

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
CENTER FOR DISEASE CONTROL  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH  
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT  
HE 79-148-716

BRIGGS & STRATTON CORPORATION  
MILWAUKEE, WISCONSIN

JULY 1980

I. SUMMARY

On September 11, 1979, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate complaints of dizziness, headaches, nausea, and miscarriages in employees working with a lead-tin solder at the Briggs and Stratton Corporation in Milwaukee, Wisconsin. To evaluate the causes of those symptoms, a medical and industrial hygiene evaluation was performed. Personal and area samples for determination of airborne lead, tin, and formaldehyde were obtained. Possible health effects of lead were evaluated by administration of a questionnaire, a limited physical examination, and blood tests for lead and free erythrocyte protoporphyrin (FEP).

Lead and tin concentrations in all samples were below the current OSHA Permissible Exposure Limit (PEL) of 50 micrograms lead per cubic meter of air and 2 milligrams tin per cubic meter, for an eight hour time weighted average (TWA). Formaldehyde levels were found to be below the current NIOSH recommended standard of 1.2 milligrams formaldehyde per cubic meter on a TWA basis. One worker out of forty-eight sampled had an elevated blood lead value.

On the basis of data obtained in this investigation, NIOSH determined that a hazard from exposure to lead and tin did not exist, at the time of this survey, in the coil department at the Briggs and Stratton Corporation. To prevent the possibility of future exposure, recommendations on ventilation, medical and environmental surveillance, and personal hygiene are incorporated on page 7 of this report.

II. INTRODUCTION

On September 2, 1979, an employee confidentially requested a health hazard evaluation to determine hazards presented by lead and other

substances in solder used in the coil department (SIC 3677) of the Briggs and Stratton Corporation (SIC 3519).\* The worker was concerned with headaches, dizziness, nausea, chest aches, and miscarriages among women involved in solder operations within the department. An initial survey was conducted by NIOSH investigators on September 26 - 27, 1979. An environmental and medical evaluation was conducted on November 13 - 14, 1979. Results of blood tests were mailed to each participant during January 1980.

### III. BACKGROUND

The company manufactures small gasoline engines. The ignition coils for these engines are produced at the plant in West Allis, Wisconsin. Solder is used to maintain electrical continuity after the attachment of wires and terminals. A predominantly female workforce carries out the four major operations which involve the use of solder.

The first job category is referred to as twist and strip, or solder pot. Two wires from the coil are placed in a machine and wound together. Next the wires are dipped in a solder pot containing a mixture of 50% lead/50% tin solder, maintained at a temperature of 900° F. Ventilation is provided by a partial hood covering the operating area, with an additional slot exhaust located directly behind the solder pot. A total of nine employees may be involved in this operation.

The next operation is the solder dial. Coils placed on a rotating disc pass under automatic soldering irons which attach terminals to the coils. A cone exhaust hood directly above the machine provides the ventilation. A total of three employees may be involved in this operation.

The third operation is the coil repair. Coils that are damaged or in need of modification are repaired with a hand soldering iron. Ventilation is provided by a flangeless duct located directly above the area where the soldering occurs. A total of eight employees may work at this process.

The fourth operation is the coil winding. A row of fine copper wires is attached to the core of the coil by drawing a bead of solder down the length of the core. The soldering occurs at the beginning of each winding process. A slot exhaust is located directly above the area where the soldering occurs. There are eight work stations with two machines at each station.

\*Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

#### IV. MATERIALS AND METHODS

##### A. Environmental

The personal samples were collected using a sampling train with a three piece cassette. The collecting media were 37 mm diameter/0.8 um pore size mixed cellulose membrane filters (type AA). The samples were later analyzed by NIOSH method S-341 for lead, and NIOSH method S-183 for tin. In addition to nitric acid, sulphuric acid was used in the ashing procedure in both analysis.<sup>1</sup>

Formaldehyde was sampled for using a Drager\* hand pump and detector tubes. The sampling was conducted at the coil repair operation where flux accumulation was greatest.

##### B. Medical

For the purposes of this study, a worker was considered potentially exposed to lead if he or she was working 1) solder pots, 2) solder repair, or 3) solder dials at the time of the study (November 13 - 14, 1979). Of the forty-eight participants, twenty-two worked on one of these jobs (eight on solder pots, six on solder dials, seven on solder repair, and one floater who worked on more than one such job). Twenty-one workers had not worked during the previous six months on a job likely to expose them to lead, so these employees served as controls. For five of the forty-eight employees, likelihood of lead exposure was difficult to determine and these five were therefore not included in the final analysis.

