

# 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.*

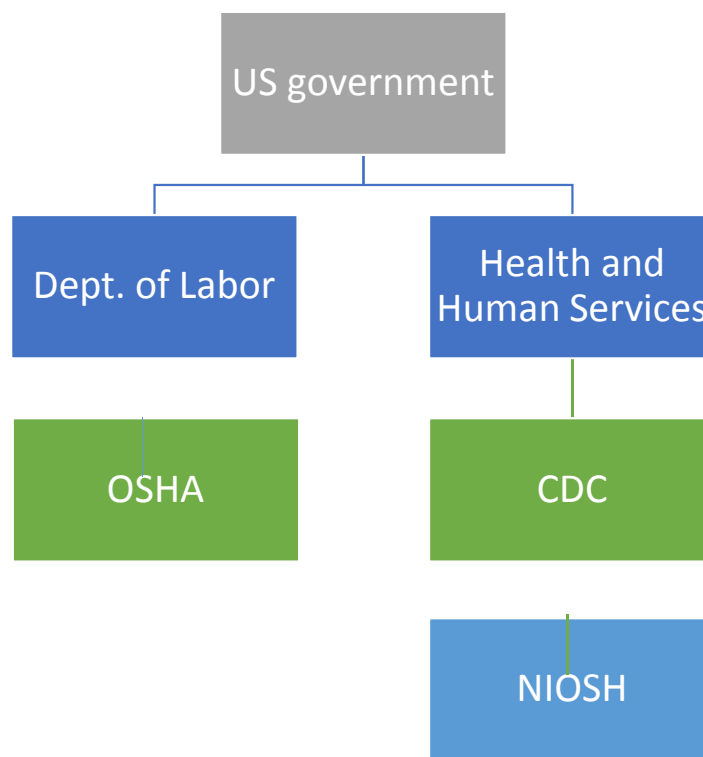
Department of Health and Human Services  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health



# 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

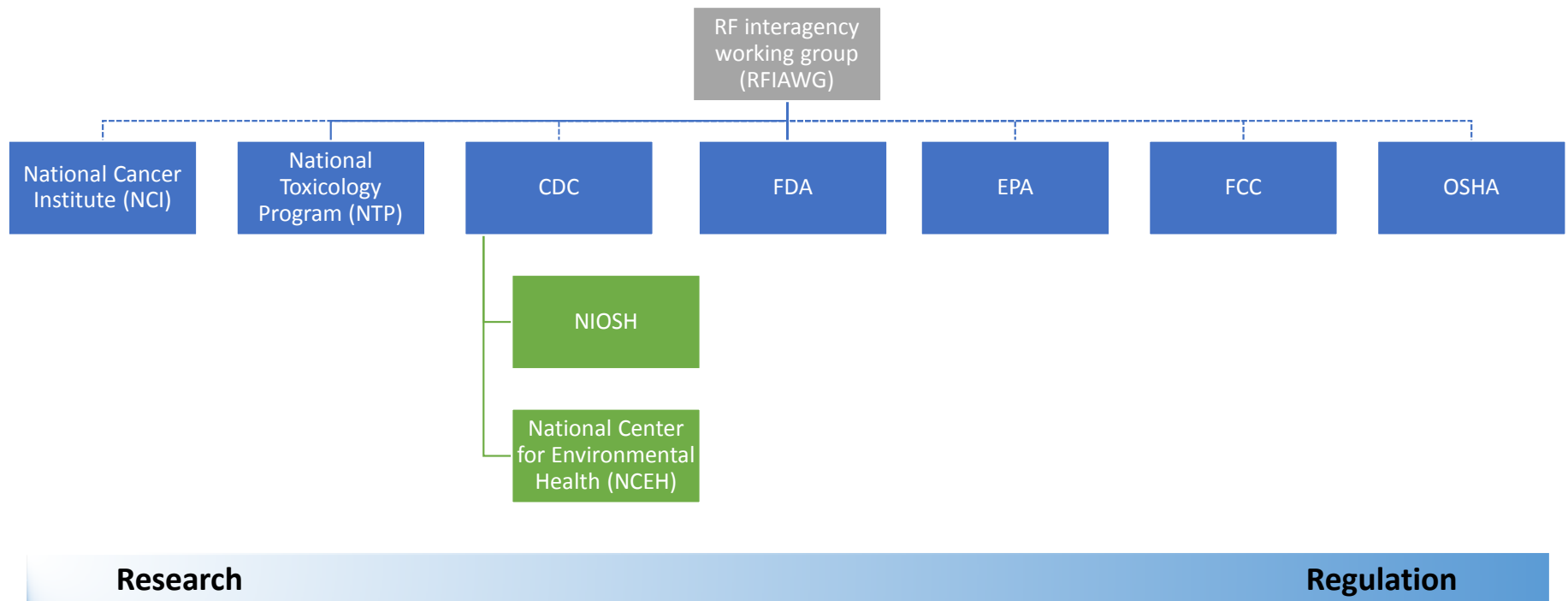
## NIOSH's role in occupational safety and health



