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LIVER FUNCTION AMONG NEOPRENE PRODUCTION WORKERS

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Liver function was tested in neoprene (9010984) production workers. Blood samples from 81 workers at the Denka Chemical Company (SIC-2822) in Houston, Texas were analyzed for various proteins and enzymes related to liver function. Information also was obtained on other medical problems of the workers. Increases in serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase, gamma glutamyl transpeptidase, and alkaline phosphatase were significantly related to reported alcohol consumption. This precluded evaluation of exposure related effects. However, some trend toward increased values was found among workers in high exposure areas. Other exposure effects included reproductive difficulties, respiratory problems, cardiac disorders, and central nervous system symptoms. The authors suggest that chemical exposures related to neoprene production cause liver function disturbances, and that exposed workers who drink alcohol may be at an even greater risk. They recommended a more comprehensive evaluation of these workers and of the health effects of neoprene exposure.

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LIVER FUNCTION AMONG NEOPRENE PRODUCTION WORKERS

I. Introduction

Chloroprene (2 chloro-1,3 butadiene, CAS# 126-99-8) is a colorless flamable liquid with a boiling point of 59.4°C which is soluble in most organic solvents. It is currently produced in the United States by the chlorination of butadiene to form a mixture of dichlorobutene isomers. The 3,4 dichloro-1-butene isomer (3,4,1 DCB) is isolated and reacted with caustic soda to produce chloroprene. The 1,4 dichloro-2-butene isomer can be isomerized to 3,4,1-DCB to produce additional chloroprene. Chloroprene is polymerized to produce polychloroprene the polymer from which butyl rubber is made. (IARC, 1979).

The Denka Workman's Group of Oil Chemical and Atomic Worker's Union (O.C.A.W.) Local 4-227, Houston, Texas numbers approximately 225 individuals. They are employed at a Denka Chemical Corporation plant in Houston which manufactures chloroprene and polychloroprene. This report is the result of a survey of serum liver enzyme and bilirubin levels as well as blood coagulation characteristics in 81 individuals from this group.

The study was undertaken for several reasons. First, chloroprene has been reported to produce several toxic effects in animals

including liver damage (IARC, 1979, Jaeger et al, 1975). Results of liver function evaluation in human populations have been inconsistant. Studies conducted in the Soviet Union and reviewed by the International Agency for Research on Cancer (IARC) indicate an association between abnormal liver enzyme levels and chloroprene exposure (IARC, 1979). Recent studies of Neoprene manufacturing facilities of Dupont Chemical Corporation failed to demonstrate any effects on liver function related to chloroprene and neoprene manufacturing (Gooch and Hawn, 1981).

Concern among individuals in this workman's group about possible adverse health effects resulting from chemical exposures in their workplace was an additional impetus to make this study. The perception, on the part of workers, that company sponsored liver function tests indicated an usually high proportion of abnormal results was probably a primary reason for their concern.

The primary objective of the survey was to screen the population to identify individuals with clinically significant abnormalities in liver enzymes, bilirubin or blood coagulation. The tests were requested by OCAW medical consultant Sharon Itaya, M.D. Once identified, individuals with abnormbal values could be referred to their personal physicians for appropriate follow-up. An additional objective of the study was to evaluate the results for the population as a whole to determine whether significant deviation from normal test values existed which could be related to occupational exposure. Because of the screening nature of the study the results obtained were

compared to the normal range of values for each test rather than to a specific control group.

II. Methods

A. Sampling Procedures

A sampling station was established at the Union Local Hall on July 13, 14, 22, and 29, 1981. Individuals came for sampling on their way to or from work. A brief questionaire was administered to determine the immediate (past 48 hr) and recent (past 2 weeks) work locations of each person within the plant. In addition information was collected on alcohol consumption in the previous 24 hours and on customary weekly consumption of alcoholic beverages. The individuals were asked to abstain from consumption of alcohol for 24 hours prior to testing. Information was also sought on recent use of medications, recent illness and history of hepatitis.

Blood samples were drawn by venipuncture into 4.5 ml draw vacutainers containing 0.5 ml 3.8% Na Citrate for prothombin time and into 10 ml draw serum separator tube (SST) vacutainers without anticoagulant for the remaining tests. The citrated blood samples were immediately stored in an ice chest. The SST vacutainers were allowed to clot for 15-30 minutes at room temperature in the dark. They were centrifuged to separate cells from serum and stored on ice. The separation plug in the tube prevented any mixing of hemolysis products with serum. All samples were transported on ice to the University of Texas Medical Branch (U.T.M.B.) Clinical Laboratories in Galveston, Texas within 2-8 hours of collection and they were analyzed

upon receipt.

B. Analytical Methods

The following analyses were performed on the samples obtained: serum glutamate-oxaloacetate transaminase (SGOT); serum glutamate-pyruvate transaminase (SGPT), gamma glutamyl transpetidase (GGT), alkaline phosphatase (AP), cholinesterase (pseudocholinestrase) (ChE), bilirubin total (BRT), bilirubin direct (BRD) and prothrombin time (PROT). All tests were run by the UTMB Clinical Laboratories. They are all run routinely on a daily basis by the Clinical Laboratories using standard methods involving commercially prepared standardized reagents. The principle and basic procedure for each test is described below. Literature on the details of each procedure provided by reagent manufactures is contained in the Appendix.

1. Serum Glutamate-Oxaloacetate Transaminase: SGOT catalyzes the transfer of an amino group from aspartic acid to α-ketoglutaric acid producing glutamic acid and oxaloacetic acid. The amount of activity is determined by reducing the oxaloacetic acid formed to malic acid simultaneously oxidizing $NADH_2$ to NAD. The rate of disappearance of $NADH_2$ is monitored spetrophotometrically at 340 nm over a specified time interval. The assay is routinely conducted using a standard reagent kit (Spin Chem SGOT reagent, Smith Kline Instruments) and is performed on an automated analyzer (Abbott VP). Details of the assay procedure are as described in the reagent package (Smith Kline Instruments, 1975 see Appendix). Values obtained are expressed in

international units (IU) according to the formula:

$$IU = \frac{\Delta A}{T} \times \frac{TV}{SV} \times \frac{1}{10^{-6}\varepsilon} \times 1000$$

where:

ΔA= absorbance change between readings

T= elapsed time between readings

SV= sample volume in ml

TV= total reaction volume in ml (sample and reagent and diluent or flush if used)

ε = molar absorptivity of NADH at 340 nm = 6.22×10^6 cm^2 /mole

Expected values were established by the manufacturer using 53 samples from normal blood donors (27 male, 23 female ages 18-57). The frequency distribution of results was approximately log gausian. Rank analysis produced a 2 standard deviation spread of 7-22 IU and the manufacturer recommends use of a "normal range" from 7-24 IU/L. UTMB Clinical Laboratories routinely validate their procedures by evaluating normal populations to see if their results are consistant with expected ranges. The UTMB procedures are currently valid and a normal range of 10-30 IU is recommended.

2. Serum Glutamate-Pyruvate Transaminase: SGPT catalyzes the transfer of an amino group from analine to a α-ketoglutarate producing glutamate and pyruvate. The rate of reaction is proportional to the amount of enzyme activity in the sample. Activity

is quantitated by the reduction of pyruvate to lactate by lactate dehydrogenase using $NADH_2$ as the electron donor. The rate of reaction is measured by following the rate of disappearance of $NADH_2$ spectrophotometrically over a specified time period. The assay is routinely conducted using a standard reagent kit (Spin Chem SGPT reagent, Smith Kline Instruments) and is performed on an automated analyzer (Abbott VP). Details of the assay are as described in the reagent package insert (Smith Kline Instruments 11974, see Appendix). Activity is expressed in International units (IU) which are calculated in the same way as described for SGOT. Expected values were determined by the manufacturer in a study of 167 normal blood donors (100 males, 61 females ages 19 to 62). An approximately log gausian distribution of values was obtained. The ranked values had a 2 standard deviation spread of 5-20 IU and the manufacturer recommended a normal range of 4-25 IU. The UTMB clinical Laboratories periodically validate their procedures by testing the distribution of a normal test sample for compatability with the manufacturer's published values. The assay procedure is currently valid and a normal range of 6-37 IU/L is used.

