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Health Hazard Evaluation Report

HETA 85-131-1731
HEXCEL CORPORATION
DUBLIN, CALIFORNIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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HEXCEL CORPORATION
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I. SUMMARY

In January, 1985 the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation at Hexcel Corporation, Dublin, California. The requestor was concerned that employees who work in the research and development (R&D) laboratory are being exposed to pyrolysis products of organic amines, isocyanates, epoxies and organic solvents. In July 1984, during employees' routine annual medical exams, it was reported that a number of workers had elevated liver enzyme levels.

A joint environmental study was conducted by California Occupational Safety and Health Administration and NIOSH. On May 1, 1985 an initial walk through survey was conducted, and on May 14, 1986 a follow-up survey was conducted. Two short-term personal air samples were collected for acetone (84 and 171 parts of a vapor per million parts of contaminated air by volume) during the cloth dipping operation. The acetone air concentrations were well below the evaluation criteria (3000 ppm). Inorganic mercury air sampling was conducted in the labs. Mercury vapor concentrations ranged from none detected to 0.01 milligrams per cubic meter of air. None of the air samples exceeded the evaluation criteria (50 micrograms per cubic meter). Fifteen fume hood capture velocities were measured and found to be operating within the CAL-OSHA capture velocities (70-100 linear feet per minute).

On July 29-31 and August 2, 1985 an initial medical investigation was conducted during which time the company's consulting physician and employees were interviewed, medical records were reviewed, and workers' liver enzyme function test data was collected. On March 17, 1986 a follow-up visit was conducted to obtain laboratory data which was unavailable during the initial visit. Many of those workers exposed to the exotherm (chemical reaction which went out of control) in June, 1984 developed elevated levels of liver enzymes with no other manifestations of illness.

No excessive exposures to acetone or inorganic mercury vapors were measured during the environmental survey. Fume hood ventilation measurements indicated that all these hoods were operating within the recommended ranges. It appears that many of those employees exposed to the exotherm in June, 1984 developed elevated liver enzyme levels suggesting a potential for liver toxicity. Recommendations are included in section VIII of this report to prevent unnecessary exposures.

KEYWORDS: 9999 (Manufacturer of lightweight structural materials) epoxy resin composites, honeycomb and fiber composites, organic amines, isocyanates, organic solvents, elevated liver enzymes

II. INTRODUCTION

In January, 1985 the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation at Hexcel Corporation, Dublin, California. The requestor was concerned that approximately 40 employees who work in the research and developement (R&D) laboratory are being exposed to pyrolysis products of organic amines, isocyanates, epoxies and organic solvents. In July 1984, during employees' routine annual medical exams, it was reported that a number of workers had elevated liver enzyme levels.

A request was simultaneously submitted to the California Occupational Safety and Health Administration (CAL-OSHA); thus a joint environmental study was conducted. On March 16, 1985 a meeting was held with the requestor at the CAl-OSHA Berkeley office to learn more about the requestor's concerns. On May 1, 1985 an initial walk-through environmental survey was conducted, and on May 14, 1986 a follow-up survey was conducted. Environmental air samples were collected for acetone and inorganic mercury during the follow-up survey and ventilation measurements were made of the fume hoods. The environmental air sampling results were presented to the company in June, 1985.

On July 29-31 and August 2, 1985 an initial medical investigation was conducted during which time employees were interviewed, medical records were reviewed, and employees' liver enzyme test data was collected. On March 17, 1986 a follow-up visit was conducted to obtain laboratory data which was unavailable during the initial visit.

III. BACKGROUND

Hexcel Corporation is a manufacturer of industrial chemicals, pharmaceutical intermediates and urethanes. This research and development facility is associated with the manufacture of strong lightweight structural materials consisting of honeycomb and fiber composites (i.e. epoxy resin composites) which are primarily manufactured for the aerospace industry. Approximately 200 employees work at this facility of whom about 50 employees work in the R&D lab (20 professional and 30 technical). Employees work from 8:00 to 4:30 five days a week.

The company has first aid capabilities. All yearly medical evaluations including a battery of 24 serum chemistries, are performed by Health Evaluation Programs (HEP) which is headquartered in Park Ridge Illinois. The company physician used Laboratory Services, Inc., San Jose, CA. to perform all follow-up liver enzyme abnormalities. It should be noted (see the medical evaluation criteria) that there are slight differences in the two laboratories' normal ranges.

All employees who work in R&D are provided safety glasses. There is no formal respirator training program; however, respirators (Wilson™) are provided to those who work in R&D.

In the course of developing materials it is often necessary to polymerize resins. On occasions these reactions accidentally run out of control producing heat, fumes, and odors referred to in the plant as "exotherms". These exotherms are pyrolysis products of organic amines, isocyanates, epoxies, and organic solvents. The amount of material involved varies from 50 grams to several hundred grams. Small exotherms may occur as often as twice a month, although those exotherms noted by odor outside of the originating laboratory occur once every month or two. In June 1984, not more than a month before the workers' yearly health screening, there was a fairly large exotherm. The company physician followed up employees who were found to have elevated liver enzymes at their yearly screening.

The exotherms occur in either the Resins Development Laboratory (Lab 115) or in the Chemicals and Resins Development Laboratory (Lab 114A). Workers in these two laboratories are considered in the "Highest Exposure" group in this study. Rooms 116 & 117, Labs 118 (Analytical/Instrumentation) & 114B (Fabric Development), and the Back Lobby are in fairly close proximity to these occurrences. In addition, the manager from Room 104F is also often involved in the major occurrences. Workers from these rooms and laboratories are considered in the "Moderate Exposure" group in this study. Personnel working in those labs or rooms not mentioned above are considered in the "Low Exposure" group.