- Sets standards
- Enforces standards
- Provides information

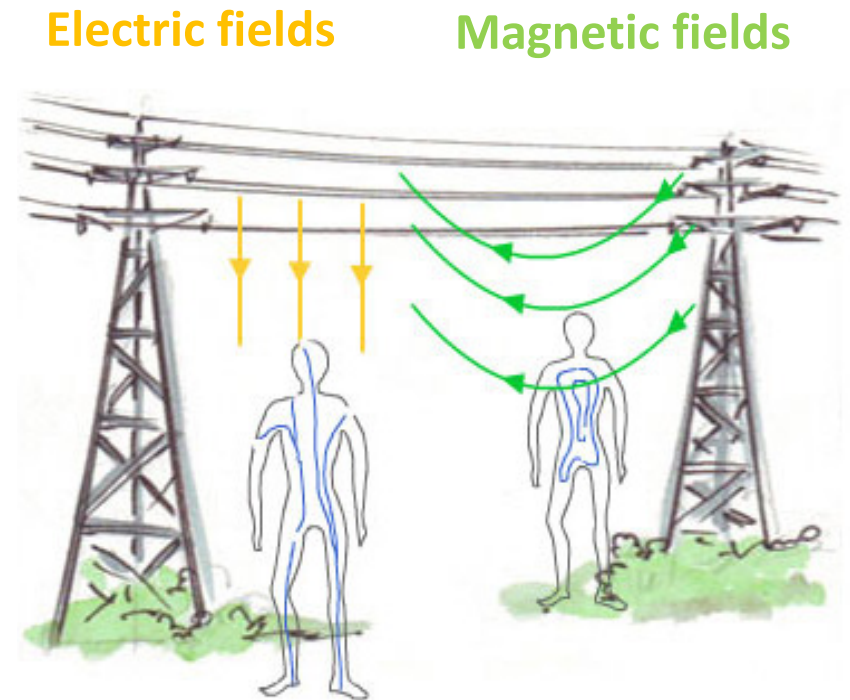
- Conducts research
- Recommends standards
- Advises workers and employers
- Evaluates health hazards upon request

# Federal agencies doing EMF research and regulation



# 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-handed work  
on live  
transmission lines



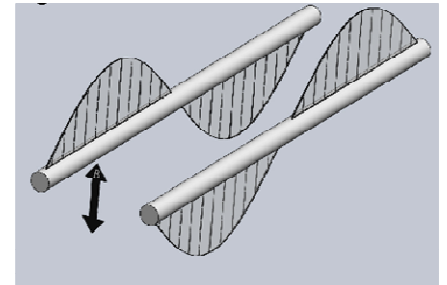
Metal welding



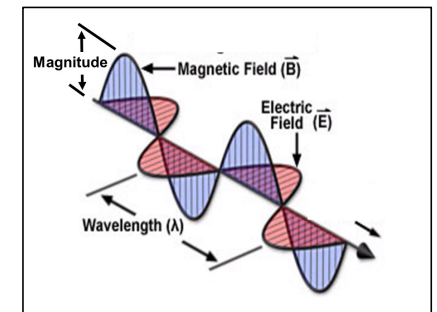
Steel furnace

## Magnetic Field Properties and Units

- Shielding: unaffected by matter, except thick steel
- Units:
  - Static & ELF: Magnetic flux density in microtesla [ $\mu\text{T}$ ]
    - Milligauss (mG) often used in North America
    - Microtesla used in most other scientific papers and reports
    - $1 \mu\text{T} = 10 \text{ mG}$
  - RF: Magnetic field strength in amperes per meter [ $\text{A/m}$ ]
    - $1 \mu\text{T} = 1.26 \text{ A/m}$  in air and biologic tissues



