REPORT ON AN INDUSTRIAL HYGIENE SURVEY OF EASTERN AIRLINES HANGAR, MIAMI, FLORIDA

A survey of working conditions and personnel in a large hangar of a commercial air transportation service, located in Miami, Florida, was carried out to determine whether hazards or potential hazards to health existed in relation to the use of aviation gasoline that contains up to 4.5 ml. of tetraethyl lead per American gallon and in connection with the operations concerned with the maintenance, fueling, repairing and overhauling of aircraft engines and fuel tanks.

Description of Subjects and Occupations

The subjects of this survey numbered 199 workmen and comprised two major groups which were classified in the following manner:

I. Exposed Group (121)

A. Motor Shop

The mechanics engaged in overhauling aircraft engines carry on their activities at all times inside large, clean adequately ventilated and well lighted shops, with the exception of those of the engine testing group, who may be required to work outside the hangar for short periods in testing engines. The major work inside the hangar consists of disassembling engines, removing cowling accessories and tubing, cleaning engine parts, making necessary repairs, reassembling engine parts and accessories, and installing the engine on test stands.

The test group have additional exposure to dust from the propeller blast, and to variable concentrations of fumes from the combustion of gasoline and oil.

B. Maintenance Department

1. Engine Service Mechanics

2. Line Crew

3. Aircraft Maintenance Crew

4. Truck Drivers

With the exception of the truck drivers, who work inside and outside under all of the weather conditions of the Miami area, and are exposed to gasoline and its products of combustion when driving trucks from the hangar to the runways to deliver fuel and oil to airplanes, these groups work inside and outside and are exposed to shop dirt, grease, oil and gasoline, and to the vapors of gasoline, oil, paint solvents and solvent cleaners. They are required to make necessary repairs, replacements of parts, and adjustments on engines, to change engines, if necessary, and to test engines.

The lines and maintenance crews are also subjected to noise and vibration in testing engines, and they are called upon frequently to make minor repairs to fuel lines and tanks and to reseal breaks in the lining of fuel tanks. In carrying out this latter job, the tank plates are removed, and after ventilating the tank for ten minutes by means of an air blower, gasoline residues are mopped up from the bottom of the tank, and the repair and sealing of the lining are completed. The sealing operation requires the use of solvents such as methyl ethyl ketone, methyl acetate,

methylene chloride and varsol, as well as "Stabond," a sealing compound. It is usually necessary for a workmen to stay in the tank for periods ranging from 10 to 30 minutes at a time, and several such entries may be made during the course of the day's work.

C. Plane Overhaul Shops

Repair of Wing Tanks

Members of a group of four mechanics are rotated in this work, each working one week in every month. Tank entires for each workman usually range from 1 to 3 per 8-hour working day and total about 30 entries per month.

The procedure for this job may be described briefly as follows:

The manhole stress plates are removed from the wings, and the tanks are aired for 12 to 14 hours by means of an air hose and fan. After this interval a foreman enters the tank to mop up residual gasoline and check for repairs. Mechanics then clean the lining surfaces at the site of damage with solvents and apply appropriate sealing compounds. Continuous air flow from a blower and fan is maintained while the men are working in the tank. A positive-pressure type of hose mask is available for use in any unusual situation or emergency. It is not used routinely because vapors are not present ordinarily after the tank has been drained and aired.

In addition to the opportunity for exposure to vapors from gasoline, solvents and sealers, there exists also the possibility of cutaneous and respiratory exposure to dust arising from the powdery deposits on the sides and bottom of the tank. This sediment is partially removed by wiping the surfaces with a damp cloth, but because of the projecting struts,

these surfaces are difficult to clean thoroughly in this manner.

These workmen were placed in a "Specially Exposed Group" in the tabulation of the data, in order to determine more readily whether greater opportunity for exposure to lead existed under these conditions.

II. Control Group (78)

A. Plane Overhaul Department

1. Sheet Metal Workers

2. Aircraft Accessory Mechanics

3. Welders

4. Riggers

These men work inside and outside under all weather conditions, and are exposed to dust in the atmosphere and to vapors from paint, paint solvents and cleaning fluids. They are required to manufacture new parts, maintain and repair structural parts, heating and ventilating systems, and to install wings, controls and rudder pedals.