3. Gamma glutamyl transpeptidase: GGT catalyses the transfer of a glutamyl group from one peptide to another peptide or amino acid. In this assay the glutamyl group is transferred from γ-glutamyl-p-nitroanilide to glycylglycine releasing free p-nitroaniline. The nitroanaline is detected by measuring its absorbance at 405 nm. The rate of its appearance is directly proportioned to the enzyme activity present. The assay is conducted

on non-hemolysed serum using a standard reagent kit (Spinchem, Smith Kline Instruments) and is quantitated on an Abbot VP spectrophotometric analyser. Details of the assay are as described in the reagent package insert (Smith Kline Instruments, 1978 see Appendix).

Values are expressed in international units (IU) which are calculated in the same way as for SGOT ($E=9.9 \times 10^6$ $cm^2/mole$). Expected values were determined by the manufacturer independently for males and females. At 37°C the ranked data for 58 males had a two standard deviation range of 8 - 43 and for 42 females of 5 - 30. The recommended "normal ranges" are 0 - 50 for males and 0 - 35 for females. These normal values have been verified at UTMB and are currently accepted as standard.

4. Alkaline Phosphase: AP measures the activities of a group of enzymes which non-specifically catalyse the hydrolysis of various organic monophosphates. The assay is conducted by measuring the rate of hydrolysis of p-nitrophenyl phosphate to inorganic phosphate and p-nitrophenoxide. The latter product can be detected by its absorption of light at 405 nm. The amount of enzyme activity is proportional to the rate increase in absorbance over a specified time period. Values are expressed in international units (IU) per liter which are calculated in the same way as for SGOT ($E=18.8 \times 10^6$ $cm^2/mole$) at 405 nm. Expected values were determined by the manufacturer at 37°C in samples from 110 normal donors (59 males, 51 females ages 18-60). The values reported were 74-243 IU/L for males and 68-216 IU/L for females. UTMB has validated its procedures as being consistent with these values and uses the range 68-243 IU/L as

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normal.

5. Cholinestrase: ChE is a liver enzyme which catalyses the hydrolysis of a wide range of aromatic and aliphatic esters. It is assayed in serum by measuring the rate of hydrolysis of butyrylthiocholine to butyric acid and thiocholine. Thiocholine reduces the blue dye 2, 6 dichlorophenolidophenol to its colorless form. The decrease in light absorbance over a 17.07 second period is directly proportional to the amount of ChE activity present. The assay is routinely conducted using a standard reagent kit (Clinical Systems ACA Analytical Test Pack: Pseudocholimestrose, DuPont see Appendix) and is performed on a DuPont Automatic Clinical Analyzer (ACA). The normal range determined by the manufacturer is 7-19 IU/ml. UTMB has validated its procedures against the manufacturer's values and a normal range of 8-20 IU/ml is being used.

6. Bilirubin, Total and Direct: Bilirubin is a bile pigment produced in a complex series of steps from hemoglobin released from aged or damaged erythrocytes. Bilirubin is convezted to the glucuronic acid conjugate in the liver. Both free bilirubin and the conjugated form are transported loosely bound to albumin in the blood. The measurement of total serum bilirubin is made by reacting it with diazotized sulfanilic acid in the presence of a caffeine-sodium benzoate solution. A red azobilirubin forms which is stabilized by the addition of hydroxalamine, which also destroys the excess diazosulfanilic acid. The color is then shifted to blue by raising the pH with alkaline tartrate so that the absorbance at 600 nm can be

measured. Direct, or conjugated, bilirubin is measured by diazotization in an aqueous acidic medium. This allows the glucuronide to react but inhibits the reaction of unconjugated bilirubin. The assay is routinely conducted using a kit (Jendrassik Bilirubin, American Monitor Company, 1978). The details of the procedures are described in the package insert (see Appendix). Current normal range values used by UTMB for adults are: for total bilirubin 0.1-1.0 mg/dl and for direct bilirubin 0.05-0.2 mg/dl.

7. Prothrombin Time: The PROT assay is a one stage test used as a general screening procedure for possible deficiencies of the clotting factors in the Extrinsic Cloagulation System (Factors II, V, VII and X). The assay is performed by the addition of a tissue thromboplastin-calcium mixture to a plasma sample. The time (in seconds) required for a fibrin to form is determined either optically or mechanically. The assay is conducted using a commercial reagent kit (Sinplastin Automated, General Diagnostics) and performed on an antomated optical instrument (Coag-A-Mate A/C, General Diagnostics). The details of the procedure are contained in the reagent kit insert (Simplasatin Automated, General Diagnostics, 1975) and the laboratory procedure manual (see Appendix). Expected values were determined on 300 normal individuals. The mean time was 10.97 sec. with a standard deviation of 0.47 sec. The normal range in current use based on these results and periodic validation assays is 10.0-12.0 sec.

C. Statistical Considerations

Summary statistics were calculated for the data to study changes in liver function measures as related to work area (WA) and customary alcohol consumption (CAC). Means and standard deviations were calculated for each WA and CAC combination and for each WA and CAC overall. Additionally, the median response was determined for each work area since the data in many instances are not normally distributed and show wide variability among subject results. As a result tests of significance concerning differences among WA are based on the rank transformation (RT) and the use of analysis of variances (AOV) methods. Thus statistical significance is based on median responses. rather than mean responses.

In addition to the above procedures, we calculated the percentage of values exceeding the normal range (extreme values) for the entire data set for each variable and for all variables combined. The criteria for an observation being classified as extreme was based on the fact that upper limits to normal ranges are set at the 95th percentile for the distribution of values from a normal population.

Finally an integrated rank sum value was calculated for each subject in order to study combined liver function values. These average rank sum results are presented and analyzed using AOVA procedures for significance.

III. Results

A. Sample Description

Blood samples and background information were obtained from a total of 81 individuals. All eight assays were performed on all samples except that 4 prothrombin times were not recorded. A total of 643 values were reported. The individual laboratory values are presented in Table 1. Values exceeding the upper limit of the normal range for each assay are underlined. The information collected by questionaire at the time of sample collection is summarized in Table 2. The results for each individual were reviewed by consulting pathologist Irwin Schoen, M.D. whose comments are presented in Table 3. The individuals were distributed in seven work areas: three units of the Neoprene Department, (monomer, polymer, and finishing) the Maintenance Department, the Quality Control Laboratory, the Maleic Acid Department, and the Warehouse. The number of individuals from each area was 10, 13, 20, 16, 9, 10, and 3 respectively. The individuals were also categorized on the basis of their customary weekly consumption of alcoholic beverages into three groups: (0) no reported consumption; (1) less than 18 beers or drinks per week; (2) 18 or more beers or drinks per week. The numbers of individuals in each group were (0) 20, (1) 47, and (2) 13. Summary statistics of results overall and according to work area and customary alcohol consumption are presented for each assay in tables 4-11. Table 12 examines the percentage of results exceeding normal range for each assay by alcohol consumption. Table 13 examines the percentage of results exceeding normal range for each assay by work area. An overall summary of the results was made by ranking the values for each assay across all individuals. The ranks were averaged for each person and the averages ranked. Table 14 summarizes the results with an

index of average ranks of all values by work area and alcohol consumption. Individual 046 was omitted because values for CHE and PROT were missing and all PROT valves were omitted because four individals were not tested for that analyte. Our interpretation of these results and conclusions are presented in the following section.

IV. Discussion

A. General Interpretation of Results

The analyses made on samples from these individuals are standard methods used in the clinical evaluation of liver function. Serum levels of SGOT, SGPT, GGt and AP are normally much lower than tissue levels. The liver contains higher levels of the enzymes than most other tissues. Tissue damage resulting from disease, toxicity, or physical damage which leads to cell disruption can cause a release enzymes into the peripheral circulation. Levels of these enzymes increase, sometimes dramatically, as a consequence of viral or toxic hepatitis, SGOT and SGPT levels also increase in response to alcohol consumption malignant liver tumors and tissue damage in the heart resulting from myocardial infection (Schmidt and Schmidt, 1976).

GGT levels increase in response to several forms of liver damage, particularly biliary obstruction and neoplasms of the liver. GGT is not as responsive to viral hepatitis as SGOT and SGPT however it is responsive to alcoholic cirrhosis and heavy drinking.

Alakaline phosphatase levels may rise in response to either liver damage or bone disease. AP responds particularly to obstructive disease and not so much parenchymal cell disease (viral hepatitis).

