U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 72-96-237

TRANS WORLD AIRLINES MAIN OVERHAUL FACILITY
KANSAS CITY INTERNATIONAL AIRPORT
KANSAS CITY, MISSOURI 64195

NOVEMBER 1975

I. TOXICITY DETERMINATIONS AND CONCLUSIONS

It has been determined that employees directly involved in spray painting of large commercial aircraft are exposed to toxic concentrations of organic solvents and isocyanate compounds during such operations. This determination is based on data collected during February 14 and 15, 1974, and July 29 through August 2, 1974, which includes: A. Medical interviews of employees; B. Medical testing of employees; and C. Environmental measurements for the specific organic solvents and isocyanate compounds associated with spray painting operations.

The environmental measurements obtained at the time of the survey indicate: A. Many of the twenty-two (22) personal air samples quantitated environmental levels of specific organic solvents (e.g., methyl ethyl ketone, toluene, cellosolve acetate) exceeding the current American Conference of Governmental Industrial Hygienists (ACGIH) recommended permissible excursions of Threshold Limit Values (TLV); B. Environmental levels which exceeded the TLV's for mixtures of organic solvents (combined effect of these solvents considered as additive) were measured for fin painters, right and left side painters, and the pot men; C. Significant concentrations of hexamethylene diisocyanate (HMDI) and the biuret compounds of HMDI [primarily a tri-molecular structure of 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B)] were measured, however, there are no established limits for exposure to these compounds; and D. There was no significant or excessive exposure of workers to toluene diisocyanate (TDI), except that TDI was apparently present at detectable levels at the time of the survey.

The results of the medical evaluation are as follows:

A. Workers are exposed to toxic levels of urethane paint spray during spraying operations. This is demonstrated by a statistically significant increase in symptoms of eye irritation, nasal irritation, throat irritation and chest discomfort for those workers engaged in spray painting when compared to non-exposed workers. An increase in wheezing, a persistence of the nasal congestion and some persistence of the eye irritation, throat irritation and chest discomfort were noted for the day following exposure. It is not clear whether symptoms are due to the isocynates, to the organic solvents, or to both, but the persistent

symptoms would suggest that the isocyanates are partially responsible for the symptoms. Neither the results of complete blood counts nor pulmonary function test results suggested that there were any toxic manifestations other than acute irritation.

B. During the initial medical evaluation conducted on February 14-15, 1974, one worker was observed during an asthmatic attack apparently precipitated by exposure to paint spray. This suggests that levels of isocyanate associated with spray painting may be sufficient to cause a reaction in persons sensitive to isocyanates, but on the follow-up study of July 29 through August 2, 1974, no evidence of pulmonary sensitization was found. Confining major painting operations to the third shift when very few other employees are working apparently has proved valuable in decreasing adverse effects on the workers.

The above determinations and conclusions have been made concerning paint spray operations of aircraft involving the intermediate and final costs of paint containing various organic solvents, HMDI and TICH-B. Detailed information concerning the above medical and environmental results of this determination are contained in the body of the report. Recommendations are included in Section IV F of this report which are designed to keep employee exposure to these agents to a minimum.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of the Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH; U.S. Post Office Building, Room 508; Fifth and Main Streets; Cincinnati, Ohio 45202. Copies have been sent to:

a. Trans World Airlines, Inc., Overhaul Base, Kansas City, Missouri

b. Authorized Representative of Employees

c. U.S. Department of Labor - Region VII

d. NIOSH - Region VII

For the purpose of informing the approximately twenty-one (21) "affected employees", the employer will promptly "post" the Determination Report in a prominent place(s) near where exposed employees work for a period of 30 calendar days.

III. INTRODUCTION

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.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees to evaluate employee exposures to various airborne contaminants associated with the spray painting of commercial aircraft. The request was precipitated by employee concern regarding possible harmful effects from exposure to emissions present during spray painting of aircraft with paints containing isocyanates.

IV. HEALTH HAZARD EVALUATION

A. Description of Process - Conditions of Use

The TWA Airframe Overhaul Division is engaged in every aspect of aircraft maintenance. The "Hangar Area" of the facility is the central depot for work on the aircraft. The Hangar Area is comprised of five south bays, and five north bays, each approximately 100 x 170 feet in area and 45 feet in height (See Attachment A). The central core area of the structure is comprised of office space, eating areas and specialized workshops. Painting operations are conducted only in the north bays. Normally there are over 600 employees in the main hangar area on a 24 hour basis with approximately 400 on day shift, 200 on second shift and 30 on the third shift. With the exception of employees on the third shift, a large fraction of workers on the other two shifts work in administration, in workshop areas, and in the main hangar. Spray painting of the outside shell of large aircraft are normally, with few exceptions, conducted on the third shift which has twenty-one (21) painters. Other than the painters directly involved with the airplane spray operations, there are no other employees in the immediate vicinity or adjoining bay. However, this has not always been the practice as a few years ago there were additional employees on the third shift, and painting was not always confined to the third shift.

The number and job titles of the employees involved with spray operations are two (2) lead men or foremen, two (2) top painters, two (2) fin painters, three (3) right side painters, three (3) left side painters, and two (2) pot men painters. The side, fin, and top painters are directly involved with the spray operations, and the pot men are responsible for the proper mixing of paints and ancillary activities near the plane at ground level.

The major paint spray operations are accomplished in four phases as follows:

Phase 1 - "Wash Down" operation which involves hand-washing of the aircraft with a mixture of organic solvents and water.

Phase 2 - "Prime Coat" spray operation which involves mixing of paints and application or spraying of primer paint on the aircraft. This coat does not involve the use of isocyanate compounds. It is not always necessary to apply a full coat of prime paint depending upon the wear or condition of the old paint. Hence, a minor touch up of the old prime coat may be all that is required. The prime coat paint is a zinc chromate-phosphoric acid catalyst mixed with a resin zinc chromate resin wash primer.

Phase 3 - "Intermediate Coat" spray operation which involves mixing of paints to appropriate texture and viscosity (about 30 minutes) with subsequent application or spraying of intermediate paint on the aircraft. Normally, a full intermediate coat is always necessary prior to application of the final coat. The intermediate coat is an aliphatic/aromatic isocyanate resin blend catalyst mixed with a pigmented polyester resin primer. There are, at most, only trace amounts of the aromatic isocyanate compounds with most being of the aliphatic isocyanate compounds.

Phase 4 - "Final Coat" or "Enamel Coat" spray operations are for all practical purposes the same as those for the intermediate coat. However, there is more isocyanate catalyst in the enamel coat. Therefore, one would expect to find more airborne isocyanates during the spray operations of the final coat than during the intermediate coat spray operations.

To accomplish the large spray jobs, a "Grabber" airless spray gun is utilized. For small jobs, such as touch up of prime coat, a "cup" gun with a one quart capacity is used. All workers wear an approved respirator with a combination organic vapor canister and a high efficiency pre-filter with the commencement of spray operations. However, the respiratory protection program was found to have several deficiencies (e.g., training, face fit, use of "socks", etc.).

B. Study Progress and Design

1. General Environmental Conditions and Design

The procedures used to evaluate the areas of concern included on-site interviews with representatives of union and management, preliminary medical and environmental studies, contacting manufacturers of products used in the process to identify toxic substances, administration of medical questionnaires and examining non-exposed and exposed workers, development of analytical techniques with sufficient sensitivity for the aliphatic isocyanates, and extensive air sampling to detect potential exposure to airborne contaminants.

Based upon the information generated from our initial studies, the final study involved the evaluation of employees exposed to the following chemicals during paint spray operations:

(1) Toluene 2,4-diisocyanate (TDI), hexamethylene diisocyanate (HMDI), and the biuret compound of HMDI which is predominantly 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B).

(2) Organic solvents such as ethyl acetate, methyl ethyl ketone, toluene, butyl acetate, naphtha, xylene, collosolve acetate, and methylene chloride.

The final medical-environmental evaluation was conducted from July 29 through August 2, 1974, with environmental evaluation of actual spray operations being conducted during the third shift on the morning of August 1, 1974. The evaluation was carried out with the hangar door open about six feet which should have simulated winter time conditions. All other operating parameters (e.g., pressure on pot, number of painters, hoses, etc.) were normal during spray painting operations of the complete intermediate and final coats of paint. The application of a touch up for the prime coat involved two (2) painters for about ten minutes using a cup gun. Although samples obtained during these operations may not be quantitative due to the short sampling period for filter samples, the results did detect the compounds of interest. Sample results for zinc chromate, phosphoric acid or phosphates and organic solvents, did not indicate significant exposure of workers to concentrations exceeding appropriate Federal or other health standards. It is further noted that exposures of the painters were minimal during the touch up of the prime coat, and would have been much greater had the plane received a full wash coat applied with the "Grabber" type spray guns. Hence, in view of the above information and that the request concerned the use of paints containing isocyanates, operations involving the wash coat are not discussed further in this report.

