Type Agreement: Proposal Acceptance

Award Period: From 2/1/82 To 4/1/82 (Performance) 4/1/82 (Reports)

Sponsor Amount: $4,900

Cost Sharing: CTRI/GRAC

Title: Industrial Hygiene Monitoring for Polychlorinated Biphenyls in Substations

ADMINISTRATIVE DATA

<table>
<thead>
<tr>
<th>OCA Contact</th>
<th>Faith G. Costello</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Sponsor Technical Contact:</td>
<td>2) Sponsor Admin/Contractual Matters:</td>
</tr>
<tr>
<td>Mr. Lynn Wallis</td>
<td>J. E. Luhring</td>
</tr>
<tr>
<td>Iowa Power</td>
<td>Vice President &amp; General Manager</td>
</tr>
<tr>
<td>823 Walnut Street</td>
<td>Iowa Power</td>
</tr>
<tr>
<td>P. O. Box 657</td>
<td>823 Walnut Street</td>
</tr>
<tr>
<td>Des Moines, Iowa 50303</td>
<td>P. O. Box 657</td>
</tr>
<tr>
<td>Des Moines, Iowa 50303</td>
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</table>

Defense Priority Rating: N/A

Security Classification: N/A

REstrictions

See Attached Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with sponsor; however one proposed

COMMENTS:

COPIES TO:

Administrative Coordinator
Research Property Management
Accounting
Procurement/EES Supply Services

Research Security Services
-Reports Coordinator (OCA)
Legal Services (OCA)
Library

EES Public Relations (2)
Computer Input
Project File
Other
SPONSORED PROJECT TERMINATION SHEET

Date: 4/22/82

Project Title: Industrial Hygiene Monitoring for Polychlorinated Biphenyls in Substations

Project No: A-3148

Project Director: James L. Burson

Sponsor: Iowa Power

Effective Termination Date: 4/30/82

Clearance of Accounting Charges: 4/30/82

Grant/Contract Closeout Actions Remaining:

☐ Final Invoice and Closing Documents
☐ Final Fiscal Report
☐ Final Report of Inventions
☐ Govt. Property Inventory & Related Certificate
☐ Classified Material Certificate
☐ Other

Assigned to: EDL/ShS

COPIES TO:

RAN

Research Property Management
Accounting
Procurement/EES Supply Services

Research Security Services
Reports Coordinator (OCA)
Legal Services (OCA)
Library

EES Public Relations (2)
Computer Input
Project File
Other

FORM OCA 10:781
April 9, 1982

Mr. Lynn Wallis
Safety Supervisor
Iowa Power & Light Co.
823 Walnut Street
P. O. Box 657
Des Moines, Iowa 50303

Subject: Final Report of Project A-3148

Dear Lynn:

I've enclosed three copies of the final report addressing industrial hygiene monitoring for PCB exposures in substations. The report summarizes the results of the surveys performed on February 2 and 3, 1982, at three substations in Western Iowa. The survey consisted of monitoring the work area and employee breathing zones for airborne PCBs, collecting wipe samples of components to determine the potential for contact exposure to PCBs, and observing employee work practices. Three recommendations are presented for your consideration based on the findings of that survey.

We here at Georgia Tech have enjoyed working with you on this project and look forward to being of further assistance to you in your efforts toward improving the occupational environment for employees at Iowa Power and Light Company.

Please do not hesitate to contact us if you have any questions about this report or if we can provide additional assistance.

Sincerely,

James L. Burson, Program Manager
Occupational Safety & Health Branch

JLB:rm
Enclosures
INDUSTRIAL HYGIENE SURVEY

FOR

IOWA POWER AND LIGHT COMPANY
Des Moines, Iowa
March 29, 1982

Submitted by
GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
Occupational Safety and Health Services
Atlanta, Georgia 30332
(404) 894-3806

Project #A-3148
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I. SUMMARY

Iowa Power and Light Company retained the Georgia Tech Engineering Experiment Station to determine exposures, or the potential for exposures, of employees performing routine maintenance on relays containing Polychlorinated Biphenyls (PCBs). The survey was performed on February 2-3, 1982 at three substations in Western Iowa. The survey consisted of monitoring the work area and employee breathing zones for airborne PCBs, collecting wipe samples of components to determine the potential for contact exposure to PCBs, and observing employee work practices.