Cholinestrase (pseudocholineotrase) levels characteristically drop in liver disorders so values below the normal range are clinically significant. The decline is attributed to decreased protein synthesis in the damaged liver, and it generally parallels a decrease in serum albumin level. Increased valves have been reported in nephrotic syndrome, progressive dimyelinating disease of the nervous system and in mental disorders (Rosalki, 1969).

Serum bilirubin levels both free and conjugated rise in response to obstructive jaundice with the conjugated from predominating. Prothrombin times are prolonged in chronic severe liver disease of either obstructive or hepatocellular nature. A more detailed discussion of the effects of liver disease on these test parameters can be formed by consulting a good clinical chemistry text such as Tietz (1976).

B. Evaluation of Individual Results

Among the 81 individuals tested only four were identified in the pathology evaluation as having clinically significant abnormalities in need of follow-up (Table 3). Among these four the abnormalities were attributed to use of an heptotoxic drug (009) or to alcohol consumption (020, 035) or the possible combined effects of alcohol and drugs.

Numerous smaller elevations above the normal range were observed distributed over all assays among the individuals. Of the 81 people tested 41 had at least one elevated value. On an individual basis no clinical significance can be ascribed to these abnormal valves.

C. Statistical Evaluation of Results

While no clinically significant abnormalities attributable to occupational exposure to toxic chemicals were observed it seemed possible that the many small abnormalities might be related to minor toxic effects of chemical exposure. The results were evaluated in two ways to test for association of the results with chemical exposure. First, we determined the descriptive statistic for each test by work area and by alcohol consumption. This allowed us to look for significant differences in the distribution of results from the Clinical Laboratory normal valves or among work area or dinking categories. Second, we determined the frequency of results above laboratory normal range for each test by work group and drinking category.

This allows us to observe whether these study subjects possess a larger percentage of extremes than the expected percentages based on all subjects being normal (5%). Further we can study these percent extreme valves for each WA and for each CAC level and for each liver function parameter. For example, if in all subjects 30% of the SGOT results were classified as extreme according to published criteria (SGOT>30 IU/L) most of those extremes might, in fact, occur among the

heavier alcohol consumers with fewer extremes occuring in the lower CAC subjects. This would suggest that CAC caused the excess and not necessarily the chemical exposure. If both high CAC and exposure results in increased LF valves one should observe higher percent extremes in WA with higher exposure and higher CAC than in WA with lower exposure and lower CAC levels.

While the results in this study for all subjects combined may be sufficient to suggest an excess number of extreme values; when one considers extremes in each WA and each CAC group there are relatively few subjects for studying trends. Therfore specific conclusions concerning both the separate and combined effects of exposure and alcohol consumption on LF results become difficult to make with any reasonable degree of accuracy. Consequently our conclusions must be based on the observance of trends and patterns of LF outcome suggesting possible rather than probable relationships between exposure and liver function outcome.

The organization of the workforce at the Denka Chemical Plant has been described for us by OCAW officials who are employed there. The workforce is divided into several departments. The Neoprene Department is responsible for the synthesis of chloroprene from butadiene and chlorine, its polymerization to polychloroprene, and its finishing to butyl rubber. Workers in this department work in three areas, the monomer unit (site of chloroprene synthesis) the polymer unit (site of polychloroprene manufacture) or the finishing unit. Workers in these areas are in close contact with the feedstocks,

intermediate , products, wastes, and fumes from the procduction process. The Maintenance Department is responsible for maintaining and repairing the equipment involved in the manufacturing process. In addition, new construction and manual labor activities such as vessel cleaning as well as warehouse operations are the responsibility of the Maintainence Department. Maintainence workers must frequently enter high exposure areas in order to make repairs to equipment. Descriptions by workers indicate that very high exposures result from the disassembly of equipment such as valves or piping which contain chloroprene or by products of its manufacture.

By contrast the quality control laboratory is an environment relatively well isolated from chemical exposures related to manufacturing. The Maleic Acid Department is responsible for the production of maleic acid. This process is unrelated to the manufacture of neoprene. Exposures in this area to the chemicals involved in neoprene production are substantially lower than those in the Neoprene Department itself. In summary, exposures to the chemicals associated with neoprene production are expected to be greatest among workers in the Neoprene and Maintenance Department while workers in the Quality Control Laboratory and Maleic Acid Department should have lower exposures. These exposure estimates are based on the organization of the production process and on descriptions of exposure provided by workers in the plant.

In evaluating our results we have grouped individuals by work area in the 3 units of the Neoprene Department (monomer, polymer, and

finishing) Maintenance, Laboratory, Maleic Acid Departments, and the Warehouse. Because alcohol consumption is the major confounding influence on liver function we have also grouped the individuals as non-drinkers, light drinkers (less than 18 drinks per week), or heavy drinkers (18 or more drinks per week). These classifications are based on self-reported customary alcohol consumption and the cutoff between light and heavy consumption is set at a fairly low level (2-3 drinks per day) in recognition of the fact that heavy drinkers may under-estimate their consumption.

1. Extreme Values

We found that overall the percentage of extreme values, 12.6% was greater than the 5% false positive rate expected in a completely normal population. While this does not imply that all study subjects have abnormal values it does suggest on the surface that there are more abnormals than would be expected by chance alone. Also, it was observed that those extreme values tend to occur to workers in the presumed higher exposure areas, (WA 1-4) when compared to workers in lower exposure areas (WA 5-7). This trend appears similar for several of the liver function tests although not for all. Extreme BRT and BRD values are not different from expected either in CAC groups or across WA groups. The percentages of extreme values for SGOT, SGPT, GGt and PROT appear generally correlated with alcohol consumption while AP and CHE appear negatively correlated. It is possible that the increased frequencies of extreme values could be due only to increased CAC. However, the tendancy for extreme values to occur more frequently in

WA 1-4, while not invariable, remains even for those asays which do not correlate with CAC. Thus based on the anlaysis of extreme value frequencies one might argue that there is a trend toward increased extremes corresponding to increased exposure. We have only considered CAC as a confounding factor even though there may in fact be a multitude of similar factors which could explain all or part of the occurance of these trends other than the presumed exposure gradient across work areas.

2. Group Statistics

Means and Medians

SGOT, SGPT, GGT means tend to be higher with higher alcohol consumption as well as in higher exposure areas. There does not appear to be an increase with alcohol consumption in lower exposure areas. In both the low and high alcohol consumption group there is the increase in higher exposure areas but this pattern is not suggested in the middle alcohol consumers. Thus, because of the small samples and alcohol consumption trends, it is difficult to assess accurately liver function's relationship with exposure.

Results for AP suggest a similar trend toward higher values in higher exposure means. Also, this AP trend is similar in each alcohol consumption group. There does not seem to be a correlation of AP and level of alcohol consumption.

Trends for ChE suggest at most only a slight trend toward an

increase in higher exposure areas. There is not a positive correltaion of ChE with alcohol consumption; in fact it may very well be a negative correlation. Values for BRT, BRD and PROT are similar regardless of alchol consumption or exposure areas.

In summary, the mean and median results suggest trends toward increased liver function test elevations in higher exposure areas. However, because of the confounding effects of alcohol consumption together with the relatively few subjects in each of the work area alcohol consumption subgroups, an accurate assessment of the relationship between exposure and liver function test is more difficult to make.

Rank Sum Index

When the values for each considered liver function test were combined for each subject by using the averaged rank liver function value, there was an overall increase with alcohol consumption but again no overall difference among exposure areas. When grouped, there is a suggestion that the high areas (1-4) are associated with higher mean ranks than are the lower areas (5-7). The trend holds for low and high alcohol consumers but not for the middle alcohol group. This was the same pattern observed for the SGPT, SGOT and GGT means as indicated earlier.

D. Other Health Effects in Group

During July and August, 1981, Local 4-227 of the OCAW sponsored a

survey of health problems in the Denka Workman's group. The time of the survey coincided with the time of sampling for these liver function tests. The survey was conducted by Carola Greengard a senior student at Yale Medical School under the supervision of Sharon Itaya, M.D. who served as occupational physician to the local. The survey consisted of in depth interviews with 40 workers from all areas of the plant and review of Company health records for those individuals . The findings of the survey are summarized here for comparison to our findings.

Liver function studies were initiated on employees in 1971, two years after the plant opened. The plant changed ownership in 1975 time and workers with experience prior to the change reported that some previous employees were denied the opportunity to stay with the new employers because of prior blood test abnormalities. Of the workers interviewed 20% reported at least one episode of significant liver disease. Four former employees were identified who have had to cease working in Neoprene production and required ongoing medical care because of liver disease.