The R&D area consists of 11 labs and 11 offices which occupy about 13,180 square feet. The R&D ventilation system was initially designed to provide one room air change per 5 minutes, but the lab has expanded during the years and additional canopy and fume exhaust hoods have been installed. There are 17 fume hoods and 15 canopy exhaust hoods. The fume hoods are checked for proper operation once every three months. The hoods are checked, with the sash full open, to confirm an average face velocity of 100 linear feet per minute (lfpm). In instances where the face velocity is below 100 lfpm the sash is re-marked (red-lined) at the height where the desired velocity is measured. The fume hood fans are inspected once every six months and the belts are replaced.

Canopy exhaust hoods are generally positioned over presses, ovens, and kilns (muffle furnaces). During the months of September through December, 1984 capron® plastic shields were attached to the canopy hoods. The plastic shields, which extend down about three to four feet, were installed to control chemical odors and prevent general room contamination generated during curing, material temperature testing, or burn-off of sizing and glass. The ovens generally operate between 350°-450°F and the muffle furnace operates at a temperature up to 1000°F during burn-off. Four of the rooms which have canopy exhaust hoods have been retrofitted with a manually controlled modulator with allows the air handlers to provide up to 70 percent of the room make-up air. This is particuliarly helpful when exotherms are created during curing or burn-off of resinous materials (at about 800°F). It should be noted that burn-off is only done after 4:30 pm when the staff goes home.

Those labs which are equipped with a modulator unit are the epoxy room (115), chemical lab (102), fabrics lab (114B), and the test lab (110).

There are 12 heating, ventilating, and air-conditioning units (HVAC) on the roof which provide about 22,585 cubic feet per minute (cfm) of air to the R&D area. The canopy and fume exhaust hoods are reported to exhaust about 45,000 cfm of air. All exhaust stacks are seven feet above the roof except for one stack which is nine feet above the roof.

The following labs included in the investigation are described below:

Room 102:	Chemical lab.
Room 103:	Honeycomb lab and print fabrics.
Room 105:	Chemical lab.
Room 107:	This is where the burn-off oven is located.
Room 110A&B:	These labs are used for testing of hot epoxies.
Room 114A&B:	These labs are for chemistry and resin formulations.
Room 115:	Resin lab.
Room 118:	Analytical lab.
Room 119:	Composites lab where lay-ups are done.
Room 120B:	The Formulations and applications room is used for long term projects.

The resin room is where strips of fabric, either glass fiber or graphite cloth are dipped into an epoxy and acetone mixture. The workers use a half mask respirator with an organic vapor cartridge, goggles, gloves, and an apron over a lab coat. After the cloth is dipped, it is air dried for 5 to 10 minutes before it is further dried (cured) in the oven for 10 to 15 minutes. The technician cleans the dipping trough with acetone while the cloth is drying.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Two personal air samples were collected from the resins lab and analyzed for acetone. One air sample was collected on a charcoal tube, and the second air sample was collected on a 3M passive dosimeter. The charcoal tube and the passive dosimeter were each analyzed by NIOSH Method 1300-1.

A Bendix Psychrometer® model 566-2 was used to measure dry bulb and wet bulb temperatures while sampling for acetone. The relative humidity is read from a chart using the difference between the two temperature readings.

Environmental air sampling was done for inorganic mercury using a Jerome Model 411 Gold Film Mercury Vapor Analyzer®.

Ventilation measurements were done on each of the fume hoods to evaluate the average capture velocity. An Alnor type 8500 Thermo-Anemometer® air velocity meter was used to perform the readings. The method used to evaluate the hoods consisted of taking from 6 to 12 readings, depending on the size of the hood, with readings being spaced uniformly across the face of the open area of the hood. The sash was fully opened or closed to the red mark which indicated the optimum sash working height based on previous ventilation measurements.

B. Medical

Using a roster of current employees, all available employees who were on duty in July 1984 were interviewed. In all, 39 out of 42 employees were interviewed individually utilizing a questionnaire covering current job, work history, medical history, and smoking habits in addition to a few specific questions concerning liver function tests and exothermic reactions. The specific questions were asked after the individual worker had been given the opportunity to volunteer information on work related illness. A meeting was held with the plant doctor to discuss his observations on health problems. The company's medical records were reviewed and the results of liver function tests from 1981 through 1985 were extracted for further analysis.

The liver enzyme test results from the routine yearly screening examination were grouped by year and exposure group (as described in the introduction) and then comparisons were made between recorded values and also between changes in value from one year to the next. Analysis of Variance was used, using a probability of chance occurrence of 0.05 or less as the test of statistical significance. In comparing the routine 1984 tests with the repeats in September 1984 a two-tailed Student t test on paired data was used with the same criteria for statistical significance.

V. EVALUATION CRITERIA

A. Environmental

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 exposure limits, by contrast, are based primarily 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. Table A provides TWA exposure levels for substances evaluated in this study. Table B contains normative ventilation rates for lab hoods.

TABLE A

Substance	Recommended Exposure Limit 8-Hour Time-Weighted Exposure Basis	Source
Acetone	250 ppm (1)	NIOSH
	750 ppm	CAL-OSHA
	3000 ppm (C)	CAL-OSHA
Mercury, inorganic	50 ug/m^3 (2)	NIOSH, CAL-OSHA

1. ppm-Parts of a vapor or gas per million parts of contaminated air by volume.
2. ug/m^3-micrograms of a contaminant per cubic meter of air.
C. maximum air concentration to which a worker should be exposed

TABLE B

LABORATORY HOOD VENTILATION RATES	
70-100 (lfpm)[1]	CAL-OSHA
60-150 (cfm/sq ft)[2]	ACGIH-TLV

1. lfpm-average face velocity of at least 100 linear feet per minute with a minimum of at least 70 lfpm at any one point.
2. cfm/sq ft-cubic feet per minute per square foot of full open area.