None of the personal samples indicated the presence of PCBs in the air in excess of the detection limits of the sampling and analytical method used. Thus, inhalation does not appear to be a significant route of employee exposure to PCBs. Area samples for airborne PCBs did not indicate concentrations above the limit of detection. Wipe samples indicated the presence of PCBs on relay components at the Council Bluffs and Shenandoah Substations. PCBs were not detected in wipe samples taken at the Sidney Substation, indicating that the relays checked at that location probably did not contain PCBs.

Three recommendations were made regarding work practices and labeling:

Recommendation #1

Develop a step-by-step procedure for substation employees to follow when performing routine maintenance and testing of PCB-contaminated equipment. This procedure should have one technician handle the contaminated items using proper protective equipment, and one technician handle only non-contaminated items. Procedures should be written so as to prevent cross-contamination of tools, equipment, manuals, and personal belongings.

Recommendation #2

Mark the entrance doors to all appropriate substation control houses with signs indicating that equipment containing PCBs are located inside. Additionally, mark individual relays containing PCB fluid with an appropriate label.

Recommendation #3

Control houses with PCB equipment should be posted with signs to prohibit eating, drinking, and smoking. This should also be incorporated into appropriate procedures and work rules.
II. INTRODUCTION

Iowa Power and Light Company retained the Georgia Tech Engineering Experiment Station to conduct a survey at three substations to monitor employee exposure to Polychlorinated Biphenyls (PCBs) during cleaning and calibration of substation relays. The survey consisted of monitoring the work area and employee breathing zones for airborne PCBs, collecting wipe samples of components for contact exposure to PCBs, and observing employee work practices.

The surveys were conducted by Mr. James L. Burson of the Georgia Tech Occupational Safety and Health Branch. Mr. Burson was accompanied by Mr. Lynn Wallis of Iowa Power and Light Company. The surveys were conducted on February 2, 1982 at the Council Bluffs Substation and February 3, 1982 at the Sidney and Shenandoah Substations. Employee breathing zone samples were collected during a cleaning and calibration procedure at the Council Bluffs Substation. Area samples for airborne PCBs and wipe samples were collected at all three locations.

This report presents the results of the surveys, a discussion of the findings, and three recommendations based on the results of the survey. Sampling and analytical methodology utilized during this survey is presented in Appendix A. Survey data and results are compiled in Appendix B. Appendix C is a summary of toxicological information concerning Polychlorinated Biphenyls.
III. RESULTS

Results of the airborne and wipe samples from the three substations are presented in Appendix B. For those samples in which PCBs were not detected the limit of detection has been reported. For air samples this value is 0.2 micrograms* (ug) per fluorsil tube, and for wipe samples this value is 5.0 ug per filter.

A. Personal Samples

Breathing zone samples were collected from two substation technicians while they cleaned and calibrated two Westinghouse (Type KD4) relays at the Council Bluff Substation on February 2, 1982. Breathing zone samples collected during the three-hour procedure did not show airborne PCB concentrations above the limit of detection for the sampling and analytical method. Accordingly, the concentration reported is less than 1 microgram per cubic meter of air sampled (ug/m^3).

B. Area Samples

Area samples to measure the airborne concentration of PCBs at the three substations were collected during the surveys. In all cases, the collecting medium (fluorsil tube) was positioned in close proximity to the front and/or rear of the relays. At the Council Bluffs and Sidney Substations, air samples analyzed for PCBs were found to be below the limit of detection (1 ug/m^3). At the Shenandoah Substation, the sample collected in front of the relay showed an airborne PCB concentration less than or equal to 12 ug/m^3. However, the sample was analyzed twice and, while there was evidence of peaks, there was poor correlation of the noted results with PCB standards. The airborne sample collected at the rear of the same relay showed PCB concentrations to be below the limit of detection.

