Evaluation of Precautionary Controls for Occupational ELF Magnetic Fields in Dutch Workplaces

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Problem

- Magnetic fields at extremely low frequencies (ELF=3-3000 Hz) are Possibly Carcinogenic to Humans

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

- However, precautionary methods for reducing workplace exposures are lacking
Resolution – NIOSH project

- NIOSH risk assessment of cancers from occupational ELF-MF [Bowman et al. 2012]
  - Risk of dying prematurely decreases by $0.32\% \pm 0.29\%$ per 1 μT reduction in TWA magnetic fields
  - Reducing TWA exposures above 0.3 μT can be cost-effective
- Pilot study of precautionary exposure reductions in the Netherlands
- Publish comprehensive NIOSH document on ELF-EMF:
  - RELs based on proven neurological effects
  - Recommendations on electromagnetic interference with implants
  - Precautionary recommendations for possible cancer risks
Goals of Dutch pilot study

• Develop precautionary methods for reducing TWA exposures to ELF magnetic fields, and evaluate their effectiveness.

• Develop messages that will persuade industrial hygienists, employers, and workers to voluntarily adopt precautionary exposure reduction measures.
Study Design

1. From an ELF-MF survey of 45 Dutch workplaces, recruit 3 companies with 8+ workers with TWA > 0.3 µT.

2. From survey monitoring and walkthrough measurements, design cost-effective reductions in long-term TWA..

3. Persuade company to train workers on work practices to reduce possible cancer risks.

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: ↑ distance, ↓ time, ↓ reps
- Modeling
Exposure Analyses

• **Unit of exposure:** Mean TWA for homogenous exposure groups (HEG)
  – Confidence limits derived from between- and within-worker variances

• **Risk metrics from NIOSH risk assessment**
  – Percent of excess deaths from cancers
  – Costs to the economy
  – Comparison with proven carcinogens
    • Ionizing radiation, benzene, ethylene oxide
Worker Training Presentations

- *Train the trainer* model
- Guided by *CDC Clear Communication Index*
- **Outline**
  - What are magnetic fields?
  - Health risks
    - Proven ➔ European limits
    - Possible ➔ precautionary measures
  - How worker can reduce exposure

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Evolution & Journey to a Safer Tomorrow
# Results – Company participation

<table>
<thead>
<tr>
<th>Request Description</th>
<th>Requests</th>
<th>Participants</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-measurements for survey study</td>
<td>66</td>
<td>35</td>
<td>53%</td>
</tr>
<tr>
<td>Walkthrough for precautionary study</td>
<td>18*</td>
<td>4</td>
<td>22%</td>
</tr>
<tr>
<td>Presentation to IHs and foremen</td>
<td>4</td>
<td>3</td>
<td>75%</td>
</tr>
<tr>
<td>IHs agree to worker training</td>
<td>3</td>
<td>2</td>
<td>67%</td>
</tr>
<tr>
<td>Management agrees to training and post-measurement</td>
<td>2</td>
<td>1</td>
<td>50%</td>
</tr>
</tbody>
</table>

*Companies with TWAs > 0.3 µT in at least 2 occupations*
# Participating companies and strong ELF magnetic field sources

<table>
<thead>
<tr>
<th>RR car refitting plant</th>
<th>Magnetic fault testers, induction heaters, <strong>induction furnace</strong>, arc welding</th>
</tr>
</thead>
<tbody>
<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>

#aihce
# Precautionary measures

**RR 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><strong>Arc welder</strong></td>
<td><strong>Do not run cable over the shoulder</strong></td>
</tr>
</tbody>
</table>

Spot measurements determine control’s position

Cable crossing the body

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*Evolution & Journey to a Safer Tomorrow*
Precautionary measures
Auto body plant

<table>
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<tr>
<th>Source</th>
<th>Exposure reduction measure</th>
</tr>
</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>
</tr>
</tbody>
</table>

**Control:** Place metal parts into jig and step back to weld
# Precautionary measures

**Plastics plant**

<table>
<thead>
<tr>
<th>Source</th>
<th>Exposure reduction measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine cell hall</td>
<td><strong>Electric-work-only zones</strong></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><strong>Electric-work-only zones</strong></td>
</tr>
<tr>
<td>Rectifier room</td>
<td><strong>Electric-work-only zones</strong></td>
</tr>
<tr>
<td>Other jobs</td>
<td>Training on EMF hazards and exposure reduction</td>
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</table>

![Electrolysis cell hall](image)

**Rectified Magnetic Field**

<table>
<thead>
<tr>
<th>Magnetic field (mT)</th>
<th>Time (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>0.4</td>
<td>4</td>
</tr>
<tr>
<td>0.6</td>
<td>6</td>
</tr>
<tr>
<td>0.8</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
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Electric-work-only Zones in the electrolysis cell hall

- Decrease time in high field areas

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

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Evolution & Journey to a Safer Tomorrow
# Precautionary measures

## Paper mill

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<td>Power plant</td>
<td><strong>Electric-work-only zones</strong></td>
</tr>
<tr>
<td><strong>Transformers by walkway</strong></td>
<td><strong>No-go zone</strong></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>
</tr>
<tr>
<td>Other jobs</td>
<td>Training on EMF hazards and exposure reduction</td>
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**19.0 µT**

Do not go into *no-go zone* except for work.
Effects on exposures – *Paper mill*

- MF JEM [µT]
  - Welder: 0.83
  - Electrician: 0.44
  - Mechanic: 0.21
  - Paper mill: 0.20

-72%
Lessons Learned – Controls

• Low-cost measures can substantially reduce TWA magnetic field exposures
• Measures designed with basic IH principles + monitoring and walkthrough data
• Developed models for setting boundaries on electric-work-only & no-go zones
• Workers easily trained to identify high-field sources
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## Lessons Learned – Barriers to Implementation

### Reasons for not participating

- Controversy over science
- The C word
- Different than OEL compliance
- Not a regulation
- Other risks are higher priority

### Replies

- Cite WHO, etc.
- Cancers raise concerns
- Precaution is a new paradigm
- Goodwill value with workers and community
- Wait until EMF and cancer is a priority

**Lesson:** Message needs improvement.
Next Steps

• Focus groups with IHs to improve message
• Create EMF control bands
  – Link controls suggested by Dutch study to the EMF \textit{Source Exposure Matrix} from our cancer epidemiology studies
• Complete draft \textit{Current Intelligence Bulletin}, so the review / approval process can start
Questions?

For more information, write me at

J Bowman@cdc.gov

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