Each participant received blood tests, including blood lead, free erythrocyte protoporphyrin (FEP), and a complete blood count (hematocrit, hemoglobin, white blood cell count). All blood tests were performed by UBTL, 520 Wakara Way, Salt Lake City, Utah. Blood lead samples were analyzed by the Delves Cup method used by the Bureau of Laboratories, Health and Welfare Department, State of Idaho<sup>2,3</sup>

FEP was determined using the method of Chisholm, et al. (1975)<sup>4</sup>.

In addition to the blood tests, each participant received a limited neurologic examination, consisting of evaluation of the biceps reflex, tremor, wrist strength, and ankle strength. A questionnaire was also administered to each participant.

\*Mention of commercial names or products does not constitute endorsement by NIOSH.

#### V. EVALUATION CRITERIA

Inhalation of lead dust and fumes is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion of lead dust contamination on food, cigarettes, or other objects. Once absorbed lead is excreted from the body very slowly. The absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/100ml whole blood are considered to be normal levels which may result from daily environmental exposure. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/100ml. Lead levels between 40-60ug/100ml in lead exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60 to 100ug/100ml represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/100ml are considered dangerous and often require hospitalization and medical treatment.

The new OSHA standard for lead in air is 50ug/M<sup>3</sup> on an eight hour time-weighted average for daily exposure. The standard also dictates that in four years workers with blood lead levels greater than 50ug/100ml must be immediately removed from further lead exposure and in some circumstances workers with lead levels less than 50ug/100ml must also be removed. At present medical removal of workers is necessary at blood lead levels of 70/ug/100ml or greater. Removed workers have protection for wage, benefits, and seniority for up to eighteen months until their blood levels adequately decline and they can return to lead exposure areas.

Another test of lead exposure is free erythrocyte protoporphyrin (FEP) which measures lead damage to red blood cells and thus can reflect lead exposure during the three months prior to measurement. While normal values for FEP are not well established, the Center for Disease Control (CDC) considers an FEP equal to or greater than 50 ugm/ deciliter of whole blood as an indication of undue lead absorption.<sup>7</sup> For a hematocrit of 41.3, which was the mean for female workers in this study, this translates to an FEP of about 1200 ugm/liter of packed red blood cells. Chisholm reported normal values for FEP as 220-870 ugm/liter packed red blood cells based on a totally unexposed population.<sup>4</sup> Small elevations in FEP are difficult to assess.

The flux in use with the solder is 99% rosin, the major pyrolysis products of which are aliphatic aldehydes such as formaldehyde. Formaldehyde, which is a gas, is an irritant which can affect the eyes, nose, throat, and skin, causing watery eyes, cough, and dermatitis. The NIOSH recommended standard is a ceiling value of  $1.2 \text{ mg/M}^3$  (.8 ppm) for a 30 minute period. The current OSHA PEL is 3 ppm on an 8 hour TWA basis, and 5 ppm for a ceiling value. The odor is noticeable at 1 ppm.

Fumes of tin, which is a component of the solder, can cause, after prolonged exposure, a benign lung disease called stannosis. Otherwise tin is relatively non-toxic. The current OSHA PEL is  $2 \text{ mg Sn/M}^3$  on a TWA basis<sup>5</sup>.

## VI. RESULTS

### A. Environmental

Laboratory analysis of the 15 air samples for lead found levels less than the limit of detection of 3 ug per sample. The 2 personal air samples analyzed for tin found levels less than the limit of detection of 15 ug per sample. Detectable levels of formaldehyde were not observed using the Drager\* tubes.

### B. Medical

#### 1. Blood Tests

Results of blood lead, FEP, hematocrit and hemoglobin determinations are summarized in Table 1. Column one lists results for controls, and columns two, three, and four list results for workers on solder pots, solder dials, and solder repair, respectively. For hematocrits and hemoglobins, only women were included, since normal values vary with sex. The numbers in parenthesis are the standard errors of the means. The means for which a "p" is printed are those for which a significant difference was found statistically between that mean and the corresponding mean in the control column. (The statistic used for this table was the Student t test with two tails).

