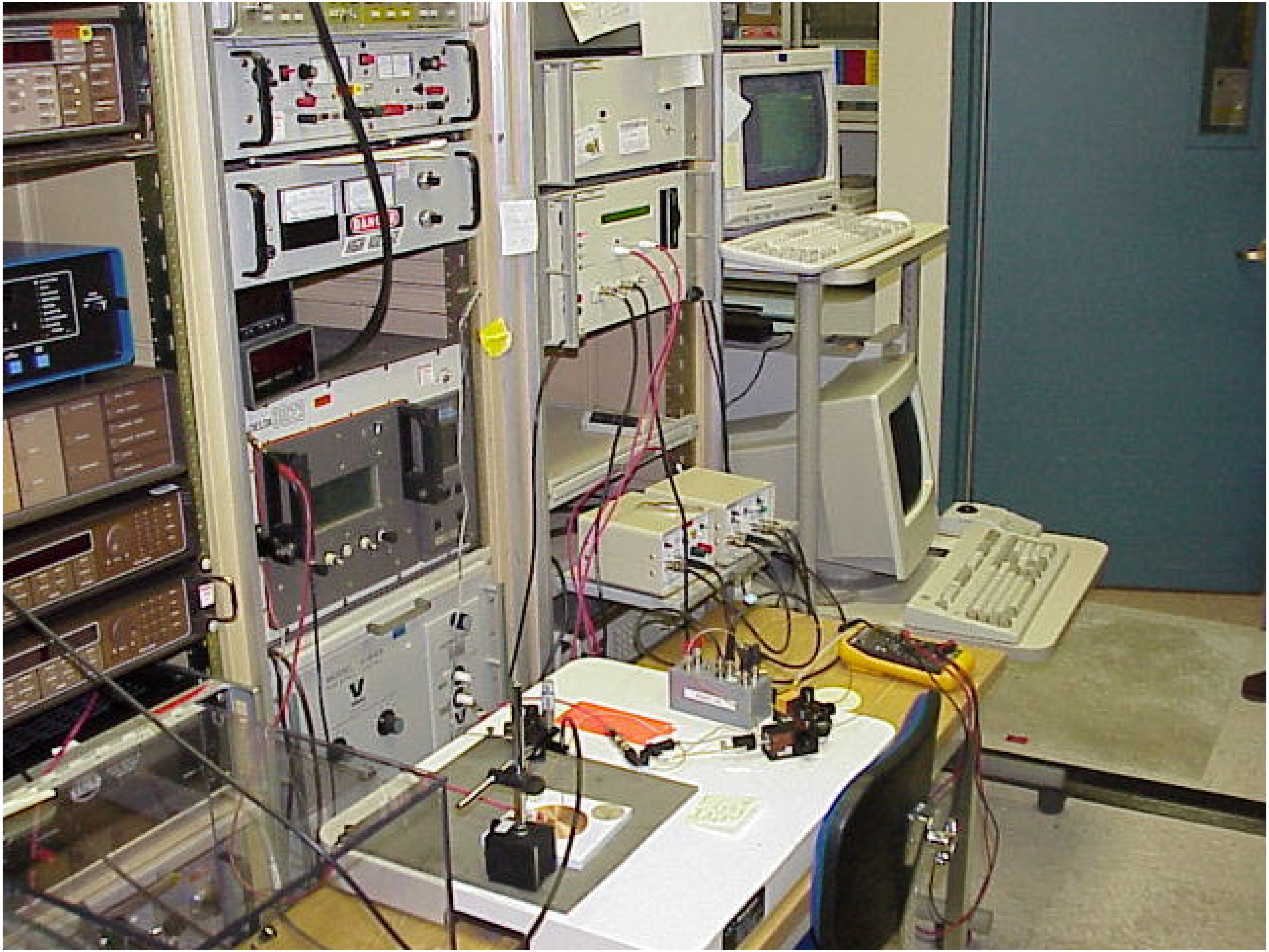

TROUBLESHOOTING HV POWER SUPPLY

Shock - March 2000

- 900 volt DC power supply
- Connected to multimeter through banana plug
- Power supply turned off
- Reached for banana connector after 2 seconds
- Voltage was still ~ 350 volts
- No recent experience

- Use shrouded banana connectors!
- Pamona part number PM 908/001

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FLUKE
TRUE RMS MULTIMETER
MIN MAX
RANGE
HOLD
REL Δ
Hz
PEAK MIN MAX
mV
mA
A
µA
OFF
A
mA µA
COM

WORKERS MUST STAY FOCUSED

Safety circuits may come later

- not the safety thought process!

Develop policies to provide Safety!

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ACCOUNT FOR NON-STANDARD WORK

Safe Work Permit Process

-prior to modifications

No energized work alone!

Radiation experiments have strict guidelines

IH - soil samples, possible bacteria

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CHANGE ANALYSIS

Critical part of Accident Investigation!

This must become a normal process

for R&D workers!

ISMS IS PRODUCING RESULTS

Workers change SOPs more often

- this didn't happen before

Feedback has moved to the foreground

'A Forum for Formality"

Lessons Learned highlights the need

Sandia National Laboratories

APPLYING ISMS TO R&D WORKERS

IT'S GETTING BETTER!

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Power Line Hazard Awareness

Paul Satti

Managing Power Line Hazards in Construction

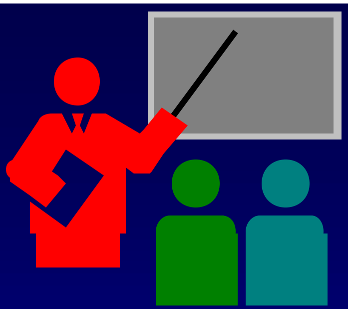
Construction Safety Council

Power Line Hazards Awareness

CSC

Construction Safety Council

Course Objectives



- Identify Sources of Power Line Contacts
- Explain Methods to Eliminate or Reduce Power Line Contacts
- Inform on Proper Responses to a Power Line Contact

Power Line Contact Means...

Loss of Lives

&

Loss of Profit

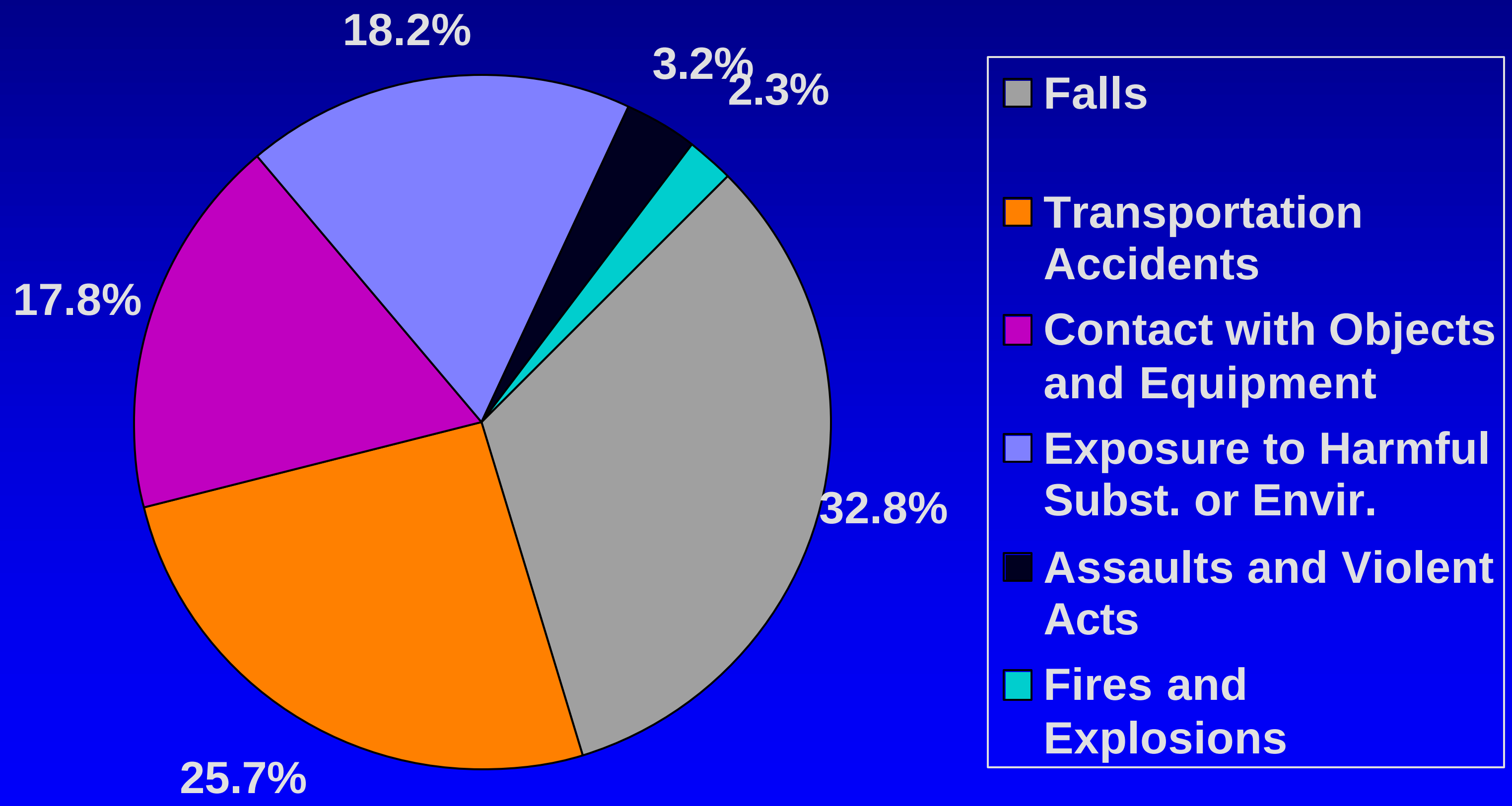
Direct Losses (May Be Covered by Insurance)

- Ambulance
- Medical Costs
- Wage replacement for injured worker
- Disability payment
- Liability lawsuits

Indirect Losses
(Not Covered by Insurance)

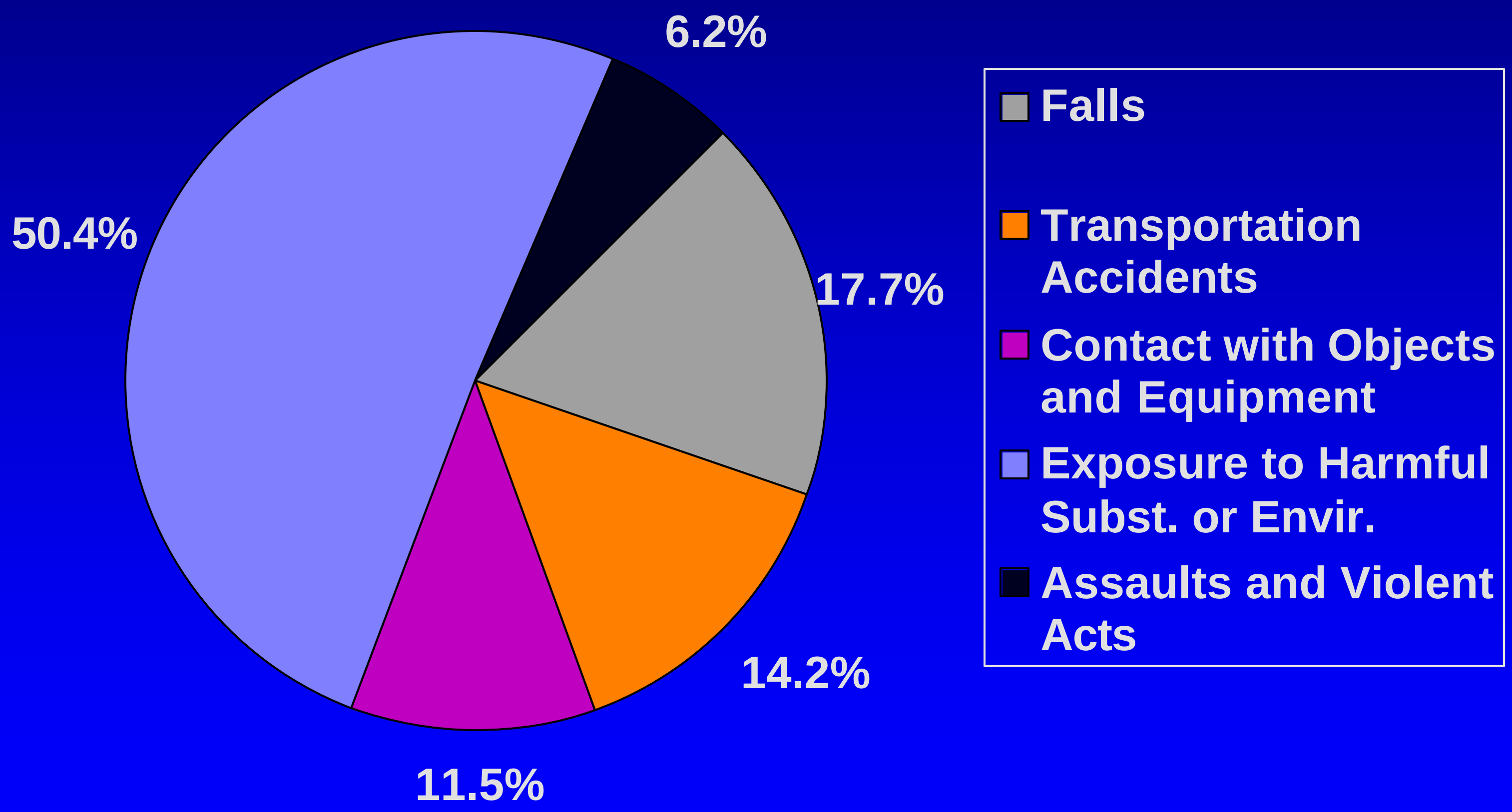
- Work Delays
- Lost Crew Efficiency
- Costs to Reschedule Work
- Orient/Train Replacement Worker
- Wages for Supervision from Accident

Construction Fatalities, U.S.



