Edison Electric Institute
Occupational Safety and Health Committee
Conference
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**Occupational Health and Safety Research Program (Program 62) at the Electric Power Research Institute**

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Electric Power Research Institute

- Founded in 1973
- Collaborative R&D for the electricity industry
- Serving over 1,000 organizations, including 150 international participants, in over 42 countries
- U.S. members represent over 90% of U.S. electricity generated
Extensive Energy Research Program

**Generation & Distributed Resources**
- Environmental Control
- Fossil Steam Plants
- Combustion Turbines
- Market Analysis
- Renewables
- Hydroelectric
- Distributed Resources

**Nuclear Power**
- Component
- Reliability & Safety
- Nuclear Operations & Asset Management
- Nondestructive Evaluation
- Plant Technology

**Power Delivery & Markets**
- Transmission
- Substations
- Grid Reliability
- Power Markets
- Distribution
- Power Quality
- Energy Utilization

**Environment**
- Air Quality
- Global Climate Change
- Electric and Magnetic Fields (EMF)
- Occupational Health & Safety (P62)
- Land & Groundwater
- Water & Ecosystems
EPRI OH&S Program – Current Scope

Occupational Injury Database
• Standardized reliable annual injury rates
• Trends, benchmarking

Ergonomics Research
• Distribution
• Generation
• Fleet vehicles

Emerging Health Issues
• Crystalline silica in coal fly ash
• Hexavalent chromium and welding
• Nanoparticles at power plants
Occupational Injury Database
Overview of EPRI Occupational Health and Safety Database Project

- Integrated database of workplace injuries among electric utility workers
- Combines various data sources:
  - Worker injuries (safety)
  - Personnel data (human resources)
  - Worker compensation (legal)
- 16 Participating utilities
  - 8 Utilities—continuous data 1995–2005
- Includes:
  - Nearly a million worker years of observation
  - More than 34,000 OHSA reportable injuries
- Database managed by Exponent
Disease and Injury “Surveillance”

• “Cornerstone” of Public Health Science and disease prevention
  – Cancer registries
  – Mortality registries
  – Birth defects registries
  – MV crash registries
  – Injury registries
  – NHANES surveys
Benefit of Injury/Illness Surveillance

- Continual injury monitoring—assessing the magnitude of the problem
- Benchmarking
- Assist in establishing health and safety program priorities
- Estimate impact of prevention programs
- Guide to develop targeted health and safety research
OHSD Project Objectives

• Monitor and evaluate injury/illness trends in the electric energy industry workforce
• Identify high risk occupations
• Quantify costs and lost time
• Provide basis for research priorities
• Improve benchmarking capabilities
• Characterize risk factors and rates for special injuries (e.g., burns, strains, motor vehicle crashes)
Comparisons with Other Safety Data

• Bureau of Labor Statistics (BLS)/ Occupational Health and Safety Administration (OSHA)
  – Survey of Occupational Injuries and Illnesses
  – National Census of Fatal Occupational Injuries
• Edison Electric Institute (EEI)
  – Industry-wide statistics
  – Less detail than OHSD
  – Relies on survey rather than original data
• Utility-specific Systems
  – Smaller number of events for rare injuries
  – Occupational and demographic analyses not routinely performed
Components of EPRI OHSD

- Continual Recruitment
- Annual Update of Database
- Annual Report
- Tailored Collaboration Projects
- Focused Special Analyses
Annual Report: Contents

• Work force characterization
• Evaluation of injury trends over time
• Summary by nature of injury
• Summary by body region affected

• Comparison of injury rates across participating utilities
• Injury rates by occupation and location
• Demographic factors and injury trends
• Injury source/ accident type
Components of EPRI OHSD

• Special projects
  – Burn injury analysis
  – Sprain/strain injury study
  – Low back injuries
  – Hand/wrist injuries
  – Injury occurrence by day of week
  – Storm duty related injuries
  – Medical costs
  – Web reporting

• Tailored collaboration projects
  – Motor vehicle crash study
  – Benchmarking studies
OHSD Database