2. Medical Design

a. Preliminary Survey

The medical portion of the preliminary survey was carried out on February 14 and 15, 1974, by NIOSH physicians Drs. Steven Cohen and Theodore Thoburn. The preliminary visit showed that both painters and other workers in the vicinity of painting developed symptoms during the painting or shortly thereafter which consisted of eye, nose, throat and chest irritation, as well as shortness of breath, cough, wheezing, chest tightness and nocturnal cough. Painters showed significantly more eye irritation and chest irritation than did other workers only indirectly exposed.

One worker was seen during an asthmatic attack which apparently was induced by exposure to residual fumes from the previous shift's painting. In addition to greatly decreased FVC and FEV_1 which improved after the administration of epinephrine, he also showed a markedly increased percent of eosinophiles in his blood and increased total eosinophile count. It was concluded that a sensitivity to isocyanates was the most likely explanation.

On February 28, 1974 Dr. Cohen returned to Kansas City and obtained blood samples from five workers considered most likely to have a pulmonary sensitization to isocyanates by medical history. This blood was tested for antibodies associated with sensitivity to isocyanates using an experimental serologic method. The results were uninterpretable, so this particular blood test was not included in the follow-up survey.

b. Follow-up Medical Survey Conducted July 29 through August 2, 1974.

On the basis of anticipated exposure, the hangar workers were considered in four categories:

(1) Third shift painters (approximately 18). These workers constituted the exposure group to be studied. All workers were included.

(2) First and second shift non-painters (approximately 378 workers on first shift and 221 on the second shift). The control was drawn as a stratified systematic sample from this group.

(3) The remainder of the third shift (approximately 17) whose exposure would be variable. These employees were not studied.

(4) The first (approximately 22) and second (approximately 11) shift painters whose exposure was intermittent and under much more controlled conditions than the third shift painters. They also were not studied because of their lesser exposure.

Each worker to be studied was to reveive: pre- and post-shift pulmonary function testing covering a shift when they were not spray painting in the hangar (the "non-exposure" shift); a brief questionnaire for current symptoms at the time the pulmonary function testing was performed and again at the start of the shift the day following testing; a detailed questionnaire for work history, respiratory illness and other medical problems; a brief physical examination of head, chest and skin; and a complete blood count. In addition, the third shift painters reveived pre- and post-shift pulmonary function testing and current symptoms questionnaires covering a shift when they were spraying white urethane paint in the hangar (the "exposure" shift). The painters' blood counts were done pre- and post-shift for the exposure shift and included a total eosinophile count.

Seventeen out of the 18 available third shift painters were included in the study. Fifteen were "mechanic" grade and two were "lead mechanic" grade. All were white males having an average age of 43.5 years (range 30-57), averaged 8.8 years in the department (range 3-28) and 9.5 years in the plant (range 5-30).

The control group consisted of 40 workers, 24 from the first shift and 16 from the second shift. Four were "helper" grade; 34 were "mechanic" grade; and 2 were "lead mechanic" grade. There were 2 white females and one black male, the rest being white males. The average age was 43.2 years (range 26-64); the average time in their current department 10.4 years (range 0-32); and the average time in the plant 13.6 years (range 0-32).

The following Departments were represented in the control group:

Aircraft	9	Fuel Tanks	4
Battery Shop	1	Hydraulics	6
Electrical	4	Instruments	1
Engines	1	Sheet Metal	8
Fleet Service	4	Radio	2

On arriving at the plant it was discovered that part of the third shift painters would be spraying with red urethane paint that evening. Because time and manpower did not permit a rescheduling, the painters who were not spray painting that shift were seen, and the painters who were spraying that shift were seen the following night.

Thus, the third shift painters who were seen in this study fall into four different exposure groups:

(1) Eight spray painted with both red and white urethane paint. Their "non-exposure" shift came the day after they sprayed red urethane paint.

(2) Three spray painted with white but not red urethane paint. Their "non-exposure" shift really was an exposure to red spray painting as a non-sprayer.

(3) Two spray painted with red urethane paint but received a non-spray exposure to white urethane paint. Their "non-exposure" shift came the day after they sprayed red urethane paint.

(4) Four did not spray either time. Their "non-exposure" shift and "exposure" shift would differ only so far as the degree of exposure as a non-sprayer varied between the red spraying and the white spraying.

C. Evaluation Methods

1. Environmental Methods

Personal air samples were used to evaluate employee exposure. The personal samplers were connected on or near the collar of the employees to collect a representative sample of air in the breathing zone of the workers. General area samples were collected in specific locations in the working environment as shown in Attachment B. Area sample number 3 was in the general vicinity of the pot mixing operations at ground level.

Short term charcoal tube samples from 10 to 70 minutes for determination of the maximum concentrations of organic solvents were obtained using modified MSA Model G pumps operating at a flow rate of approximately 0.35 liters of

air per minute (1 pm). Long term charcoal tube samples for determination of the average concentrations of organic solvents were obtained using a Sipin pump at a flow rate of approximately 50 cubic centimeters of air per minute (ccm) over longer periods of time. Charcoal tubes were analyzed by the gas chromatographic method reported by W. D. White, et al[1].

TDI, HMDI and TICH-B were collected by bubbling the air through midget impingers with 15 cc of absorbing solution using an MSA Model G pump at a flow rate of 1 liter of air per minute (1pm). Sampling and analytical procedures were those developed and reported by Sandridge, Dunlap and Keller[2].

Some total and respirable particulate samples were collected on polyvinylchloride (PVC) filters, 3-piece cassettes, and 2-piece cassettes with a 10 mm cyclone using MSA Model G pumps operating at a flow rate of 1.7 lpm respectively. These PVC filters were gravimetrically analyzed for total and respirable particulate matter as such information, if valid, would be of general interest, although not necessary for the findings contained in this report. Field observations (e.g., partial plugging of filter, etc.) and the analytical results varied to such an extent that the results are not considered valid. Hence, this aspect of the survey is not considered further.

2. Medical Methods

a. Sample Selection

A 100% sample of the third shift painters was desired. Seventeen out of 18 were seen.

The systematic sample for use as controls was drawn by taking lists of workers for each shift as supplied by the company (duty roster, by department, by seniority), starting at a random point and taking every 16th worker on the first shift and every 14th worker on the second shift. The following worker on the list was substituted if the designated worker was unavailable.

b. Pulmonary Function Testing

Pulmonary function testing was done utilizing one Medistor and one Vertex Pulmonary Function testing machine. Both machines utilize a pneumotachograph to measure air flow. There were no statistically significant differences between the group means for the various functions as recorded on each machine. As each individual worker was always tested on the same machine by the same operator, the differences in the machines should not introduce a significant error in the results. Forced Vital Capacities (FVC) and Forced Expiratory Volume at 1 Second (FEV_1) and, in the case of the Medistor, the Forced Expiratory Flow 0.2 to 1.2 liters ($FEF_{0.2-1.2}$) were read directly from the machine. The Mean Maximum Expiratory Flow-between 25% and 75% of the maximum FVC (MMF_{25-75}) and, in the case of the Vertex, the $FEF_{0.2-1.2}$) were calculated from a strip recording (in part accounting for a decreased precision of these measurements).

The best results from five tries were utilized for each set of tests, and the individual's best effort from all tests were considered his normal functioning. In calculating MMF_{25-75}'s, a worker's best FVC from all tries was utilized.

Pulmonary function data was converted to percent of predicted using the formula of Morris[3] for white workers and Lapp[4] for black workers. This adjusts for differences in height, age, sex, and race.

c. Blood Testing

A venous blood specimen for Hemoglobin, Hematocrit, Leukocyte Count and Differential Count was obtained from all men in the study. In addition a Total Eosinophile Count was obtained on the third shift painters and on any of the control group with an Eosinophile Count of 3% or greater on differential, or a total leukocyte count of 15,000 or greater. The third shift painters had two specimens each, one pre-shift and one post-shift on the night of the spray painting. The control group had only one sample per person with both shifts drawn at one afternoon session.

Several of the control group were missed at the afternoon drawing and so had their specimens obtained at the same time the painters were being drawn.

The blood specimens were drawn at the plant by a technician supplied by Upsher Laboratories, Kansas City, Missouri, who then took the specimens to the laboratory for processing. They utilized a Coulter Counter for all but the Differential and Total Eosinophile Count.

d. Questionnaires

The brief pre-shift, post-shift and follow-up questionnaires were designed to record acute symptoms occurring during the tested day or the period from the end of shift until the worker came on duty the following day. The bulk of the questionnaire was designed to collect historical data, particularly relating to the alleged hazard and the status of the respiratory tract. The brief physical examination concentrated on evaluation of the mucous membranes of the eyes, nose, and throat and of the respiratory tract for physical signs of abnormality.

D. Evaluation Criteria

1. Environmental Standards or Criteria

The three primary sources of environmental evaluation criteria considered in this report are: (1) NIOSH Criteria Documents recommending occupational standards; (2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) with supporting documentation; and (3) Federal occupational health standards as promulgated by the U.S. Department of Labor. For brevity, the recommended health standards or guides as used by the ACGIH are used as reference points in the following presentation

of evaluation criteria. Use of the two other sources of criteria would not change any conclusions contained in this report.