Reproductive effects were explored in the survey. Most employees reported using contraception unless trying to have children and therefore no conclusions can be drawn regarding occupational effects on their reproductive status. Nineteen employees were interviewed who have had children or planned for children since working at Denka. Seven of them have had children without complications however, the remaining twelve have experienced complications in reproduction.

Eight families reported infertility, and four (including one of the former eight) reported birth defects. One family reported a spontaneous abortion. While the numbers reported are small and the data collected anecdotally a suggestion of higher than normal reproductive complications exists in this group.

Respiratory problems were highlighted in the survey report as being particularly widespread among the Denka Workforce. Reported effects of recurrant acute exposures resulting from equipment malfunctions included chemical penuemonia and breathing difficulties following chloroprene exposures. Two thirds of those interviewed complained of upper respiratory problems including sinusitus recurrent respiratory tract infections, chest complaints or a combination of these problems. None of the persons reporting these problems had a history of them prior to their employment in neoprene production.

A number of other health problems were cited in the report as common to a large percentage of the workforce. Chest pains, possibly associated with respiratory or gastrotestinal problems were reported by a third of the workers interviewed. Abnormal electrocardiogram readings were reported for about a third of those interviewed. Dermatolgical complaints were almost universal among workers in neoprene production or maintenance. Chemical burns caused by DCB's were the most common complaint but rashes resulting from chloroprene exposure were also commonly reported. Similarly eye irritation from DCB exposure was commonly reported. Central nervous system effects including dizziness, loss of equilibrium, headaches, nausea, fatigue,

and irritability were also reported by a high percentage of those interviewed. Fumes in the polymer and finishing units were particularly associated with these effects.

V. Final Summary and Conclusions

A sample of 81 out of 225 members of workforce at the Denka Chemical Plant, Houston, Texas were evaluated for abnormalities in liver function using clinically accepted blood chemistry techniques. The tests used were: enzyme assays for serum glutamate-oxaloacetate transaminase (SGOT), serum glutamate-pyruvate transaminase (SGPT), gamma glutamyl transpeptidase (GGT), alkaline phosphatase (AP) and cholinestrase (ChE); determination of bilirubin levels both total (BRT) and direct (BRD); and determination of prothrombin (blood clotting) time (PROT). Four individuals in the sample were identified as having clinically significant abnormalities. In all four cases alcohol consumption or use of medications were identified as at least contributory factors. The results were evaluated by grouping individuals according to their work area in the plant and their customary alcohol consumption. The frequencies of results occuring above the 95% confidence interval of the normal range were determined (extreme values). Extreme values were found to correlate with alcohol consumption for SGOT, SGP, GGT and PROT but not AP, ChE, BRT, or BRD. However, the extreme values also clustered in the work areas in the Neoprene Department and Maintenance Department as contrasted with the Quality Control Laboratory and Maleic Acid Department. Exposures to chemicals associated with Neoprene production are also higher in the

former departments as contrasted with the latter. Group statistics for each test indicated associations between alcohol consumption and elevated values but numbers were not sufficient to test significant associations between drinking, work areas, and results. A health survey conducted at the same time these tests were run indicated that a variety of adverse health effects are prevalent in this population. These effects include past history of liver disorders, possible reproductive problems, widespread respiratory and dermatologic problems and evidence of central nervous system effects. The results of our tests suggest that chemical exposures associated with Neoprene production may contribute to liver function abnormalities and that individuals who customarily consume moderate to higher amounts of alcohol may be particularly at risk. Given the health background of this group of workers and the results of these tests we recommend that a more detailed evaluation of this population and of the health hazards of Neoprene production be made.

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TABLE 1 Individual Values for All Tests on Samples from All Individuals

CODE	SGOT	SGPT	GGT	AP	CHE	BILI-RUBIN T	BILI-RUBIN D	Protrombin Time CONT.	Protrombin Time SUBJECT
001	25	33	44	175	13.9	0.5	0.1	12	11.3
002	19	30	37	107	15.1	0.9	0.0	12	11.7
003	12	8	26	152	10.9	0.6	0.0	12	11.9
004	22	7	42	158	13.8	0.3	0.0	12	11.9
005	14	17	12	198	15.5	0.6	0.0	12	11.8
006	19	16	24	215	16	0.2	0.0	12	10.8
007	22	21	31	261	20.3	0.9	0.0	12	11.3
008	56	86	99	222	17.4	0.3	< 0.1	12	12.0
009	42	76	122	186	22.1	0.9	< 0.1	12	11.7
010	26	47	33	180	20.0	2.1	< 0.1	12	11.7
011	34	18	39	146	15.1	0.3	< 0.1	12	11.4
012	20	35	43	119	15.5	0.2	< 0.1	12	11.4
013	23	26	16	245	16.3	0.8	< 0.1	12	12.6 88% activity
015	20	18	26	206	13.5	0.4	< 0.1	12	11.4
016	19	18	30	142	14.0	0.3	0.1	12	11.3
017	15	20	20	198	12.8	0.6	0.0	12	11.6

Note: Underlined values are above normal range.

TABLE 1 (continued)

CODE	SGOT	SGPT	GGT	AP	CHE	BILI-RUBIN T	BILI-RUBIN D	Protrombin Time CONT.	Protrombin Time SUBJECT
018	22	18	32	109	16.3	0.2	0.0	12	12.1
019	22	9	22	140	17.2	0.4	0.0	12	12.0
020	83	119	141	249	18.7	0.6	0.0	12	12.2
021	29	50	61	217	17.2	0.8	0.0	12	11.6
022	16	18	26	144	16.2	1.5	0.0	12	12.0
023	22	33	36	316	22.7	0.0	0.0	12	11.1
024	16	11	19	112	10.6	1.0	0.1	12	12.4 88% activity
025	20	17	18	195	13.9	0.6	0.0	12	11.4
026	25	24	46	209	17.2	0.5	0.0	12	11.9
027	24	23	31	84	14.4	0.7	0.0	12	11.5
028	18	12	29	134	10.5	0.6	0.0	12	12.9 77% activity
029	20	16	80	145	13.0	0.3	0.0	ND	ND
030	18	15	19	165	14.9	0.1	< 0.1	12	12.4 88% activity
031	29	41	31	254	16.6	1.8	< 0.1	ND	ND
032	16	15	22	179	16.6	0.4	< 0.1	ND	ND
033	17	20	30	180	20.8	0.5	< 0.1	12	11.7

TABLE 1 (continued)

CODE	SGOT	SGPT	GGT	AP	CHE	BILI-RUBIN T	BILI-RUBIN D	Protrombin Time CONT.	Protrombin Time SUBJECT
034	27	48	63	191	15.4	0.8	<0.1	12	11.4
035	124	194	266	218	19.2	0.5	<0.1	ND	ND
036	35	42	54	175	16.3	0.7	<0.1	12	11.0
037	18	13	30	146	14.5	0.6	<0.1	12	11.3
038	23	16	25	207	16.5	0.3	<0.1	12	12.1
039	25	13	15	178	10.7	0.8	<0.1	12	12.4 88% activity
040	27	26	29	167	12.1	0.1	<0.1	12	11.4
041	27	25	20	161	11.5	0.4	<0.1	12	11.8
042	19	13	19	199	19.4	1.0	<0.1	12	11.5
043	20	19	116	218	14.7	0.6	<0.1	12	11.2
044	35	14	13	169	11.1	0.6	<0.1	12	12.5 88% activity
045	31	53	56	200	21.9	0.3	<0.1	12	11.0
046	24	18		182	14.8	0.8	<0.1	12	11.2
047	16	11	17	213	15.6	0.6	<0.1	12	11.8

TABLE 1 (continued)