- Confidentiality issues
- Appropriate use of data
- Access to other researchers
- Reporting of events
- Identifiers removed
- Summary data set (not individually reported)
Average Annual Number of Employees

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Overall Company-Wide Injury Rates by Year and Company Code, 1995–2005
Distribution and Injury for Electric Utility Workers by Age Group, 1995–2005

- **Percentage of Age Group**
  - 20 or Less: 1.0%
  - 21-30: 10.0%
  - 31-40: 21.9%
  - 41-50: 35.1%
  - 51-60: 26.0%
  - 61-65: 3.7%
  - 65+: 2.3%

- **Injury Rate per 10,000 Employee-Years**
  - 20 or Less: 2.3
  - 21-30: 4.3
  - 31-40: 4.4
  - 41-50: 4.0
  - 51-60: 2.5
  - 61-65: 1.4
  - 65+: 0.3

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Occupational Classification Coding

- Line workers
- Electricians
- Meter readers
- Plant and equipment operators
- Mechanics
- Machinists
- Maintenance workers
- Welders
- Custodians/cooks
- Technical/professional support
- Material handlers/porters
- Engineers
- Foremen
- Managers
- Supervisors
- Administrative support
- Security
- Other technicians
- Coordinators
- Drivers/deliverers/inspectors/patrol
Injury Rates per 100 Employee Years by Occupational Group

Body Part Injured Coding

- Back/trunk
- Eye
- Knee
- Hand/finger
- Head
- Neck/shoulder
- Ankle
- Feet/toe

- Other lower extremities
- Upper extremities: arm, forearm, elbow
- Multiple parts
- Body system
- Wrist
- Non-classifiable
Distribution of Injuries by Body Region Affected

Nature of Injury Coding

- Burns (chemical, flashburn, thermal, unclassified)
- Electric shock/electrocution
- Sprains/strains
- Concussion
- Crushing
- Fractures
- Lacerations/cuts/punctures
- Contusions/bruises
- CTD/RSI
- Bite
- Scratches/abrasions
- Infection
- Inflammation/swelling
- Hernia/rupture

- Occupational disease, not elsewhere classified
- Respiratory
- Hearing loss or impairment
- Dermatitis/skin
- Multiple injuries
- Heat/cold environment
- Death
- Other
- Non-classifiable
Distribution of Injuries by Nature of Injury

Source of Injury Codes

- Animal or insect bite
- Caught in, under or between
- Contact with electric current
- Contact with radiation/caustic substances
- Fall—same level
- Fall—different levels
- Overexertion/body motion
- Strike against
- Struck by
- Vehicle accident
Injury Rates per 100 Employee Years by Injury Source

Work-Related Fatalities

• 41 fatalities were reported during the 11-year period
  – 16 involved line workers; 4 involved maintenance workers
  – 8 involved contact with an electric current
  – 6 involved vehicle accidents; 4 involved helicopter accidents
  – Rate of 4.3 fatalities per 100,000 employee-years
Primary Work Location Codes

• Customer service
• Field
• Generation station
• Office
• Other facilities
• Substation
• Training
• Transmission and distribution
Injury Rates per 100 Employee Years by Primary Work Location

- Transmission and Distribution: 6.98
- Other Facilities: 6.23
- Substation: 3.84
- Office: 3.37
- Generation Stations: 3.34
- Field: 3.32
- Customer Service: 2.98
- Training: 1.57

Age Distribution of the Electric Utility Workforce

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Injury Rate for Electric Utility Workers per 100 Employee Years by Age Group

Age Distribution of Line Workers

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Injury Rate for Line Workers per 100 Employee Years by Age Group

Ergonomics Research
Poor Ergonomics is Extremely Costly to the Industry

• Ergonomics is the science of evaluating and designing work environments and products around the strengths and limitations of the human user

• EPRI Study Design:
  – Laboratory testing (tools)
  – Work simulation and testing
    • Marquette University
    • We Energies
  – Site visits to other companies
EPRI Document
#1005199
November 2001
EPRI Ergonomics Handbook for the Electric Power Industry