The occupational health exposure limits adopted by the ACGIH (1975) applicable to the principal individual substances of this evaluation are as follows:

Substance	TLV 8-Hour Time-Weighted Average (TWA) Exposure Standard or Guide		Excursion Factor See "D" Below	
	ppm[a]	mg/M^3[b]	ppm[a]	mg/M^3[b]
"C" Toluene-2,3-diisocyanate (TDI)	0.02	0.14	0.02	0.14
"D" Ethyl Acetate	400	1400	500	1750
"D" Methyl Ethyl Ketone	200	590	250	740
"D" Toluene - Skin	100	375	150	560
"D" Butyl Acetate	150	710	190	890
"D" Naphtha	100	400	150	600
"D" Xylene - Skin	100	435	150	650
"D" Cellosolve Acetate-Skin	100	540	150	810
"D" Methylene Chloride	200*	720	250	900

a - Parts of vapor or gas per million parts of contaminated air by volume (ppm).

b - Approximate milligrams of substance per cubic meter of air (mg/M^3).

* - ACGIH has issued a Notice of Change from 100 ppm to 200 ppm in 1975.

"C" - Denotes a ceiling limit of concentration for the substance which should not be exceeded.

"D" - Denotes an excursion factor for all substances not bearing a "C" notation which are:

TLV 0-1 (ppm)	Excursion Factor = 3
TLV 1-10 (ppm)	Excursion Factor = 2
TLV 10-100 (ppm)	Excursion Factor = 1.5
TLV 100-1000 (ppm)	Excursion Factor = 1.25

The product of the TLV times the excursion factor represents a "ceiling value" which should not be exceeded (i.e., "ceiling value" = TLV x Excursion Factor). The number of times the excursion above the TLV is permitted is governed by conformity with the time-weighted average TLV.

When two or more hazardous substances are present, their combined effect should be given consideration. In the absence of information to the contrary, the effects of different hazards should be considered additive. The sum of the fractions, concentration over the occupational exposure limit for each substance ($C_1/T_1+C_2/T_2+C_3/T_3+ \ldots +C_N/T_N$) should not exceed unity or one. In this regard the effects of the above organic solvents (not TDI) would be considered as additive.

Occupational health exposure limits for individual substances are generally established at levels designed to protect workers occupationally exposed on an 8-hour per day, 40-hour per week basis over a working lifetime.

It should be noted that NIOSH recommends in a recent publication[5] that the health standard for TDI be lowered to the following level: time-weighted average (TWA) concentrations of TDI should not exceed 0.036 mg/M^3 (0.005 ppm) and ceiling concentrations for any 20-minute period should not exceed 0.14 mg/M^3 (0.02 ppm).

There are no current recommended standards and little background information concerning hexamethylene diisocyanate (HMDI) and the biuret compound of HMDI or tri-molecular structure 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B), although TICH-B is generally considered by the investigators as less hazardous than HMDI or TDI. In this regard it is noted that HMDI has about the same molecular weight (M.W. approximately 168) and cyanate-NCO-groups as TDI, while TICH-B has a molecular weight of approximately 478 (TDI-174) and three cyanate-NCO-groups (TDI-2 cyanate groups). For purposes of this report, the authors feel that a level of 0.1 mg/M^3 or more for HMDI, and a level of 0.6 mg/M^3 or more for TICH-B might be considered as levels which could be considered as significant.

2. Medical Standards or Criteria

a. Organic Solvents (MEK, cellosolve acetate, toluene, etc.)

The acute effects resulting from excessive exposure to these agents are generally the same with some minor differences. Toluene has been the most extensively studied, giving rise to mild fatigue, weakness, and paresthesias of the skin, with excessive exposure at or slightly above the TLV. At higher concentrations, confusion ensues, and nausea, headache, and dizziness appear. At very high concentrations, loss of coordination, extreme nervousness and finally unconsciousness may be present. Xylene is similar in its acute toxic effects but is noted to give rise to more pronounced gastrointestinal symptoms (nausea, vomiting, flatulence, etc.). MEK and cellosolve acetate differ from toluene and xylene in giving rise to eye and mucous

membrane irritation with similar excessive exposures. Higher concentrations may produce effects similar to the other two agents.

Chronic effects of exposure to each agent range from weakness, dizziness, and fatigue (toluene) to dermatitis (MEK, toluene, etc.) Other chronic effects are less well defined; none of the agents by themselves have been noted to be toxic to the bone marrow. For the most part the effects from each of the organic solvents are considered as additive and contribute to a cumulative effect.

b. Aromatic and Aliphatic Isocyanates (TDI, HMDI, and TICH-B)

Toluene diisocyanate (TDI) has been studied fairly intensively and has been discussed in a NIOSH criteria document.[5] TDI is a primary irritant of the mucous membranes of the eyes, nose and throat and of the respiratory tract. In addition, it may cause a progressive, allergic sensitization of the respiratory tract, ultimately resulting in severe asthmatic attacks after exposure to even minute traces of TDI. The sensitizing effect appears related to the number of available isocyanate groups, which if fully reacted no longer elicit the allergic or irritative response. Presumably if the isocyanate were partly reacted, thus reducing the number of available isocyanate groups, the response would also be reduced.

Because the biuret compound of hexamethylene diisocyanate has both a very low vapor pressure and a diminished number of available isocyanate groups, it would be expected to be considerably less hazardous than TDI in use. However, when sprayed during painting considerably higher air levels are obtainable than might occur by evaporation alone.

c. Pulmonary Function Testing

The FVC measures the total volume of air that can be moved in and out of the lungs. It would be decreased in conditions which interferred with chest motion, the elasticity of the lungs (as fibrosis) or with the ability of the lungs to empty themselves (as emphysema). It is measured in liters.

The other three function tests are measures of speed with which the lungs can get air out. The FEV_1 has been in use the longest, but is felt to be somewhat effort dependent[1]. To avoid this the $FEF_{0.2-1.2}$ has been proposed to give a measure of the steep portion of the flow curve and is felt not to be as effort dependent. The MMF_{25-75} also avoids the initial effort dependent part of the flow curve and includes portions of the curve more dependent on the patency of small airways. Following general practice, 80% of predicted value has been used as the lower limit of normal for FVC and FEV_1, but due to the inprecision of our measurements and the greater variability of the results, 70% of predicted was accepted as the lower limit of normal for $FEF_{0.2-1.2}$. An MMF_{25-75} of less than 60% of predicted will be considered abnormal following Leuallen, et al[6], and allowing for the inprecision of our measurements. Also, any drop in percent of predicted of greater than 10 percentage points over shift in FVC or FEV_1 will be considered clinically

significant. In evaluating changes in $FEF_{0.2-1.2}$ and MMF_{25-75} changes of 20 percentage points or less will not be considered significant. To be considered significant both must drop at least 10 percentage points.

d. Blood Testing

The normal blood work standards were taken from Todd Sanford[7] (Refer to Table XII-A). Hemoglobin and hematocrit are interrelated. Low levels are diagnostic of anemia which can be caused by a number of different things. High levels can occur as an adaption to living at high elevations, as a result of severe dehydration, or as a result of overproduction of red cells.

The white blood count may be depressed by certain toxic agents or leukemia. Elevated counts may be caused by infection, allergy, or leukemia. Acute infections are most likely to raise the count of polymorphonuclear leukocytes (polys). In chronic infections the number of lymphocytes (lymphs) are more usually raised. An elevation in the eosinophile count is characteristic of an allergic reaction.

E. Evaluation Results and Discussions

1. Environmental Results and Discussions

a. Results for TDI, HMDI, and TICH-B

Environmental results of thirteen (13) short term personal air samples were obtained and analyzed for these compounds and are presented in Tables I and II. Results did not show any evidence of any excessive exposure of workers to TDI, except that TDI was apparently present at detectable levels at the time of the survey. Of the thirteen (13) personal air samples, seven (7) samples were 0.1 mg/M^3 or more for HMDI with a maximum of 0.3 mg/M^3. Of the thirteen (13) personal air samples, ten (10) samples were in excess of 0.6 mg/M^3 for TICH-B with an average for these ten (10) samples of 3.8 mg/M^3. It is further noted that there was a much heavier concentration of the HMDI and TICH-B during spray operations involving the final enamel coat. This confirms the amounts used in the final coat compared to the intermediate coat as well as the increased amount of eye irritation noted by the NIOSH investigators at the time of the survey. Time Weighted Averages (TWA) based on the 13 short term samples for the various painters are presented in Table III. The estimated TWA for TICH-B concerning exposures of the fin, right and left side painters were 0.6 to 0.7 mg/M^3. Although perhaps not significant, the results do show some exposure potential to TICH-B during spray operations between Bays 2 and 4. Also, there may be some detectable airborne levels of HMDI and TICH-B very near the plane after the spray operations have ceased.

b. Results for Organic Solvents

Environmental results of twenty-two (22) short and long term personal air samples obtained and analyzed for methyl ethyl ketone (MEK), toluene, cellosolve acetate, and other organic solvents (butyl acetate, xylene, etc.) are presented in Tables IV and V. About forty percent of the samples exceeded the excursion value of 738 mg/M^3 for MEK, about 20 percent of the samples exceeded the excursion value of 563 mg/M^3 for toluene, and approximately 55 percent exceeded the excursion value of 810 mg/M^3 for cellosolve acetate.