B. Medical

Normal laboratory values are usually set by each laboratory based on their own experience. The acceptable range is commonly given as 2 standard deviations below their mean (average) level for presumably normal individuals to 2 standard deviations above the mean. Statistically, 5% of normal tests should fall outside of this range although one would not expect them to be very far outside the limits. Also a reading considered "high normal" might actually represent an abnormality for a given individual. As with most clinical tests, there is considerably more variation between individuals than over time for a single individual. Looking at differences between tests on the same individual may, therefore, be of value by "correcting" for this variation between individuals.

In most cases laboratory tests are used to screen for possible illness, to help determine which of several diagnosis is the more likely, and/or to help assess the degree of illness. It is seldom that a laboratory test by itself is sufficiently specific to allow one to make a diagnosis without any clinical information. In the case of this study, the laboratory tests were being used as a screening mechanism. Any abnormalities would be followed up, as has been done, the first action often being to repeat the test. Unless clinical illness is found, or laboratory results are so far out of range as to suggest a serious problem, it is usual to then follow the individual with repeat tests until levels return to normal.

In this investigation, the tests studied were: SGOT (Serum Glutamate Oxaloacetate Transaminase), SGPT (Serum Glutamate Pyruvate Transaminase), SGGT (Serum Gamma-Glutamyl Transpeptidase), LDH (Lactate Dehydrogenase), and Alk. Phos. (Alkaline Phosphatase). All these are enzymes which can reflect changes in liver function, although most of them also can reflect changes in other organs as well. Enzymes are tested for by their activity in a test system. Variations in reaction temperature and alkalinity of the test will influence results, hence good quality control in the laboratory doing the tests is important. An elevated level of an enzyme usually indicates some degree of tissue injury, not necessarily irreversible. Normal values will be noted as (HEP) for Health Evaluation Programs, Inc., and (LS) for Laboratory Services, Inc. Although the two laboratories use "different" units, the numerical values IU/L (International Units per liter) and mU/mL (milliunits per milliliter)are the same. The slight differences in ranges represent differences in the laboratories' past experience.

Enzyme Normal Ranges

Type Test	HEP IU/L	LS mU/mL
SGOT	1 - 70	5 - 50
SGPT	1 - 70	0 - 40
SGGT	1 - 40	0 - 42
LDH	90 - 280	90 - 225
Alk. Phos.	10 - 56	30 - 100

SGOT[1] (Serum Glutamate Oxaloacetate Transaminase) is found in a number of tissues with heart muscle being the richest, followed by liver, skeletal muscle, kidney, brain, pancreas, spleen, and lung. Besides liver disease, elevations are seen after a heart attack, with some muscle diseases and in several other conditions. In liver disease levels are much higher with disease of the liver cells than in biliary obstruction.

SGPT[1] (Serum Glutamate Pyruvate Transaminase) is found in much greater concentration in the liver than in other tissues. In liver injury it behaves in much the same manner as SGOT.

SGGT[1] (Serum Gamma-Glutamyl Transpeptidase) is rich in the kidney, and to a lesser extent in the liver and pancreas. The enzyme is primarily located in the microsomes within the cells and will increase with increased microsomal activity, as can occur when the body is exposed to a number of drugs and other substances (including alcohol). This increased activity need not indicate tissue damage. As is the case with Alk. Phos., SGGT levels are considerably higher in cases of biliary obstruction than in other liver conditions.

LDH[1] (lactate dehydrogenase) is found in many tissues, being rich in heart muscle, kidney, liver, and skeletal muscle. In general it is normal or only slightly elevated in liver disease except for cancers which have metastasized to the liver. The LDH level can be influenced by hemolysis of the blood specimen as red cells contain considerably more LDH than does the serum.

Alk. Phos.[1] (Alkaline Phosphatase) is found in a number of tissues, most particularly liver, bone, the intestines, the placenta, and in a small percentage of carcinomas. Mild elevations are normal in growing children, during the last trimester of pregnancy, and with healing fractures. Although levels are elevated in many individuals with liver diseases, elevations are particularly high in individuals with conditions in which there is biliary obstruction. Levels can also be high in several bone diseases.

C. Toxicological

1. Acetone has been considered to be a low hazard to health, since few adverse effects have been reported, despite widespread use for many years. Awareness of mild eye irritation occurs at airborne concentrations of about 1000 ppm. Very high concentrations (12,000 ppm) depress the central nervous system, causing headache, drowsiness, weakness, and nausea. Repeated direct skin contact with the liquid may cause redness and dryness of the skin.[2] However, at least 6 studies have been reported in the literature which have documented possible adverse effects on humans at exposures below 1000 ppm. Furthermore, the available evidence indicates that occupational exposure to acetone may lead to its accumulation in the body. NIOSH has therefore recommended lowering the current exposure limit from 1000 ppm to 250 ppm.[3]

2. Mercury can enter the body through the lungs by inhalation, through the skin by direct contact, or through the digestive system.[4]

Acute or short-term exposure to high concentrations of mercury causes tightness and pain in the chest, difficulty in breathing, coughing, inflammation of the mouth and gums, headaches, and fever.[4,5] Acute mercury poisoning is, however, relatively rare in industry today.

Chronic or long-term exposure to lower concentrations of mercury is more common. Chronic mercury poisoning is known to cause kidney damage (nephrosis), tremors and shaking (usually of the hands), inflammation of the mouth and gums, metallic taste, increase in saliva, weakness, fatigue, insomnia, allergic skin rash, loss of appetite and weight, and impaired memory. These symptoms generally occur gradually and may be associated with personality changes such as irritability, temper outbursts, excitability, shyness, and indecision.[4,5] Liquid mercury has sufficient vapor pressure at room temperature to lead to a significant long term exposure if carelessly handled.