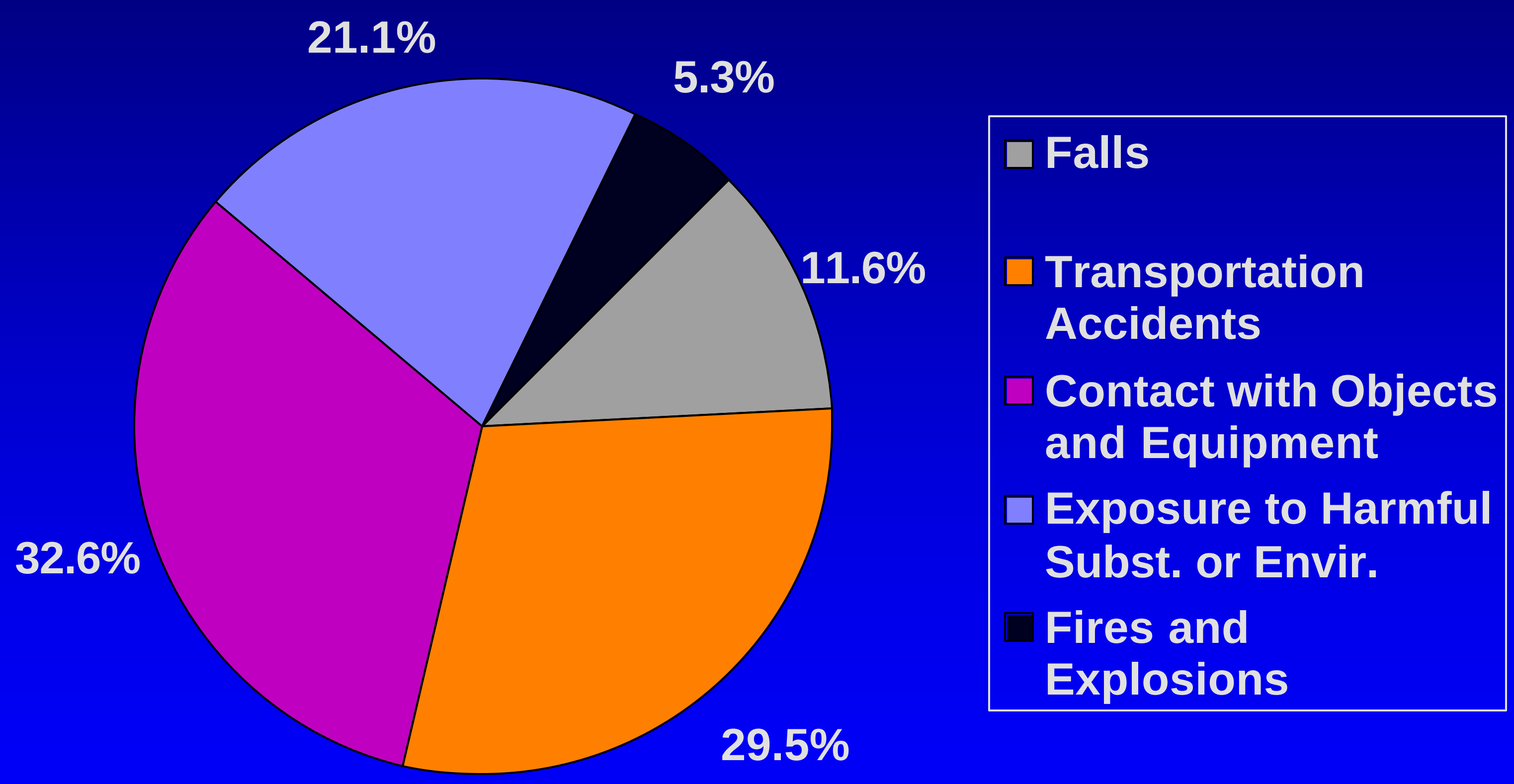
BLS-CFOI, 1998 (Total = 1171)

Cable & Telecommunication Contractor Fatalities– SIC 1731



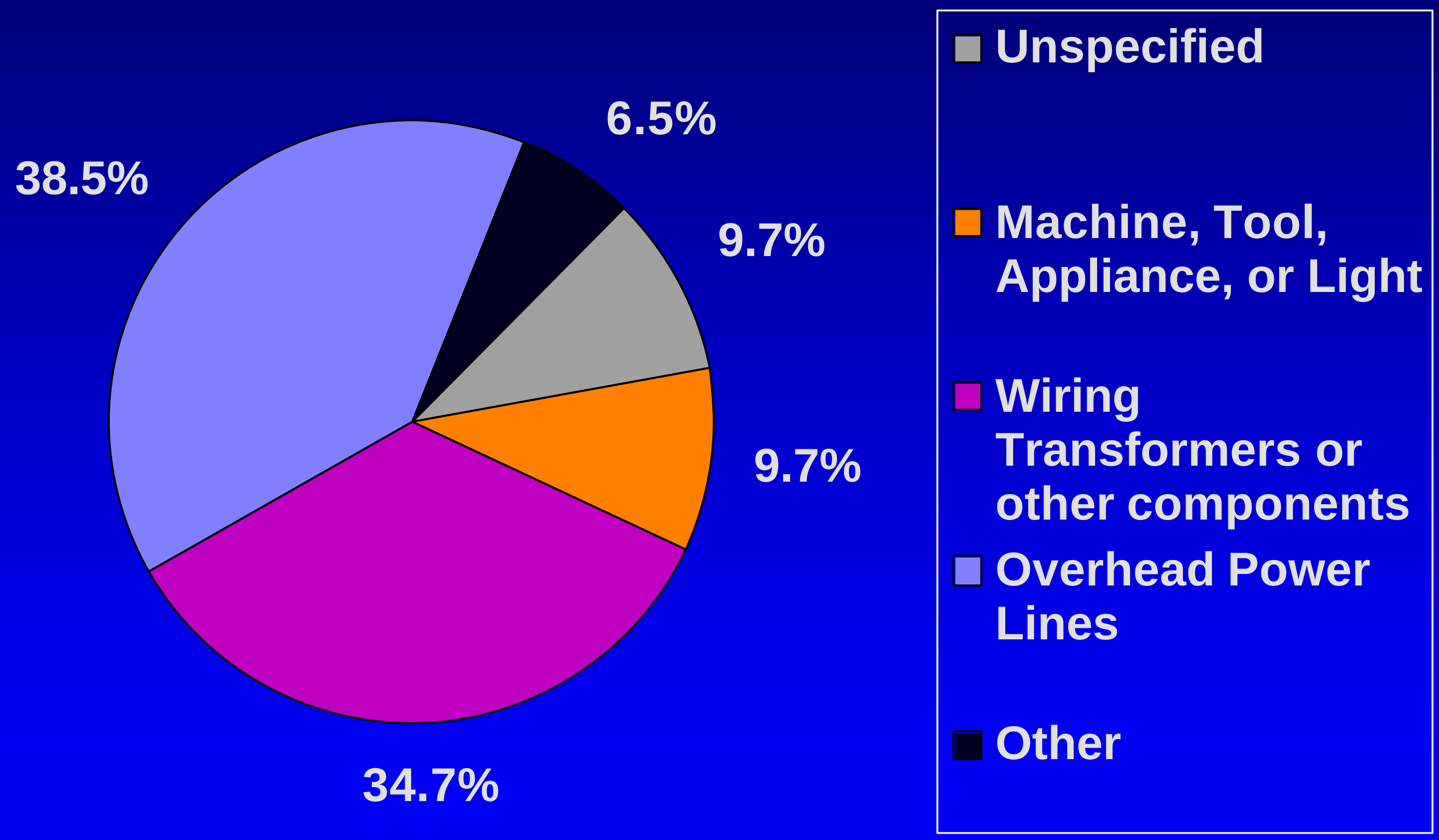
BLS-CFOI, 1998 (Total = 114)

Water, Sewer & Utility Line Contractor Fatalities – SIC 1623



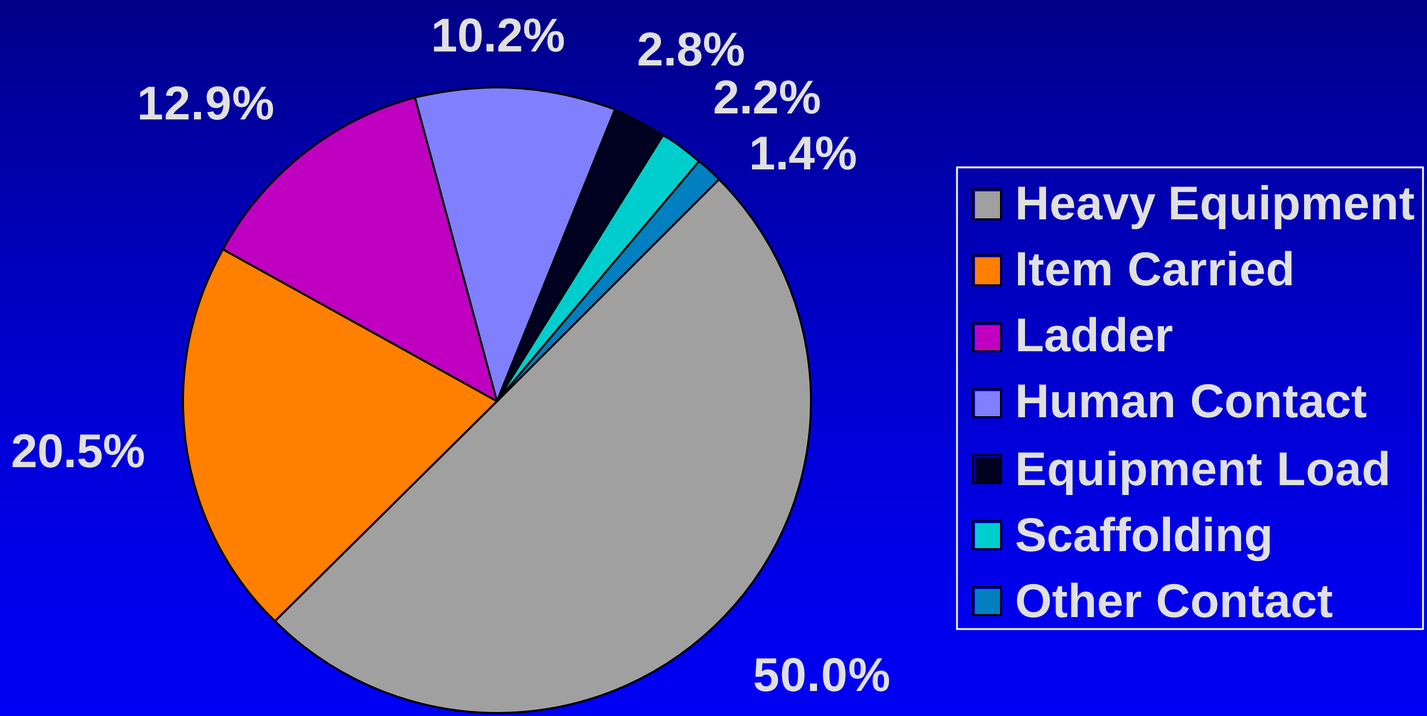
BLS-CFOI, 1998 (Total = 96)

Construction Electrocutions U.S.



BLS - CFOI, 1993

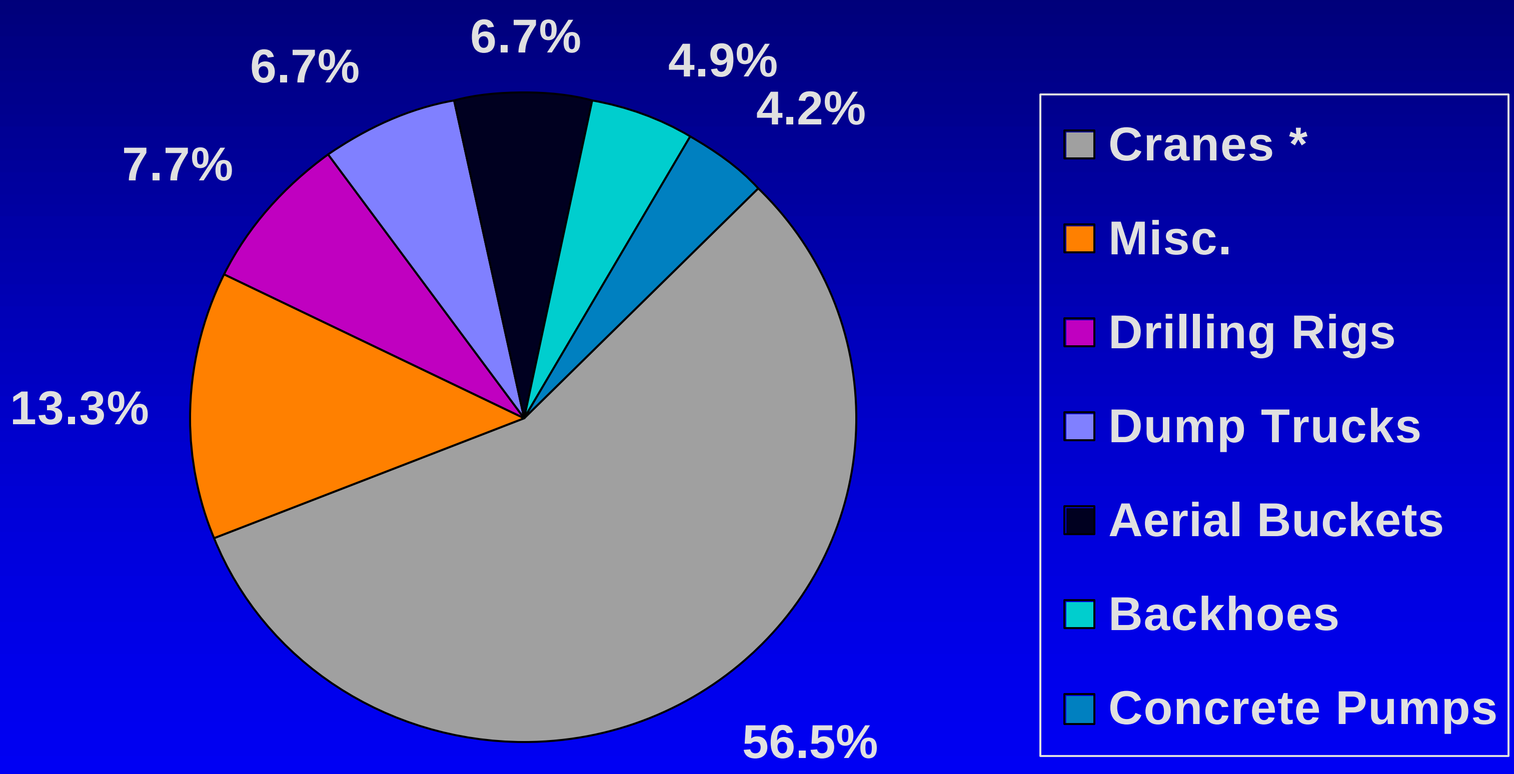
Power Line Contacts in Construction, U.S.



OSHA IMIS, 1985 - 1994

Construction Safety Council

Heavy Equipment Power Line Contacts, U.S.