CODE	SGOT	SGPT	GGT	AP	CHE	BILI-RUBIN T	BILI-RUBIN D	Protrombin Time CONT.	Protrombin Time SUBJECT
048	17	9	14	176	11.9	0.6	0.0	12	12.4 88% activity
049	30	41	87	220	14.7	0.3	0.0	12	10.8
051	23	6	42	193	14.5	0.6	0.0	12	11.2
052	21	17	24	240	17.5	0.3	0.0	12	11.5
053	19	17	15	200	18.6	0.4	0.0	12	11.6
054	22	12	18	257	17.6	0.3	0.0	12	11.4
055	28	15	27	147	16.0	0.5	0.0	12	11.3
056	21	7	19	228	6.6	0.4	0.0	12	11.5
057	24	5	22	142	14.2	0.7	0.0	12	11.5
058	6	5	17	153	15.5	0.4	0.0	12	11.2
059	23	20	21	191	13.3	0.9	0.0	12	11.5
060	28	17	39	143	9.5	0.5	0.0	12	11.2
061	25	29	67	141	11.8	0.6	0.1	12	11.2
062	23	21	25	135	13.8	0.4	0.1	12	11.7
063	25	22	34	134	20.9	0.6	> 0.1	12	10.9

TABLE 1 (continued)

CODE	SGOT	SGPT	GGT	AP	CHE	BILI-RUBIN T	BILI-RUBIN D	Protrombin Time CONT.	Protrombin Time SUBJECT
064	35	36	27	226	14.8	0.6	0.1	12	11.7
065	23	25	24	175	13.7	0.5	0.1	12	11.5
066	20	23	13	180	13.8	1.4	0.0	12	11.4
067	15	12	14	159	10.1	0.8	0.0	12	11.8
068	32	42	72	235	18.5	0.3	0.0	12	10.7
069	23	9	30	243	15.2	0.0	0.0	12	11.3
070	16	15	24	175	18.8	0.0	0.0	12	11.3
071	23	36	76	246	8.3	0.4	0.1	12	11.6
072	23	36	41	242	12	0.7	0.0	12	12.1
073	13	14	29	244	20	0.2	0.0	12	11.5
074	21	25	54	244	13	0.1	0.0	12	11.1
075	16	11	14	230	22	0.4	0.0	12	11.3
076	15	10	10	154	10	0.3	0.0	12	11.7
077	53	39	158	211	13	0.4	0.0	12	11.2
078	15	14	20	144	13	0.5	0.1	12	11.4

TABLE 1 (continued)

CODE	SGOT	SGPT	GGT	AP	CHE	BILI-RUBIN T	BILI-RUBIN D	Protrombin Time CONT.	Protrombin Time SUBJECT
079	20	23	33	185	14	0.6	0.0	12	11.6
080	20	28	45	209	22	0.4	0.0	12	11.1
081	24	25	27	133	18	0.5	0.0	12	11.6
082	21	15	51	180	11	0.3	0.0	12	11.7
083	19	26	37	182	13	0.2	0.0	12	11.3

TABLE 2

Summary of Information Collected by Questionairre From All Individuals at the Time of Sampling

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION last 48 hrs.	WORK LOCATION last 2 weeks	ALCOHOL CONSUMPTION last 24 hrs.	ALCOHOL CONSUMPTION customary drinks/wk.	MEDICATION last 24 hrs.	MEDICATION last month	HEPATITIS HISTORY	ILLNESS
001	7/13/81		M	B	Finishing Unit	Finishing Unit	None	15-B	None	20 nicin per week	None	None
002	7/13/81		M	W	Lab	Lab	None	None	None	Sinutab ASA, Excedrin, Tylenol	None	GI virus 2 wks ago
003	7/13/81		M	B	Polymer Unit-3rd fl.	Polymer Unit	None	5-6 Cans B	None	Maalox	None	None
004	7/13/81		M	B	Polymer Unit	Polymer Unit(all floors)	None	None	None	Tylenol Extra Strength	None	Headaches
005	7/13/81		M	M	Lab	Lab	None	None	None	Sudafed (a few tablets over month ago)	None	Sore throat (no fever)
006	7/29/81		M	W	Lab	Lab	None	None	Pronestyl 500 mg. 3x day, Digokin 25 mg. 1x day	Same	None	Hypertension Cardiac-Arrythic
007	7/13/81	46	M	W	Off	Maintenance (all areas)	None	About 1 month	Antibiotics	Tylenol III 4 per day last 2 wks.	None	Removal of basal cell carcinoma on side of nose (history of skin cancer)
008	7/13/81	31	M	W	Off	Polymer Unit 1st fl.	3-B	24-B	Penicillin, ACT antinflammattery cough medicine w/ codine	Same	None	Head & Chest Cold

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
009	7/13/81	27	M	M	Off	Finishing Unit (rear ropes)	None	6-B	Depakene 250 mg.	Same for last 2 yrs.	None	None high LFT 2 yrs. ago, high LFT 2/wks. ago
010	7/13/81	36	M	W	Polymer Unit (3rd fl.)	Polymer Unit	None	None	None	None	None	Herpes last month
011	7/13/81	51	M	B	Finishing Unit (front end)	Finishing Unit	2-B	12-B	None	None	None	None
012	7/13/81	45	M	W	Maintenance (Monomer Unit)	Maintenance (Monomer Unit)	None	½ Gal-W	Aspirin (2), Sudafed (2) 3 hrs. before sample	Diet Med.	None	None
013	7/13/81	(25)	M	M	Polymer Unit 1st fl.	Polymer Unit	None	None	None	None	None	None
015	7/13/81	55	M	W	Maleic Acid Unit-Reactors 0-202 203	Maleic Acid Unit	1-B	11-B	Vitamins, Slenium tabs, Zinc, Dolomite tabs	Same	None	None
016	7/13/81	44	M	B	Finishing Unit	Finishing Unit	None	4-B	None	None	None	None
017	7/13/81	40	M	W	Maleic Acid Unit-Reactors 0-201, 202,203	Maleic Acid Unit	None	None	1 aspirin	1 aspirin	None	None
018	7/13/81	35	M	M	Finishing Unit	Finishing Unit	None	1-B	None	Aspirin (20) vitamins (B complex)	None	None

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
019	7/13/81	27	M	W	Maleic Acid Unit-Reactors 201,202,203, 1000	Maleic Acid Unit	None	3-B	None	Aspirin	None	Sinus trouble
020	7/13/81	36	M	W	Maintenance	Maintenance	None	42-B	None	Novacain 3 sessions wk. of 7/1	None	Root canal
021	7/13/81	36	M	B	Monomer Unit	Vacation 1st wk Monomer Unit	None	None	Vitamins	Aspirin, vitamins	None	None
022	7/13/81	26	M	W	Maintenance (Monomer Unit)	Maintenance (all areas)	None	6-B 2-W	None	None	None	Mononucleosis 3 yrs. ago
023	7/13/81	40	M	W	Maintenance (Maleic Acid unit)	Maintenance (all areas)	None	1	1-Bronkaid	Primatene, Bronkaid last 2 wks.	None	Bronchitis
024	7/14/81	28	M	B	Finishing Unit(all areas)	Finishing Unit	None	6-B	None	None	None	None
025	7/14/81	40	M	W	Finishing Unit	Finishing Unit	None	6-B	None	2 Tylenol 2 wks ago	None	None
026	7/14/81	31	M	W	Lab	Lab	None	4-5 B	None	Aspirin	None	None
027	7/14/81	55	M	W	Lab	Lab	None	25-B	None	Diazide-none in last 2 wks.	None	None
028	7/14/81	25	M	W	Polymer Unit (2nd floor)	Polymer Unit	None	3-6 B	None	Penicillin, Tylenol (prescription)	None	Abcessed tooth

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
029	7/14/81	34	M	B	Off	Finishing Unit	3-B	2-B	Correctol	Aspirin (6 tabs) Decongestant (4 tabs)	None	Throat Infection
030	7/14/81		M	W	Maintenance (all areas)	Maintenance	None	1-B	None	ASA, Vitamins	None	Viral Flu
031	7/14/81	33	M	M	Finishing Unit (all areas)	Finishing Unit	None	2-6 pack B	Aspirin-2	None	None	None
032	7/14/81	48	M	W	Monomer Unit	Monomer Unit	None	3-6 pack B	None	None	None	None
033	7/14/81	42	M	W	Maintenance (all areas)	Maintenance	1-B	2-3 6 packs B	Diazide	Same-1x day for year	None	None
034	7/14/81	27	M	W	Off	Polymer Unit (1st & 3rd Fl.)	None	12-B	None	2-Sudafed	None	Sinus trouble
035	7/14/81	40	M	W	Monomer Unit	Monomer Unit	None	14-21 W	None	Aspirin 2 day	None	Upper respiratory infection 6/29-7/31
036	7/14/81	31	M	W	Maleic Acid Unit	Maleic Acid Unit	None	1-B	Actifed 1 tab	Naldecon 6 wk./1 day	Yes-Viral 1972	Sinus Infection in hosp
037	7/14/81	35	M	B	Finishing Unit	Finishing Unit	1-B	6-B	None	Aspirin (2)	None	None
038	7/14/81	35	M	W	Maintenance (Maleic Acid Unit)	Maintenance (all areas)	None	6-W	None	Aspirin (5)	None	Chronic Sinus Infection