B. Motor Shop

1. Electricians

2. Machine Shop Mechanics

Both of these groups work inside at all times in well lighted and well ventilated shops.

The electricians are required to remove, repair and install electrical appliances on the engine mount assembly. They are subject to electric shock in carrying out testing procedures.

The shop mechanics are exposed to dust and dirt. They are required to operate punch presses, lathes and other machine tools in the manufacture and repair of metal parts and equipment.

METHOD OF SURVEY

The data of a comprehensive clinical study of each workman were recorded on forms detailed in Figures 1, 2 and 3.

The history (Figure 1) included the usual medical information, as well as a detailed occupational history, special emphasis being placed on the determination of the nature and degree of exposure to lead in any manner, and the time at which such exposure had occurred.

The physical examination was detailed and dealt with all of the systems of the body (Figure 2). Visual tests were made with the Keystone instrument.

Other examinations included X-ray of the chest, electrocardiogram and comprehensive laboratory investigations (Figure 3), including serologic examination of the blood*, erythrocyte, leucocyte and differential blood counts, hemoglobin estimation (Spencer hemoglobinometer), enumeration of the erythrocytes containing basophilic granules (stippling), and urinalysis.

The lead content of the samples of blood and urine was determined. Extensive experience over a number of years has demonstrated the reliability and significance of the results of a procedure by which small (40 to 200 ml.) or "spot" samples of urine are collected in chemically clean bottles with latex caps and analysed for their lead content. Standards have been established, on the basis of this experience, for determining the normal range of values and for classifying various groups of individuals with respect to the extent of their lead absorption. (This can be done for the individual only on the basis of the analytical information obtainable from a sufficient number of samples of small volume.)

The significance of the levels of concentration of lead in the blood has

* Courtesy of Dr. Albert V. Hardy, Director, Bureau of Laboratories, Florida State Board of Health, Miami, Florida

also been defined with reference to the range of normal values and of those associated with varying degrees of exposure to lead, including those which represent hazardous exposure. The precise point of differentiation between the highest concentration in the blood of an individual which is safe (i.e. unattended by any likelihood of his developing any signs of lead intoxication) and the lowest which is dangerous (i.e. associated with a low incidence of mild intoxication) cannot be fixed with absolute certainty, if for no other reason than that there is an analytical error intrinsic in all methods of analysis, which creates a narrow range rather than a point for the threshold value. On the basis of the analytical methods employed in this Laboratory, this range can best be described as 0.075 mg. to 0.085 mg. of lead per 100 grams of whole blood. Since this is well beyond the range of the results encountered, it need not be referred to again, except as a point for reference. The findings on duplicate samples of blood are most useful in conjunction with those obtained on samples of urine. From the examination of these combined data on individuals and groups of men, it is possible to recognize the occurrence of occupational lead exposure on the part of the individual or within the group, and to appraise its significance without question.

In the relatively few instances in which abnormalities were encountered in the subjective and objective findings, laboratory data, electrocardiograms, or X-ray films of the chest, the clinical aspects of the case were discussed with the individual workman for the purpose of giving helpful advice for the specific ailment, as well as for utilizing the information as part of the overall investigation.

On the completion of all of the examinations, the data were tabulated and reviewed. Each case was studied as a unit, and the various groups were

compared to discover any significant variations from the normal. Statistical methods were applied in the examination of certain data, where such treatment seemed feasible. The data on subjective and objective abnormalities are given in Tables 1 and 2, while the mean values of various attributes of these groups are recorded in Table 3.

Tables 4 and 5 illustrate the range of concentration of lead in samples of blood and urine for both the exposed and control groups of workers. Statistical evaluation does not reveal any significant difference between these groups, and indicates that the exposed workers have not absorbed amounts of lead that have approached or exceeded the upper limits of safety.