OSHA IMIS, 1985 - 1994

*** Includes: mobile cranes, boom-trucks and shovels**

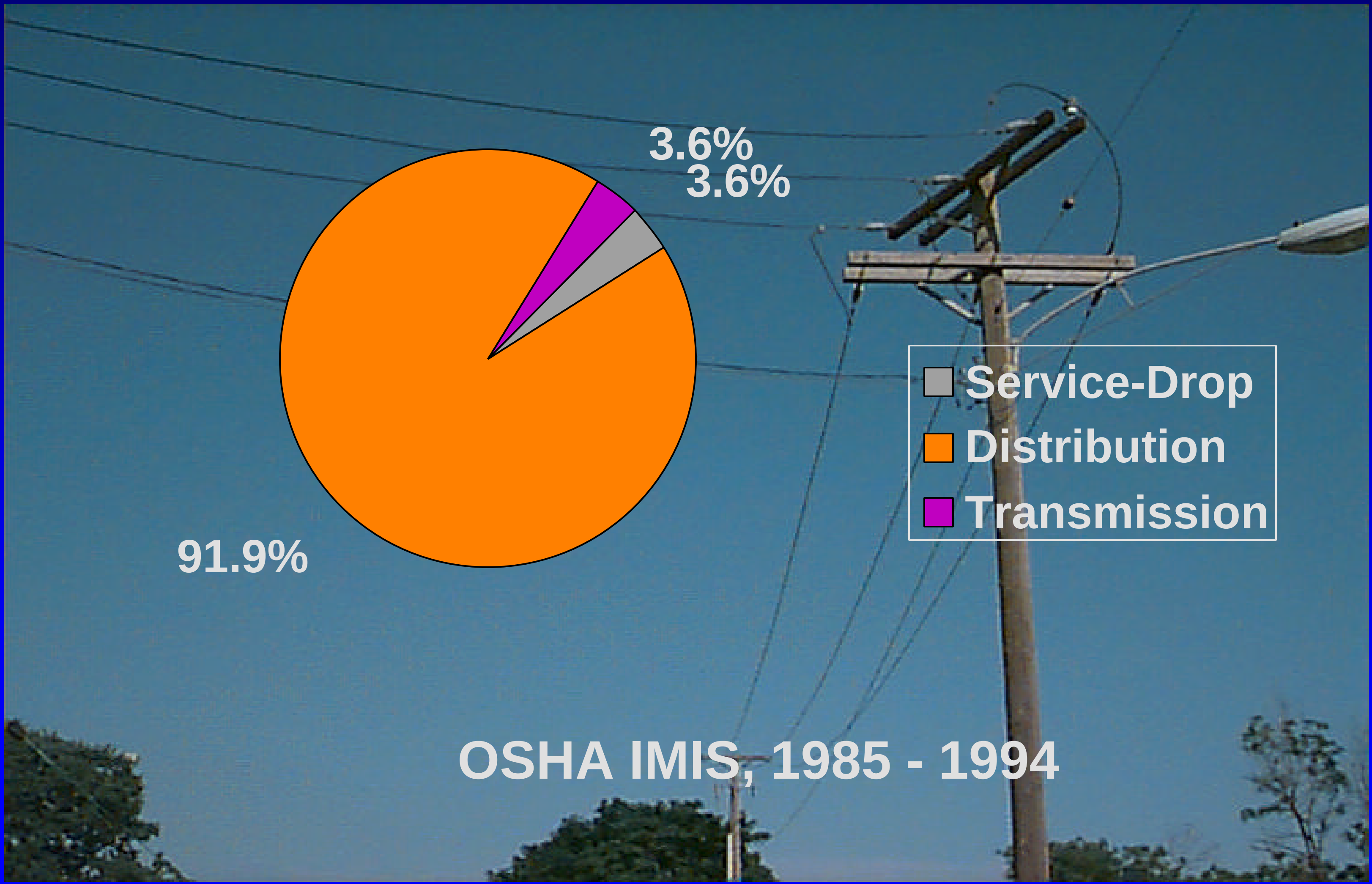
Transmission

Distribution

Service-Drop

Construction Safety Council

Type of Line Contacted, U.S.

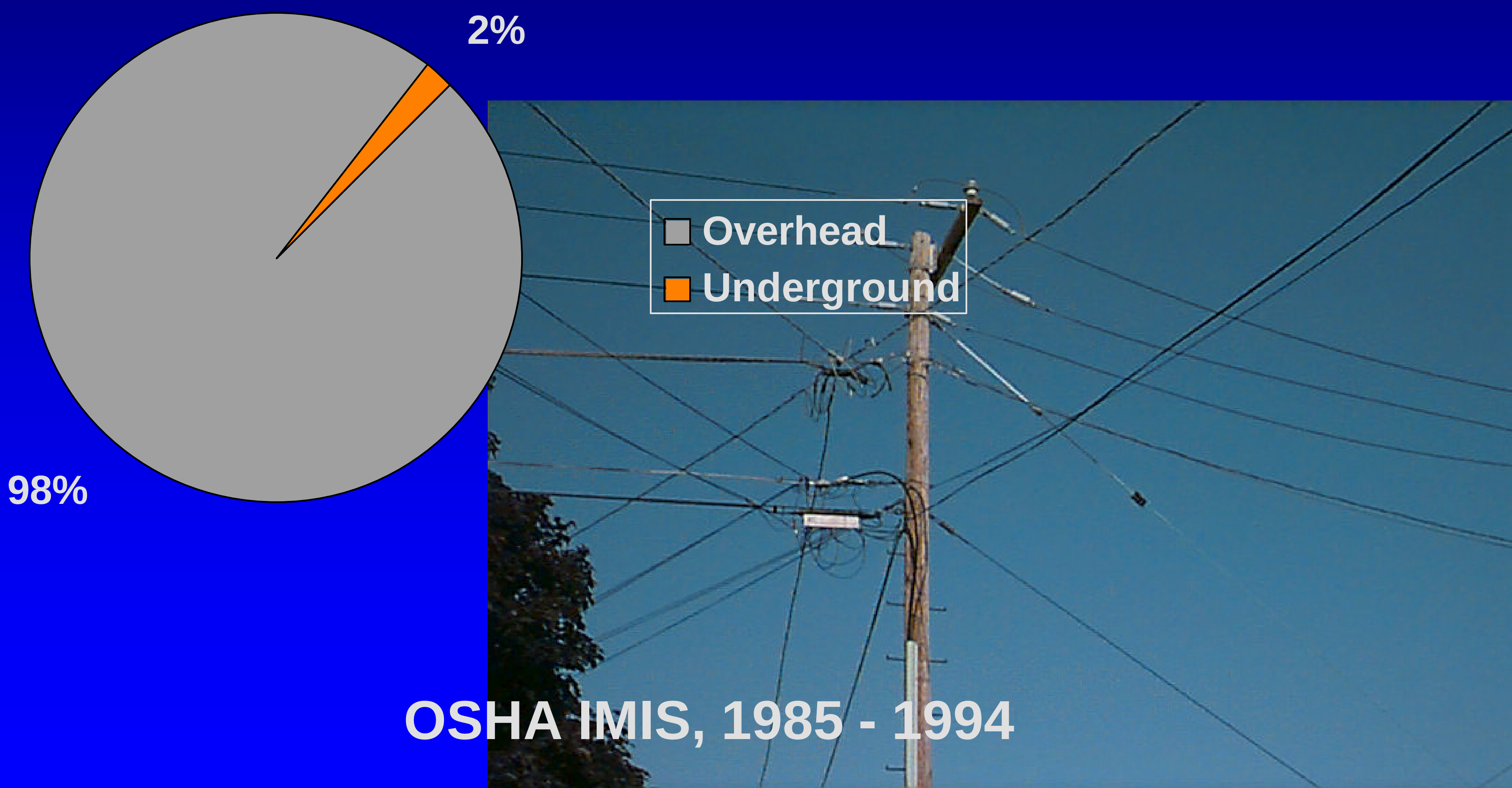


Contractors Who Frequently Contact Power Lines

- Roofing, Siding and Sheet Metal Contractors (9.3%)
- Tree Trimming Contractors (8.5%)
- Water, Sewer, Pipeline and Communication Contractors (7.9%)
- Painting and Paper Hanging Contractors (7.3%)

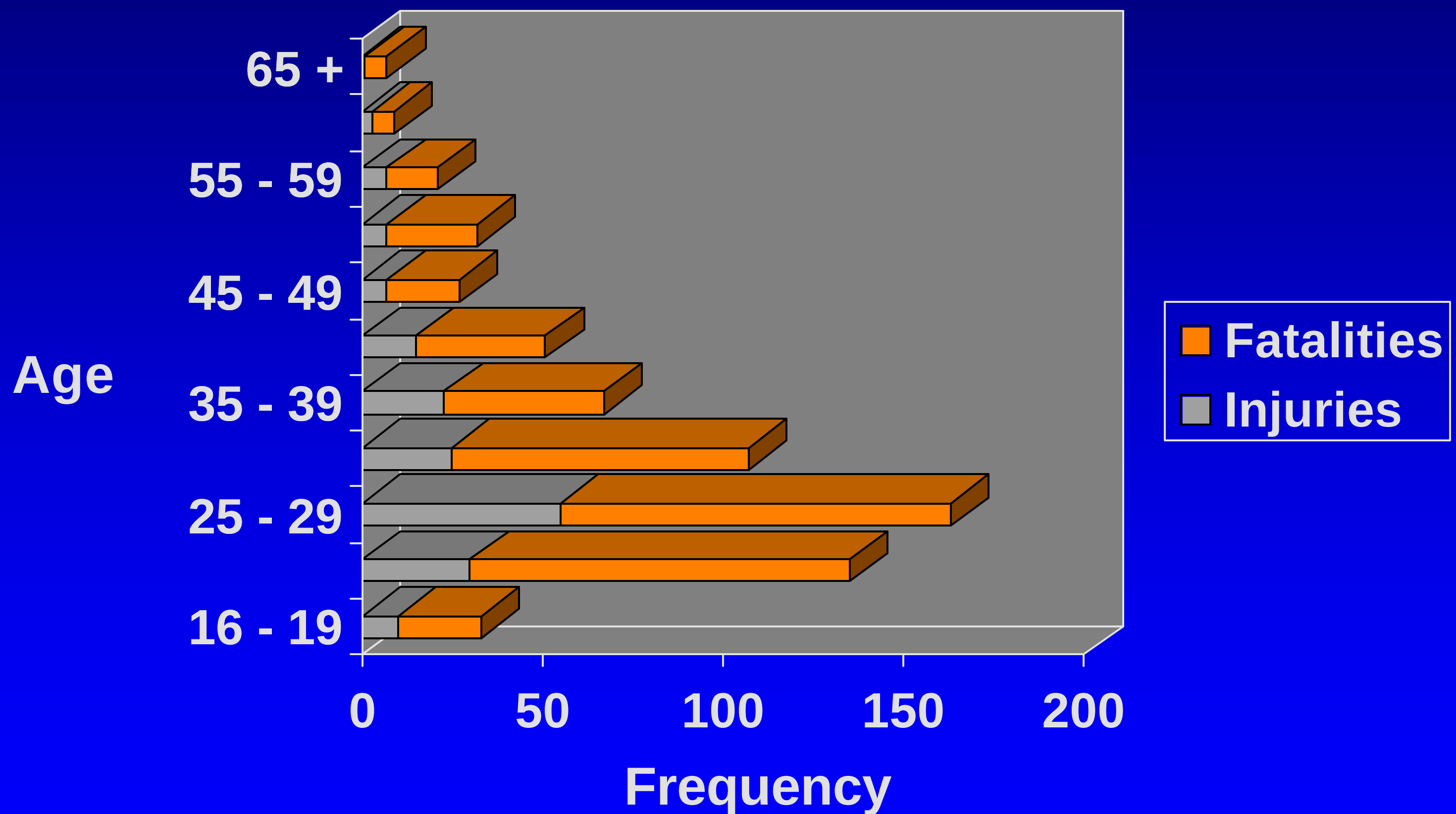
OSHA IMIS, 1985 - 1994

Location of Line Contacted, U.S.



OSHA IMIS, 1985 - 1994

Power Line Contacts by Age of Worker, U.S.



OSHA IMIS, 1985 - 1994

General Industry – 29 CFR 1910

- Subpart R – Special Industries
  - 1910.268 Telecommunications
  - 1910.268 (q) Tree Trimming Electrical Hazards
  - 1910.269 Electrical Power Generation, Transmission and Distribution
- Subpart S – Electrical

Construction Standards – 29 CFR 1926

- Subpart K – Electrical
- Subpart L – Scaffolds
- Subpart N – Cranes, Derricks, Hoists, Elevators and Conveyors
- Subpart P – Excavations
- Subpart V – Power Transmission and Distribution

29 CFR 1910.269 Vs. Subpart V

1910.269 (a)(1) *Application.* (i) This Section covers the operation and maintenance of electric power generation, control, transformation, transmission, and distribution lines and equipment.

1926.950 (a) *Application*. The occupational safety and health standards contained in this Subpart V shall apply to the construction of electric transmission and distribution lines and equipment.

Training Needed to Work Around High Voltage Wires

- 1910.269 (a)(2)(ii) – Power Line Workers
  - Safety related work practices, safety procedures, and other safety requirements in 1910.269 (such as PPE requirements and precautionary techniques).
  - Emergency procedures (such as pole top and manhole rescue).
  - Skills and techniques necessary to distinguish exposed live parts and the nominal voltage.
  - Minimum approach distances specified in 1910.269.

OSHA Directive
CPL 2-1.18A – Enforcement of the Electrical Power Generation, Transmission, and Distribution Standard

Foot Note 12

A qualified electrical worker normally undergoes a multi-year apprenticeship training program before he or she becomes fully qualified to perform all the different types of work that he or she would be expected to perform. This training includes not only the safety aspects of working on or near exposed energized circuit parts, it includes training in the actual performance of specific tasks so that work is of an acceptable level of workmanship.

Training Needed to Work Around High Voltage Wires

- 1910.268 (c). Telecommunications Workers
  - Various precautions and safe practices required by 1910.268.
  - Dangers relating to encounters with harmful substances and animal, insect, or plant life.
  - Procedures to be followed in emergency situations.
  - First aid training, including CPR.

Training Needed to Work Around High Voltage Wires

- 1910.331 - 1910.333 (c). *Safety Related Work Practices*
  - Safety related work practices as required by this section.
  - The skills and techniques necessary to distinguish exposed live parts and nominal voltage from other parts of electric equipment.
  - The clearance distances specified in 1910.333(c).

OSHA Directive
STD 1-16.7 – Electrical Safety-Related Work Practices

Enforcement/Citation Guidance.

The failure to train "qualified" and "unqualified" employees as required for their respective classifications shall normally be cited as a serious violation.

Power Line Myth #1

"Overhead Power Lines Don't Carry Enough Power to Hurt You."

Power Line Myth #2

"Overhead Power Lines Are Well-Insulated."

