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BESTOP, INC.
BOULDER, COLORADO

NIOSH INVESTIGATOR:
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I. SUMMARY

On April 6, l987, the National Institute for Occupational Safety and Health (NIOSH) received a request from management of Bestop, Inc., to evaluate potential exposures to radiofrequency (RF) during the heat sealing of automobile accessories (bras).

On April 28, l987, an environmental evaluation was conducted. Radiofrequency measurements were made on 7 RF heat sealers in Boulder, Colorado, and one RF heat sealer in Longmont, Colorado. Measurements of electric (E) and magnetic (H) fields were taken at the head, chest, stomach, groin, and knee on all the RF sealer operators.

Twenty-eight out of 40 measurements taken for electric (E) fields exceeded the American Conference of Governmental Industrial Hygienist (ACGIH) Threshold Limit Values (TLVs) of 3.77 x 10^3 V^2/M^2. Six of the 40 measurements for (E) fields exceeded the Occupational Health and Safety Administration (OSHA) standard of 4.0 x 10^4 V^2/M^2. Values for the (E) fields ranged from 6.0 x 10^1 to 1.04 x 10^5 V^2/M^2.

Six out of 40 measurements taken for the magnetic (H) fields exceeded the ACGIH TLV of 0.027 A^2/M^2. Values ranged from 0.0002 A^2/M^2 to 0.100 A^2/M^2. None of the H-field measurements exceeded the OSHA standard of 0.25 A^2/M^2.

Employees were questioned about the use of the RF sealers. Several employees had been burned by touching metal parts that had been heated by the RF sealers. This was the only complaint or problem presented by the workers.

Based on the environmental data, the investigator concluded that there was a health hazard from overexposure to RF at the time of this evaluation. Recommendations for reducing RF exposure are included in this report.

KEYWORDS: 2396 (Automotive Trimmings, Apparel Findings, and related products) Radiofrequency heat-sealers, Electric and Magnetic fields.

II. INTRODUCTION

On April 6, l987, NIOSH received a request from management of Bestop, Inc., in Boulder and Longmont, Colorado to evaluate potential exposure to RF during the process of using RF heat sealers to make automobile bras. Bras are a flexible plastic protective covering for the front of a automobile.

NIOSH investigators conducted an environmental investigation on April 28, l987. Eight RF heat sealer operators were monitored for exposure. Results were discussed with management and tables of the results were sent to the company on June 8, 1987.

III. BACKGROUND

The Boulder and Longmont, Colorado Bestop, Inc., facilities manufacture automobile bras. There are seven RF sealers in the Boulder facility and one RF sealer in the Longmont facility. There is usually one worker operating the RF sealer.

Management at the facility was interested in knowing if an excessive exposure existed to their workers operating the RF machinery. It is difficult to obtain private consultation on RF monitoring. Therefore, a request for a health hazard evaluation was submitted to NIOSH.

IV. METHODS

During this evaluation, RF exposure measurements were made at 8 heat sealers in normal operation (several of the machines had to be started but were operated in the most normal mode). RF measurements were made with a recently calibrated Holiday Model HI 3002 broadband field strength meter equipped with a electric (E) probe and a magnetic (H) probe. The E-field probe was used to measure the electric field strength in volts squared per meter squared (V^2/M^2). The H-field probe was used to measure the magnetic field strength in amperes squared per meter squared (A^2/M^2).

E-and H-field strength measurements were taken at the worksite of each operator for the 8 heat sealers. Measurements were taken at the head, chest, stomach, groin and knee. Since the RF output of all heat sealers was not continuous, the measurements made with the Holiday monitor were corrected for the work cycle of the heat sealer before comparisons could be made with the occupational exposure standards and evaluation criteria. The work cycle of the heat sealer was considered to be the RF on-time divided by the total process time.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure.

Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The Occupational Safety and Health Administration radiation protection standard for occupational exposure to RF and microwave radiation (29 CFR 1910.97) applies to the frequencies of 10-100,000 MHz. It establishes as a limit for occupational exposures a maximum power density of 10 mW/cm^2, as averaged over any possible 6-minute period. In the far field, a power density of 10 mW/cm^2 is equivalent to a mean squared electric (E) field strength of 40,000 $volts^2/meter^2$ (V^2/M^2) or a mean squared magnetic (H) field strength of 0.25 $amperes^2/meter^2$ (A^2/M^2).[1]

By comparison, the American Conference of Governmental Industrial Hygienists (ACGIH) currently recommends threshold limit values (TLV's) of 3.77×10^3 V^2/M^2 (E-field) and 0.027A^2/M^2(H-field).

B. Biological effects of radiofrequency radiation.

Radiofrequency (RF) radiation is that portion of the nonionizing electromagnetic spectrum from approximately 0.01 - 300,000 MHZ. The principal biological effect of RF radiation is heating of tissues.[3] The extent of heating is primarily dependent on the water content of the tissue and the intensity and duration of the RF energy. Most parts of the body have sufficient blood supply to dissipate heat resulting from absorption of RF radiation. However, the eye (especially the lens) is particularly vulnerable to heating since it lacks an efficient blood supply to dissipate heat. Consequently, damage may occur to the transparent cells around the lens resulting in the formation of cataracts.[4] Other tissues which display high sensitivity to heat include the testes and brain (specifically the reticular formation of the brain stem and hypothalamus).[5]

In addition to thermal effects, absorption of RF radiation may result in nonthermal effects which may occur without a measurable increase in tissue of body temperature, and at RF field strengths lower than those necessary to cause thermal effects.[6] Nonthermal effects have been widely reported in the Soviet and Eastern European literature. Effects which have been described but poorly substantiated include those on the nervous system (headache, fatigue, irritability, altered memory function, altered EEG recordings, and sleep disturbances), and effects on the blood (leukocytosis, thrombocytopenia). Also reported are sweating, hypotension, dyspnea, chest pain, cardiac arrhythmias, and changes in blood lead levels of enzymes, hormones, and immunity factors. These studies, however, have been severely criticized for problems with subjective measurements and for lack of appropriate experimental design and statistical analysis of data.

Experimental and observational data from animal and human studies indicate no carcinogenic or mutagenic effects resulting from exposure to RF radiation.[6] Human studies indicate that no teratogenic effects occur, but are inconclusive as to whether reproductive effects occur. Animal studies have shown some reproductive and teratogenic effects, but the evidence is often contradictory. It appears that the reproductive effects in animals correlate well with RF-induced heat production.

VI. RESULTS AND DISCUSSION

Table 1 summarizes RF exposures of operators to the eight (RF) sealers included in this survey. Overexposures to the electric field (E) were documented in seven out of eight of the sealers. Values ranged from 6×10^1 to 1.04×10^5 V^2/M^2. Twenty-eight out of 40 E-field measurements exceeded the ACGIH criteria of 3.77×10^3 V^2/M^2. Six of the 40 measurements exceeded the OSHA standard of 4.0×10^4 V^2/M^2. Three of the eight (RF) sealers had exposures to the magnetic (H) fields that exceeded the ACGIH evaluation criteria of 0.027 A^2/M^2. Six measurements on these sealers exceeded the evaluation criteria. The highest value was 0.125 A^2/M^2 which is well within the OSHA standard of 0.25 A^2/M^2. None of the (H) field measurements exceeded the OSHA standard.

In two previous NIOSH hazard evaluations HETA 84-228 and 85-153 we recommended improved shielding on RF sealers that were very similar to these and the results following the installation of the shielding showed exposures well within the ACGIH TLVs. The shielding used to control RF emissions from the heat sealers were constructed with perforated aluminum sheet stock and flexible phosphor bronze contacts. The aluminum sheet stock was used to construct a box-like enclosure around the press die and was connected to the dielectric insulation supporting the top plate of the heat sealer. The phosphor bronze contacts were attached around the bottom of the enclosure and were used to ensure good electrical contact between the bottom fixed (ground) plate of the sealer and the open bottom of the aluminum enclosure.

VII. CONCLUSION

On the basis of data collected during this evaluation, it was concluded that additional shielding is necessary in order to lower exposures to levels less than the ACGIH TLVs.