Four of the 22 samples (on an individual basis) exceeded the TLV on an eight-hour time-weighted average (TWA) for the mixture (considering effects from each are additive) of all organic solvents.

There were twenty (20) short term and long term general area samples obtained during and after spray operations and analyzed for organic solvents. Results from these samples show potential exposures (if occupied) between bays 2 and 4 to be of significance, although somewhat less than the TLV-TWA for the mixture (considering effects from each are additive) of all organic solvents. Also, the levels of organic solvents near or around the plane after spray operations have ceased, although far less than during spray operations, would contribute to an employees overall exposure.

Summaries of estimated combined exposure to organic solvents on a TWA basis on short term samples and on long term samples are presented in Table VI-A and Table VI-B respectively. The results show that the exposures of right and left side painters, fin painters and the pot men were from 1.2 to 5.6 times (average 2.3 times) the appropriate occupational exposure limit for the mixture of organic solvents.

c. Discussion of Environmental Results

From the above review of the environmental levels, it is apparent that painters are potentially being exposed to excessive concentrations of organic solvents, HMDI and its biuret compound TICH-B. The survey simulated winter time conditions with the hangar door open approximately six feet. There was no study made as to the degree of protection afforded by the use of half-mask respirators from the airborne organic solvents and isocyanates detected in this study, although it is felt (see medical sections of report) that it does provide some degree of protection.

2. Medical Results and Discussions

a. Historic Data

Smoking history and past medical history (excluding experience with urethane paints) are tabulated in Tables VII and VIII-A respectively. The only significant difference was that almost the total paint crew were smokers or ex-smokers whereas 35% of the control group had never smoked.

Of the control group, nine (9) gave no history of exposure to urethane paint. Of the remaining 31, twenty-eight (28) received their exposure in the hangars and three (3) elsewhere. Seventeen (17) received exposures currently - 9 once or more weekly and 7 only occasionally (1 unspecified). Ten (10) are not currently exposed although four of them indicated frequent exposure at the time they were being exposed. Four (4) did not indicate whether their exposures were current or not. Of 14 indicating frequent past or current exposure (at least once weekly) 11 indicated it occurred during spraying operations and three indicated it was exposure to the residual fumes after

spraying operations (These latter three indicated it was a current exposure).

Table VII-B details exposures to respiratory irritants prior to coming to this job. None of the painters and five of the control group indicated they had had some medical problems from such exposures. Four involved the sinuses and one the skin.

In response to the non-directed question "Do you have any health problems which you believe are related to your work?", nine (53%) of the painters and 27 (68%) of the controls said "no". Seven (41%) painters and three (8%) controls complained about the urethane paint. One (6%) painter and 10 (25%) controls complained about a variety of other things.

Five painters mentioned eye irritation specifically and four painters mentioned pulmonary congestion as major symptoms. Other symptoms mentioned were: dizziness, fever, nasal irritation, throat irritation, cough and skin irritation.

One painter and 3 controls mentioned respiratory complaints which they did not feel were job related.

Table IX details job related symptomatology as obtained by direct questioning. The painters all complained of eye irritation from the urethane paint. About half complained of throat irritation, nasal irritation, cough and chest discomfort. About a third complained of shortness of breath. Of the non-painters with some exposure to urethane paint about one-fifth complained of eye irritation, throat irritation and cough due to the urethane paint. Nasal stuffiness and breathing problems were also mentioned by a few. Twenty percent of the control group complained about eye irritation from the hydraulic fluid, Skydrol, which sometimes leaked while the planes were being worked on. Since the spray painters do not have eye protection while spray painting, but are otherwise protected from the spray, it is not surprising that all should complain about eye irritation.

b. Physical Findings

Physical examination of the eyes, nose, throat, exposed skin and chest were performed during a shift when the workers were not spray painting. The painters and control group had about equal proportions of workers showing some redness, inflammation or increased vascularity of the mucous membranes of the eyes, nose or throat (46% for eyes, 39% for nose and 49% for throat). One control worker had an increased antero-posterior chest diameter, wheezing, rhonchi and clubbing of his fingers. Three other workers (1 painter and 2 controls) had rales or rhonchi on auscultation. Two smokers (1 painter and 1 control) could not perform the pulmonary function testing without coughing and two of the painters coughed on testing after exposure to spray painting.

c. Acute Symptomatology

Table X details the symptomatology as obtained on the pre-shift, post-shift and follow-up questionnaires. Due to the great variety of relationships to spray painting with urethane paint, each questionnaire was treated independently

of the others. Thus each painter accounted for 6 questionnaires and each control accounted for 3 questionnaires. Follow-up questionnaires were combined with pre-shift questionnaires as appropriate. The only group showing increased symptomatology at a statistically significant level were the workers who spray painted. Acute symptoms were: burning and tearing of the eyes, stuffy and runny nose, throat irritation and chest discomfort. Cough and shortness of breath also increased, but at a lower level (not reaching statistical significance). By the next day there was a statistically significant increase in wheezing and the stuffy nose persisted unabated. The burning of the eyes, irritated throat and chest discomfort had decreased but were still above normal levels. Cough and shortness of breath persisted at about the same levels.

d. Pulmonary Function Testing

Table XI-A details baseline pulmonary function for the painters and controls. The statistically significant difference in mean percent of predicted Forced Vital Capacity between painters and controls may well relate to the statistically significant difference in their smoking habits. It is of note that none of the painters were significantly low (less than 80% of predicted value). Of the two painters with abnormally low Maximum Midexpiratory Flows, one was a smoker and one an ex-smoker.

Table XI-B details the changes in percent of predicted over shift. As with the acute symptomatology, shifts have been grouped by the type of exposure, hence, the painters are entered twice. Three controls either did not have post-shift testing, or the post-shift testing was unsatisfactory and so are not included in this table. No statistically significant differences between groups were found in mean differences or in the number with abnormally great decreases in function over shift, nor could the changes be definitely related to any particular symptom complex. None of the workers with significant changes in pulmonary function showed any significant increase in eosinophile count.

e. Blood Work

Table XII-A shows normal blood values, and Table XII-B details the blood findings. These could not be related specifically to urethane paint. Both painters who finished the shift with elevated white blood cell counts gave a history of chronic bronchitis. Also the increase was not in their eosinophiles. The painter who showed an increased number of eosinophiles both pre- and post-shift gave a history of chronic bronchitis with the weather affecting his breathing. The only symptoms he related specifically to urethane painting on the shift tested involved his eyes. The painter whose eosinophiles rose to a significant level over the shift complained of irritation of his eyes and throat and a stuffy nose after spray painting on that shift, but these symptoms had cleared by the next day. The one non-painter with an elevated eosinophile count gave no history which would suggest the cause of this finding.

F. Recommendations

In view of the above detailed findings and the medical and environmental determination (refer to Section I of this report), the following recommendations are made to ameliorate existing or potential hazards, and to provide a better environment for the employees covered by this determination:

1. Immediate action should be taken to lower the air concentrations of organic solvents and isocyanates, and to lower the potential exposure to employees. This could be accomplished in part by the use of a different type of spray gun which would significantly reduce (factor of 5 or more) the amount of overspray, and/or downdraft or other types of ventilation which would also reduce the amount of airborne contaminants.

2. The respirator currently in use by employees does not appear to be adequate since it does not protect the entire face and has a limited capacity in removing organic vapors, and/or perhaps other contaminants. The preferred respiratory protection for this spray operation would be the Type C, continuous-flow, supplied air, positive-pressure, impervious hood.

3. We encourage the continuation of the current practice of confining spray painting operations to the graveyard shift and allowing only those personnel involved in the operations be allowed in the particular hangar area during spray operations.

4. Serious consideration should be given to providing a separate hangar (e.g., wet dock) with some modifications (e.g., downdraft ventilation, isolation, etc.) for airplane spray operations to confine the overspray.

5. The recommendations contained in Chapters I and VI of Criteria for a Recommended Standard . . . . Occupational Exposure to Toluene Diisocyanate[5] are applicable with some modification to airplane paint spraying operations using paint containing HMDI and the biuret compound of HMDI. Because of the considerably lower volatility of the HMDI the detailed directions for handling spills and clothing contamination do not seem appropriate. Although we do not advocate workers remaining in contact with HMDI, and do recommend that the clean up crew wear respiratory protection, it is unlikely that one would need respiratory protection during initial evacuation. Also environmental monitoring methods and frequency may need to be modified.