Threshold Effects of Electricity

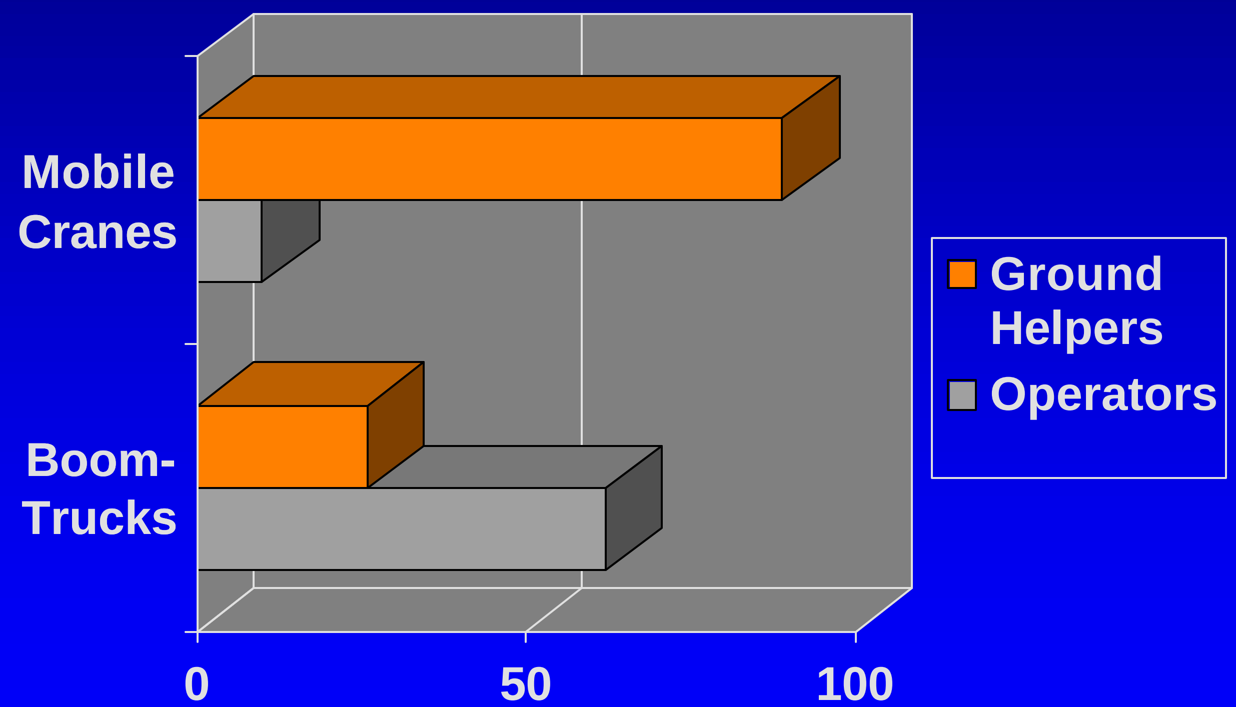
Response	Threshold Current
Perception	0.5 mA - 1.0 mA
Let-go	11 mA - 16 mA
Ventricular Fibrillation	100 mA
Skeletal Muscle Damage	1,500 mA (est.)

Lee, Gottlieb and Krizek

Cranes

Construction Safety Council

Accident Distribution by Worker Function



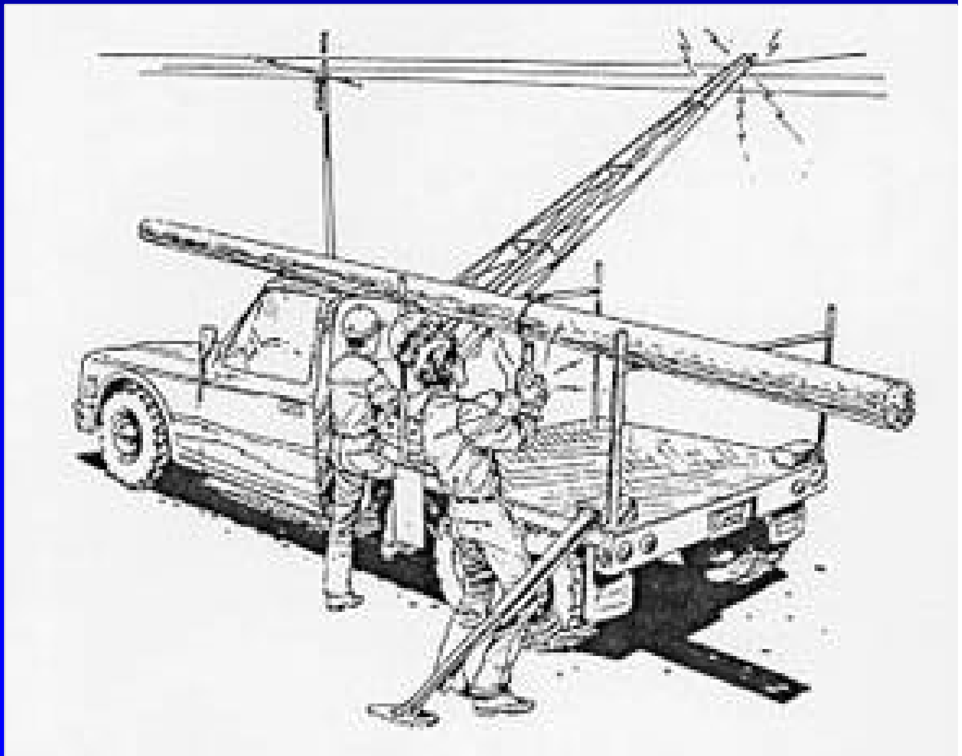
Paques, 1993

Fatal Fact – 7,200 Volts

Competent Safety Monitor on Site?	Yes – Victim
Safety and Health Program in Effect?	No
Training/Education Provided?	No
Experience at this Type of Work	4 Months
Time on Project	4 Hours

Fatal Fact – Unknown Voltage

Competent Safety Monitor on Site?	No
Safety and Health Program in Effect?	Yes
Training/Education Provided?	No
Experience at this Type of Work	5 Years
Time on Project	1 Day



Mobile Cranes

"Path to Ground" Isolated

Construction Safety Council

Boom Truck Operator

- Operator is “Path to Ground”

Other High Reach Equipment

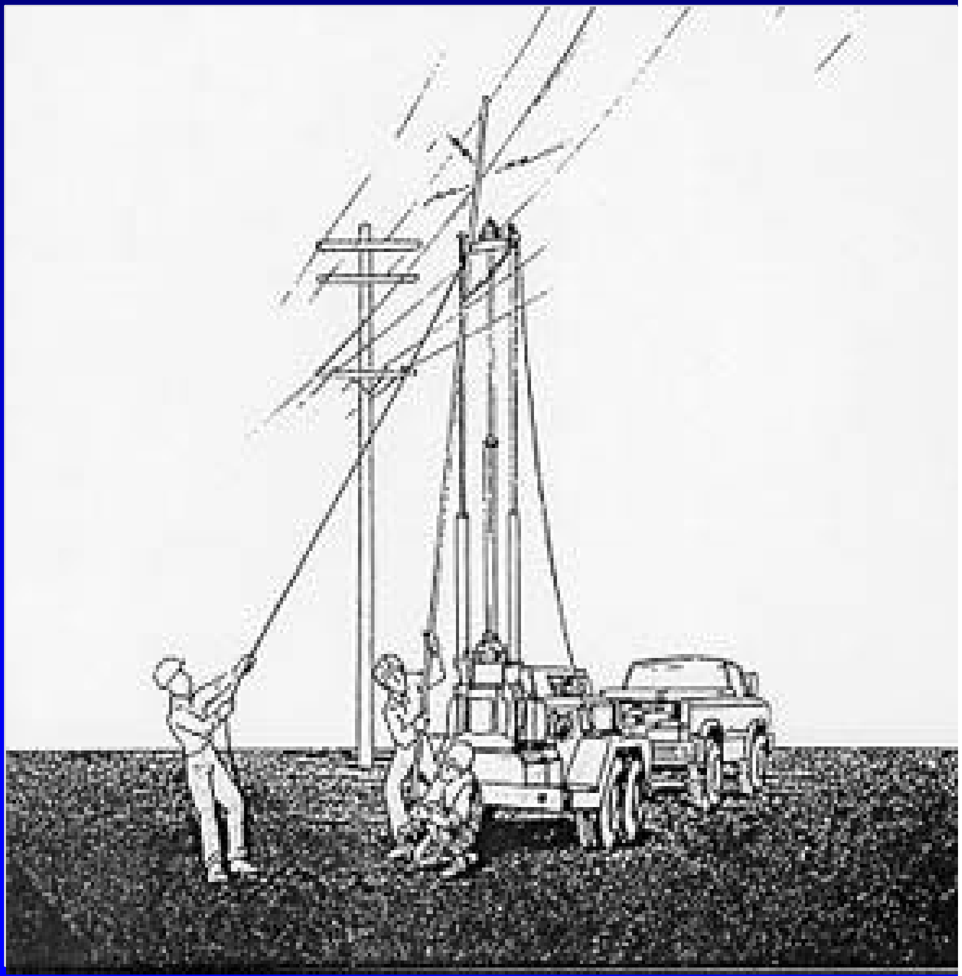
- Drilling Rigs
- Dump Trucks
- Aerial Lifts
- Backhoes
- Concrete Pumps

Drilling Rigs

- Maintain Proper Line Clearance
- Locate All Underground Utilities

Fatal Fact – 4,160 Volts

Competent Safety Monitor on Site?	Yes
Safety and Health Program in Effect?	Yes
Training/Education Provided?	Yes
Experience at this Type of Work	2 Days
Time on Project	2 Days



Dump Trucks

- Maintain Proper Line Clearance
- Ensure that Power Lines will not be Contacted while Driving Away, Lower Bed if Necessary

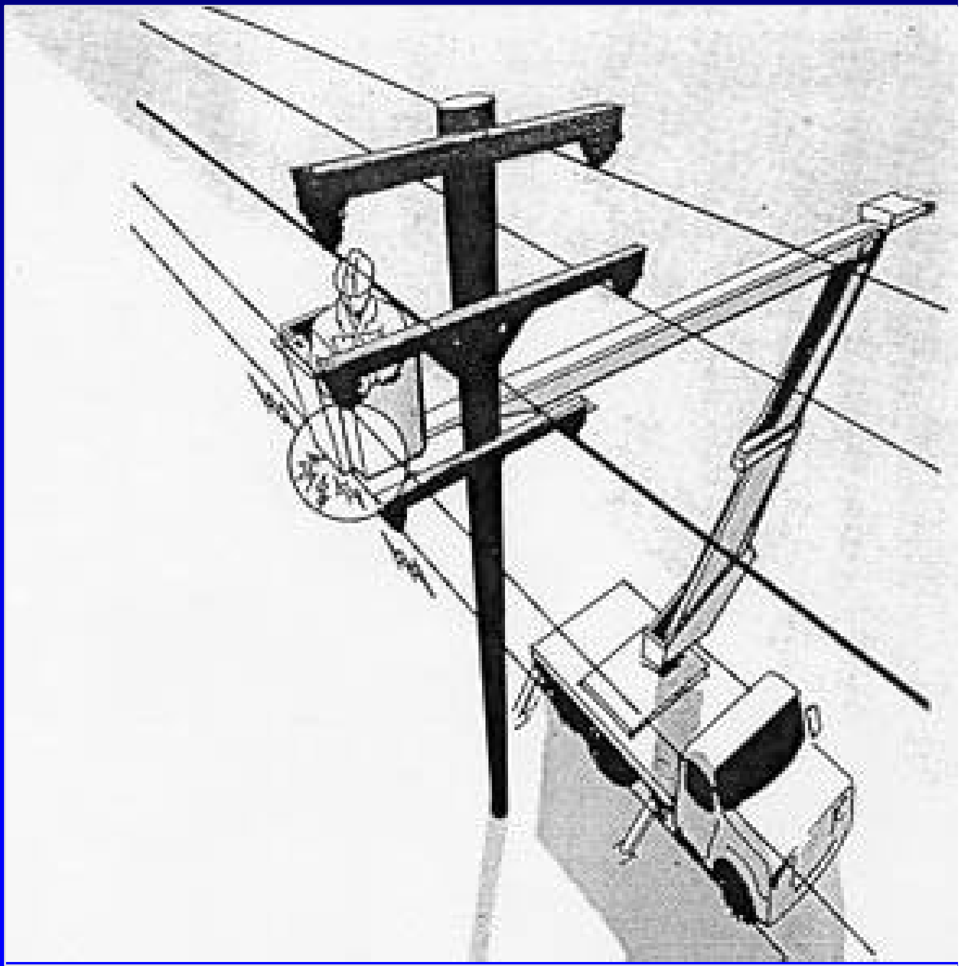
Aerial Buckets

- Maintain Proper Line Clearance
- The Insulated Portion of the Lift Shall Not be Altered in any Manner

Fatal Fact – Unknown Voltage

- Defective bucket – drain hole in bottom.

Competent Safety Monitor on Site?	Yes
Safety and Health Program in Effect?	No
Training/Education Provided?	No
Experience at this Type of Work	11 Months
Time on Project	6 Weeks

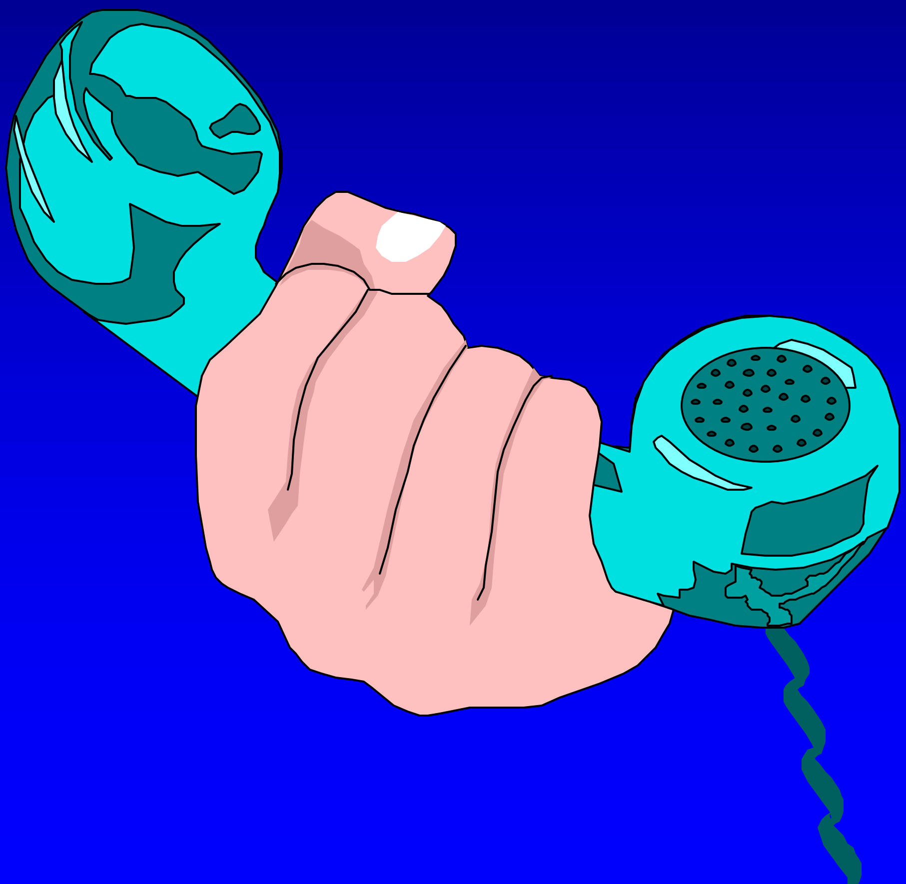


Excavating Equipment

- Maintain Proper Line Clearance
- Locate All Underground Utilities

Construction Safety Council

Call Before You Dig!!