NIOSH currently recommends that exposure to inorganic mercury be limited to 50 micrograms per cubic meter (ug/m^3) as an 8-hour time-weighted average (TWA).[6] The American Conference of Governmental Industrial Hygienists (ACGIH) also recommends that inorganic mercury exposure be limited to 50 ug/m^3 as an 8-hour TWA.[7] The current Occupational Safety and Health Administration (OSHA) standard for inorganic mercury is a ceiling level of 100 ug/m^3.[8]

VI. RESULTS AND DISCUSSION

A. Environmental

On May 14, 1985 NIOSH and CAL-OSHA investigators conducted environmental air monitoring during the cloth strip dippping and clean-up operation. Two personal breathing zone air samples were collected for acetone as ceiling air samples (Table IV). The air concentrations measured on the charcoal tube and the passive dosimeter were 171 and 84 ppm, respectively. Although there is a difference in the environmental results for the two methods, neither of these air concentrations exceeded the acetone evaluation criteria listed in Table A. It should be noted that room air temperature measurements (dry bulb temperature was 74° F, the wet bulb temperature was 60° F, and the relative humidity was calculated to be 43 percent) were taken during the operation.

Inorganic mercury vapor measurements were taken in each of the labs where thermometer breakage might occur (Table V). It was reported that of all the thermometer breakage, about 50 percent occurs in room 102, 20 percent occurs in room 105, and the rest of the breakage occurs in the other labs. Based on several measurements in each lab, no overexposures to inorganic mercury were measured during the dates of the study.

Environmental air monitoring was not done for any of the pyrolysis products of organic amines, isocyanates, epoxies and organic solvents because there is no way of determining when these chemicals (exotherms) might be released. Also, it would be difficult to determine which chemicals might be present. Instead, the investigators evaluated the ventilation system (fume hoods) to determine whether it was working properly. In an effort to prevent chemical dispersal into the general work areas during the curing or burn-off of products, all of the canopy exhaust hoods were retrofitted with a plastic shield which extended down below the ovens or muffle furnaces. Although this was an attempt to control work room contamination, it should be remembered that canopy exhaust hoods should not be used to prevent employee exposure.

Ventilation measurements (Table VI) were made of 15 fume hoods. The average face velocity of the fume hoods ranged from 72 to 147 lfpm which meets the evaluation criteria (Table B) on page 7. However, it needs to be remembered that if the capture velocity is too high, eddy currents may be created around the employee's body which can drag the chemical contaminants out of the hood and into the workers breathing zone. Caution should be exercised when evaluating the fume hood capture velocity to ascertain that the face velocity is not too high. In one room (#115) a portable fan was used to help circulate the room air. The fan created eddy currents at the face of the fume hood making it difficult for the hood to properly contain the contaminants. Once the fan was turned off, the eddy currents ceased.

Over the years, the R&D demands for exhaust ventilation has grown so large that exhaust systems (fume and canopy hoods) have been installed throughout the lab area. Unfortunately, the R&D area is currently under a strong negative pressure. This is evident by the whistling noise heard when approaching the swinging doors to R&D which are continually ajar, the difficulty in opening hinged doors to the R&D area, and the difficulty in opening lab doors relative to the hallway and adjacent rooms.

As mentioned earlier, the air handlers provide about 22,585 cfm of make-up air to the R&D area. The ventilation system (fume and canopy exhaust hoods) exhausts about 45,000 cfm of room air. Given the volume of make-up air provided by the air handlers, this leaves a deficit of about 20,000 cfm which must then be made up from the adjacent hallway and rooms.

Manually operated modulators were installed in four labs which can provide up to 70 percent of the make-up air for each room in case exotherms are created under the canopy exhaust hoods. The company is considering retrofitting all the labs with a manually adjusted modulator unit, but no time frame was provided as to when this would be accomplished. The canopy exhaust hoods all have a Capron® plastic shield attached to it to help contain any chemical contaminants which might be generated by the presses, ovens or muffle furnace during burn-off. In some instances, the plastic has melted or burned (temperatures usually in excess of 350°F) due to the oven heat. Aluminum rods were placed in the bottom of the plastic to keep it from moving back and forth due to the general air movement, however, the rods are not heavy enough to stop the movement.

Respirators are available to the employees who work in R&D; however, there is no formal respirator program in which employees are instructed how to wear and maintain their equipment properly. Respirators were observed to be worn only during the cloth dipping operation.

B. Medical

Of the 39 employees interviewed 4 worked in either the Resins Development Laboratory (Lab 115) or in the Chemicals and Resins Development Laboratory (Lab 114A) and so are considered in the "Highest Exposure" group. Eight (8) worked in Rooms 104F, 116, & 117, Labs 118 (Analytical/Instrumentation) & 114B (Fabric Development), or the Back Lobby and so constitute the "Moderate Exposure" group. The remaining 27 are in the "Low Exposure" group. There was only one elevation of Alk. Phos. and none of LDH. The SGOT, SGPT, and SGGT elevations are discussed by each exposure group.

Of the 4 "Highest Exposure" workers, the one who was most exposed to the "exotherm" of June 1984 had mildly elevated SGOTs and SGPTs which persisted through the remainder of the year. On one of the follow-up tests the SGGT was also mildly elevated. One of the other workers had a one time elevation of SGOT, SGPT, and SGGT with values within normal limits on the follow-up testing. Another had elevations of SGPT and SGGT which persisted for the rest of the year. The fourth worker showed only a mildly elevated SGGT on the general retest. Other medical problems identified were some unilateral decrease in hearing, possibly due to unidirectional noise; and some decrease in near vision and some elevated blood pressure, both probably due to age.

Of the 8 "Moderately Exposed" group, 4 had normal liver enzymes and no work related health complaints. One had normal liver enzymes but reacted adversely to epoxy exposures. Two who had been exposed to the 1984 "exotherm" had elevations of their SGPTs, one persisting for the remainder of the year. One also had a transient elevation of SGOT and a persisting elevation of the SGGT. Neither had any work related health complaints. The last worker had a persistent elevation of SGGT, but none of SGOT or SGPT. This abnormality appeared to be related to a medication rather than a work exposure.