Table 6 shows the values for lead in the blood and urine of individuals without exposure, as well as of groups of men subjected to various concentrations of lead in their working environment, taken from reports of previous investigations. It demonstrates the similarity between the exposure of mechanics, maintenance workers and repairmen of a commercial airline and that of filling station attendants and automotive mechanics. Examination of these data in their entirety failed to disclose any analytical evidence of hygienically significant lead absorption of any relevant clinical evidence of such absorption.

Summary

This comprehensive investigation of the likelihood of hazardous exposure in relation to the use of aviation gasoline that contains up to 4.5 ml of tetraethyl lead compound per American gallon to tetraethyl lead and/or its degradation products on the part of mechanics and maintenance crews engaged in servicing and repairing airplanes, aircraft fuel tanks and engines comprises a survey of 121 test and 78 control workers, and fails to disclose the occurrence of significant exposure to lead. On the basis of these findings there is no indication

that maintenance crews and airplane mechanics have an opportunity for the absorption of significant amounts of lead either through contact with aviation gasoline or from exposure to the sediment or residues of aviation fuel that have been deposited on engine parts and on the lining of fuel tanks.

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Table 1

Distribution of Subjects According to Subjective Abnormalities

Subjective Abnormalities	Exposed Group		Specially Exposed Group		Control Group	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
	109		12		78	
Weakness	1	0.9				
Drowsiness						
Insomnia	2	1.8				
Disturbing Dreams	1	0.9				
Headache	9	8.3	2	16.7	3	3.8
Vertigo						
Indigestion	4	3.7	2	16.7	15	19.2
Anorexia	9	8.3			2	2.6
Metallic Taste						
Abdominal Pain	1	0.9			2	2.6
Nausea	1	0.9			2	2.6
Vomiting						
Diarrhea						
Constipation	8	7.3			6.	7.7

Table 1 (Continued)

Distribution of Subjects According to Subjective Abnormalities

Subjective Abnormalities	Exposed Group		Specially Exposed Group		Control Group	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
	109		12		78	
Recent Weight Loss						
Muscle Weakness						
Muscle Tremor						
Muscle Cramps	1	0.9				
Painful Extremities	1	0.9				
Numbness						
Tingling						
Loss of Sensation					1	1.3
Abdominal Pain	2	1.8			1	1.3
Chest Pain	2	1.8			3	3.8
Dyspnea	2	1.8				
Joint Pains			1	8.3	6	7.7
Colds, Sinus, Nasal Allergy	20	18.3	4	33.4	19	24.4

Table 2

Distribution of Subjects According to Objective Abnormalities

Objective Abnormalities	Exposed Group		Specially Exposed Group		Control Group	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
	109		12		78	
Pallor			1	8.3		
Anxious Expression	1	0.9	1	8.3		
Weight Loss	1	0.9			1	1.3
Temp. Elev. (Above 99.6°F.)	5	4.6			4	5.1
Temp. Dep. (Below 97.4°F.)	3	2.8			2	2.6
Tachycardia (100)	7	6.4			3	10.3
Bradycardia (60)	7	6.4			1	1.3
G. E. Tract					1	1.3
Lead Line						
Extensor Weakness					1	1.3
Sensory Disturbance						
Cardiac Lesion	1	0.9			1	1.3
Pulmonary Lesion	1	0.9				
Hernia					1	1.3

Table 2 (Continued)

Distribution of Subjects According to Objective Abnormalities

Objective Abnormalities	Exposed Group		Specially Exposed Group		Control Group	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
	109		12		78	
Spine Lesion					1	1.3
Lymph Adenopathy	9	8.3				
Extremities	4	3.7			1	1.3
Varicose Veins	3	2.8			3	3.8
Abnormal Reflexes						
Skin Lesion	3	2.8			2	2.6
Nose and Throat Findings	10	9.2			2	2.6
Renal Colic (Stone)	1	0.9				
Psychopathic Personality	1	0.9				
Anxiety State	2	1.8				
Prostatitis	2	1.8				
Varicocele	4	3.7			1	1.3
Hemorrhoids	2	1.8			1	1.3
Bell's Palsy (Residual)	1	0.9				