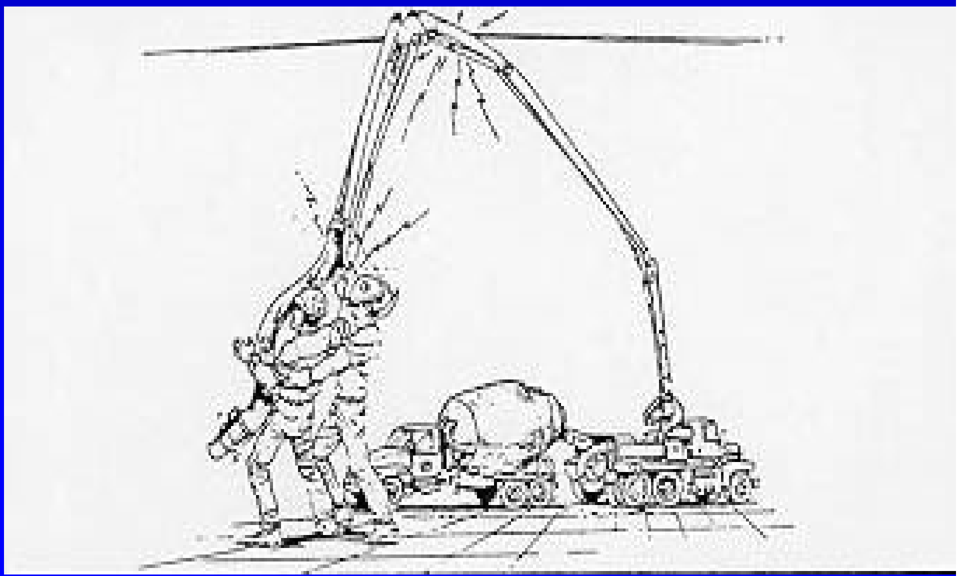
Electrical Standards - Construction

1926.416 (a)(2) In work areas where the exact location of underground electric power lines is unknown, employees using jack-hammers, bars,or other hand tools which may contact a line shall be provided with insulated protective gloves.

Fatal Fact – 7,620 Volts

Competent Safety Monitor on Site?	No
Safety and Health Program in Effect?	No
Training/Education Provided?	No
Experience at this Type of Work	10 Years
Time on Project	1 Day

Concrete Pump Truck



Power Line Clearance Distance

The closest distance that any worker or equipment can get to an overhead power line.

Power Line Clearance – Construction (Unqualified)

1926.550 (a)(15) Except where electrical distribution and transmission lines have been de-energized and visibly grounded at point of work or where insulating barriers, not a part of or an attachment to the equipment has been erected to prevent contact, the following line clearance shall be adhered to:

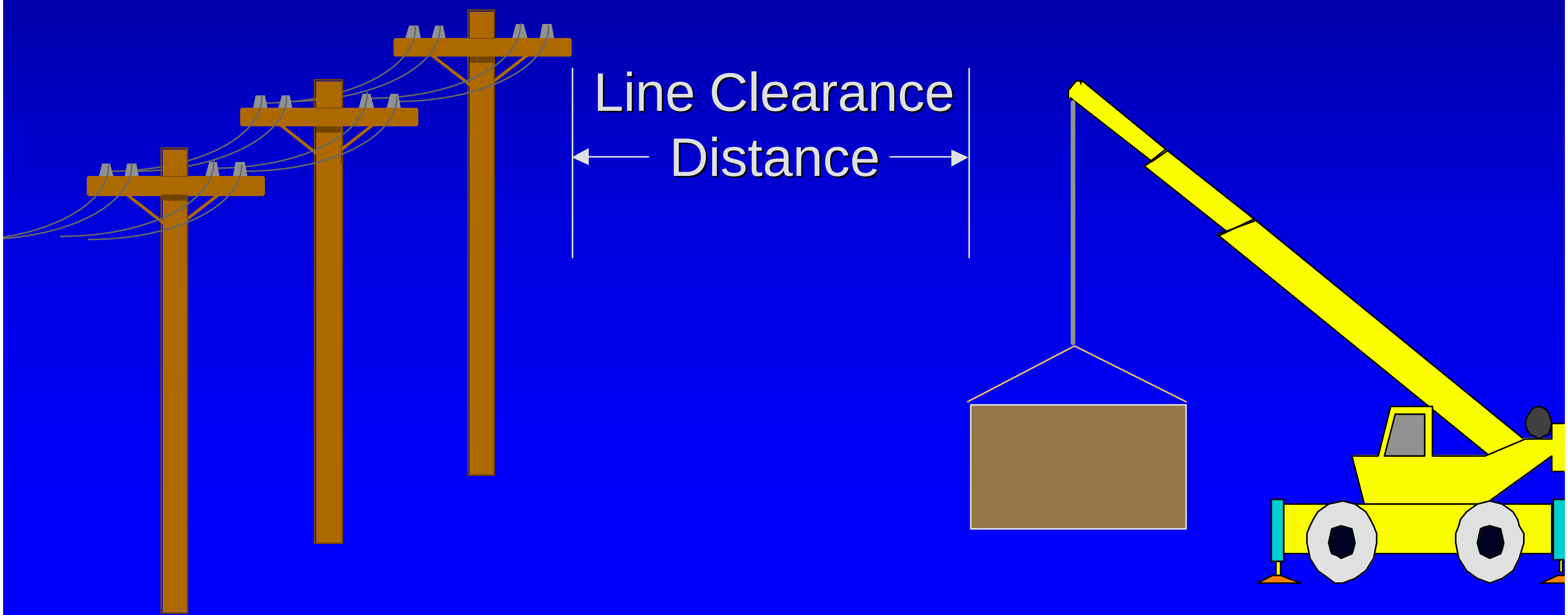
50 kV or Less

10 feet

Greater than 50 kV

10 feet + (0.4 inches)(# of kV over 50 kV)

Power Line Clearance



Rule of Thumb

If the overhead power line is 50 kV or less, stay at least 10 feet away. For everything else, keep at least 35 feet away.

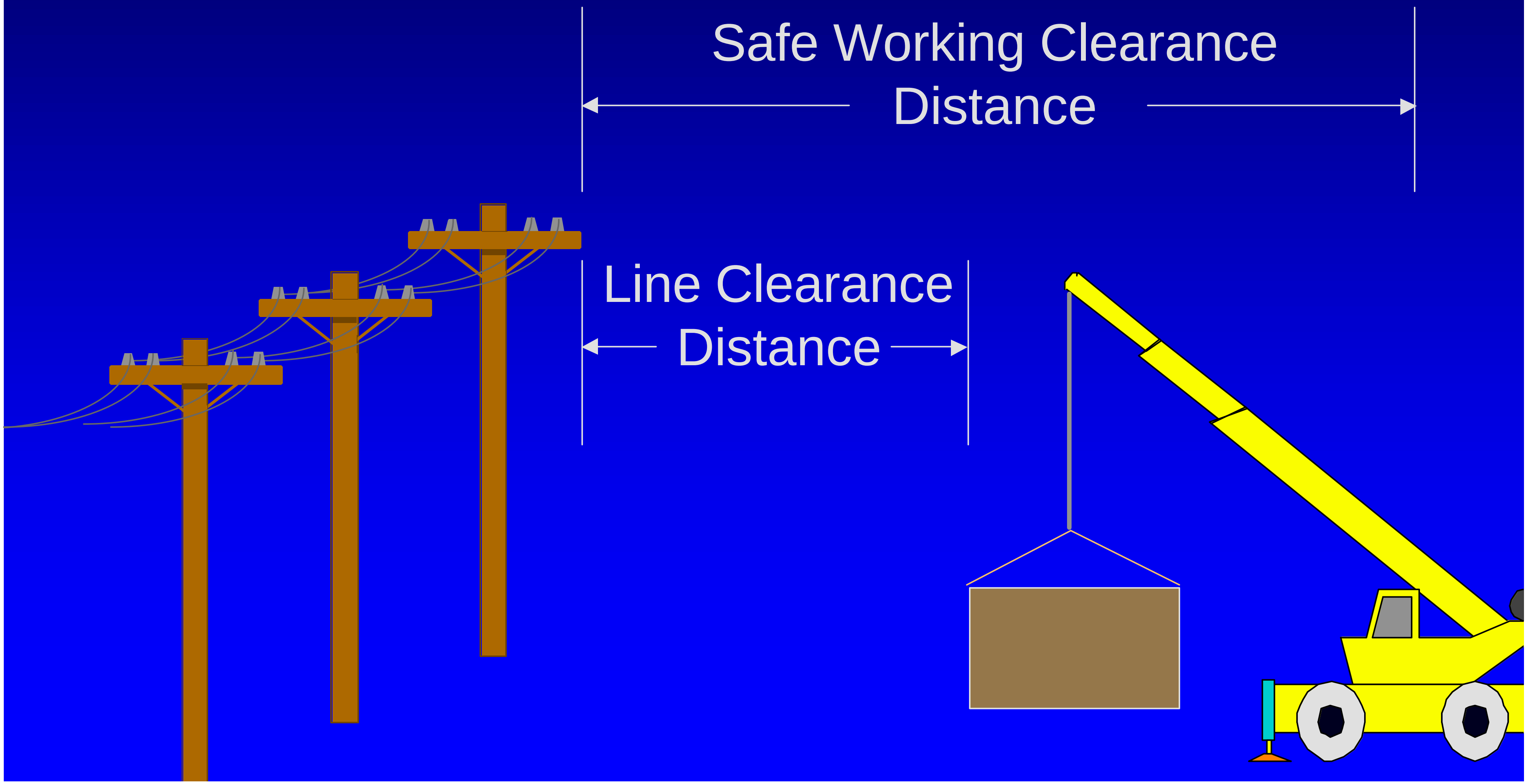
Safe Working Clearance

The Closest Distance that a Piece of Equipment Can Be Placed to an Overhead Power Line So That the Equipment's Farthest Reach Will Not Cross the Line Clearance Distance

Safe Working Clearance

100	feet	(crane boom and attachments)
15	feet	(1/2 width of 30 ft. X 20 ft. concrete form work)
+35	feet	(line clearance for unknown voltage)
150	feet	(safe working clearance)

Safe Working Clearance

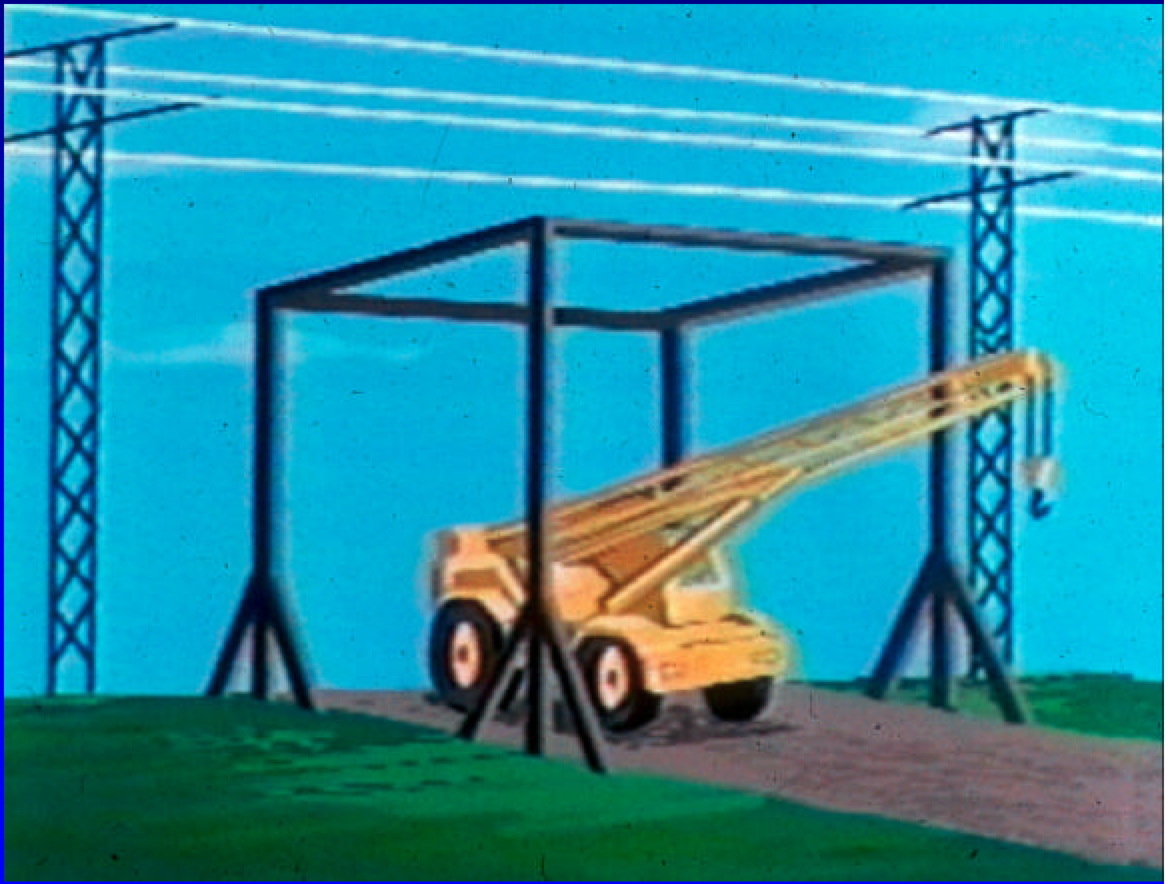


Vehicle in Transit

1926.550 (a)(15)(iii)
With no load and boom lowered.