Of the 27 "Low Exposure" group, 13 had no health problems. For one there are no lab results available. Of the other 12 only one had any elevated liver enzymes - a persistently elevated SGGT over the last several years, and a mildly elevated SGPT on one of the follow-up tests. The remaining 14 workers in the "Low Exposure" group had some health complaints, not necessarily specifically related to the workplace. All but one participated in the annual screening tests. Complaints included: respiratory allergies and/or irritation, particularly during dry weather or indoors during winter - 8; skin rashes - 3 (with two mentioning contact with gloves at work as the cause); headaches from exposures at work - 3; irregularities of heart rate - 2; gout with occasional medication - 1; and 2 other conditions. Five of the 13 workers with lab tests showed some abnormality at some time. All 3 of the workers who complained of work related headaches had had at least one elevation of a liver enzyme - one had an elevated Alk. Phos. in 1984, another elevated SGGTs in 1984 and 1985 (but not on the follow-up tests after 1984), and the last elevations of SGOT, SGPT, and SGGT in 1985, and SGGT in 1983. Of the other two, one had an elevated SGPT and SGGT in 1984 persisting on follow-up and gave a history of intermittent exposure to hood exhausts when working on the roof as well as occasional medication. The other had an elevated SGGT in 1984 with normal follow-up and no apparent precipitating factors.

Tables I A, I B, & I C compare the "Highest" and the "Moderate Exposure" groups with the "Low Exposure" group for numbers of workers with elevated SGOTs, SGPTs, and SGGTs respectively in the 1984 annual screening and/or the follow-up examinations. For all three tests the more exposed groups showed statistically significantly more workers with enzyme levels above the normal range than did the low exposure group ($p = 0.028$, 0.025, & 0.039 respectively). Thus it appears probable that the exposure to the June 1984 exotherm did have an effect on the workers' liver enzyme profile. It is problematical if the continuing elevations of SGGT was due to the in-plant exposure because of the possibility of confounding factors.

The mean of the individual mean values for SGOT and SGPT showed the "Low Exposure" group to be statistically significantly lower than the two higher exposure groups combined. Further, there appears to be a dose response effect as the "Highest Exposure" group has the highest mean and the "Moderate Exposure" group an intermediate mean. This suggests that there is an effect from exposure to exotherms in addition to that caused by the one occurrence in 1984.

An analysis of trends in the laboratory results since 1981 suggests that for SGOT, SGPT, SGGT, and Alk. Phos. values generally were low during 1982 and 1983, with a sharp increase in 1984 and some reduction in 1985. Table II details the changes in mean values, and Table III details the amount of change between years. Tables II A and III A give the corresponding statistical tests for significance. Because the trends seem fairly uniform across all exposure groups, it would appear that changes in sample collection and/or laboratory analysis techniques are the major cause of the variation. 1984 is an exception as there are also significant differences in levels between exposure groups. Comparisons were also made between years for a group of 12 workers who had laboratory results for all years from 1981 through 1985. They showed the same trends as did the total study group. A comparison of the levels of SGOT, SGPT, and SGGT for 35 workers who participated in both the July 1984 routine evaluation and the September 1984 follow-up showed no significant differences between the mean of the individual differences between the two testings.

VII. CONCLUSIONS

Environmental air monitoring for acetone and inorganic mercury revealed no overexposures during the dates of this survey. Ventilation measurements were taken of 15 fume hoods in the R&D area, and all the capture velocities were within the recommended guidelines, although there is a strong negative pressure due to an inadequate volume of make up air. Some of the labs appeared to be under stronger negative pressure than others based on the difficulty in trying to open the doors to the hallways.

Those most exposed to the exotherms of June 1984 did develop elevated levels of the enzymes SGOT, SGPT, and probably SGGT apparently as a result of their exposure. These levels remained elevated for some months thereafter, but the elevated levels were not associated with any other manifestations of illness. This suggests at least a potential for liver toxicity, so exposures are best minimized.

There was a general fluctuation in laboratory results over the years of testing which appears to relate to specimen collection and processing. Reported levels of SGOT, SGPT, and SGGT were generally below individual mean values in 1982 and 1983, followed by a sharp rise in 1984 followed by some decline in 1985. This trend was evident in all exposure groups making exposure at the plant much less probable as a cause for the fluctuations. However, the sharp rise in 1984 coupled with the effects of the 1984 exposure a few weeks before the liver enzyme test undoubtedly contributed to several workers having results above the reference level, and thus helped call attention to the situation.

There appears to be some effect on SGOT and SGPT levels from exposure to exotherms in general as the mean of individual means for these two tests showed a dose response relation when separated by exposure group with the "Low Exposure" group being statistically significantly lower than the other two groups taken together.

By the nature of the exotherms as uncontrolled reactions, it is hard to predict or reconstruct the exact composition of the fumes produced. This makes it nearly impossible to pinpoint a particular substance(s) as the culprit, and makes it likely that each exotherm will have a somewhat unique effect.

VIII. RECOMMENDATIONS

1. Each lab should have an adequate volume of make-up air to compensate for the air being exhausted by the hoods.

2. Each of the lab ventilation systems should be balanced relative to the hallways.

3. All unnecessary items should be removed from inside the fume hoods.

4. The company respirator program should be in accordance with the Occupational Safety and Health Act (OSHA) requirements outlined in 29 CFR Part 1910.134. The respirator program should include the following: proper respirator selection, training and education of the user, fit testing, maintenance of equipment, proper and adequate storage, periodic inspection, surveillance of work area condition, periodic inspection of program to determine continued effectiveness and medical determination of user.

5. Portable fans should not be used in the labs since they disrupt the collection efficiency of the fume hoods.

6. Procedures should be established to reduce worker exposures to the products of exotherms. These procedures should include personal protection for those workers who will be controlling the exotherm and the manipulation of the ventilating system to prevent the spread to other areas of the plant.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Hexcel Corporation, Dublin, California

2. Requestor

3. NIOSH, Region IX

4. California Occupational Safety and Health Administration

5. U.S. Department of Labor, Region IX

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.