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
039	7/14/81	24	M	W	Finishing Unit	Finishing Unit	None	2-B	None	Aspirin (2)	None	None
040	7/14/81	46	M	W	Lab	Lab	None	10-B	C & B complex vitamins	Vitamins	None	None
041	7/14/81	40	M	W	Maleic Acid Unit	Maleic Acid Unit	None	None	Vitamins	Vitamins	None	None
042	7/14/81	44	M	W	Maleic Acid Unit	Maleic Acid Unit	None	None	None	Sudafed Prescription 2 wks ago	None	Allergies ear inf.
043	7/14/81	34	M	B	Maleic Acid Unit	Maleic Acid Unit	None	24-B	None	Bufferin & Actifed	None	None
044	7/14/81	30	M	B	Finishing Unit	Finishing Unit	None	5-6 W	Geritol	Geritol	None	None
045	7/14/81	28	M	M	Monomer Unit M-412-413 waste tanks	Monomer Unit	None	3-4 W	None	None	None	None
046	7/14/81	33	M	W	Maintenance (welding shop)	Maintenance	None	2-4 B	Vitamins	None	None	None
047	7/14/81	23	M	W	Finishing Unit (all areas)	Finishing Unit (all areas)	None	2-B	None	Aspirin 4-tabs	None	None
048	7/14/81	26	M	W	Maintenance (Monomer unit)	Maintenance (utility machine shop & finishing unit)	1-B	2-6 packs B	None	None	None	None

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
049	7/14/81	37	M	W	Maintenance (all areas)	Off prior to 7/13	None	21-28 B	Ser-ap-Es Nicobid 2 day	Same	None	None
051	7/14/81	53	M	W	Maintenance	Maintenance	None	6 pack/day	None	None	Yes-yellow jaundice long time ago	None
052	7/14/81	42	M	W	Warehouse	Off	2-B	2-3 6 pack B	None	Penicillin following surgery	None	Hemorrhoid surgery 5/29 /81 upper/ lower GI series btw/ surg
053	7/14/81	25	M	W	Maintenance (Polymer unit)	Maintenance (all areas)	None	None	None	None	None	Sinus drainage
054	7/14/81	27	M	W	Polymer Unit	Polymer Unit & Warehouse	None	1-W	None	None	None	Sinus trouble
055	7/14/81	34	M	B	Maintenance	Maintenance	None	6-B 1 pt. wine	None	Antiflam-matory drug 6 wks ago, 2 tabs day	None	Knee injury 6 wks ago severe bruise on arm water blister 3 wk ago
056	7/14/81	27	F	B	Maleic Acid Unit	Off	None	1-B	Iron Pills Antibiotic	Iron Pills, antibiotics for 2 wks	None	Low blood count, spider bite, infection

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
057	7/14/81	35	M	B	Off	Finishing Unit (rope area)	2-B	6-B	None	Aspirin (1) Alka-seltzer (2) 2 wks ago	None	Heat exposure
058	7/14/81	54	M	W	Maintenance (all over)	Maintenance	None	2-B	Pill for heart murmur	Same	None	None
059	7/14/81	37	M	M	Polymer Unit	Polymer Unit	None	3-6 packs B	None	None	Aspirin(4)	None
060	7/14/81	35	M	B	Maleic Acid Unit	Monomer and Finishing Units	None	5-6 B	None	None	None	Sinus Problem
061	7/22/81	54	M	W	Lab	Lab	2-B	1 case B	None	Sudafed & Tylenol	None	Sinus Allergy
062	7/22/81	34	M	M	Lab	Lab	None	6-B	None	Aspirin	None	None
063	7/22/81	25	M	W	Maintenance (Monomer unit)	Maintenance	None	1-B	1 extra-strength Excedrin	None	None	None
064	7/22/81	33	M	W	Polymer Unit (1st & 2nd fl.)	Polymer Unit	None	None	None	None	None	None
065	7/22/81	33	M	W	Maintenance (all areas)	Maintenance	2-B	6-B	None	Aspirin	None	None
066	7/22/81	35	M	W	Finishing Unit (bagging area)	Finishing Unit	None	2-3 B	2 Aspirin	Ampicillin 2 days	Yes May, 1980 Viral	Sore throat (that wk.)
067	7/22/81	28	F	B	Finishing Unit	Finishing Unit	1/3 B	3-B	None	None	None	None
068	7/22/81	31	M	W	Maintenance	Maintenance	None	6-B	None	Aspirin	None	None

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
069	7/22/81	60	M	W	Lab	Lab	1-B	7-B/day	None	None	None	None
070	7/22/81	33	M	W	Off	Off (Monomer Unit)	None	2-B	Inderal/day	Same	None	Hypertension
071	7/22/81	40	M	W	Maintenance	Maintenance	None	None	Tylenol	Same	None	None
072	7/29/81	43	M	B	Finishing Unit (front area)	Finishing Unit	None	None	None	Prescription Diet Pills ending 3 wks. ago	None	Sinus Allergy
073	7/29/81	52	M	W	Monomer Unit	Monomer Unit	None	None	Sorbitrate 200 mg. 4x daily Corgard 1x day Adapin 250 mg. 1x day	Same	None	Hypertension
074	7/29/81	31	M	W	Polymer Unit (3rd fl.)	Polymer Unit	None	None	Tagamet 300 mg 4x day Donnatal #40 4s day	Same	None	Acute gastritis
075	7/29/81	35	F	W	Off	Finishing Unit (bagging area)	None	None	None	2 Dristan	None	Cold
076	7/29/81	29	F	W	Maleic Acid Unit	Polymer Unit	None	½-B	Crystodigin 1x day	Same	Yes-Toxic 4/80	None
077	7/29/81	47	M	B	Finishing Unit	Finishing Unit	None	2-6 pack B	None	Percodan Insulin 1x day	None	Diabetes

TABLE 2 (continued)

CODE	DATE SAMPLED	AGE	SEX	RACE	WORK LOCATION		ALCOHOL CONSUMPTION		MEDICATION		HEPATITIS HISTORY	ILLNESS
					last 48 hrs.	last 2 weeks	last 24 hrs.	customary drinks/wk.	last 24 hrs.	last month		
078	7/29/81	33	M	W	Monomer Unit	Monomer Unit	None	1-B	None	Tylenol 2 tabs wk. ago	None	None
079	7/29/81	33	M	W	Polymer Unit (4th Fl.)	Polymer Unit	4-B	12-B	None	None	None	None
080	7/29/81	45	M	W	Warehouse	Warehouse	None	None	Inderal Bid 2 different pills to slow heart rate down & Alka-seltzer 4x daily	Same	None	Mitral valve defect
081	7/29/81	57	M	M	Finishing Unit	Finishing Unit	None	None	None	None	None	None
082	7/29/81	60	M	M	Warehouse	Warehouse	2-B	12-B	None	Pepto-bismol	None	None
083	7/29/81	50	M	W	Finishing & Polymer units	all over	1-B	10-B	None	None	None	None

Table 3

Comments on Possible Clinical Significance
of Results from Selected Individuals

CODE	REMARKS
007	Not significant.
009	Significant - Depakene-hepatotoxic drug (Valproic acid).
010	Elevated bilirubin may be evidence for Constitutional Hyperbilirubinemia.
013	Not significant.
020	Significant - effects of alcohol.
021	Probably not significant.
023	Probably not significant - effects of Bronkaide-should follow up AP.
029	Not significant - drugs or alcohol.
035	Significant - probably due to alcohol-should be followed up.
036	No significance - follow up.
043	Probably alcohol induced.
044	Not significant.
045	Possibly significant - drugs?, normal?
049	Possibly significant - probably alcohol.
066	Not significant.
068	Possibly significant - drugs, alcohol?
077	Significant - drugs?, alcohol?-needs follow up.
082	Probably not significant.