Line Clearance:

Less than 50 kV……. 4 ft
50 kV to 345 kV ……10 ft
Over 345 kV ………. 16 ft

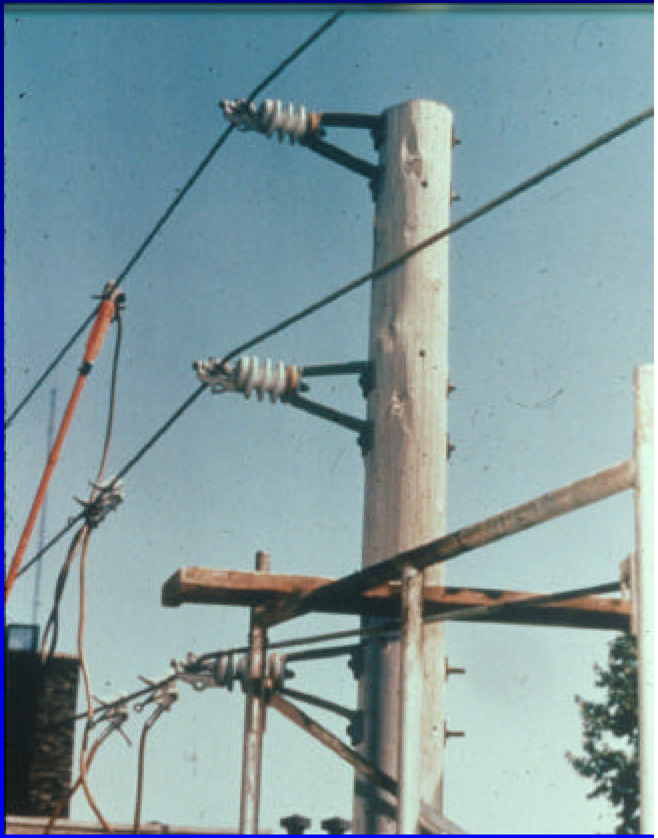


Other Preventative Measures

- Have Utility De-energize and Visibly Ground the Power Line
- Have Utility Move the Power Line Beyond the Safe Working Clearance
- Use Barrier Protection
- Use Warning Lines with Flags
- Use an Observer

De-energizing the Power Line

- Conducted by the Utility Company
- Allow Sufficient Time
- Line Must be Visibly Grounded
- Never Assume that All Lines Near a Grounded Line are De-energized
- Always Meet with the Utility to Have Them Identify the De-energized Sections

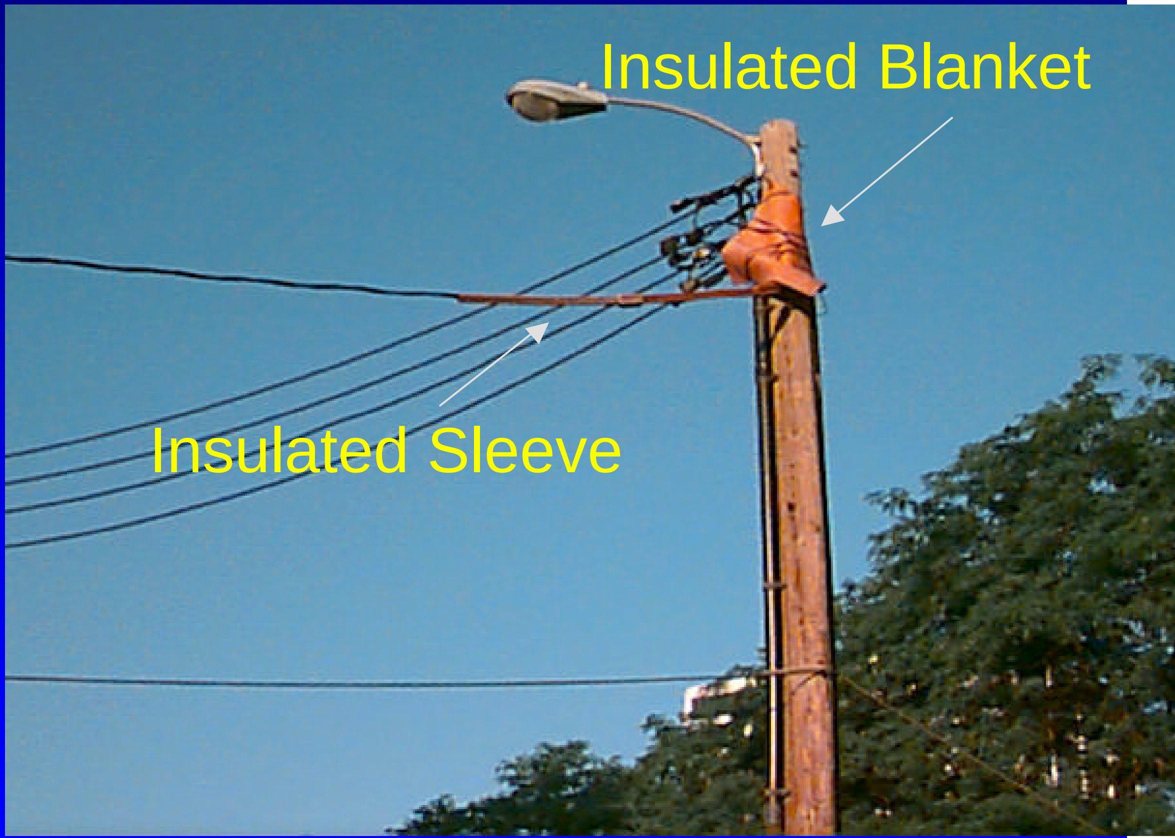


Moving the Line

- Conducted by the Utility Company
- Allow Sufficient Time

Barrier Protection

- Insulated Sleeves Must be Installed by the Utility Company
- Allow Sufficient Time
- Should Maintain Minimum Line Clearance Distance



Warning Lines With Flags

- Visibly Marks the Line Clearance Distance
- Must be of Non-Conductive Material
- Not Attached to Power Line(s) or Utility Pole(s)

Use of an Observer

- Must not be Given Other Responsibilities
- Must Have Clear View:
  - Horizontal Clearance: Stand to the Side of the Equipment and Below the Line
  - Vertical Clearance: Stand to the Side of the Equipment
- For Horizontal Clearance, Mark Off the Line Clearance Distance on the Ground with Caution Tape

Engineering Solutions

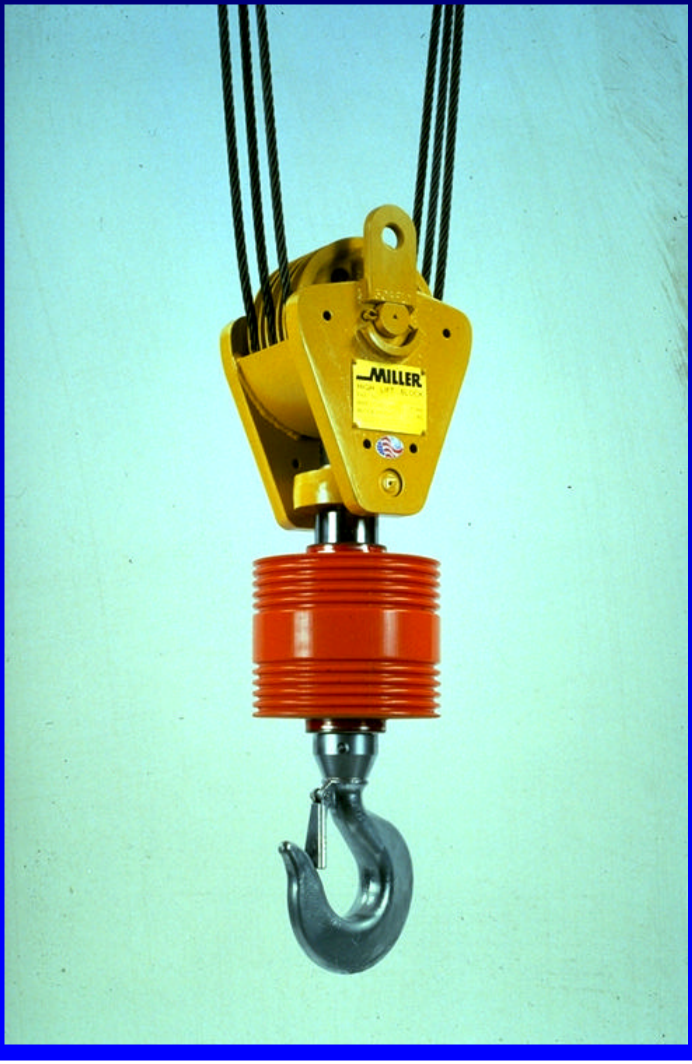
- Designed by a Professional Engineer
- Can Reduce the Likelihood of Electrocution
- Must Still Maintain Line Clearance Distance

Protective Technologies

- Insulating Links
- Boom-Cage Guards
- Proximity Devices

Insulated Link

- Inspect Daily
- Protects Only the Riggers

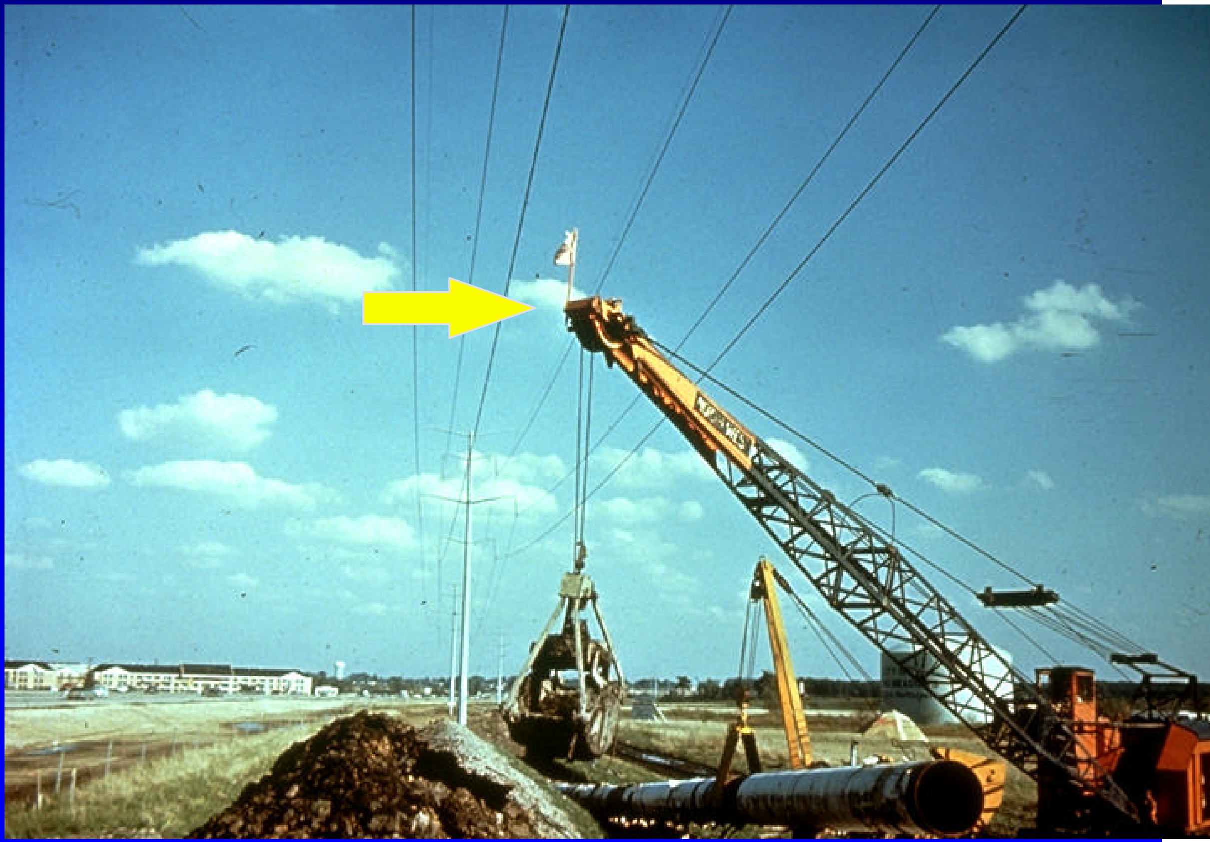


Boom-Gage Guard

- Inspect Daily
- Protects Only Covered Portion of Boom
- Load and Load Line are Still at Risk

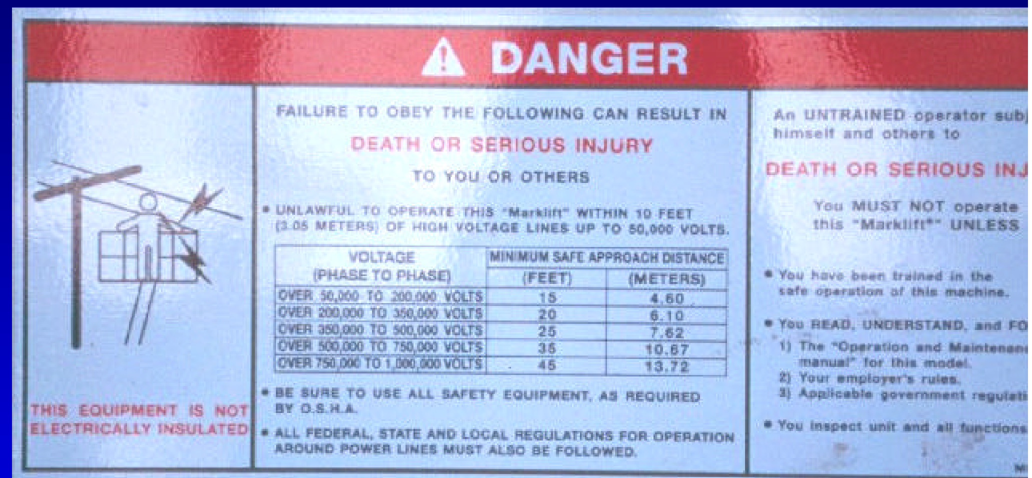
Proximity Devices

- Inspect Daily
- Detects Electromagnetic Field
- May Give False Readings
- Be Aware of Limitations



Remote Control Devices

Warning Signs Posted



Protective Technologies

- Protective Technologies are Supplemental
- They Do Not Allow Work to be Performed Closer than the Clearance Distance to an Overhead Power Line

1910.268 Telecommunications

268 (b)(7) Approach distances to exposed energized overhead power lines and parts.

No worker or conductive object closer to an energized power line as prescribed in Table R-2, unless:

- Employee is insulated or guarded form the line, or
- The line is insulated or guarded from the employee, or
- Power is de-energized and grounded.