Comparison of Observed and Expected
Number of Workers with Abnormally Elevated
SGOTs, SGPTs, and SGGTs on Routine Testing in 1984
and the Subsequent Follow-up Determinations

Hexcel Corporation
Dublin, California

TABLE I A -- SGOT

	Elevated SGOT		No Elevated SGOT		
	Observed	Expected	Observed	Expected	Totals
Highest & Moderate Exposure Groups	3	14.0	9	11.0	12
Low Exposure Group	0	2.0	25	23.0	25
Totals	3		34		37

Fisher's Exact Test p = 0.028

TABLE I B - SGPT

	Elevated SGPT		No Elevated SGPT		
	Observed	Expected	Observed	Expected	Totals
Highest & Moderate Exposure Groups	5	2.3	7	9.7	12
Low Exposure Group	2	4.7	23	20.3	25
Totals	7		30		37

Fisher's Exact Test p = 0.025

TABLE I C - SGGT

	Elevated SGGT		No Elevated SGGT		
	Observed	Expected	Observed	Expected	Totals
Highest & Moderate Exposure Groups	6	3.2	6	8.8	12
Low Exposure Group	4	6.8	21	18.2	25
Totals	10		27		37

Fisher's Exact Test p = 0.039

TABLE II

Mean Values for Several Liver Enzyme
Determinations Obtained on Routine Annual Examination

Hexcel Corporation, Dublin, California
1981 - 1985

Years Group & n	SGOT Mean	± Std.Dev.	SGPT Mean	± Std.Dev.	SGGT Mean	± Std.Dev.	LDH Mean	± Std.Dev.	Alk. Phos. Mean	± Std.Dev.
1981										
Exp. n= 3	32.67	± 5.51	34.33	± 6.66	11.67	± 3.06	199.00	±47.15		
Mod. n= 2	42.00	± 1.41	48.50	± 4.95	35.50*	±20.51	219.50	±24.75		
Low n= 8	30.50	± 5.53	29.00	± 8.83	12.88	± 7.88	185.00	±40.33		
Total n=13	32.77	± 6.38	33.23¶	±10.30	16.08	±12.14	193.54@	±39.23		
1982										
Exp. n= 3	22.00	± 4.00	25.33	± 5.51	6.33	± 4.51	166.67	±34.03	27.67	± 5.51
Mod. n= 3	33.67	± 8.50	35.00	±19.08	24.67	±15.50	156.00	±27.84	33.00 (n=2)	± 9.90
Low n=12	20.42	±11.66	23.50	±15.95	13.83	± 7.16	159.92	±25.66	28.73 (n=11)	± 6.84
Total n=18	22.89#	±11.10	25.72	±15.15	14.39	± 9.70	160.39	±25.77	29.06 (n=16)	± 6.66
1983										
Exp. n= 4	22.50	± 4.80	33.25	±12.12	8.75	± 1.71	184.25	±45.92	14.75#	± 2.75
Mod. n= 3	28.00	± 6.56	37.00	±14.42	28.67	±20.74	198.00	±13.11	19.50 (n=2)	± 9.19
Low n=17	20.94#	±10.02	24.29	±17.11	15.12	±11.59	177.71	±18.60	17.40# (n=15)	± 4.58
Total n=24	22.08#	± 9.06	27.38	±16.31	15.75	±12.72	181.33	±24.04	+17.10# (n=21)	±4.67
1984										
Exp. n= 5	52.20	±22.51	66.40@	±20.74	28.00@	± 9.59	153.40	±20.07	31.50@ (n=4)	± 5.00
Mod. n= 7	41.43	±16.92	48.29	±31.36	38.14	±36.92	157.57	±35.68	29.00	± 8.43
Low n=26	36.81@	±10.63	35.44* (n=25)	±14.70	29.65	±19.87	140.27#	±20.74	33.13@ (n=24)	±11.26
Total n=38	39.68@	±14.32	42.05@ (n=37)	±21.82	31.00@	±22.58	145.18#	±24.41	32.11@ (n=35)	±10.16
1985										
Exp. n= 4	44.00	±17.19	50.00	±21.60	23.50	±11.82	161.50	±33.20	28.25	± 1.89
Mod. n= 7	36.29	±10.14	36.29	±20.73	32.00	±28.59	165.71	±26.61	26.43	± 6.11
Low n=25	33.40	±11.29	30.16	±16.77	24.44	±22.72	168.48	±30.39	28.08	± 6.98
Total n=36	35.14	±11.90	33.56	±18.63	25.81	±22.71	167.17	±29.23	27.78	± 6.37
Mean of Individual Means										
Exp. n= 5	43.77$	±22.33	51.47	±19.82	20.73	±12.48	168.25	±29.60	25.33 (n=4)	± 2.28
Mod. n= 7	36.22	±11.02	37.44	±19.50	27.74*	±20.56	162.53	±29.70	27.46	± 5.79
Low n=26	30.38*	± 6.67	29.61*	±11.90	21.55$	±13.28	159.08	±21.80	28.58	± 8.10
Total n=38	33.22	±11.23	33.93	±16.03	22.58	±14.51	160.92	±23.85	28.02 (n=37)	± 7.26

Exp. = Highest Exposure Mod. = Moderate Exposure Low = Low Exposure

Statistically Significant Differences using Analysis of Variance

@ Year statistically significantly higher than rest of years for exposure group.
# Year statistically significantly lower than rest of years for exposure group.
Overall statistical significance but no one year statistically significantly different.
Statistically significant different from other exposure groups.
¶ Statistically significant difference between exposure groups without a specific group identified.