Ergonomic Interventions for Manhole, Vault and Conduit Applications

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Ergonomics Research at Fossil Fuel Power Plants

• Definition of fossil-fueled generating stations
  – Coal
  – Natural gas
  – Oil
• Why fossil-fueled generating stations?
  – Incidence and severity of injuries to workers
  – Growing reliance on fossil fuels for electricity in US
• Two projects
  – Interventions
  – Design
Ergonomic Interventions at Fossil Fuel Power Plants

Objectives

• Develop ergonomics process for workers at fossil-fueled generating stations
  – Electricians (published Jan 2008)
  – Plant operators and mechanics (Dec 2008)

• Quantitative evaluation of a few tasks in laboratory at Marquette University

Timeline

• 2005-2008
Working in a Kneeling Posture: Current Work Practice
Working in a Kneeling Posture: Problems

- Contact stress to the knees
- Various knee disorders
  - Bursitis
  - Osteoarthritis
  - Meniscal tears
  - Chondromalacia patella
Working in a Kneeling Posture: Recommended Ergonomic Intervention

• Knee protection
  – Kneeling cushion
  – Strap-on knee pads
  – Pants with pockets for knee pads
Working in a Kneeling Posture: Recommended Ergonomic Intervention

- Decreased contact stress on knees by distributing pressure over a larger area
Business case for knee protection

- The business case chapter makes a firm research case for knee injuries as preventable work-related injuries, especially osteoarthritis, often assumed to be age related.
- Power plant workers must repeatedly kneel on concrete, metal grating, and other surfaces.
- They often do not use knee protection:
  - Knee pad straps are uncomfortable to walk in.
  - Kneeling pads are something extra to carry.
  - They are not required PPE.
Laboratory Experiment: Screwdrivers

• Screwdriver is the tool most commonly used by electricians

• Background:
  – A pistol grip screwdriver reduces deviated wrist posture (ulnar deviation)
  – A pistol grip screwdriver theoretically increases torque

Research question

• Compared to a conventional screwdriver:
  – Does a pistol grip screwdriver increase torque?
  – Does a pistol grip screwdriver increase the efficiency of muscle activity:
    • More torque (Nm) per unit of normalized EMG
Screwdriver Experiment Results – Torque

Torque (Nm)

Pistol Grip Pronating Dir.
Pistol Grip Supinating Dir.
Conv. Pronating Dir.
Conv. Supinating Dir.

Forearm Position

Pronated Neutral Supinated

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There is a significant interaction between the forearm position and the handle design.
Screwdriver Experiment Findings

• Pistol grip allows for an average output torque 2 times that of the conventional handle
• Pistol grip allow users to output 2 times as much torque per unit %MVC of muscle activity
• Pistol grip – 4 times more efficient than conventional for high torque tasks
Ergonomics Design Handbook for Fossil Fuel Power Plants

Why a Separate Handbook?

• Retrofitting is costly and often judged infeasible
• In the next 20-30 years, hundreds of new fossil plants will be designed, approved and constructed to meet energy needs

Objectives

• Document the injury, cost and efficiency benefits of addressing MSD risk factors proactively during design
• Provide a reference for utilities and designers with relevant ergonomic specifications
• Cheaper to design and build well than to retrofit later
Expected Benefits

• Improved worker occupational health
• Reduced MSD workers’ compensation costs
• Enhanced quality of work
• Improved job satisfaction
• Reduced construction costs for new power plants
  – No retrofits
• Reduced operational and maintenance costs for existing and new power plants
Key Concepts

- Maintainability
- Accessibility
- Plan ahead in design phase
Ergonomics for Fleet Vehicles

Vehicle Design – Original and Upfit
Process Guidelines for Selection
Repair/Maintenance Operations
Background

• Large number of vehicles in utility industry
  – $10-$100M annual cost per company
  • Purchase and retrofit
• Motor vehicles are major contributors to occupational injuries
• Problems
  – Users not involved at purchase/retrofit
  – Insufficient process for selection and purchase
  – Lack of ergonomics guidelines for fleet vehicle designs
Objectives