1910.268 Telecommunications

Table R-2

Voltage Range (phase to phase)	*Approach Distance (inches)*
300 V and less	Avoid Contact
300 V - 750 V	12
750 V - 2 kV	18
2 kV - 15 kV	24
15 kV - 37 kV	36
37 kV - 87.5 kV	42
87.5 kV - 121 kV	48
121 kV - 140 kV	54

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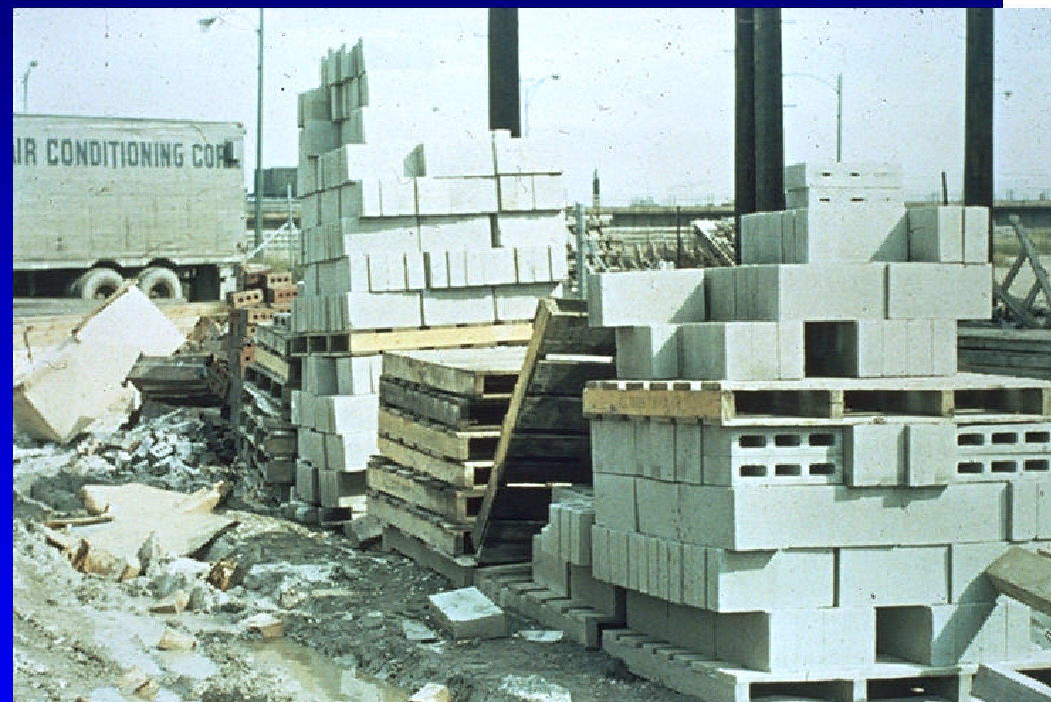
Material Handling and Storage

Get Help When Handling Materials



Avoid Storing Materials Under Power Lines

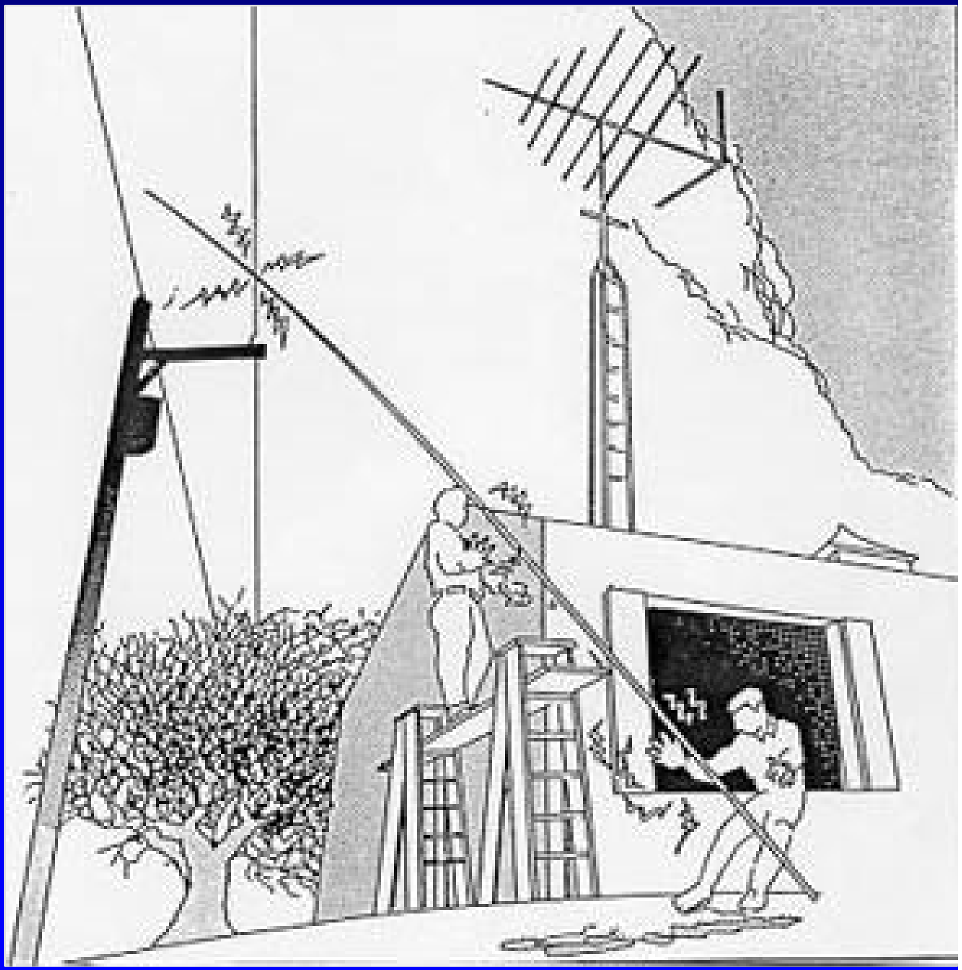
Material Handling

Material Handling

- Maintain Line Clearance Distance when Handling Materials and Other Hand Held Equipment.
- Be Aware of All Adjacent and Overhead Power Lines

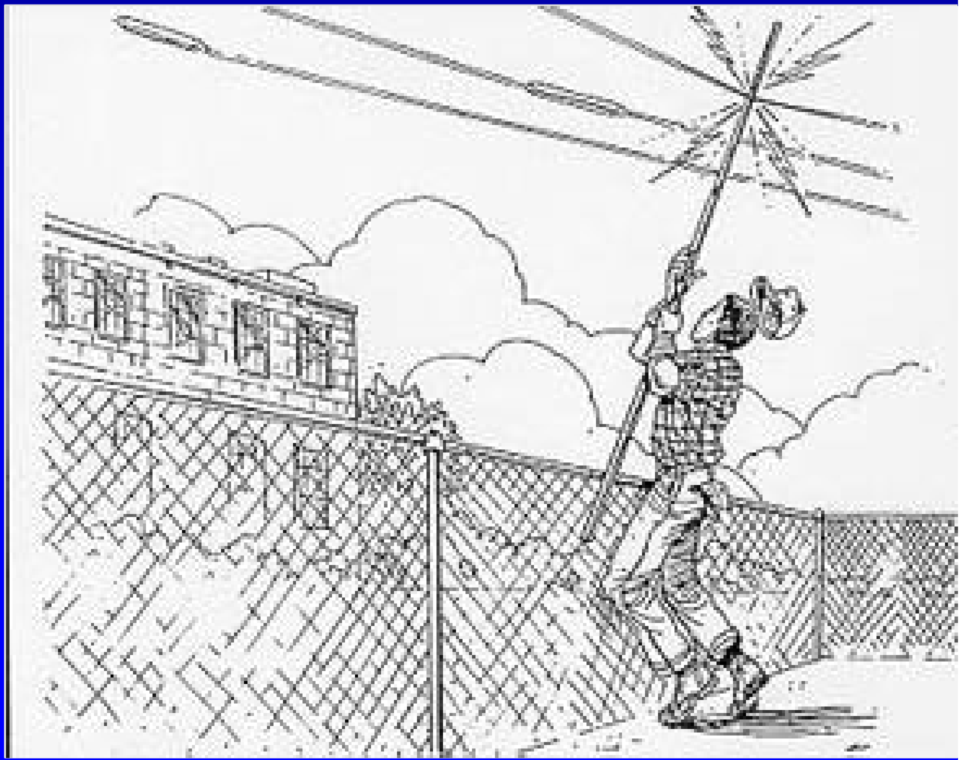
Fatal Fact – 7,200 Volts

Competent Safety Monitor on Site?	Yes
Safety and Health Program in Effect?	No
Training/Education Provided?	No
Experience at this Type of Work	30 Days
Time on Project	3 Days



Fatal Fact – 7,200 Volts

Competent Safety Monitor on Site?	No
Safety and Health Program in Effect?	Yes
Training/Education Provided?	No
Experience at this Type of Work	3 Months
Time on Project	1 Day



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Ladders

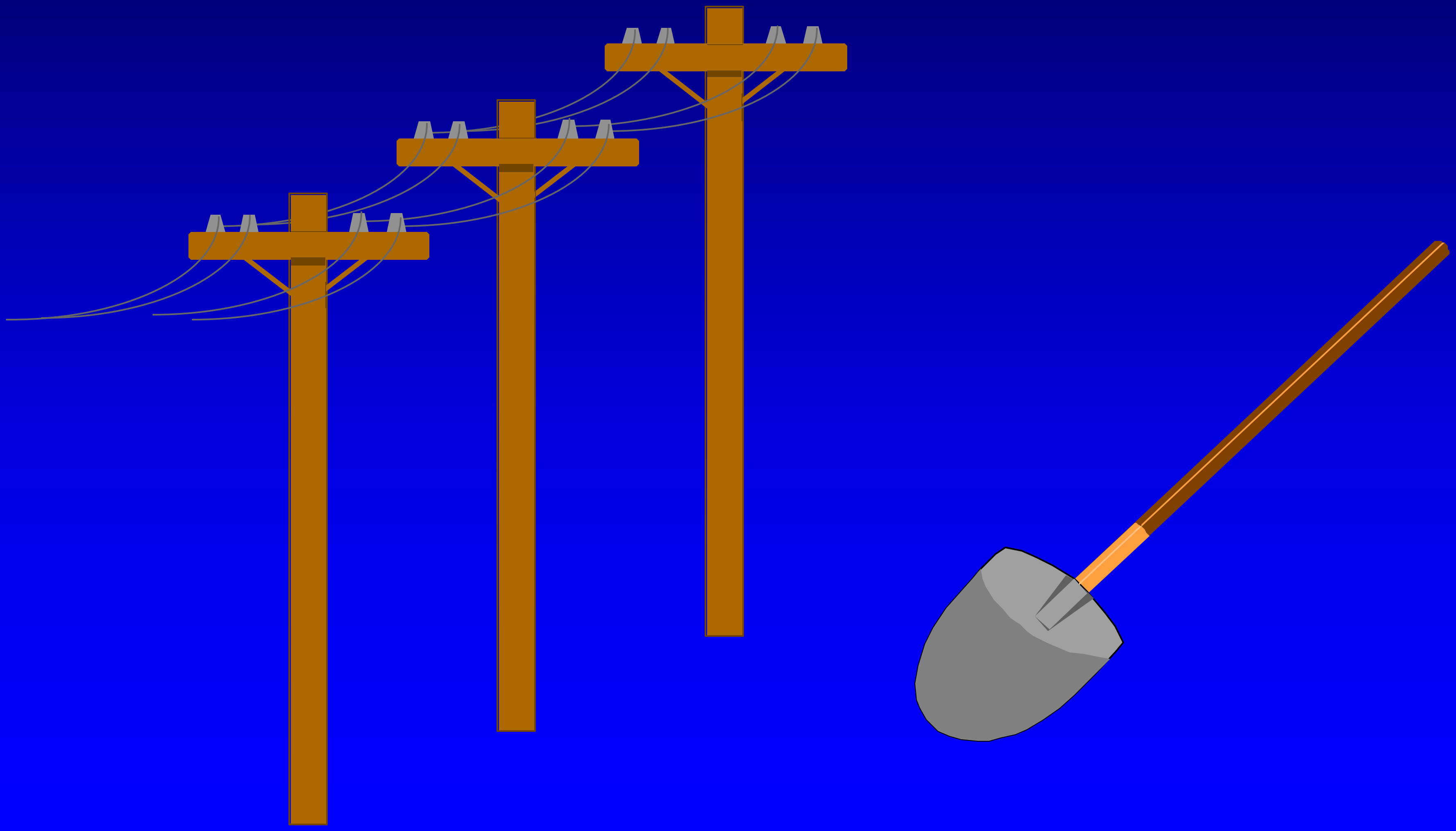
Ladders

- Must Be Non-Conductive
- Don’t Carry or Move Extended
- Get Help When Moving

Preventive Measures

- Have Utility De-energize the Line
- Have Utility Move the Line
- Have the Utility Install Insulating Sleeves
- Non-Conductive Tools and/or Materials
- When Using a Ladder:
  - Must Be Non-Conductive
  - Don't Carry or Move Extended
  - Get Help When Moving
- Always Maintain the Clearance Distance

What to Do if You Hit a Line

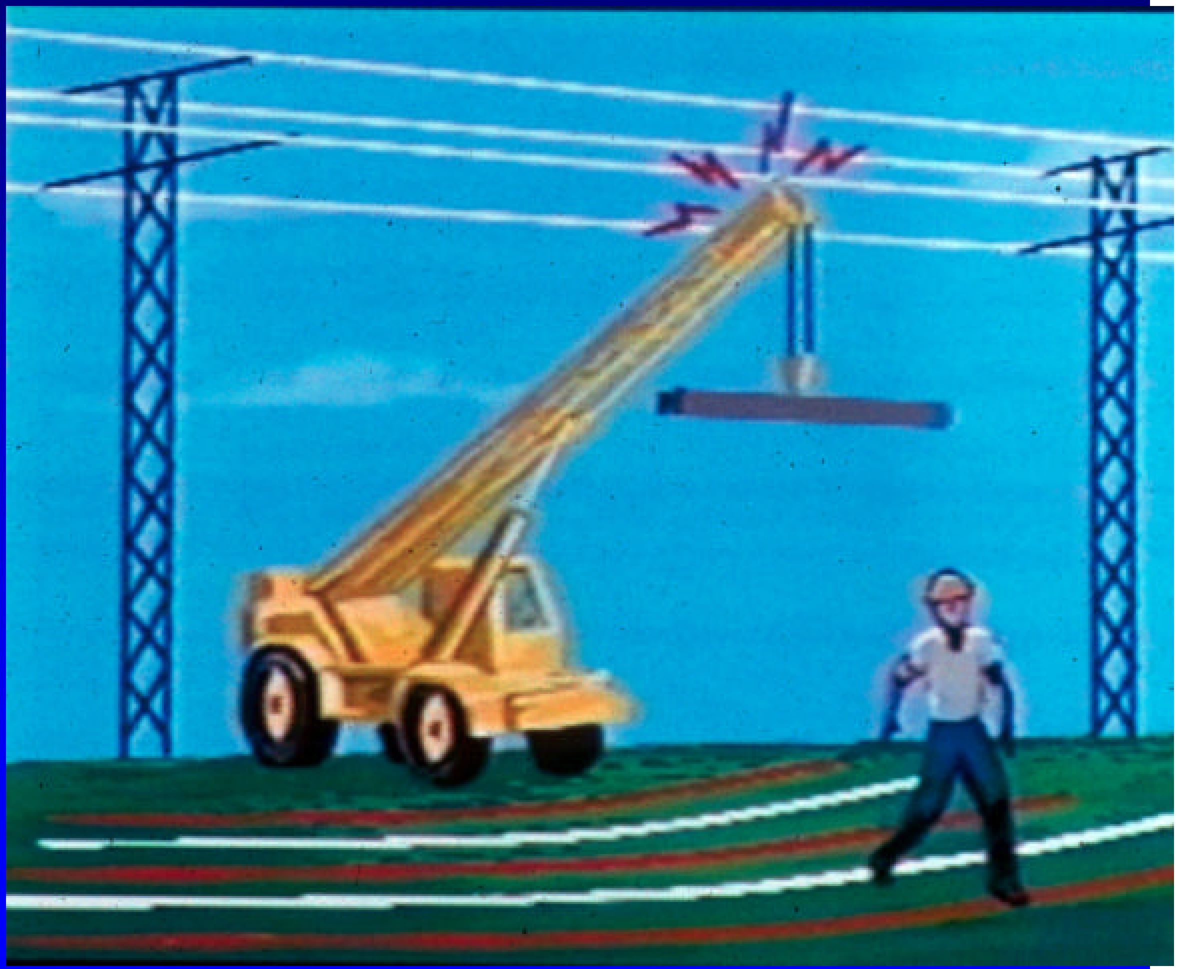


Power Line Contact with Worker Isolated on Equipment

- Stay on the Equipment Until Line is De-energized
- If you Must Leave the Equipment:
  - Jump From Equipment Landing on Your Feet
  - Never Touch the Equipment and the Ground at the Same Time
  - Shuffle with Very Small Steps Away from Energized Equipment

Remember...