Table 4

Summary of SGOT Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC)
(IU/L)
Normal Range - 10-30 IU/L

Work Area[1]	Stats	CAC[2] 0	CAC[2] 1	CAC[2] 2	Work Areas	Median	%> 30
1	$\bar{x}$	21.0	21.2	70.0	30.9	20.0	20.0
	SD	11.3	6.3	76.4	33.3		
	n	2	6	2	10		
2	$\bar{x}$	25.4	19.7	39.5	24.9	22.0	15.4
	SD	5.7	4.9	23.3	10.8		
	n	5	6	2	13		
3	$\bar{x}$	21.0	25.5		24.8	22.5	20.0
	SD	4.4	10.3	-	9.7		
	n	3	17		20		
4	$\bar{x}$	21.3	21.1	34.6	25.4	22.5	18.8
	SD	2.1	8.0	27.5	16.5		
	n	3	8	5	16		
5	$\bar{x}$	17.3	25.0	23.5	22.1	23.0	0
	SD	2.9	1.6	0.7	4.0		
	n	3	4	2	9		
6	$\bar{x}$	20.3	23.5	20.0	22.2	20.5	10.0
	SD	6.1	7.0	-	6.2		
	n	3	6	1	10		
7	$\bar{x}$	20.0	21.0	21.0	20.7	21.0	0
	SD	-	-	-	0.6		
	n	1	1	1	3		
CAC	$\bar{x}$	21.5	23.1	36.9	24.9	22.0	
	SD	5.3	7.9	32.3	15.1		
	n	20	48	13	81		
	% -30	5.0%	14.6%	23.1%			13.6%

Table 4 (continued)

Foot Notes

[1]Work areas

1 - Monomer Unit (Neoprene Dept.)
2 - Polymer Unit (Neoprene Dept.)
3 - Finishing Unit (Neoprene Dept.)
4 - Maintenance Dept.
5 - Quality Control Laboratory
6 - Maleic Acid Department
7 - Warehouse (Maintenance Dept.)

[2]CAC - Customary Alcohol Consumption

0 - none
1 - less than 18 beers/drinks per week
2 - 18 or more beers/drinks per week

Table 5

Summary of SGPT Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC)
(IU/L)
Normal Range - 6-37 IU/L

Work Area[1]	Stats	CAC[2] 0	CAC[2] 1	CAC[2] 2	Work Areas	Median	%> 37
1	$\bar{x}$	32.0	21.5	104.5	40.2	15.5	30.0
	SD	25.5	16.0	126.6	56.2		
	n	2	6	2	10		
2	$\bar{x}$	28.2	21.5	53.0	28.9	25.0	23.1
	SD	14.8	14.7	46.7	21.7		
	n	5	6	2	13		
3	$\bar{x}$	24.0	22.2	-	22.5	17.5	15.0
	SD	12.5	17.1	-	16.2		
	n	3	17	0	20		
4	$\bar{x}$	24.7	21.4	44.2	29.1	20.5	18.8
	SD	10.1	11.6	43.9	26.5		
	n	3	8	5	16		
5	$\bar{x}$	21.0	25.0	16.0	21.7	23.0	0.0
	SD	7.8	3.4	9.9	0.8		
	n	3	4	2	9		
6	$\bar{x}$	19.3	17.2	19.0	18.0	17.5	10.0
	SD	6.0	13.0	-	10.1		
	n	3	6	1	10		
7	$\bar{x}$	28.0	15.0	17.0	20.0	17.0	0.0
	SD	-	-	-	7.0		
	n	1	1	1	3		
CAC	$\bar{x}$	25.0	21.4	46.5	26.3	18.0	
	SD	11.6	13.9	55.0	26.2		
	n	20	48	13	81		
	%> 37	10	12.5	30.8			16.1

[1] & [2] See Table 4

Table 6

Summary of GGT Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC) (IU/L)

Normal Range: Males - 0-50 IU/L
Females - 0-35 IU/L

Work Area[1]	Stats	CAC[2] 0	1	2	Work Areas	Median	%>50
1	$\bar{x}$	45.0	28.8	144.0	55.1	27.0	30.0
	SD	22.7	14.8	172.5	75.7		
	n	2	6	2	10		
2	$\bar{x}$	34.4	34.3	60.0	38.3	33.0	23.1
	SD	14.5	15.5	55.2	22.7		
	n	5	6	2	13		
3	$\bar{x}$	27.3	41.0	-	39.0	28.5	15.0
	SD	13.5	41.2	-	38.4		
	n	3	17	0	20		
4	$\bar{x}$	40.7	31.6	68.6	45.7	31.0	33.3
	SD	31.6	18.9	45.9	34.5		
	n	3	7	5	15		
5	$\bar{x}$	24.3	41.8	30.5	33.4	30.0	11.1
	SD	12.5	19.1	0.7	15.6		
	n	3	4	2	9		
6	$\bar{x}$	19.7	28.3	116.0	34.5	21.0	20.0
	SD	0.6	15.8	-	31.2		
	n	3	6	1	10		
7	$\bar{x}$	45.0	51.0	24.0	40.0	45.0	33.3
	SD	-	-	-	14.2		
	n	1	1	1	3		
CAC	$\bar{x}$	32.2	35.9	73.2	41.0	29.5	
	SD	17.0	27.8	70.5	38.5		
	n	20	48	13	80		
	%> 50	17.7	52.9	29.4			21.8

[1] & [2] See Table 4

Table 7

Summary of AP Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC) (IU/L)
Normal Range - 68-243 IU/L

Work Area[1]	Stats	CAC[2] 0	1	2	Work Areas	Median	%> 243
1	$\bar{x}$	230.5	172.7	198.5	189.4	189.5	10.0
	SD	19.1	29.2	27.6	34.3		
	n	2	6	2	10		
2	$\bar{x}$	210.6	183.5	206.5	197.5	191.0	23.1
	SD	39.5	42.2	21.9	38.5		
	n	5	6	2	13		
3	$\bar{x}$	201.7	168.4	-	173.4	172.0	5.0
	SD	59.8	37.2	-	41.1		
	n	3	17	0	20		
4	$\bar{x}$	235.7	189.6	192.2	199.1	187.5	25.0
	SD	31.8	58.7	48.8	52.1		
	n	3	8	5	16		
5	$\bar{x}$	173.3	163.0	163.5	166.6	167.0	0.0
	SD	58.1	33.7	112.4	53.6		
	n	3	4	2	9		
6	$\bar{x}$	186.0	174.3	218.0	182.2	186.5	0.0
	SD	21.7	35.9	-	31.8		
	n	3	6	1	10		
7	$\bar{x}$	209.0	180.0	240.0	209.7	209.0	0.0
	SD	-	-	-	30.0		
	n	1	1	1	3		
CAC	$\bar{x}$	205.7	174.9	196.6	186.0	182.0	
	SD	41.0	39.4	48.5	42.7		
	n	20	48	13	81		
	%>243	25.0	6.3	7.7			11.1

[1] & [2] See Table 4

Table 8

Summary of ChE Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC) (IU/ml)
Normal Range - 8-20 IU/ml

Work Area [1]	Stats	CAC [2] 0	1	2	Work Areas	Median	%> 20
1	$\bar{x}$	18.60	17.20	17.90	17.60	18.0	20.00
	SD	1.98	4.11	1.84	3.25		
	n	2	6	2	10		
2	$\bar{x}$	15.60	13.60	15.35	14.60	14.0	0.0
	SD	2.76	2.71	2.90	2.70		
	n	5	6	2	13		
3	$\bar{x}$	17.30	14.00	-	14.5	14.0	10.0
	SD	5.01	2.85	-	3.31		
	n	3	17	0	20		
4	$\bar{x}$	15.70	16.50	16.80	16.50	15.8	18.8
	SD	6.50	2.86	2.78	3.41		
	n	3	8	5	16		
5	$\bar{x}$	15.50	13.70	14.80	14.60	15.1	0.0
	SD	0.45	2.48	0.57	1.76		
	n	3	4	2	9		
6	$\bar{x}$	14.60	12.20	14.70	13.20	13.2	0.0
	SD	4.2	4.17	-	3.90		
	n	3	6	1	10		
7	$\bar{x}$	22.00	11.00	17.50	16.80	17.5	33.3
	SD	-	-	-	5.5		
	n	1	1	1	3		
CAC	$\bar{x}$	16.3	14.5	16.4	15.2	14.9	
	SD	3.74	3.41	2.23	3.26		
	n	20	48	13	81		
	%> 20	15.0	8.3	7.7			9.9