Table 3

Comparison of the Mean Values of Various Attributes of the Groups

Classification	Exposed Group (109)		Specially Exposed Group (12)		Control Group (78)	
	Per Cent of Group	Mean, P.E., St.Dev.	Per Cent of Group	Mean, P.E., St.Dev.	Per Cent of Group	Mean, P.E., St.Dev.
Age	100	34.372 ± 0.674 ± 10.438	100	32.667 ± 1.319 ± 6.774	100	35.577 ± 0.645 ± 8.444
Erythrocytes 10^6/mm.^{3}	100	5099.082 ± 26.173 ± 405.128	100	5075.000 ± 65.125 ± 334.477	100	5184.614 ± 29.096 ±380.978
Hemoglobin (Spencer) g./100 c.c.	100	16.255 ± 0.056 ± 0.865	100	16.125 ±0.098 ± 0.505	100	16.186 ± 0.055 ±0.727
Leucocytes 10^3/mm.^{3}	100	6701.834 ± 129.735 ± 2008.150	100	6708.334 ± 378.009 ± 1941.415	100	6884.610 ±150.884 ± 1975.670

Table 4

Concentration of Lead in Urine of Men Employed by a Commercial Airline

Lead Mg./L.	Frequencies of Occurrence of Quantities of Lead Indicated		
	Exposed Group	Specially Exposed Group	Control Group
0.02 - 0.029	23	4	34
0.03 - 0.039	20	1	16
0.04 - 0.049	11	1	3
0.05 - 0.059	19	1	9
0.06 - 0.069	11	1	6
0.07 - 0.079	8	2	3
0.08 - 0.089	6	1	3
0.09 - 0.099	2	0	1
0.10 - 0.109	5	0	1
0.11 - 0.119	2	0	0
0.12 - 0.129	0	1	0
0.13- 0.139	0	0	1
Total	107	12	77
Mean	0.052	0.055	0.042
Probable Error	± 0.002	± 0.006	± 0.002
Standard Deviation	± 0.024	± 0.030	± 0.023

Table 5

Concentration of Lead in Blood of Men Employed by a Commercial Airline

Lead Mg./100 g. Whole Blood	Frequencies of Occurrence of Quantities of Lead Indicated		
	Exposed Group	Specially Exposed Group	Control Group
0.020 - 0.024	12	0	12
0.025 - 0.029	18	2	3
0.030 - 0.034	24	2	16
0.035 - 0.039	26	3	18
0.040 - 0.044	13	3	15
0.045 - 0.049	7	1	5
0.050 - 0.054	8	1	8
0.055 - 0.059	1	0	0
0.060 - 0.064	0	0	1
Total	109	12	78
Mean	0.036	0.038	0.037
Probable Error	±0.001	± 0.001	± 0.001
Standard Deviation	±0.009	±0.007	± 0.009

Table 6

The Concentration of Lead in the Urine and Blood of Groups of Persons Without Known Exposure to Lead and of Others Subjected to Various Degrees and Types of Actual and Suspected Exposure to Lead

	Urine Mg./L.	Blood Mg./100 Gm.
No occupational exposure	0.01 - 0.08	0.01 - 0.06
Garage Mechanics	0.04 - 0.10	0.039
Paint Manufacture	0.08 - 0.12	0.04
White Lead Manufacture (Hazardous)	0.14 - 0.18	0.08
Lead Smelting (Hazardous)	0.18 - 0.22	0.15
Occupational Exposure Resulting in Cases of Lead Poisoning	0.24 - 0.96	0.15 - 0.30
	Mean Values	Mean Values
Garage Mechanics - 1948 (12)	0.058	0.043
Garage Mechanics - 1949 (8)	0.072	0.035
Garage Mechanics - 1949 (12)	0.106	0.051
Filling Station Attendants and Warehousemen - 1949 (52)	0.073	0.041
Engine Mechanics, Maintenance Men, Overhaul and Repair Men - Commercial Airline		
Exposed Group (109)	0.052	0.036
Specially Exposed Group (12)	0.055	0.037
Control Group (78)	0.042	0.037