Precautionary Strategies for Reducing Worker Exposures to Extremely Low Frequency (ELF) Magnetic Fields, a Possible Carcinogen

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The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.
Outline

• Overview of NIOSH and other federal agencies involved with EMF
• What is EMF?
• Precautionary strategies to reduce workers’ possible cancer risks from extremely low frequency (ELF) magnetic fields
• Q&A
NIOSH’s role in occupational safety and health

- Sets standards
- Enforces standards
- Provides information

- Conducts research
- Recommends standards
- Advises workers and employers
- Evaluates health hazards upon request
Federal agencies doing EMF research and regulation

- National Cancer Institute (NCI)
- National Toxicology Program (NTP)
- CDC
- FDA
- EPA
- FCC
- OSHA
- RF interagency working group (RFIAWG)
- NIOSH
- National Center for Environmental Health (NCEH)
What are EMF?

- EMF are force fields emitted by electricity
- Voltage ➔ Electric fields
  - Like plugging a person into an electric socket
- Current ➔ Magnetic fields
  - Like having an electric generator inside
Sources of high ELF electric fields

- Substations
- Transmission lines
Sources of high ELF magnetic fields

Transformer

Electrochemical cells

Bare-hands work on live transmission lines

Metal welding

Steel furnace
Magnetic Field Properties and Units

- **Shielding**: unaffected by matter, except thick steel

- **Units**:  
  - **Static & ELF**: Magnetic flux density in microtesla [\(\mu T\)]  
    - Milligauss (mG) often used in North America  
    - Microtesla used in most other scientific papers and reports  
    - 1 \(\mu T = 10\) mG  
  - **RF**: Magnetic field strength in amperes per meter [A/m]  
    - \(1\ \mu T = 1.26\) A/m in air and biologic tissues
Precautionary strategies for managing occupational ELF magnetic fields

Outline

• Meaning of *Possibly Carcinogen to Humans* rating by IARC and WHO
• Quantitative risk assessment for ELF-MF and cancer
• Dutch study of precautionary measures*
• Messages to persuade industrial hygienists, managers and workers to adopt precautionary measures

*JD Bowman and Y Christopher-de Vries, Evaluation of Precautionary Controls for Occupational ELF Magnetic Fields in Dutch Workplaces, AIHce (2014); BioEM (2015).
Problem

• ELF magnetic fields are Possibly Carcinogenic to Humans
  • Based on epidemiology:
    • Childhood leukemia with home exposures
    • Brain cancer and leukemia from occupational exposures
  • Animal studies inconclusive in 2007
  • No proven mechanism in 2007
  • Interpretation: Credible risks have been observed, but they may be due to errors.

• WHO’s *Environmental Health Criteria* on ELF-MF:
  “low-cost precautionary procedures to reduce exposures [are] reasonable and warranted ...”

• But precautionary methods for reducing workplace exposures are lacking
NIOSH’s Proposed Resolution

   - Risk of dying prematurely decreases by $0.32\% \pm 0.29\%$ per $1 \mu T$ reduction in time-weighted average (TWA) magnetic field magnitude

   **Deaths attributable to occupational ELF-MF compared to other causes of death**

   ![Graph showing deaths attributable to different causes compared to ELF-MF](image)

   - **Evidence-based precautions:** Low cost measures to reduce TWA
NIOSH’s Proposed Resolution

2. Dutch study to develop and test precautionary measures
   • Collaboration with EMF Professor Hans Kromhout, U. Utrecht

3. Develop and test messages to persuade industrial hygienists, managers and workers to adopt precautionary measures
   • Started with Dutch study and has been continuing in the US

4. Publish NIOSH bulletin to advise industrial hygienists on managing cancer risks
   • Concept approved by the NIOSH Lead Team in 2012
Participating Dutch companies and their strong ELF magnetic field sources

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Magnetic Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railroad car refitting plant</td>
<td>Magnetic fault testers, induction heaters, <strong>induction furnace</strong>, arc welding</td>
</tr>
<tr>
<td>Auto body plant</td>
<td><strong>Spot resistance welding</strong>, arc welding, electric power center</td>
</tr>
<tr>
<td>Plastics company</td>
<td><strong>Chlorine electrolysis cells</strong>, rectifier room, electric power center</td>
</tr>
<tr>
<td>Paper mill</td>
<td>Generator, <strong>transformers</strong>, large motors, arc welding, electric fork lift</td>
</tr>
</tbody>
</table>
Tools for Designing Controls