C. Wipe Samples

Wipe samples of relay components and other selected surfaces were taken at all three substations. PCBs were detected in a wipe sample (W-3) from the Zone 2 relay at the Council Bluffs Substation. PCBs were not detected on any of the wipes at the Sidney Substation. The largest amount of PCBs relative to the other locations were found in wipes from components at the Shenandoah Substation.

D. Work Practices

Observation of employee work procedures during cleaning and calibration of relays at the Council Bluffs Substation revealed a need to develop procedures and supervise employees to minimize contamination of equipment, tools, and manuals with PCB fluids. Although the substation technicians wore impervious gloves while

* microgram = 0.001 milligram or 0.000001 gram (1x10^-6 gram)
performing their work, they contaminated several items with PCBs that had gotten on their gloves. Items contaminated included the work table, chairs, test equipment, and instruction manuals. The use of gloves to prevent skin contact with PCBs was essentially negated when the employees handled other non-contaminated items with PCBs on the gloves.

Iowa Power and Light Company has developed operational guidelines for handling, marking, storing, and disposing of all PCB containing items. This information is contained in PCB Operation Plan 7.1-5, dated 4/10/81. Principle paragraphs addressing personnel protection are Section 5 - page 2, Section 9 - page 3, and Section 11 - page 3. However, in all cases these guidelines address protection during clean-up of spills, etc. Thus, this document is primarily used for unusual circumstances and emergencies. It is recommended that a procedure be developed to instruct employees in proper precautions to be taken when working with PCB contaminated equipment on a routine basis. Specifically, develop a step-by-step procedure for the two substation technicians to follow during routine maintenance work that would minimize their contact with PCB fluids and contamination of their tools, test sets, and manuals.

**Recommendation #1**

Develop a step-by-step procedure for substation employees to follow when performing routine maintenance and testing of PCB-contaminated equipment. This procedure should have one technician handle the contaminated items using proper protective equipment, and one technician handle only non-contaminated items. Procedures should be written so as to prevent cross-contamination of tools, equipment, manuals, and personal belongings.

**E. Labeling and Placarding**

During the survey of the three substations, it became evident during conversations with employees and their supervisors that all the relays do not contain PCB fluid. As components are replaced, they are often done so with ones not containing PCBs. However, there was no indication as to which relays contained PCBs and which ones did not.

**Recommendation #2**

Mark the entrance doors to all appropriate substation control houses with signs indicating that equipment containing PCBs are located inside. Additionally, mark individual relays containing PCB fluid with an appropriate label.

**Recommendation #3**

Control houses with PCB equipment should be posted with signs to prohibit eating, drinking, and smoking. This should also be incorporated into appropriate procedures and work rules.
APPENDICES
APPENDIX A

SAMPLING AND ANALYTICAL PROCEDURES
POLYCHLORINATED BIPHENYLS

A measured volume of air is drawn through a small sorbent tube containing deactivated florisil using a battery-operated portable pump at a nominal flowrate of 1 liter per minute. Subsequent to sample collection the ends of the sorbent tube are sealed and immediately shipped to the laboratory where they are refrigerated until analysis.

Wipe sampling is accomplished by wiping a surface or other item with a 110 millimeter Whatman filter. The filter is immediately placed in a clean glass vial and sealed with a teflon-lined cap. These samples are then shipped separately to the laboratory to avoid any chance for cross-contamination of the air samples from the wipe samples.

Each sample is desorbed using hexane and analyzed by gas chromatography with electron capture detection. The concentration of PCB relative to a PCB standard is determined from a standard curve. The concentration of polychlorinated biphenyls present in the sample is calculated, after corrections (if necessary) for blanks and recovery samples run in parallel, and reported as total micrograms per sample.
APPENDIX B