6. We suggest that Trans World Airlines conduct periodic environmental evlauations of employee exposures to organic solvents and isocyanates to assure that the extent of implementation of the above recommendations are adequate to protect the "affected employees".

V. REFERENCES

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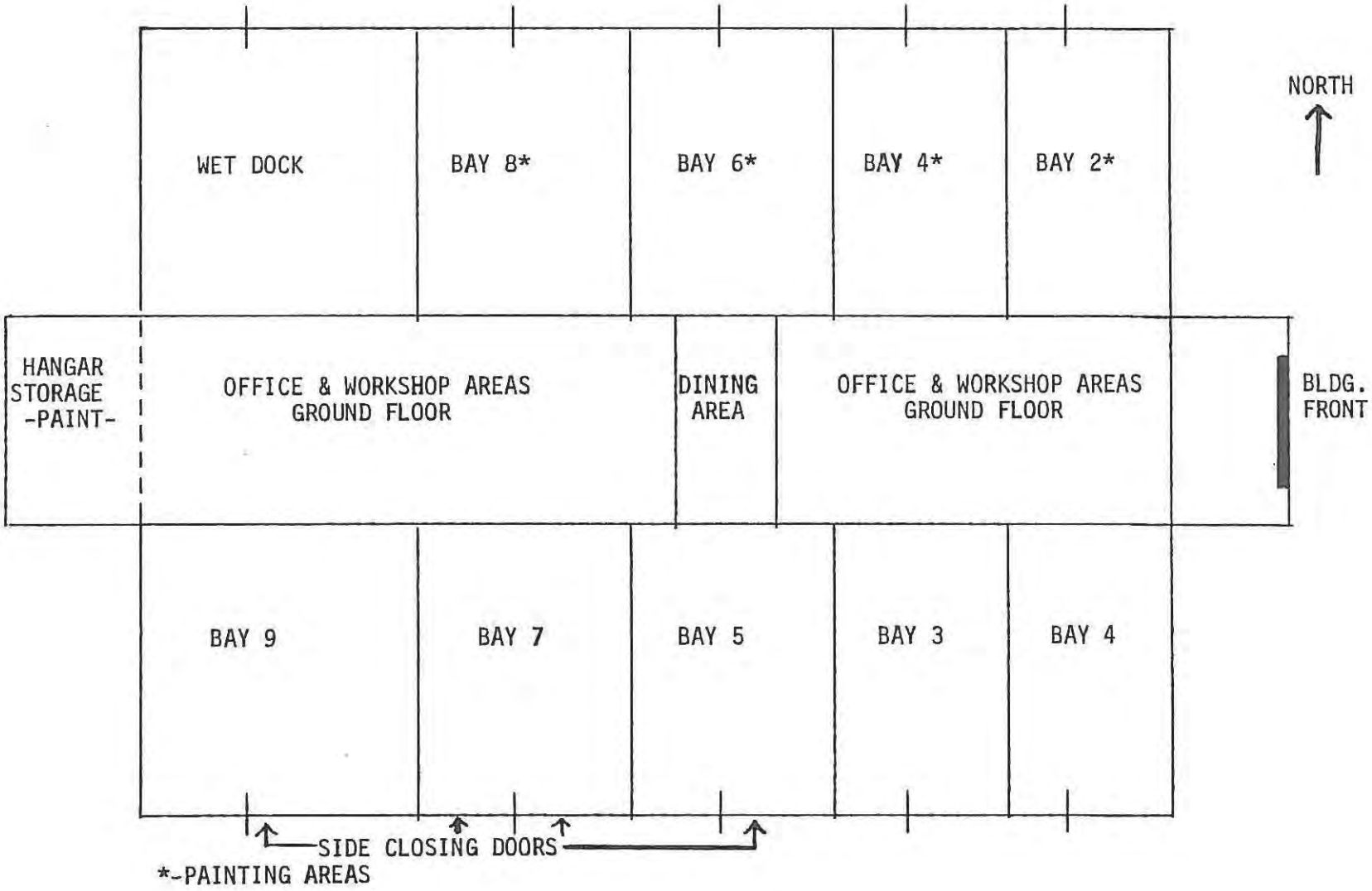
ATTACHMENT A

SCHEMATIC DIAGRAM OF FLOOR PLAN OF MAIN HANGAR AREA - GROUND FLOOR



ATTACHMENT B

Schematic of General Area
Sampling Locations 1, 2, 3, + 4

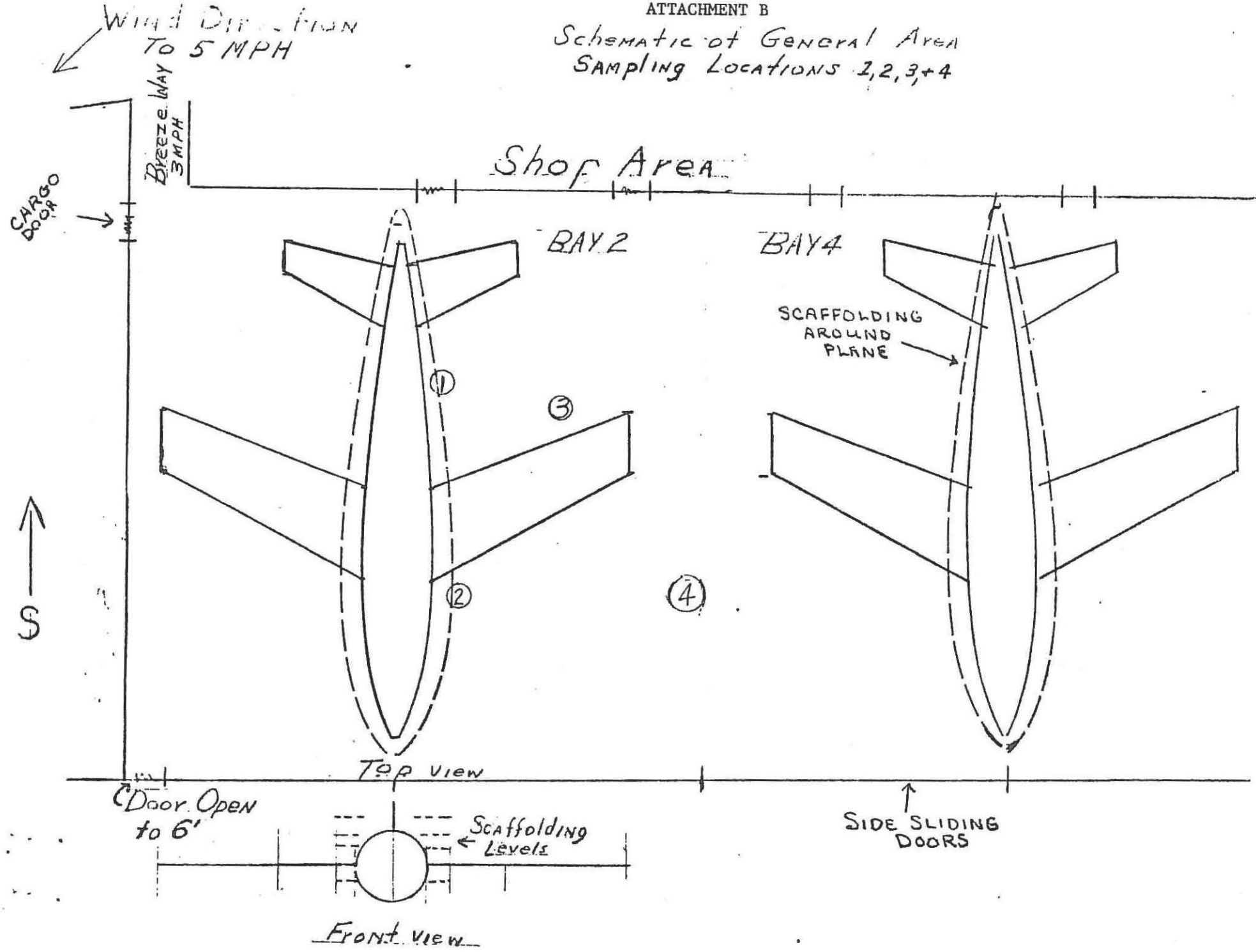


TABLE I

SUMMARY OF ENVIRONMENTAL RESULTS FOR TOLUENE DIISOCYANATE (TDI), HEXAMETHYLENE DIISOCYANATE (HMDI) AND THE BIURET COMPOUND OF HMDI OR TRI-MOLECULAR STRUCTURE 1, 3, 5 TRIS (6-ISOCYANATOHEXYL) BIURET (TICH-B) DURING PAINT SPRAY OPERATIONS (I-INTERMEDIATE COAT) AT TRANS WORLD AIRLINES OVERHAUL BASE

(All sample results expressed as milligrams of compound per cubic meter of air sampled-mg/M^3)

Sample No.	Time (A.M.)	Operation or Location	Resulting Concentrations-mg/M^3 TDI	HMDI	TICH-B
I-01	1:47-2:11	LM	< 0.03	<0.03	0.3
I-03	1:46-2:05	TP	0.04	<0.10	0.5
I-02	1:45-2:08	RSP	<0.03	0.07	2.0
I-04	1:45-2:13	LSP	<0.03	0.10	2.0
I-05	1:46-2:01	FP	<0.05	0.10	2.0
I-17	1:22-2:09	PM	<0.02	<0.04	0.3
I-12	1:51-2:58	GA#4	0.01	<0.01	0.2
I-13	2:20-3:05	GA#2	0.02	<0.02	0.1

Abbreviations:
LM - Leadman
TP - Top Painter
RSP - Right Side Painter
LSP - Left Side Painter
FP - Fin Painter
PM - Pot Man
GA#1 - General Area, Scaffold by Fin
GA#2 - General Area, Scaffold by Wing
GA#3 - General Area, Floor by Pot Mixing
GA#4 - General Area, Floor Between Hangar 2 & 4

NOTES: The NIOSH suggested health limits for TDI are .036 mg/M^3 for an eight hour time weighted average (TWA) and .14 mg/M^3 for a 20 minute excursion limit.