- Personal monitoring with task log
  - High exposure tasks
  - Duration of exposure
- Spot measurements
  - Identify sources
  - Fall off with distance
- Basic IH principles:
  \[ \text{distance, time, reps} \]
- Modeling

![Graph showing induction heater exposure levels vs distance](image)
Precautionary measures

*Railroad car refitting plant*

<table>
<thead>
<tr>
<th>Source</th>
<th>Exposure reduction measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction furnace</td>
<td>Install remote control</td>
</tr>
<tr>
<td>Handheld fault tester</td>
<td>Purchase lower emission model</td>
</tr>
<tr>
<td>Metal induction heater</td>
<td>Increase distance when operating</td>
</tr>
<tr>
<td>Arc welder</td>
<td>Do not run cable over the shoulder</td>
</tr>
</tbody>
</table>

Spot measurements determine control’s position

Cable crossing the body
Worker Training Presentations for Dutch study

**Outline**

- What are EMF?
- Health risks
  - Definite risks ➔ standards
  - Possible risks ➔ precautionary measures
- How worker can reduce TWA exposures

Risk gauge compares worker cancer risks from TWA measurements to other causes of death.
Effects on exposures – Paper mill

-72% reduction

However, no company fully implemented the worker training.
Lessons Learned
*Barriers to Acceptance of Precautionary Measures*

- Controversy over science
- Not a regulation
- Other hazards are higher priorities
- Reluctance to raise cancer issue with workers
- Telling workers about cancer and EMF may create fear

**Lesson:** Messages need improvement.
Next Steps

• Two *Current Intelligence Bulletins* planned:
  • Managing electromagnetic interference with implants
  • Cancer precautions + Recommended Exposure Limits for neurological effects

• Website with additional information

• NIOSH review and approval process will require several years
Other precautionary measures from the Dutch study
Precautionary measures

*Auto body plant*

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</thead>
<tbody>
<tr>
<td>Arc welding</td>
<td>Do not run cable over the shoulder</td>
</tr>
<tr>
<td><strong>Manual spot welding</strong></td>
<td><strong>Re-design process</strong></td>
</tr>
<tr>
<td>Robotic spot welding</td>
<td>Electric-work-only zones</td>
</tr>
<tr>
<td>Power center</td>
<td>Electric-work-only zones</td>
</tr>
<tr>
<td>Other jobs</td>
<td>Training on EMF hazards and exposure reduction</td>
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**Control:** Place metal parts into jig and step back to weld
Precautionary measures
*Plastics plant*

<table>
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<tr>
<th>Source</th>
<th>Exposure reduction measure</th>
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</thead>
<tbody>
<tr>
<td>Chlorine cell hall</td>
<td>Electric-work-only zones</td>
</tr>
<tr>
<td></td>
<td>Install video cameras to decrease inspections</td>
</tr>
<tr>
<td></td>
<td>Turn surrounding cells off during repairs</td>
</tr>
<tr>
<td>Power center</td>
<td>Electric-work-only zones</td>
</tr>
<tr>
<td>Rectifier room</td>
<td>Electric-work-only zones</td>
</tr>
<tr>
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Electrolysis cell hall

![Graph of Rectified Magnetic Field](image)
Electric-work-only Zones in the electrolysis cell hall

Work practices for electric-work-only zones
• First prepare all tools
• Step out of zone for other tasks
• Do not take any safety risks.

Decrease time in high field areas
Precautionary measures

*Paper mill*

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<tr>
<td>Power plant</td>
<td>Electric-work-only zones</td>
</tr>
<tr>
<td><strong>Transformers by walkway</strong></td>
<td>No-go zone</td>
</tr>
<tr>
<td>Arc welding</td>
<td>Do not run cable over the shoulder</td>
</tr>
<tr>
<td>Maintenance mechanics</td>
<td>Identify sources to avoid, e.g. large motors</td>
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- **Power plant**
  - Transformer
  - Transformer

- **19.0 µT**

  Do not go into *no-go zone* except for work.