It should be noted that, for all columns, the means for hematocrit and hemoglobin are within the normal range. The means for blood lead are all within the acceptable range. The fact that the mean blood lead for workers on the solder pots is significantly higher than the mean for the controls suggests that workers on solder pots do have more lead exposure than other workers; however, they do not have a high enough exposure to give them a dangerous lead level. The exception to this is one worker on solder pots who had a lead level of 69; this is certainly high enough to be worrisome. (A repeat blood lead test done for this person by West Allis Hospital, West Allis, Wisconsin, was below 20 ug/100 gm.) All other lead levels are below 30 ug/100 gm.

The means for FEP of workers on solder pots and solder dials are not higher than the control mean by a statistically significant amount. Both lead and FEP means for workers on solder repair are well within normal limits.

## 2. Neurologic exams

All neurologic examinations were normal, with one exception which could not be related to lead.

## 3. Questionnaire

For the questionnaire, participants were queried as to the presence or absence of various symptoms during the two day period preceding the study.. Table II summarizes this data. Only women were included in this analysis, and exposed workers were considered those who worked on solder pots and solder dial (one woman who worked as a floater on these jobs was also included).

Mean age for exposed workers was 31.6 years, whereas mean age for controls was 38.7 years; these differ significantly ( $p < .05$  by two-tailed Student t test). There was no significant difference in smoking history between the two groups - 64% of the exposed workers smoke compared to 56% of the controls. Of the seventeen symptoms listed only one, cough, was present significantly more among exposed workers than controls ( $p = .04323$ , Fisher's exact test).

The forty-two women interviewed had had seventy-six pregnancies. Of the nine pregnancies which had ended in miscarriage or stillbirth, four had started while the women was working at the plant. Two of these four resulted from an illness in the mother which was unrelated to lead. The other two miscarriages occurred since spring, 1979 to women with normal lead and FEP levels in this study.

## VII. DISCUSSION

The blood lead and environmental data demonstrate that there was, at the time of this study (November 13 - 14, 1979), no significant lead exposure among workers at this Briggs and Stratton plant. Workers on the job called solder pots did have significantly higher blood lead levels when compared to the control group but, with one exception, all the values were less than 30 ug/100 gm, which would be considered a safe level.

The mean FEP values for workers on solder pots and solder dials were not significantly higher than for controls. Only one worker on these jobs had an FEP greater than the CDC recommended normal. FEP values for workers on solder repair were also within normal limits.

Six workers had FEP values greater than the CDC normal. One of these was a set-up man, one worked on tape and saw, one was a floater, two worked on coil testing, and one worked on solder pots. Only the one on solder pots had much potential for lead exposure. These elevations were modest and thus difficult to interpret, but do represent a small possibility that these six people may have had some lead exposure during the three months prior to the survey. There is, however, no suggestion of the presence of lead poisoning in this population.

It is very difficult to demonstrate a particular factor as a cause for miscarriages unless one is dealing with a very large population. Because of this, and because the two miscarriages noted in this study occurred to women with normal lead values by the time of this study, it is not possible to relate the miscarriages to a lead effect.

The increased rate of cough among exposed workers as compared to controls is difficult to interpret. Since there is evidence that rosin fluxes can cause such respiratory symptoms as cough and wheezing, it is possible that this is the source of the difference in rates of cough<sup>6</sup>.

Ventilation appeared to perform adequately at the time of the survey. However, employees cited instances in the past when the system had failed to function properly, e.g. an instance where a glove became lodged in an exhaust duct. Resultant inefficiencies of the system could lead to an increase in employee exposure to harmful and irritant components of the solder.

Also noted was the residual smoke that was emitted from the soldering irons at the coil repair operation. After attachment of the terminals, the soldering iron would be positioned away from the ventilation. The smoke, created by the thermal decomposition of flux on the tip of the soldering iron, was then subject to air currents from fans and drafts. Such air currents could direct the smoke into the breathing zone of the employees.

#### VIII. RECOMMENDATIONS

- 1) All individuals with elevated lead or FEP values in this study should have the opportunity to have the tests repeated.
- 2) Periodic sampling of the environment should be done to ensure that the exposure situation, which is satisfactory at present, does not change.
- 3) Given a possibility of lead exposure in the past, it would be prudent for workers to pay close attention to personal hygiene in the workplace. Workers should wash their hands prior to eating or smoking, should keep cigarettes protected against the air (and thus prevent them from becoming contaminated with lead), and should shower and change clothing upon arriving home from work.