MONITORING RESULTS
### INDUSTRIAL HYGIENE SAMPLING SUMMARY

**Plant**: Iowa Power & Light Company  
**Materials**: Polychlorinated Biphenyls (PCBs)  
**Council Bluffs Substation (703)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample Number</th>
<th>Description</th>
<th>Sampling Period</th>
<th>Sample Volume (Liters)</th>
<th>Sample Time (Min.)</th>
<th>Concentration</th>
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<tbody>
<tr>
<td>2/2/82</td>
<td>F-1</td>
<td>Area Sample - Front of Relay</td>
<td>0813 1124</td>
<td>181</td>
<td>181</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cabinet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1) Temperature inside control house ≈ 80°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-2</td>
<td>Area Sample - Front of Relay</td>
<td>0813 1124</td>
<td>181</td>
<td>181</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cabinet (duplicate of F-1)</td>
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<td></td>
<td>F-3</td>
<td>E. W. Smith, Substation</td>
<td>0817 1115</td>
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<td>178</td>
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<tr>
<td></td>
<td></td>
<td>Technician</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-4</td>
<td>Bob Highsmith, Substation</td>
<td>0818 1118</td>
<td>180</td>
<td>180</td>
<td>&lt;0.2</td>
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<td></td>
<td></td>
<td>Technician</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-5</td>
<td>Area Sample - Front of Relay</td>
<td>1127 1447</td>
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<td>200</td>
<td>&lt;0.2</td>
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<td>Cabinet</td>
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<td></td>
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(1) Temperature inside control house ≈ 80°F  
(2) Outside temperature <0°F  
(3) PCB's in Westinghouse type KD4 relays  
(4) Technicians cleaned & tested relays
## INDUSTRIAL HYGIENE SAMPLING SUMMARY

**Plant**: Iowa Power & Light Company  
**Materials**: Polychlorinated Biphenyls (PCB's)

### Council Bluffs Substation (703)

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample Number</th>
<th>Description</th>
<th>Sampling Period</th>
<th>Sample Volume (Liters)</th>
<th>Sample Time (Min.)</th>
<th>Concentration PCB's (ug)</th>
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<tr>
<td>2/2/82</td>
<td>W-1</td>
<td>Wipe Sample - Front Side of Zone 1 Relay</td>
<td>0831</td>
<td>-</td>
<td>-</td>
<td>&lt;5.0</td>
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<td>W-2</td>
<td>Wipe Sample - Back Side of Zone 1 Relay</td>
<td>0836</td>
<td>-</td>
<td>-</td>
<td>&lt;5.0</td>
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<td>2/2/82</td>
<td>W-3</td>
<td>Wipe Sample - Front, Back, &amp; Bottom of Zone 2 Relay</td>
<td>1048</td>
<td>-</td>
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<td>5.9</td>
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<td>Wipe Sample - Work Table in Front of Relay Cabinet</td>
<td>1101</td>
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<td>&lt;5.0</td>
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(1) Temperature inside control house ≈ 80°F  
(2) Outside temperature <0°F
# INDUSTRIAL HYGIENE SAMPLING SUMMARY

<table>
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<tr>
<th>Date</th>
<th>Sample Number</th>
<th>Description</th>
<th>Sampling Period</th>
<th>Sample Volume (Liters)</th>
<th>Sample Time (Min.)</th>
<th>Concentration</th>
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<td>Area Sample - Front side of Relay</td>
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<td>&lt;0.2</td>
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<td></td>
</tr>
<tr>
<td>2/3/82</td>
<td>F-7</td>
<td>Area Sample - Rear side of Relay</td>
<td>0843 1229</td>
<td>226</td>
<td>226</td>
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<td>2/3/82</td>
<td>W-5</td>
<td>Wipe Sample - Outside Glass of Cover of Relay</td>
<td>0907</td>
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<td>-</td>
<td>&lt;5.0</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/3/82</td>
<td>W-6</td>
<td>Wipe Sample - Inside Glass of Cover of Relay</td>
<td>0909</td>
<td>-</td>
<td>-</td>
<td>&lt;5.0</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>2/3/82</td>
<td>W-7</td>
<td>Wipe Sample - Front, Back, &amp; Bottom of Zone 3 Relay</td>
<td>0910</td>
<td>-</td>
<td>-</td>
<td>&lt;5.0</td>
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(1) Temperature inside control house ≈ 58°F
(2) Outside temperature <0°F
# INDUSTRIAL HYGIENE SAMPLING SUMMARY