There are no current suggested limits for HMDI and TICH-B; although the monomer HMDI is considered as more toxic than TICH-B.

Intermediate paint spray operations occurred from approximately 1:50 to 2:50 a.m.

TABLE II

SUMMARY OF ENVIRONMENTAL RESULTS FOR TOLUENE DIISOCYANATE (TDI), HEXAMETHYLENE DIISOCYANATE (HMDI) AND THE BIURET COMPOUND OF HMDI OR TRI-MOLECULAR STRUCTURE 1, 3, 5 TRIS (6-ISOCYANATOHEXYL) BIURET (TICH-B) DURING PAINT SPRAY OPERATIONS (F-FINAL COAT) AT TRANS WORLD AIRLINES OVERHAUL BASE

(All sample results expressed as milligrams of compound per cubic meter of air sampled-mg/M^3)

Sample No.	Time (A.M.)	Operation or Location	Resulting Concentrations-mg/M^3 TDI	HMDI	TICH-B
F-29	4:30-5:12	LM	<0.02	0.10	1.0
F-26	4:32-4:58	TP	<0.03	0.04	2.0
F-30	4:32-5:10	RSP	<0.02	0.20	7.0
F-28	4:32-5:09	LSP	0.02	0.20	7.0
F-27	4:32-4:59	FP	< 0.03	0.30	10.0
F-35	4:00-4:45	PM	0.02	0.04	1.0
F-38	4:47-5:10	PM	< 0.03	0.20	4.0
F-33	4:35-5:26	GA#3	0.02	0.30	4.0
F-36	4:37-5:22	GA#4	0.02	< 0.02	0.3
F-31	5:13-5:43	GA#1	< 0.03	0.10	0.4
F-32	5:10-5:45	GA#2	< 0.02	0.06	0.4
F-45	5:44-6:10	GA#1	< 0.03	0.04	0.4
F-34	5:46-6:10	GA#2	< 0.03	< 0.03	< 0.1
F-39	5:29-6:15	GA#3	0.02	< 0.02	< 0.1
F-37	5:23-6:15	GA#4	< 0.02	< 0.02	0.1

Abbreviations:
LM - Leadman
TP - Top Painter
RSP - Right Side Painter
LSP - Left Side Painter
FP - Fin Painter
PM - Pot Man
GA#1 - General Area, Scaffold by Fin
GA#2 - General Area, Scaffold by Wing
GA#3 - General Area, Floor by Pot Mixing
GA#4 - General Area, Floor Between Hangar 2 & 4

NOTES: The NIOSH suggested health limits for TDI are .036 mg/M^3 for an eight hour time weighted average (TWA) and .14 mg/M^3 for a 20 minute excursion limit. There are no current suggested limits for HMDI and TICH-B; although the monomer HMDI is considered as more toxic than TICH-B. Final spray operations occurred from approximately 4:35 to 5:15 A.M.

TABLE III

ESTIMATED 8 HOUR TIME WEIGHTED AVERAGE (TWA) FOR HEXAMETHYLENE DIISOCYANATE (HMDI) AND THE BIURET COMPOUND OF HMDI OR TRI-MOLECULAR STRUCTURE TRIS (6-ISOCYANATOHEXYL) BIURET (TICH-B) DURING PAINT SPRAY OPERATIONS AT TRANS WORLD AIRLINES OVERHAUL BASE

(mg/M^3 - milligrams of compound per cubic meter of air)

Job Classification	Estimated TWA - mg/M^3 HMDI	TICH-B
Lead Man	.01	.1
Top Painter	< .01	.1
Right Side Painter	.02	.7
Left Side Painter	.02	.7
Fin Painter	.02	.6
Pot Man	.01	.3

NOTE: There are no current suggested limits for HMDI and TICH-B; although the monomer HMDI is considered more toxic than TICH-B. The above results are strictly estimated TWA's based on short term samples from Tables I and II.

TABLE IV - SUMMARY OF ENVIRONMENTAL RESULTS FOR ORGANIC SOLVENTS* FROM SHORT TERM CHARCOAL TUBE SAMPLES OBTAINED DURING PAINT SPRAY OPERATIONS (I-INTERMEDIATE COAT AND F-FINAL COAT) AT TRANS WORLD AIRLINES OVERHAUL BASE. (Note: Any operation sample was in breathing zone of operator - e.g. FP in breathing zone of fin painter, and any general area sample was in general location specified by number - GA#1-General Area on Scaffold by Fin.)

SAMPLE RESULTS EXPRESSED AS MILLIGRAMS OF COMPOUND PER CUBIC METER OF AIR SAMPLES-mg/M^3 (ND - None Detected)

Sample No.	Time (A.M.)	Operation or Location	1-EA	2-MEK	3-T	4-BA	5-N	6-X	7-CA	8-MC	Combined Exposure - Weighing Based on One Sample (TWA)
I-65	1:46-2:01	FP	770	2290	970	60	50	250	3070	ND	.42
I-57	1:49-2:09	RSP	1020	2450	1230	120	90	270	3540	ND	.65
I-77	1:45-2:13	LSP	700	1870	970	90	80	230	3460	ND	.78
I-62	1:45-2:09	TP	160	340	290	20	20	60	670	ND	.15
I-1	1:23-2:14	PM	460	1440	470	20	ND	140	1350	ND	.73
I-22	2:14-2:40	PM	1780	3250	1130	120	80	250	25170	2830	3.30
I-11	1:50-2:17	GA1	1330	4380	1600	130	140	380	6820	ND	1.50
I-4	2:16-3:26	GA2	60	160	180	10	ND	30	760	ND	.33
I-8	1:56-2:48	GA3	50	150	120	10	ND	2870	400	ND	.86
I-9	1:50-3:10	GA4	110	310	1060	20	ND	50	850	ND	.85
F-55	4:32-5:01	FP	2120	950	410	70	120	410	4840	ND	.87
F-66	4:32-5:09	RSP	3520	1990	510	150	80	1330	8360	ND	2.01
F-70	4:32-5:08	LSP	1610	760	270	50	10	340	3310	ND	.76
F-54	4:34-4:57	TP	750	240	140	20	ND	160	1360	ND	.20
F-19	4:00-4:46	PM	380	590	270	10	ND	110	790	2180	.64
F-20	4:47-5:25	PM	1500	1060	330	40	ND	260	2190	2840	.98
F-23	5:45-6:10	GA1	140	70	70	ND	ND	30	490	ND	.07
F-16	4:35-5:10	GA1	850	450	150	30	80	170	2300	ND	.48
F-28	5:10-5:47	GA2	10	ND	10	ND	ND	ND	60	ND	.01
F-26	5:48-6:10	GA2	ND	ND	30	ND	ND	ND	80	ND	.01
F-13	4:36-5:19	GA3	1420	690	590	50	30	ND	2790	ND	.81
F-30	5:20-6:15	GA3	110	20	160	10	ND	40	650	210	.24
F-12	4:37-5:20	GA4	100	30	40	ND	ND	20	150	ND	.05
F-27	5:21-6:15	GA4	60	10	130	ND	10	30	250	ND	.10

* ACGIH Standards for 8 hour Time Weighted Average (TLV) for Organic Solvents (ppm-Parts of vapor or gas per million parts of contaminated air by volume; mg/M^3 - See Below)

	ppm	mg/M^3		ppm	mg/M^3		ppm	mg/M^3
1-EA/Ethyl Acetate	400	1400	4-BA/Butyl Acetate	150	710	7-CA/Cellosolve Acetate	100	540
2-MEK/Methyl Ethyl Ketone	200	590	5-N/Naphtha	100	400	8-MC/Methylene Chloride	200	720
3-T/Toluene	100	375	6-X/Xylene	100	435	Combined Exposure - Weighing-1.0 or more		

EXCURSION FACTORS: For all above substances, the Excursion Factor is governed by the following Excursion Factors which are dependent upon conformity with th Time Weighted Average TLV: TLV 10ppm-100ppm 1.5 The number of times the excursion above the TLV is permitted, is governed by conformity with the TLV 100ppm-1000ppm 1.25 Time Weighted Average TLV.