- 4) Coil repair operations should be provided with ventilation such that residual smoke from the soldering iron is removed from the workers breathing zone.
- 5) Ventilation should be periodically checked to insure proper removal of contaminants. Attention should be given to employee complaints of improperly functioning systems.

IX. REFERENCES

1. NIOSH Manual of Analytical Methods, Volume 3  
DHEW (NIOSH) Publication No. 77-157C
2. Delues, H.T., Analyst, 95, 431 (1970)
3. Barthel, W.F., J A OAC 56 No. 5 (1973)
4. Chisholm, J.J., and Brown, D.H., "Microscale Photofluorometric Determination of free erythrocyte protoporphyrin (IX)" in Clinical Chemistry, pp. 1669-1682, Vol. 21, No. 11 (1975).
5. Hamilton and Hardy, Industrial Toxicology, pp. 177-8, Publishing Sciences Group, Inc., (1974)
6. Lancet, August 25, 1979, pp 397-8.
7. Journal of Pediatrics, Vol. 93, No. 4, pp 709-720.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:

William J. Daniels  
Industrial Hygienist  
NIOSH - Region V  
Chicago, Illinois

Donald Slovin M.D.  
Medical Section, HETAB  
Cincinnati, Ohio

Originating Office:

Hazard Evaluation and  
Technical Assistance Branch  
Division of Surveillance,  
Hazard Evaluations and,  
Field Studies  
Cincinnati, Ohio

Environmental Evaluation: Richard S. Kramkowski  
Regional Consultant  
NIOSH - Region V  
Chicago, Illinois

Analytical Laboratory Services: Utah Biomedical Test  
Laboratory  
Salt Lake City, Utah

Report Typed By: Elizabeth D. Richmond  
Secretary  
NIOSH - Region V  
Chicago, Illinois

VIII. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH publications office at the Cincinnati address. Copies of this report have been sent to the following:

- A. Briggs and Stratton Corporation, Milwaukee, Wisconsin
- B. Requestor
- C. NIOSH - Region V
- D. U. S. Department of Labor, OSHA - Region V
- E. Director of Public Health - Springfield, Illinois

For the purpose of informing the 28 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

Table 1  
Results of Lead, FEP, Hematocrit, and Hemoglobin  
in Controls and Workers on Solder Pots, Solder Dials, and Solder Repair

	<u>Controls</u> 16 Females, 5 Males	<u>Solder Pots</u> 1 Male, 7 Females	<u>Solder Dials</u> 6 Females	<u>Solder Repair</u> 7 Females
<u>Age (years)</u>	36.5 (2.21)*1	30.9 (3.28)	31.2 (7.22)	27.7*3(2.41)
<u>LEAD (ug/100g)</u> NL* = 0-40	13.2 (1.26)	21.6*2(6.82)	13.7 (2.03)	9.3*4(0.87)
<u>FEP (ug/L)</u> NL = 220-870	861.1 (66.1)	941.2 (135.72)	952.8 (73.32)	712.1 (72.27)
<u>Hematocrit</u> (Females only) NL = 37-47	41.5 (0.63)	42.6 (1.14)	41.3 (0.83)	39.3 (1.64)
<u>HEMOGLOBIN</u> (Females only) NL = 12-16	12.8 (0.20)	13.3 (.35)	12.8 ( .30)	12.2 (0.53)

---

\*NL = normal level  
\*1 Standard error of mean in ( ).  
\*2  $p < .05$   
\*3  $p < .025$   
\*4  $p < .05$

TABLE II

Frequency of Symptoms Among Workers  
of the Briggs and Stratton Corporation

<u>Symptom</u>	<u>Exposed workers (14) Percent with symptom</u>	<u>Controls (16) Percent with symptom</u>
Trouble sleeping	36	25
Unusually tired	43	44
Dizziness	14	6
Irritability	21	19
Headache	43	44
Muscle weakness	14	6
Muscle cramps	7	12
Tremors (shakes)	7	0
Poor appetite	14	6
Cough	71	31*
Abdominal pain	7	19
Nausea	7	7
Vomiting	0	0
Diarrhea	14	6
Constipation	0	0
Fever	0	0
Runny nose	29	6

\*p = .04323 Fisher's exact test