60 Hz magnetic field  
from AC circuit



Radio frequency  
radiation



# 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

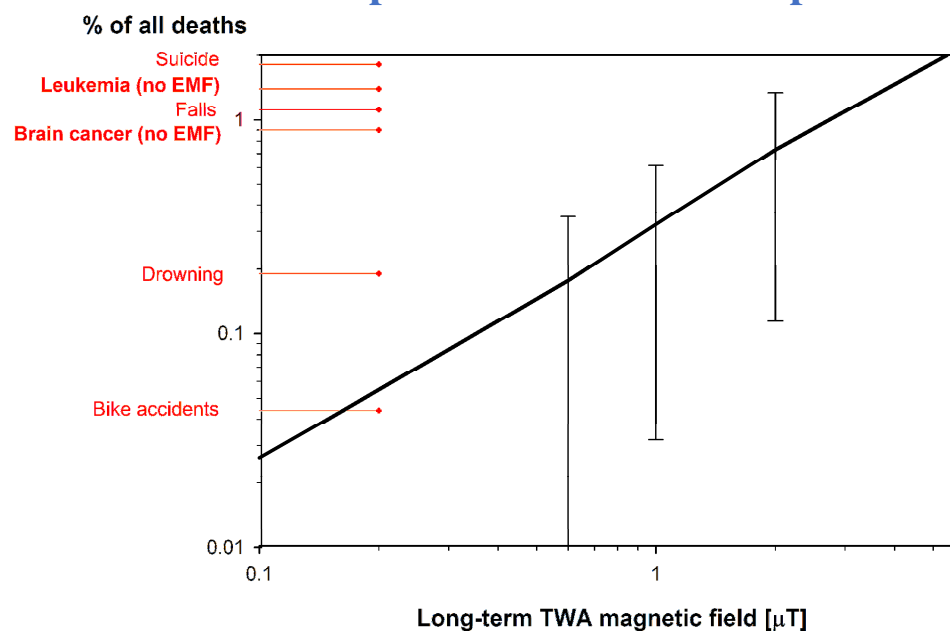
- ELF magnetic fields are Possibly Carcinogenic to Humans
  - NIEHS (1998), IARC (2002), WHO (2007)
  - Based on epidemiology:
    - Childhood leukemia with home exposures
    - Brain cancer and leukemia from occupational exposures
  - Animal studies inconclusive in 2007
  - No proven mechanism in 2007
  - 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

## 1. Risk assessment of cancers from occupational ELF-MF [Bowman et al. 2012]

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

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



➤ 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

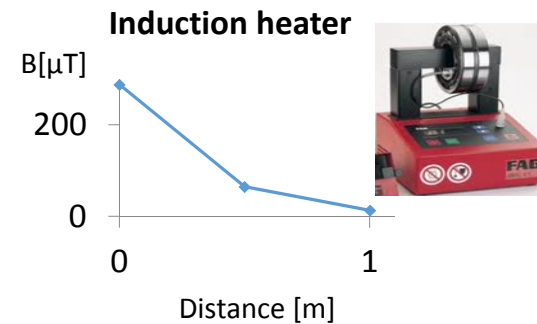
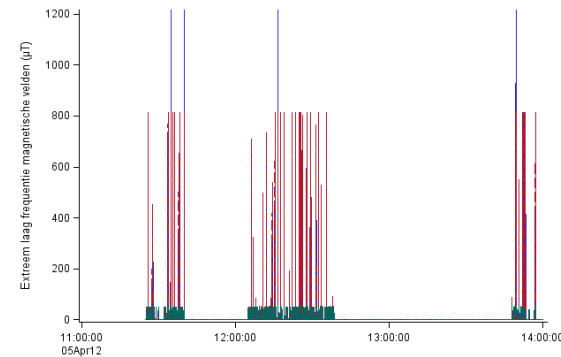
# Participating Dutch companies and their strong ELF magnetic field sources