**Note as follows:

TP-Top Painter
RSP-Right Side Painter
LSP-Left Side Painter
FP-Fin Painter
PM-Pot Man
GA#1-General Area, Scaffold by Fin
GA#2-General Area, Scaffold by Wing
GA#3-General Area, Floor by Pot Mixing
GA#4-General Area, Floor between Hangar 2 and 4

TABLE V - SUMMARY OF ENVIRONMENTAL RESULTS FOR ORGANIC SOLVENTS* FROM LONG TERM CHARCOAL TUBE SAMPLES OBTAINED DURING PAINT SPRAY OPERATIONS (I-INTERMEDIATE COAT AND F-FINAL COAT) AT TRANS WORLD AIRLINES OVERHAUL BASE.

(Note: Any operation sample was in breathing zone of operator, e.g. FP** - in breathing zone of fin painter, and any general area sample was in general location specified by number - GA#1-Scaffold by fin.)

SAMPLE RESULTS EXPRESSED AS MILLIGRAMS OF COMPOUND PER CUBIC METER OF AIR SAMPLES-mg/M^3. (ND - None Detected)

Sample No.	Time (A.M.)	Operation or Location	1-EA	2-MEK	3-T	4-BA	5-N	6-X	7-CA	8-MC	Combined Exposure - Weighing Based on One Sample (TWA)
I-63	12:15-3:15	TP	20	60	220	ND	ND	10	70	ND	.32
I-50	12:15-3:10	RSP	10	20	60	ND	10	10	140	ND	.18
I-75	12:15-3:24	LSP	110	410	450	10	160	40	540	ND	1.36
I-64	12:15-3:08	FP	90	260	190	10	20	30	480	ND	.73
I-2	12:31-2:30	PM	150	250	200	10	ND	50	300	240	.52
I-3	2:20-3:36	GA1	60	180	130	10	60	ND	1510	ND	.57
I-6	12:45-3:41	GA2	40	30	90	10	ND	20	310	ND	.34
I-7	12:30-2:50	GA3	40	100	140	ND	ND	20	240	ND	.30
I-10	12:54-3:12	GA4	40	100	260	10	ND	20	280	ND	.41
F-52	3:17-5:38	TP	100	40	30	ND	ND	30	240	ND	.21
F-69	3:12-5:32	RSP	1100	440	200	50	ND	270	2490	ND	2.14
F-59	3:28-5:39	LSP	390	130	90	20	10	100	940	50	.77
F-56	3:10-5:36	FP	470	220	100	10	ND	110	960	ND	.91
F-35	3:56-5:25	PM	200	140	80	ND	ND	40	340	760	.43
F-34	3:46-6:10	GA1	290	140	60	10	10	80	1460	ND	1.05
F-33	3:33-6:10	GA2	ND	30	10	ND	ND	10	120	ND	.10
F-31	2:52-6:15	GA3	350	160	120	10	ND	70	960	200	1.31
F-32	3:13-6:15	GA4	20	10	20	ND	ND	10	110	ND	.11

* ACGIH Standards for 8 hour Time Weighted Average (TLV) for Organic Solvents (ppm-Parts of vapor or gas per million parts of contaminated air by volume; mg/M^3 - See Below)

	ppm	mg/M^3		ppm	mg/M^3		ppm	mg/M^3
1-EA/Ethyl Acetate	400	1400	4-BA/Butyl Acetate	150	710	7-CA/Cellosolve Acetate	100	540
2-MEK/Methyl Ethyl Ketone	200	590	5-N/Naphtha	100	400	8-MC/Methylene Chloride	200	720
3-T/Toluene	100	375	6-X/Xylene	100	435	Combined Exposure -Weighing-1.0 or more		

EXCURSION FACTORS

For all above substances, the Excursion Factor is governed by the following Excursion Factors which are dependent upon conformity with the Time Weighted Average TLV : TLV 10ppm - 100ppm 1.5 The number of times the excursion above the TLV is permitted, is governed by conformity with the TLV 100ppm - 1000ppm 1.25 Time Weighted Average TLV.

**Note as follows:

TP-Top Painter
RSP-Right Side Painter
LSP-Left Side Painter
FP-Fin Painter
PM-Pot Man
GA#1-General Area, Scaffold by Fin
GA#2-General Area, Scaffold by Wing
GA#3-General Area, Floor by Pot Mixing
GA#4-General Area, Floor between Hangar 2 and 4

TABLE VI A - SUMMARY OF ESTIMATED COMBINED EXPOSURE FROM ALL ORGANIC SOLVENTS - TIME WEIGHTED AVERAGE - BASED ON SHORT TERM SAMPLES. (ACGIH OR FEDERAL HEALTH STANDARD - 1.0)

Operation or Location	Estimated Combined Exposure
Top Painter	.34
Right Side Painter	2.66
Left Side Painter	1.54
Fin Painter	1.29
Pot Man	5.65 (This would be 2.35 if the one sample of 3.3 was deleted from others.)
General Area#1-Scaffold Fin	2.07
General Area#2-Scaffold Wing	.59
General Area#3-Floor Pot Mix	1.91
General Area#4-Between Bays 2-4	1.00

TABLE VI B - SUMMARY OF ESTIMATED COMBINED EXPOSURE FROM ALL ORGANIC SOLVENTS - TIME WEIGHTED AVERAGE - BASED ON LONG TERM SAMPLES. (ACGIH OR FEDERAL HEALTH STANDARD - 1.0)

Operation or Location	Estimated Combined Exposure
Top Painter	.53
Right Side Painter	2.32
Left Side Painter	2.13
Fin Painter	1.64
Pot Man	.95
General Area#1-Scaffold Fin	1.62
General Area#2-Scaffold Wing	.44
General Area#3-Floor Pot Mix	1.61
General Area#4-Between Bays 2-4	.52

TABLE VII

SMOKING HABITS

	PAINTERS	CONTROLS
Non-Smokers	1	14
Ex-Smokers	6	8
Avarage Pack-Years	17.2	21.2
95% Confidence Limits	± 10.1	± 7.2
Range	1 - 37	9 - 42
Average Age of Starting	20.3	17.2
95% Confidence Limits	± 5.9	± 2.2
Range	9 - 31	13 - 21
Average Age of Quitting	39.7	35.2
95% Confidence Limits	± 7.5	± 5.9
Range	25 - 51	21 - 45
Current Smokers	10	18
Average Packs/Day	1.2	1.1
95% Confidence Limits	± 0.4	± 0.2
Range	0.0 - 2.1	0.5 - 2.0
Average Pack-Years	26.7	21.5
95% Confidence Limits	± 9.8	± 5.3
Range	8 - 64	5 - 40
Average Age of Starting	17.7	19.2
95% Confidence Limits	± 1.5	± 1.3
Range	15 - 23	15 - 25

The difference in numbers of non-smokers is statistically significant (Chi probability 0.049) when compared to current smokers and ex-smokers together.

TABLE VIII A

PAST HISTORY - PERCENT REPORTING VARIOUS CONDITIONS

Condition	PAINTERS (n=17)	CONTROLS (n=40)
General Health		
Good	82	87(n=38)
Fair	18	13(n=38)
Poor	0	0
Allergies Prior to Coming to the Plant		
Hay Fever, Pollen, Dust or Sinus	24	15(n=39)
Asthma	0	0
Chemicals	0	0
Skin	6	5(n=39)
Allergies Developing Since Coming to the Plant		
Hay Fever, Pollen, Dust or Sinus	6	13(n=39)
Asthma	6	2
Chemicals	18	5
Skin	24	10(n=39)
Chronic Nasal Discharge	29	32
Winter Only	6	15
Chronic Cough With Phlegm Production	35	18
Chest Illness With Phlegm Production	6	10
Acute Bronchitis	6	10
Pneumonia	29	28
Pleurisy	6	10
Weather Bothers Breathing	18	18
Other Respiratory Irritants Bother Breathing	18	15
Wheezing	29	13(n=39)
Occasional	12	8
Frequent	18	5
Breathlessness on Walking	53	25
Slight	35	25
Moderate to Severe	18	0
Emphysema	0	5

No statistically significant differences present.