- Current is Flowing Through the Ground
- Never go Near the Energized Equipment or Worker



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Isolated Worker

If a Power Line Contact Occurs, Stay on the Equipment. Don't Leave Unless There is an Extreme Emergency.

Power Line Contact with Worker

- Do Not Attempt a Rescue
- Wait Until the Line is De-energized

Worker "Path To Ground"

Avoid Unnecessary Contact with Equipment While Working Around Power Lines

Avoid Unnecessary Contact with the Load While Working Around Power Lines

1926.416 General Requirements

1926.416 (a)(3) Before work is begun the employer shall ascertain by inquiry or direct observation, whether any part of an energized electric power circuit is so located that the performance of work may bring any person, tool, or machine into contact. The employer shall post warning signs and advise employee of the location of such lines, the hazards involved, and the protective measure to be taken.

Systematic Approach to Power Line Hazards

Survey

Identify

Eliminate

Control

Survey

“Where are the Power Lines on the Job Site?”

Identify

“What Will Our Company Be Doing that May Result in a Power Line Contact?”

Eliminate

"How Can the Power Line Electrocution Hazard be Eliminated?"

Control

"What Controls Can Be Used to Prevent Contact with the Line?"

Emergency Action Plan

- Post Significant Phone Numbers
- Train Management and Workers
- Response to a Power Line Contact
- Job Hazard Analysis - Power Lines
- Job Site Specific Plan

Job Site Plan

- List of Power Line Hazards on Job Site
- Methods to Eliminate or Reduce those Hazards
- Worker Training (content & verification)
- Assignment of Responsibility (e.g. observer)
- Communication Between Contractors
- Emergency Response

Management & Worker Training

- Identification of High-Risk Activities & Equipment
- Methods to Eliminate/Reduce Contact Risks
- OSHA and Other Requirements
- Overall Emergency Plan and Procedures
- Power Line Contact Emergency Response
- Project Specific Safety Requirements

Phone Numbers

- EMS, Local Hospital
- Power Utility
- Management

Response Procedures to a Power Line Contact

- Contact Emergency Responders
- Keep Other Workers Away
- Notify Power Utility

Investigate All Accidents and Near Misses & Communicate Your Findings

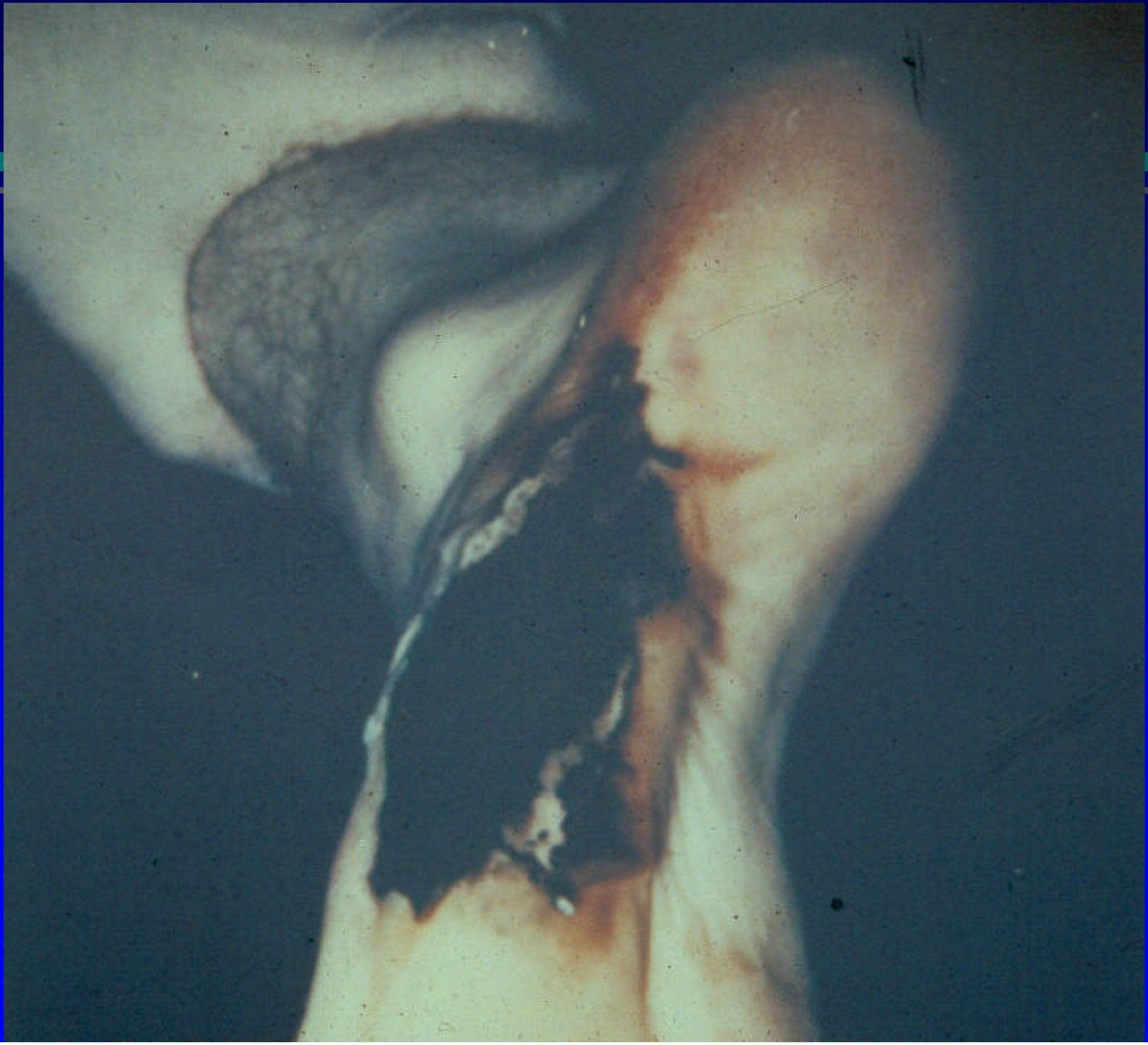
Return to Work

Contractor

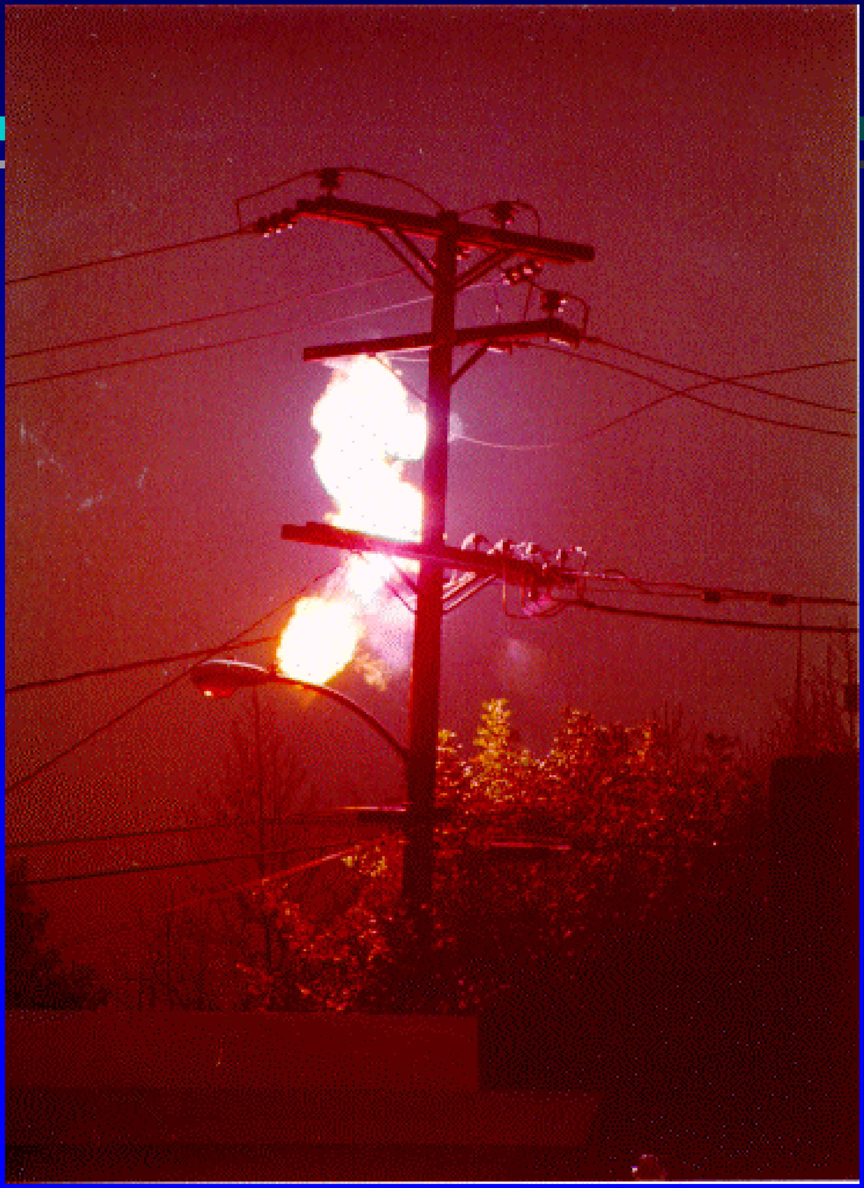
Worker

Hospital/Clinic

Insurer







POWER LINE AWARENESS PERMIT

Today's Date ___________ **Job Number** _______________________________________

Contractor Name			
Job Address			
Telephone Number		**Fax Number**	

Emergency Contact Number	

Survey

Before beginning any project, you must first survey your work area to find power lines at the job site. (See job site sketch on reverse side)

Identify

After finding all of the power lines at your site, identify the activities you'll be doing that may put you or your workers at risk. Mark one or more of the following:

- ☐ Cranes (mobile or truck mounted)
- ☐ Drilling rigs
- ☐ Backhoes/Excavators
- ☐ Long-handled tools
- ☐ Other tools/high-reaching equipment
- ☐ Concrete pumper
- ☐ Aerial lifts
- ☐ Dump trucks
- ☐ Ladders
- ☐ Material Handling & Storage
- ☐ Scaffolding
- ☐ Other____________________

Eliminate or Control

After identifying the power line and high-risk activities on our job site, we must determine how to eliminate or control the risk of electrocution (a successful determination is often reached only after consultation with the utility). Mark one or more of the following:

- ☐ Move the activity
- ☐ Change the activity
- ☐ Have the utility de-energize the power line
- ☐ Have the utility move the power line
- ☐ Use barrier protection (insulated sleeves)
- ☐ Use an observer
- ☐ Use warning lines with flags
- ☐ Use non-conductive tools
- ☐ Use a protective technology;
  - ☐ Insulated link
  - ☐ Boom cage guard
  - ☐ Proximity device

Always maintain your minimum safe clearance distance from the power line, except when the utility has de-energized and visibly grounded the power line.

Voltages	Distance from Power Line
Less than 50 kV	10 Feet
More than 50 kV	10'+(0.4")(# of kV over 50 kV)

WARNING!
It is unlawful to operate any piece of equipment within 10' of energized lines

Jobsite sketch

(draw in location of power lines and their proximity to construction site, include such things as; proposed excavations, location of heavy equipment, scaffolding, material storage areas, etc.)

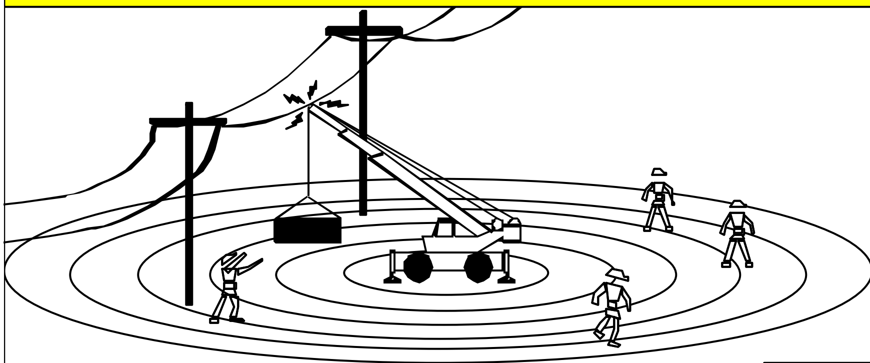
Completed by____**Date**_______________

Title____

Approved by____**Date**_______________

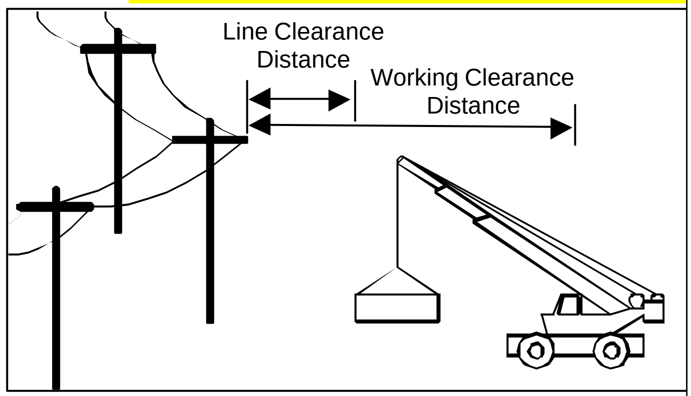
Title____

Power Lines = Lethal Weapons



Line Clearance =

10'+



- Move equipment/activity to the safe working clearance distance from power lines.
- Have utility de-energize and visibly ground power lines.
- Install flagged warning lines to mark horizontal and vertical power line clearance distances.
- Don't store any materials under power lines.
- Use an observer.

Construction Safety Council 1-800-552-7744

Closing

TOTAL FATILITIES BY YEAR

ELECTROCUTIONS BY YEAR

PERCENT OF TOTAL FATILITIES BY YEAR