Railroad car refitting plant	Magnetic fault testers, induction heaters, <b>induction furnace</b> , arc welding
Auto body plant	<b>Spot resistance welding</b> , arc welding, electric power center
Plastics company	<b>Chlorine electrolysis cells</b> , rectifier room, electric power center
Paper mill	Generator, <b>transformers</b> , large motors, arc welding, electric fork lift



# 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



# Precautionary measures

## *Railroad car refitting plant*

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



Spot measurements determine control's position

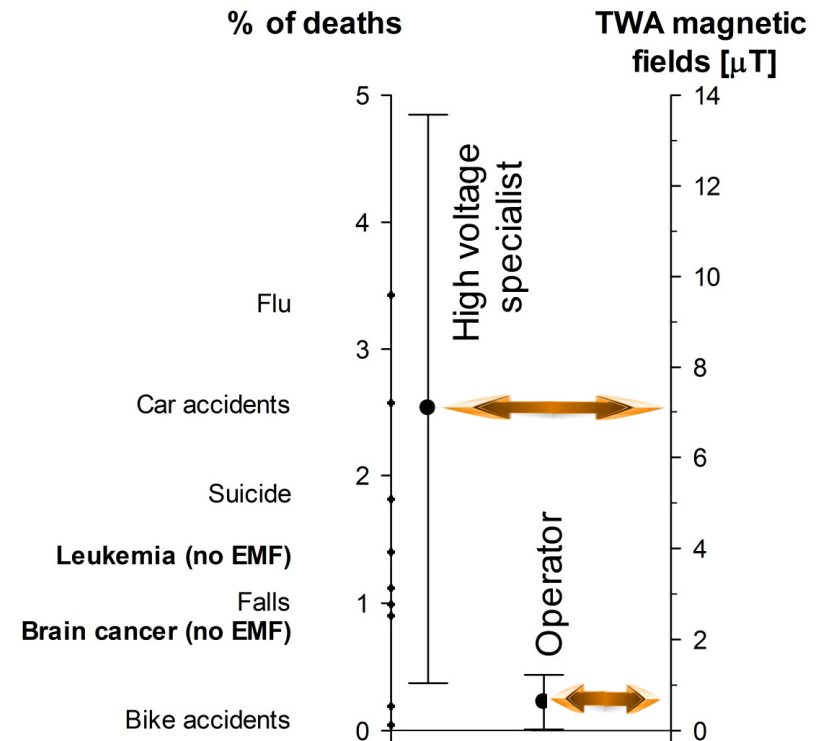


Cable crossing the body