TABLE VIII B

PAST HISTORY - EXPOSURE TO RESPIRATORY IRRITANTS
PRIOR TO COMING TO THIS PLANT

	PAINTERS (n=17)	CONTROLS (n=40)
No Prior Exposure	6	25
History of Prior Exposure to Respiratory Irritants	11	15
Dusts Only	1	6
Dust and Fumes or Vapors	4	1
Urethane Paints	1	0
Other Paints	4	6
Other Fumes or Vapors Only	2	8
History of Medical Problems Arrising From the Exposure	0	5
Sinus Problems		4
Dermatitis		1

TABLE IX

HISTORY OF JOB RELATED SYMPTOMATOLOGY ON DIRECT QUESTIONING

Cause	CURRENT STUDY						DR. COHEN'S STUDY	
	3rd Shift Painters (n=17)		Controls (n=40)				Painters (n=28)	Others With Incidental Exposure (n=26)
Specific Complaints	Urethane Paint	Other	Urethane Paint	Skydrol	Solvents	Other	Urethane Paint	Urethane Paint
	%	%	%	%	%	%	%	%
Throat Irritation	47	12	15 (19)	0	0	8	39	23
Burning Eyes	100	0	15 (19)	20	12	10	93	19
Tearing Eyes	76	0	12 (16)	15	12	10		
Stuffy Nose	41	0	8 (10)	5	0	2	29	19
Runny Nose	41	0	0 (0)	8	2	2		
Cough	44(n=16)	0	18 (23)	5	2	8	29	15
Chest Discomfort or Tightness	47	0	5 (6)	2	2	0	18	8
Wheezing	12	0	2 (3)	0	0	0	21	8
Shortness of Breath	35	0	5 (6)	0	0	2	-	-

The third shift painters mentioned throat irritation and burning or tearing eyes as a usual symptom of exposure. On the other symptoms about half identified them as a usual symptom and the other half as a symptom occurring only sometimes on exposure. The stuffy nose and wheezing usually lasted a long time. The chest discomfort and shortness of breath also usually lasted a long time when they were reported as a usual symptom of exposure but not when they only occurred sometimes.

Percentages in parenthases are calculated on the basis of the 31 controls who have had exposure to urethane paint.

TABLE X

ACUTE SYMPTOMATOLOGY BY RELATION TO URETHANE SPRAY PAINTING
(% of those interviewed showing the symptom)

Relation of Interview to Work Shift & Urethane Spray Painting / Symptoms	THROAT IRRITATION	BURNING OF EYES	TEARING OF EYES	STUFFY NOSE	RUNNY NOSE	COUGH	CHEST DISCOMFORT	WHEEZING	SHORTNESS OF BREATH
Pre-Shift, No recent exposure to urethane paint n=102	4	6	6	16	10 (n=101)	15	8	4	8
Post-Shift, No exposure to urethane paint n=38	8	13	11	16	13	21	13	3	3
Post-Shift, Sprayed urethane paint n=11	45	100	82	45	36	36	45	9	27
Probability of Chance Occurrence	.001	.001	.001	.040	.045		.002		
Post-Shift, Incidental exposure to urethane paint n=13	8	15	0	23	0	8	0	0	0
Post-Shift, Exposure to residual from urethane paint spray n=12	0	8	0	0	0	0	0	0	0
Pre-Shift, Sprayed urethane paint previous day n=21	19	24	10	48	14	33	29	19	24
Probability of Chance Occurrence	.043	.030		.003			.020	.043	
Pre-Shift, Incidental exposure to urethane paint previous day n=13	0	0	0	8	0	8	0	0	0
Pre-Shift, Exposure to residual from urethane paint spray previous day n=12	8	0	0	0	0	8	0	0	0

TABLE XI A

PULMONARY FUNCTION TESTS - BASELINES

(Based on best value recorded)

	FVC	FEV_1	$FEF_{.2-1.2}$	MMF_{25-75}
Actual Values (liters or liters/sec.)				
Controls (n=40)				
Mean	4.87	3.76	7.2	3.6
Range	3.1-6.8	1.5-5.3	2.0-12.5	0.4-5.5
Painters (n=17)				
Mean	4.43	3.61	7.8	3.7
Range	3.4-5.6	2.5-4.6	5.0-11.0	1.6-7.5
% of Predicted Values				
Controls (n=40)				
Mean	101.0	102.0	98.0	96.7
95% Confidence Limits	+4.1	+5.2	+8.8	±10.4
Range	76-123	55-135	32-175	14-152
Number Abnormally Low	2	3	6	7
Painters (n=17)				
Mean	93.1	99.5	107.3	95.5
95% Confidence Limits	+4.4	+6.0	+9.8	±15.6
Range	80-117	85-125	73-152	50-166
Number Abnormally Low	0	0	0	2
Probability of chance variation	0.029	*	*	*

*Not statistically significant

TABLE XI B

PULMONARY FUNCTION TESTS, CHANGE IN PERCENT OF PREDICTED OVER SHIFT
(Post-Shift - Pre-Shift)

	FVC	FEV_1	$FEF_{.2-1.2}$	MMF_{25-75}
No Exposure to Urethane Paint(n=25)				
Mean Difference	0.0	- 4.0	- 4.0	- 0.6
95% Confidence Limits	± 2.6	± 3.3	± 7.5	± 7.5
Range	- 7/+22	-26/+16	-37/+48	-45/+35
Number with Abnormally Decreased Function	0	3	Both Down 3	
Sprayed Urethane Paint Previous Day(n=10)				
Mean Difference	- 0.4	- 5.4	- 3.5	0.7
95% Confidence Limits	± 1.7	± 5.7	± 9.8	± 10.2
Range	- 4/+ 6	-23/+ 5	-30/+15	-33/+22
Number with Abnormally Decreaced Function	0	2	Both Down 2	
Exposure to Residual from Spraying on Shift Immediately Prior to Tested Shift (n=12)				
Mean Difference	0.6	- 6.3	- 5.3	1.7
95% Confidence Limits	± 3.7	±10.3	±19.3	± 13.9
Range	-10/+ 7	-52/+ 9	-61/+54	-53/+40
Number with Abnormally Decreased Function	0	3	Both Down 2	
Incidental Exposure During Spray Painting (n=13)				
Mean Difference	2.4	- 1.5	0.6	1.6
95% Confidence Limits	± 2.7	± 14.0	± 16.5	± 13.8
Range	- 5/+10	-78/+29	-44/+62	-47/+30
Number with Abnormally Decreased Function	0	2	Both Down 4	
Exposed While Spray Painting(n=11)				
Mean Difference	0.6	1.2	- 4.9	- 4.3
95% Confidence Limits	± 2.1	± 5.2	± 5.9	± 10.3
Range	- 7/+ 5	- 8/+23	-20/+ 9	-33/+34
Number with Abnormally Decreased Function	0	0	Both Down 2	

TABLE XII A

NORMAL BLOOD VALUES

TEST	NORMAL RANGE	UNITS	ADDITIONAL CRITERIA USED IN THIS STUDY AND NOTES
Hemoglobin (HGB)	Males 13.5 - 18.0 Females 12.0 - 16.0	g/dl	
Hematocrit (HCT)	Male 40 - 54 Females 38 - 47	%	
White Blood Count (Total Leukocyte Count)	4,500 - 11,000	cells/mm^3	Increase greater than 5,000 over shift considered abnormal
Polymorphonuclear Leukocytes (Polys)	1,800 - 7,700	cells/mm^3	Calculated by: % polys x WBC
Lymphocytes (Lymphs)	1,000 - 4,800	cells/mm^3	Calculated by: % lymphs x WBC
Eosinophiles (Eos)	0 - 450	cells/mm^3	Calculated by: % eos x WBC if not done directly

TABLE XII B - Blood Findings of Workers	HGB	HCT	WBC (x1000)	% POLYS	% LYMPS	TOTAL EOS
Normals	---	---	4.5-11.0	%xWBC=1.8-7.7	%xWBC=1.0-4.8	0-450
Males	13.6-18.0	40-54				
Females	12.0-16.0	38-47				
Controls - Pre-Shift						
Mean (n=25)	15.0	42.5 (n=24)	7.4	66	30	---
95% Confidence Limits	±0.5	±3.7	±0.7	± 3	± 3	
Range	11.9-17.6	35.9-50.2	5.4-11.9	55-78	16-42	
Number Low	1	1	0	0	0	
Number High	0	0	2	2	0	
Controls - Post-Shift						
Mean (n=15)	14.9	42.4	7.5	57	40	---
95% Confidence Limits	±0.5	±1.0	± 0.8	± 5	±5	
Range	13.8-16.3	39.9-46.0	5.0-9.6	35-69	29-62	
Number Low	0	1	0	0	0	
Number High	0	0	0	0	0	1 (528)
Painters - Pre-Shift						
Mean (n=17)	14.8	43.5	7.7	61	36	241
95% Confidence Limits	±0.4	±1.1	±1.0	± 4	±4	±62
Range	13.5-16.5	39.4-47.0	4.4-10.5	51-74	23-47	53-458
Number Low	0	1	1	0	0	0
Number High	0	0	0	0	1	1
Painters - Post-Shift						
Mean (n=17)	14.4	42.5 (n=16)	8.0	62	34	274
95% Confidence Limits	±0.4	±1.1	±1.5	± 4	±4	±87
Range	13.1-15.9	38.6-46.2	4.0-15.6	47-76	22-48	88-651
Number Low	3	2	1	0	0	0
Number High	0	0	2	1	1	2
Painters - Difference Over Shift						
Range	-0.8-+0.2	-2.8-+0.7	-1.8-+5.1	-14-+15	-15-+15	-211-+246
Number With a Significant Change	--	--	1	--	--	--