**Plant** | Iowa Power and Light Company  
Shenandoah Substation  

**Materials** | Polychlorinated Biphenyls (PCB's)

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample Number</th>
<th>Description</th>
<th>Sampling Period</th>
<th>Sample Volume (Liters)</th>
<th>Sample Time (Min.)</th>
<th>Concentration PCB's (ug)</th>
<th>PCBs (ug/m³)</th>
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<td>2/3/82</td>
<td>F-8</td>
<td>Area Sample - Front of Relay Cabinet</td>
<td>1011-1310</td>
<td>179</td>
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<td>&lt;12</td>
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<td>2/3/82</td>
<td>F-9</td>
<td>Area Sample - Rear of Relay Cabinet</td>
<td>1011-1309</td>
<td>178</td>
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<td>&lt;1</td>
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<td>2/3/82</td>
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<td>Wipe Sample - Inside of Glass Cover for Relay</td>
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<td>2/3/82</td>
<td>W-9</td>
<td>Wipe Sample - Front, Back, &amp; Rear of Zone 1 Relay</td>
<td>1016</td>
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<td>-</td>
<td>42.0</td>
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(1) Temperature inside control house ≈ 65°F  
(2) Outside temperature <0°F
APPENDIX C

TOXICOLOGICAL INFORMATION
POLYCHLORINATED BIPHENYLS (PCBs)

PCBs (C\textsubscript{12}H\textsubscript{10-x}Cl\textsubscript{x} chlorodiphenyls) are diphenyl rings in which one or more hydrogen atoms are replaced by chlorine atoms. Most widely used are trichlorophenyl (42% chlorine) containing three chlorine atoms in unassigned positions and pentachlorophenyl (54% chlorine) containing five chlorine atoms in unassigned positions. These compounds are light, straw-colored liquids with typical chlorinated aromatic odors; 42% chlorodiphenyl is a mobile liquid and 54% chlorodiphenyl is a viscous liquid. In industry, PCBs can enter the human body mainly via inhalation of fume or vapor and percutaneous absorption of liquid.

The major effects that have been found in workers exposed to PCBs are chloracne, liver injury, and irritation of skin and mucous membranes. Generally, the toxic effects are dependent upon the degree of chlorination; the higher the degree of substitution, the stronger the effects.

In humans, systematic effects are anorexia, nausea, edema of the face and hands, and abdominal pain. In a survey of 34 workers exposed to concentrations of up to 2.2 mg/m\textsuperscript{3}, complaints were of a burning sensation of the face and hands, nausea, and a persistent (uncharacterized) body odor. Cases of mild-to-moderate skin irritation with an acneform eruption have been reported in workers exposed to 0.1 mg/m\textsuperscript{3}.

PCBs are poorly metabolized and tend to accumulate in animal tissues, including humans. Currently, a possible link between PCBs exposure and cancer has been reported.

To protect against systemic intoxication, the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) both have established eight-hour, time-weighted average concentration limits of 1 mg/m\textsuperscript{3} for chlorodiphenyl (42% chlorine) and 0.5 mg/m\textsuperscript{3} for chlorodiphenyl (54% chlorine). ACGIH currently lists as "tentative" short-term exposure limits (up to 15 minutes) of 2 mg/m\textsuperscript{3} and 1 mg/m\textsuperscript{3} for the two substances, respectively.

Based on the findings of adverse reproductive effects, on its conclusion that PCBs are potential carcinogens in humans and on its conclusion that occupational and animal studies have not demonstrated on exposure level that will not subject the workers to possible liver injury, the National Institute for Occupational Safety and Health (NIOSH) recommends a TWA concentration limit of 1 microgram total PCBs per cubic meter of air (1 ug/m\textsuperscript{3}) for up to a 10-hour workday, 40-hour workload. The standards established by OSHA and ACGIH carry the "skin" notation, warning of the potential for percutaneous absorption; the specific concentration limits are based on the presumption that there is no concurrent exposure via the skin and oral ingestion routes.

The Environmental Protection Agency (EPA) has taken action under Toxic Substances Control Act (TSCA) aimed at controlling the production, distribution, use, and disposal of PCBs.