# Worker Training Presentations for Dutch study

## • Outline

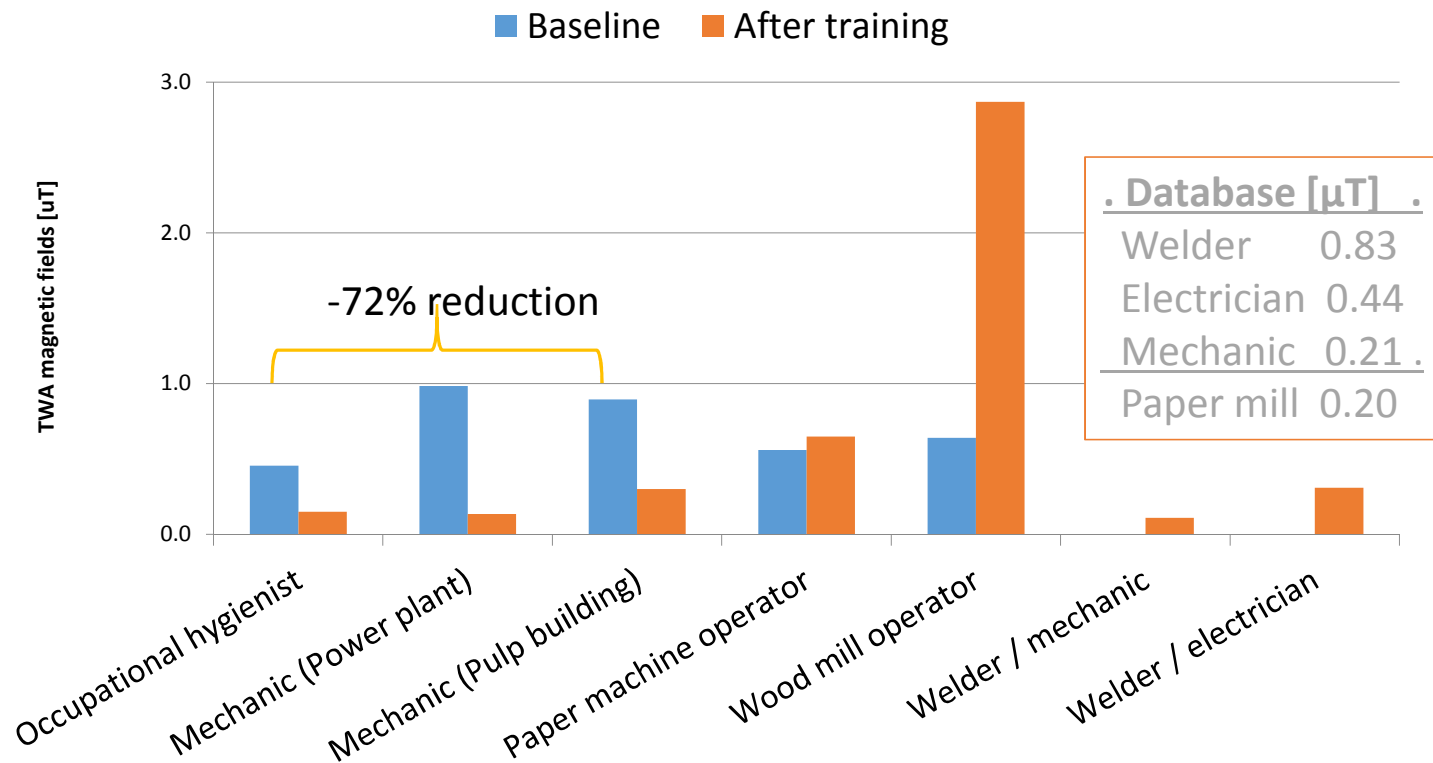
- What are EMF?
- Health risks
  - Definite risks → standards
  - Possible risks → precautionary measures
- How worker can reduce TWA exposures



**Risk gauge compares worker cancer risks from TWA measurements to other causes of death.**



# Effects on exposures – Paper mill



***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*

Source	Exposure reduction measure
Arc welding	Do not run cable over the shoulder
<b>Manual spot welding</b>	<b>Re-design process</b>
Robotic spot welding	Electric-work-only zones
Power center	Electric-work-only zones
Other jobs	Training on EMF hazards and exposure reduction