• Define users’ needs
  – Anthropometry, ingress and egress, access, maintenance

• Define needs of utility
  – Minimize overall cost, standardization, process development

• Establish guidelines for design and process
  – Decision models
  – Critical dimensions (cab, storage, maintenance, information tech)
Approach

• Literature review
• Data collection
  – Site visits to volunteering companies
  – Software modeling of anthropometric factors (cab, storage areas)
  – Laboratory studies testing layouts and dimensions (cab, storage areas)
  – Field studies of layouts and design features
• Interaction with utilities on feasibility, desirability
• Develop recommendations and guidelines
Sample vehicle types
MSD concern for storage of and removal of equipment, tools, etc
Ingress/egress

Second step at 33 inches
Running board at 16 inches
No step no handle enter @24 inches
Laptop Computer Issues
Fleet Mechanics

Ergonomic Issues:

Changing a wiper blade
Fleet ergonomic issues: work under trucks

• But lifts at full height still force worker who is 6’2” to duck
• MSD risk factors
  – Twisted back and neck posture
  – Arms overhead
  – Extended durations
Fleet Mechanic Ergonomic Issues: Work under trucks

- Reaching overhead
- Twisting
Fleet Mechanic Ergonomic Issues: Under the hood
Fleet Ergonomic issues: inside the cab
Benefits

• Improved reliability from enhanced performance of workers
  – Reduced risk of MSD
  – Increased productivity
  – Decreased incidence of vehicle related injuries
  – Retention of skilled workers
• Cost reduction of original and upfitted vehicles
  – Decreased administrative cost and effort
  – Reduction in vehicle repairs/replacements
• Improved relationship between labor and management
  – Improved working relationship
  – Involvement of end-users builds sense of ownership
• Industry leadership
Timeline, Deliverables

• Timeframe – three-year project
  – July 2008 – August 2011
• Two Handbooks by August 2011
  – Ergonomic Design of Original and Upfitted Fleet Vehicles
  – Process Guideline for the Evaluation and Selection of Fleet Vehicles
• Yearly progress reports in 2009, 2010
• Peer-reviewed manuscripts (2-4)
Nanoparticles at Power Plants

Background

- Continued concern about health effect of nanoparticles
- Power plants are potential emission sources
- No published data on worker exposure
- Unsettled scientific debate – mixed, inconsistent results

Abstract—Air pollution is associated with significant adverse health effects, including increased cardiovascular morbidity and mortality. Exposure to particulate matter with an aerodynamic diameter of <2.5 μm (PM_{2.5}) increases ischemic cardiovascular events and promotes particles that pose the greatest danger because of their size. To test this hypothesis, we compared the proatherogenic effects of small particles to that of large particles in genetically modified mice exposed to PM_{2.5} or filtered air. We observed that small particles promote early atherosclerosis and systemic oxidative stress, while large particles do not. These findings suggest that small particles may be a significant cardiovascular risk factor. (Circ Res 2008;102:0-0.)

Key Words: air pollution, ultrafine particles, atherosclerosis, oxidative stress, HDL
Nanoparticles at Power Plants

The Project

• Characterize the presence, concentration and composition of nanoparticles at power plants

• Air sampling (50 to 75) at three power plants
  – One natural gas, two coal fired (positive pressure & balanced draft)

• Particle number and surface area concentration analyses

• Second sampling at one power plant for chemical analyses
  – Elemental analysis
  – Ion analysis (Cl⁻, SO₄²⁻, NO₃⁻, etc.)
  – Organic carbon, elemental carbon
  – Size distribution

• J. Hicks, Exponent
Potential Future Research Areas

• Detailed job-exposure matrix for electric utility industry
  – Occupational epidemiologic studies
• Shiftwork
  – Recently classified as probable human carcinogen (IARC 2A)
• NIOSH
  – National Occupational Research Agenda (NORA)
Thank you!

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