VIII. RECOMMENDATIONS

1. Additional shielding and grounding as described in this report should help eliminate exposure.

IX. REFERENCES

1. American Conference of Governmental Industrial Hygienists. Threshold Limit Values for chemical substances and physical agents in the workroom environment with intended changes for 1984-85. Cincinnati, Ohio ACGIH, 1984.

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4. Carpenter, RL and Ummerson, CA. The action of microwave radiation on the eye. J. Microwave Power. 3:3, 1968.

5. International Labour Office Encyclopedia of Occupational Health and Safety. Volume 2. 3rd Revised Edition. L. Parmeggiani editor, pp. 1983-78, 1973.

6. National Institute for Occupational Safety and Health. Current Intelligence Bulletin 33 - radiofrequency (RF) sealers and heaters: potential health hazards and their prevention. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1979. (DHHS (NIOSH) Publication No. 80-107).

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XI. DISTRIBUTION AND AVAILABILITY

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Copies of this report have been sent to:

1. Bestop, Inc.
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH - Denver Region
4. Colorado Department of Health
5. State Designated Agency.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I
ELECTRIC & MAGNETIC FIELD STRENGTH MEASUREMENTS
RADIOFREQUENCY SEALER
Bestop, Inc.
Boulder, Colorado
April 28, 1987

MACHINE	BODY LOCATION	E - Field (V^2/M^2)	H - Field (A^2/M^2)
Kobar SN 10034		Average	Average
	HEAD(eyes)	1.05×10^4	0.0075
	CHEST	1.05×10^4	0.0075
	STOMACH	1.5×10^3	0.0105
	GROIN	1.5×10^2	0.0075
	KNEE	3.0×10^3	0.003
Collanan 1810			
	HEAD	5×10^3	0.0005
	CHEST	5×10^3	0.0002
	STOMACH	1.5×10^3	0.003
	GROIN	4.0×10^3	0.002
	KNEE	2.0×10^3	0.003
Kabar		Average	Average
	HEAD	8×10^3	0.008
	CHEST	8×10^3	0.008
	STOMACH	8×10^3	0.012
	GROIN	8×10^3	0.012
	KNEE	8×10^3	0.008
Kabar SN 10512		Average	Average
	HEAD	1×10^5	0.050
	CHEST	1×10^5	0.050
	STOMACH	1×10^5	0.075
	GROIN	1.5×10^4	0.100
	KNEE	2.5×10^4	0.125
ACGIH Evaluation Criteria (TLV)		3.77×10^3	0.027
OSHA Standard		4.0×10^4	0.250

TABLE I
(continued)

ELECTRIC & MAGNETIC FIELD STRENGTH MEASUREMENTS
RADIOFREQUENCY SEALER
Bestop, Inc.
Boulder, Colorado
April 28, 1987

MACHINE	BODY LOCATION	E - Field (V^2/M^2)	H - Field (A^2/M^2)
Cosmos SN 821		Average	Average
	HEAD	6×10^1	.0006
	CHEST	1.8×10^2	.0015
	STOMACH	6×10^2	.0018
	GROIN	3×10^3	.0018
	Knee	3×10^2	.0018
Thermatron 410			
	HEAD	2.8×10^4	0.055
	CHEST	2.8×10^4	0.022
	STOMACH	5.5×10^3	0.022
	GROIN	2.8×10^3	0.044
	Knee	5.5×10^2	0.044
Kobar 6645 FS			
	HEAD	1.3×10^3	0.104
	CHEST	1.0×10^5	0.039
	STOMACH	1.04×10^5	0.052
	GROIN	3.9×10^4	0.104
	Knee	2.3×10^4	0.052
		Longmont, Colorado Plant	
Dynatherm 15502.1			
	HEAD	2×10^4	0.025
	CHEST	7.5×10^5	0.025
	STOMACH	3.5×10^4	0.015
	GROIN	5×10^3	0.013
	Knee	1.5×10^3	0.003
ACGIH Evaluation Criteria (TLV)		3.77×10^3	0.027
OSHA Standard		4.0×10^4	0.250