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

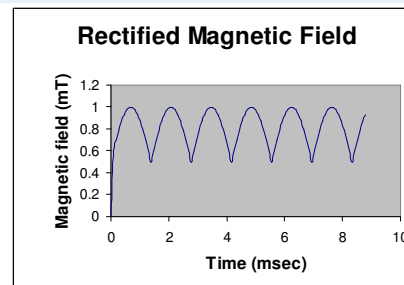
# Precautionary measures

## *Plastics plant*

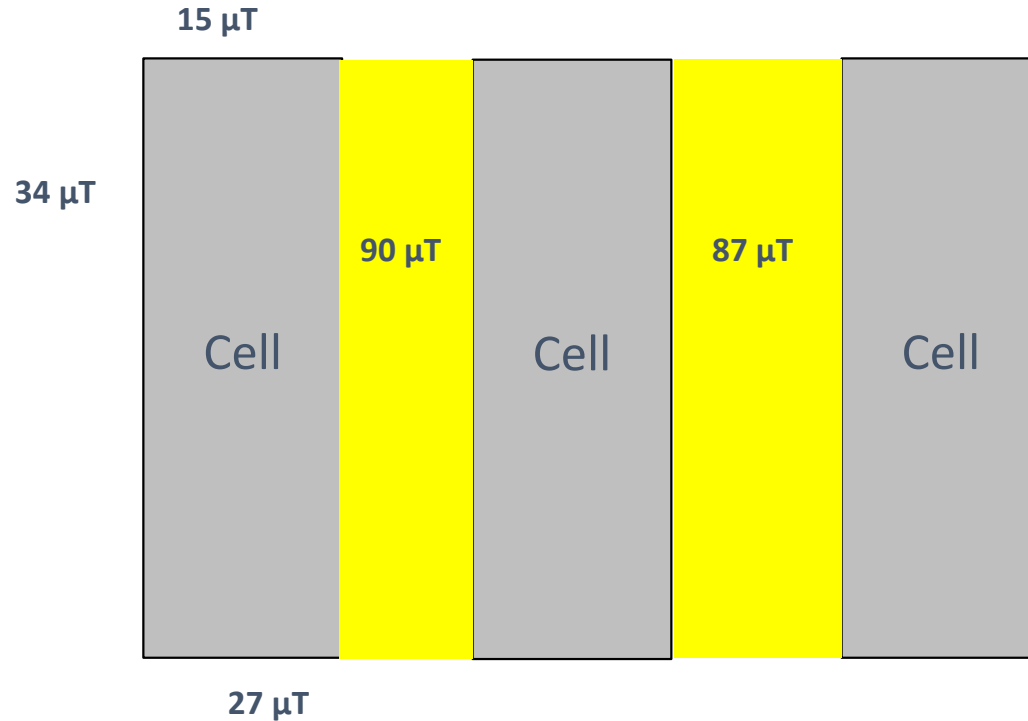
Source	Exposure reduction measure
Chlorine cell hall	<b>Electric-work-only zones</b>
	Install video cameras to decrease inspections
	Turn surrounding cells off during repairs
Power center	<b>Electric-work-only zones</b>
Rectifier room	<b>Electric-work-only zones</b>
Other jobs	Training on EMF hazards and exposure reduction



Electrolysis cell hall



## *Electric-work-only Zones* in the electrolysis cell hall



### Work practices for *electric-work-only zones*

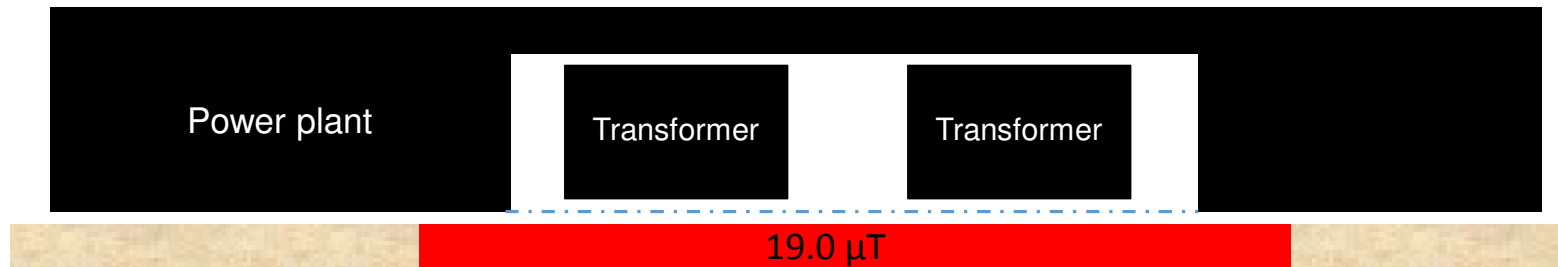
- First prepare all tools
- Step out of zone for other tasks
- Do not take any safety risks.

Decrease time in high field areas

# Precautionary measures

## *Paper mill*

Source	Exposure reduction measure
Power plant	<b>Electric-work-only zones</b>
<b>Transformers by walkway</b>	<b>No-go zone</b>
Arc welding	Do not run cable over the shoulder
Maintenance mechanics	Identify sources to avoid, e.g. large motors
Other jobs	Training on EMF hazards and exposure reduction



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