1 & 2 See Table 4

Table 9

Summary of BRT Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC)
(mg/dl)
Normal Range - 0.1-1.0 mg/dl

Work Area[1]	Stats	CAC[2] 0	1	2	Work Areas	Median	%> 1.0
1	$\bar{x}$	0.50	0.38	0.45	0.42	0.45	0.0
	SD	0.42	0.23	0.07	0.23		
	n	2	6	2	10		
2	$\bar{x}$	0.78	0.52	0.60	0.63	0.60	7.7
	SD	0.78	0.22	0.42	0.51		
	n	5	6	2	13		
3	$\bar{x}$	0.53	0.69	-	0.67	0.60	10.0
	SD	0.15	0.41	-	0.39		
	n	3	17	0	20		
4	$\bar{x}$	0.57	0.51	0.44	0.50	0.45	6.3
	SD	0.29	0.47	0.18	0.35		
	n	3	8	5	16		
5	$\bar{x}$	0.56	0.40	0.35	0.44	0.50	0.0
	SD	0.35	0.22	0.49	0.30		
	n	3	4	2	9		
6	$\bar{x}$	0.66	0.45	0.60	0.53	0.45	0.0
	SD	0.31	0.14	-	0.21		
	n	3	6	1	10		
7	$\bar{x}$	0.40	0.30	0.30	0.33	0.30	0.0
	SD	-	-	-	0.06		
	n	1	1	1	3		
CAC	$\bar{x}$	0.62	0.54	0.45	0.54	0.50	
	SD	0.43	0.35	0.24	0.36		
	n	20	48	13	81		
	%>1.0	5.0	6.3	0.0			5.0

1 & 2 See Table 4

Table 10

Summary of BRD Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC) (mg/dl)
Normal Range - 0.2-0.5 mg/dl

Work Area[1]	Stats	CAC[2] 0	1	2	Work Areas	Median	%> .20
1	$\bar{x}$	0.0	0.07	0.10	0.06	0.10	0.0
	SD	0.0	0.05	0.0	0.05		
	n	2	6	2	10		
2	$\bar{x}$	0.06	0.02	0.05	0.04	0.0	0.0
	SD	0.05	0.04	0.07	0.05		
	n	5	6	2	13		
3	$\bar{x}$	0.0	0.06	-	0.05	0.05	0.0
	SD	0.0	0.05	-	0.05		
	n	3	17	0	20		
4	$\bar{x}$	0.03	0.04	0.04	0.04	0.0	0.0
	SD	0.06	0.05	0.05	0.05		
	n	3	8	5	16		
5	$\bar{x}$	0.0	0.08	0.0	0.03	0.0	0.0
	SD	0.0	0.05	0.0	0.05		
	n	3	4	2	9		
6	$\bar{x}$	0.07	0.03	0.10	0.05	0.05	0.0
	SD	0.06	0.05	-	0.05		
	n	3	6	1	10		
7	$\bar{x}$	0.0	0.0	0.0	0.0	0.0	0.0
	SD	-	-	-	0.0		
	n	1	1	1	3		
CAC	$\bar{x}$	0.03	0.05	0.05	0.04		
	SD	0.05	0.05	0.05	0.05		
	n	20	48	13	81		
	%> .20	0.0	0.0	0.0			0.0

[1] & [2] See Table 4

Table 11

Summary of PROT Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC) (seconds)
Normal Range - 10.1-12.1 seconds

Work Area[1]	Stats	CAC[2] 0	CAC[2] 1	CAC[2] 2	Work Areas	Median	%> 12
1	$\bar{x}$	11.4	11.5	-	11.5	11.35	25.0
	SD	0.3	0.6	-	0.5		
	n	2	6	0	8		
2	$\bar{x}$	11.8	11.8	11.8	11.8	11.70	15.4
	SD	0.5	0.6	0.4	0.5		
	n	5	6	2	13		
3	$\bar{x}$	11.7	11.7	-	11.7	11.55	27.8
	SD	0.4	0.5	-	0.4		
	n	3	15	0	18		
4	$\bar{x}$	11.5	11.4	11.5	11.5	11.35	12.5
	SD	0.2	0.5	0.5	0.5		
	n	3	8	5	16		
5	$\bar{x}$	11.4	11.6	11.4	11.5	11.50	0.0
	SD	0.6	0.3	0.1	0.3		
	n	3	4	2	9		
6	$\bar{x}$	11.6	11.5	11.2	11.5	11.50	0.0
	SD	0.2	0.4	-	0.3		
	n	3	6	1	10		
7	$\bar{x}$	11.1	11.7	11.5	11.4	11.5	0.0
	SD	-	-	-	0.3		
	n	1	1	1	3		
CAC	$\bar{x}$	11.6	11.6	11.5	11.6	11.5	
	SD	0.4	0.5	0.4	0.4		
	n	20	46	11	77		
	%> 12	10.0	16.7	7.7			14.3

[1] & [2] See Table 4

Table 12

Percent Extreme Values According to Liver Function Test and Customary Alcohol Consumption

Liver Function Test	CAC[2] 0	CAC[2] 1	CAC[2] 2	All Subjects
SGOT	5.0	14.6[b]	23.1[b]	13.6[b]
SGPT	10.0[a]	12.5[b]	30.8[b]	16.1[b]
GGT	17.7[b]	52.9[b]	29.4[b]	21.8[b]
AP	25.0[b]	6.3	7.7	11.1[b]
ChE	15.0[b]	8.3	7.7	9.9[b]
BRT	5.0	6.3	0	5.0
BRD	0	0	0	0
PROT	10.0[a]	16.7[b]	7.7	14.3[b]
All tests				12.6[b]

[a] significantly greater than hypothesized false positive rate, 5%; $p < .10$.

[b] significantly greater than hypothesized false positive rate, 5%; $p < .05$.

[2] See Table 4.

Table 13

Percent Extreme Values According to Liver Function Test and Work Area

Work Area[1]	(n)	SGOT	SGPT	GGT*	AP	ChE	BRT	BRD	PROT
1	(10)	20.01[b]	30.0[b]	30.0[b]	10.0	20.0[b]	0.0	0.0	25.0[b]
2	(13)	15.4 [b]	23.1[b]	23.1[b]	23.1[b]	0.0	7.7	0.0	15.4[b]
3	(20)	20.0 [b]	15.0[b]	15.0[b]	5.0	10.0	10.0	0.0	27.8[b]
4	(16)	18.8 [b]	18.8[b]	33.3[b]	25.0[b]	18.8[b]	6.3	0.0	12.5[b]
5	(9)	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0
6	(10)	10.0	10.0	20.0[b]	0.0	0.0	0.0	0.0	0.0
7	(3)	0.0	0.0	33.3	0.0	33.3	0.0	0.0	0.0
All Subjects	(81)*	13.6 [b]	16.1[b]	21.8[b]	11.1[b]	9.9[b]	5.0	0.0	14.3[b]

* one subject had no GGT value.

[b] significantly greater than hypothesized false positive rate, 5%; $p < .05$.

[1] See Table 4.

Table 14

Summary of RSUM Results Overall and According to Work Area (WA) and Customary Alcohol Consumption (CAC)

Work Area[1]	Stats	CAC[2] 0	1	2	Work Areas
1	$\bar{x}$	49.5	35.0	54.0	41.7
	SD	30.4	31.0	35.4	29.2
	n	2	6	2	10
2	$\bar{x}$	54.0	31.2	61.3	44.6
	SD	25.6	27.3	20.9	27.2
	n	5	6	2	13
3	$\bar{x}$	43.3	36.1	-	37.2
	SD	19.1	23.1	-	22.2
	n	3	17	0	20
4	$\bar{x}$	52.8	37.3	56.2	46.7
	SD	23.7	24.5	14.4	21.9
	n	3	7	5	15
5	$\bar{x}$	27.2	48.6	34.5	38.3
	SD	17.0	12.2	10.6	15.7
	n	3	4	2	9
6	$\bar{x}$	37.0	27.0	66.0	33.9
	SD	19.0	27.2	-	25.3
	n	3	6	1	10
7	$\bar{x}$	57.0	18.0	40.5	38.5
	SD	-	-	-	19.6
	n	1	1	1	3
CAC	$\bar{x}$	45.4	35.0	52.8	40.5
	SD	21.3	23.9	17.9	23.0
	n	20	47	13	80

[1] & [2] See Table 4.