TABLE II A
Mean Values for Several Liver Enzyme Determinations
Obtained on Routine Annual Examination
Analysis of Variance (Means of Exposure Groups over the Years)

Hexcel Corporation
Dublin, California
1981 - 1985

Exposure Group & Value Given	SGOT	SGPT	SGGT	LDH	Alk. Phos.
Most Exposed					
Mean of Means	36.37	44.42	17.00	170.89	25.40
F Value	3.320	4.185	6.029	0.976	14.098
Probability of Chance	0.043	0.021	0.0050	N.S.	0.001
Moderately Exposed					
Mean of Means	36.95	41.14	32.82	171.09	27.39
F Value	0.773	0.350	0.134	2.665	1.189
Probability of Chance	N.S.	N.S.	N.S.	N.S.	N.S.
Low Exposure					
Mean of Means	29.97	29.51	21.68	162.26	27.65
F Value	9.008	1.836	3.213	7.925	11.290
Probability of Chance	0.001	N.S.	0.018	0.001	0.001
Total Group					
Mean of Means	32.10	33.72	22.89	165.04	27.30
F Value	11.763	3.555	4.179	10.594	17.562
Probability of Chance	0.001	0.0091	0.0040	0.001	0.001
Means of Means between Exposure Groups					
Mean of Means	33.22	33.93	22.58	160.92	28.02
F Value	3.788	4.994	0.534	0.317	0.360
Probability of Chance	0.035	0.014	N.S.	N.S.	N.S.
1981 between Exposure Groups					
Mean of Means	32.77	33.23	16.08	193.54	
F Value	3.825	4.651	5.119	0.614	
Probability of Chance	N.S.	0.040	0.031	N.S.	
1984 between Exposure Groups					
Mean of Means	39.68	42.05	31.00	145.18	32.11
F Value	2.716	5.747	0.427	1.785	0.440
Probability of Chance	N.S.	0.0075	N.S.	N.S.	N.S.

Selected Comparisons of Means with 95% Confidence Levels (L Values)

Highest Exposure Group between Years - SGOT			
1984 & 1985	vs. 1982 & 1983	+25.85	±26.57
1984	vs. 1982 & 1983	+29.95	±30.74
For the Year 1981 between Exposure Groups - SGPT			
Moderate Exposure	vs. Low Exposure	+19.50	±18.38
Moderate Exposure Group between Years - SGGT			
1984 & 1985	vs. 1981, 1982, & 1983	+16.83	±12.76

TABLE III
Mean Yearly Change in Several Liver Enzyme Determinations
Obtained on Routine Annual Examination

Hexcel Corporation, Dublin, California
1981 - 1985

Years & Group	n	SGOT Mean	± Std.Dev.	SGPT Mean	± Std.Dev.	SGGT Mean	± Std.Dev.	LDH Mean	± Std.Dev.	Alk. Phos. Mean	± Std.Dev.
1982-1981											
Exp.	n= 3	-10.67	± 5.13	-9.00	± 3.46	-5.33#	± 1.53	-32.33	±13.65		
Mod.	n= 2	-4.00	± 7.07	-4.50	±10.61	-3.00	± 9.90	-61.00#	±14.14		
Low	n= 8	-8.00	±16.12	-7.00	±17.95	-1.25	± 5.06	-25.37#	±29.38		
Total	n=13	-8.00#	±12.83	-7.08	±14.19	-2.46	± 5.16	-32.46#	±26.84		
1983-1982											
Exp.	n= 3	-0.33	± 2.52	+2.33	± 7.77	+2.67	± 2.52	+28.00	±24.58	-13.33#	± 5.77
Mod.	n= 3	-5.67	± 6.66	+2.00	± 5.29	+4.00	± 6.08	+42.00@	±36.43	-13.45 (n=2)	± 0.71
Low	n=11	+1.09	± 5.89	-2.09	± 8.42	+0.55	± 6.47	+18.27@	±21.94	-11.09#	± 4.72
Total	n=17	-0.35	± 5.89	-0.59	± 7.73	+1.53	± 5.80	+24.18@	±25.07	-11.81# (n=16)	± 4.53
1984-1983											
Exp.	n= 4	+22.50@	±16.40	+28.75	±19.82	+15.75@	± 5.12	-34.50	±31.38	+16.75@	± 3.20
Mod.	n= 3	+16.67	±14.57	+27.67	±23.97	+32.33	±29.91	-14.67	±22.03	+5.50* (n=2)	± 7.78
Low	n=17	+15.82@	±12.09	+13.76@	±18.77	+19.76@	±17.70	-34.06#	±18.26	+14.57@ (n=14)	± 4.48
Total	n=24	+17.04@	±12.24	+18.00@	±19.79	+20.67@	±17.93	-31.71#	±21.12	+14.10@ (n=20)	± 5.29
1985-1984											
Exp.	n= 4	-1.00	±13.74	-12.00	±32.91	-4.00	± 9.09	+11.75	±12.97	-3.25	± 6.24
Mod.	n= 7	-5.14	± 9.48	-12.00	±14.43	-6.14	±13.81	+8.14	±24.56	-2.57	± 6.55
Low	n=25	-3.24	±16.83	-3.96 (n=24)	±19.71	-4.60#	±10.37	+29.60@	±23.63	-5.67# (n=24)	± 8.52
Total	n=36	-3.36	±15.07	-6.49 (n=35)	±20.24	-4.50#	±10.75	+23.44@	±24.29	-4.77# (n=35)	± 7.87
Mean of Individual Mean Differences											
Exp.	n= 4	+4.10	± 3.34	+1.45	± 9.44	+3.63	± 2.02	-7.05$	± 4.64	+1.63	± 3.30
Mod.	n= 7	-3.01	± 7.69	-3.59$	±11.56	+1.14*	± 5.81	+6.51	±12.64	-4.47*	± 3.19
Low	n=26	+0.84	±12.80	-0.81 (n=25)	±11.93	+1.75	± 8.87	+5.87	±13.89	-3.27 (n=25)	± 9.60
Total	n=37	+0.46	±11.34	-1.10 (n=36)	±11.41	+1.84	± 7.81	+4.59	±13.39	-2.96 (n=36)	± 8.30

Exp. = Highest Exposure   Mod. = Moderate Exposure   Low = Low Exposure

Statistically Significant Differences using Analysis of Variance
@ Year statistically significantly higher than rest of years for exposure group.
# Year statistically significantly lower than rest of years for exposure group.
$ Overall statistical significance but no one year statistically significantly different.
* Statistically significant different from other exposure groups.

TABLE III A
Mean Yearly Change in Several Liver Enzyme Determinations
Obtained on Routine Annual Examination
Analysis of Variance (Means of Exposure Groups over the Years)

Hexcel Corporation
Dublin, California
1981 - 1985

Exposure Group & Value Given	SGOT	SGPT	SGGT	LDH	Alk. Phos.
Most Exposed					
Mean of Means	+3.79	+3.36	+3.64	-7.43	+1.27
F Value	6.181	2.904	8.885	6.632	31.378
Probability of Chance	0.013	N.S.	0.0043	0.0097	0.001
Moderately Exposed					
Mean of Means	-0.73	-0.27	+4.00	+1.13	-3.09
F Value	3.788	4.793	3.809	6.810	4.596
Probability of Chance	0.045	0.023	0.045	0.0079	0.048
Low Exposure					
Mean of Means	+2.23	+1.00	+3.56	+2.61	-1.10
F Value	7.969	4.233	14.881	32.126	53.790
Probability of Chance	0.001	0.0094	0.001	0.001	0.001
Total Group					
Mean of Means	+1.98	+1.16	+3.64	+0.80	-1.04
F Value	16.176	10.539	23.088	38.997	79.951
Probability of Chance	0.001	0.001	0.001	0.001	0.001
Means of Means between Exposure Groups					
Mean of Means	+0.46	-1.10	+1.84	+4.59	-2.96
F Value	0.535	0.263	0.128	1.776	0.733
Probability of Chance	N.S.	N.S.	N.S.	N.S.	N.S.
1984-1983 between Exposure Groups					
Mean of Means	+17.04	+18.00	+20.67	-31.71	+14.10
F Value	0.460	1.381	0.792	1.130	4.317
Probability of Chance	N.S.	N.S.	N.S.	N.S.	0.032

Selected Comparisons of Means with 95% Confidence Levels (L Values)

Moderate Exposure Group between Years - SGPT			
1984-1983	vs. 1985-1984	+39.67	+34.60
1984-1983	vs. 1982-1981 & 1985-1984	+35.92	±35.24
Highest Exposure Group between Years - LDH			
1983-1982	vs. 1982-1981 & 1984-1983	+61.42	+51.85
1983-1982 & 1985-1984	vs. 1982-1981 & 1984-1983	+53.29	±40.45

TABLE IV

SUMMARY OF PERSONAL AIR SAMPLES
COLLECTED DURING CLOTH DIPPING

Hexcel Corporation
Dublin, California
May 30, 1985

Sample Number	Description/Location	Exposure Period (min)	Volume Liters	Acetone Concentration
A-1	Cloth dipped in a resin/ acetone mixture and acetone used to clean-up	18	1.6	171 ppm[1]
7799	Cloth dipped in a resin/ acetone mixture and acetone used to clean-up	18		84 ppm

1. ppm - parts of a vapor or gas per million parts of contaminated air.

2. CAL-OSHA Standard:
   Acetone - 3000 ppm ceiling limit.

TABLE V

SUMMARY OF MERCURY
VAPOR AREA MONITORING

Hexcel Corporation
Dublin, California
May 30, 1985

Lab Number	Location	Mercury Vapor Concentration (mg/m^3)
102	On counter tops, inside hoods, on floors	None detected
105	On counter tops	0.002
	Inside smaller hood	None detected
	On floor at base of counters	None detected
110A	On floor at base of counters, at sink and floor drain	0.004
114A	Inside Hood (27"x86")	0.002
	Inside Hood (28"x50")	None detected
	On counter tops and on floor at base of counters	None detected
114B	At sink	0.002
	On floor at base of counters	None detected
115	Inside four hoods from left to right numbered 1 to 4	
	#1	0.006
	#2,3,4	None detected
	On floor infront of hoods	None detected
	On counter tops	0.001
118	On floor infront of hood	0.002
119	Inside Hood (50"x26")	0.01
	At sink between hood/canopy	0.007
	On counter tops	0.002
	On floor infront of counter tops	0.002
120B	At sink	0.008
	On counter tops	0.004

1. mg/m^3 milligrams of a substance per cubic meter of air.
2. NIOSH Evaluation Criteria:
Mercury - 0.1 mg/m^3

TABLE VI

SUMMARY OF HOOD
VENTILATION MEASUREMENTS

Hexcel Corporation
Dublin, California
May 30, 1985

Lab Number	Location	Average Face Velocity (lfpm)[1]
103	Hood (28"x50")	135
105	Hood (86"x27")	147
	Hood (52"x29")	72
114A	Hood (86"x27")	145
	Hood (50"x28")	116
114B	Hood (sash fully open)	91
	Hood (sash at red mark)	155
115	Hoods (numbered from left to right numbered 1 to 4	
	#1 (40"x30")	137
	#2 (52"x30")	92
	#3 (40"x30")	80
	#4 (40"x30")	80
118	Hood (sash full open)	108
	Hood (sash at red mark)	176
119	Hood (41"x33")	127
	Hood (50"x26")	96

1. lfpm - linear feet per minute

2. The CAL-OSHA Standard requires that the exhaust system provides an average face velocity of at least 100 lfpm with a minimum of 70 lfpm at any one point.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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CENTERS FOR DISEASE CONTROL
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