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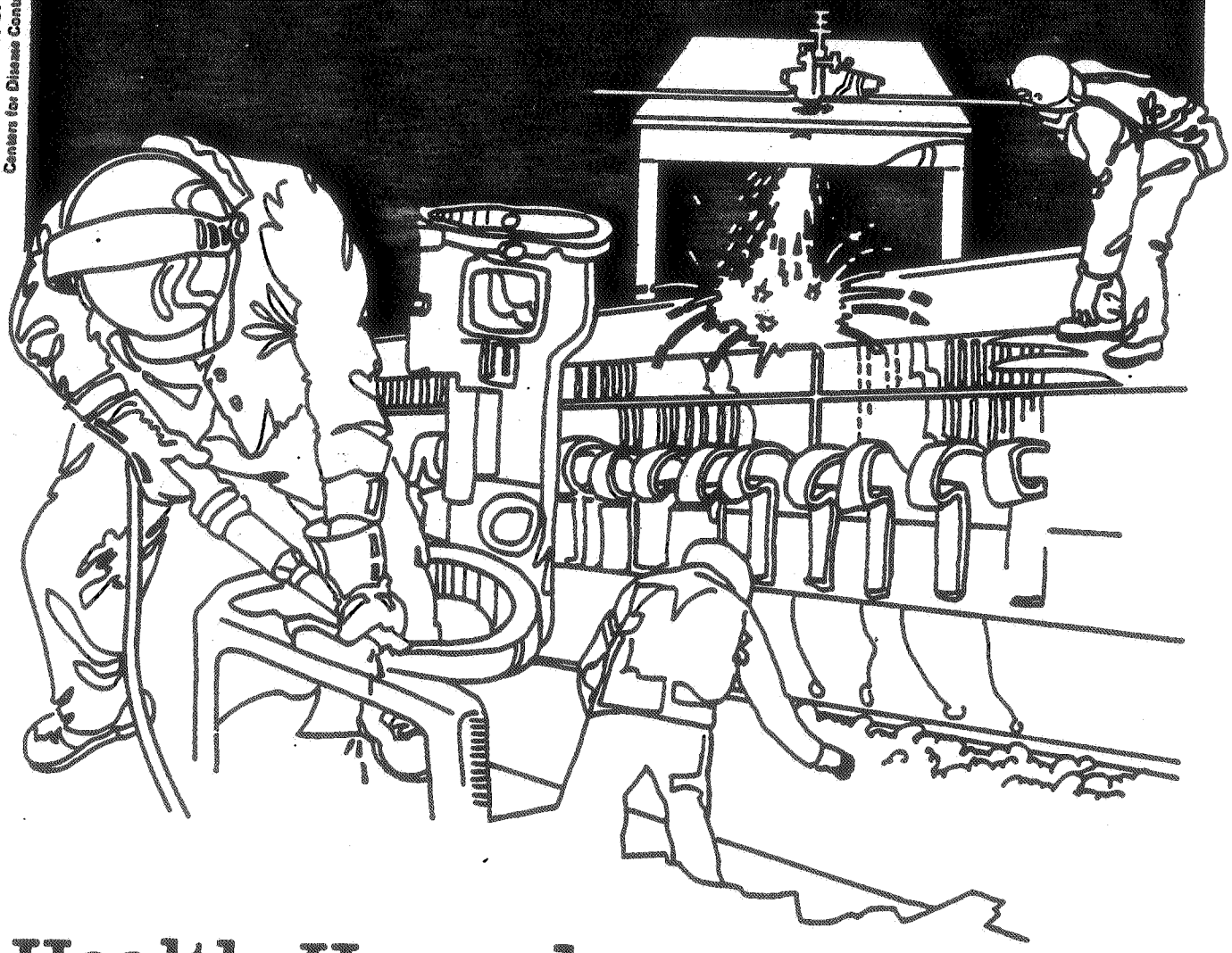

Health Hazard Evaluation Report

HETA 80-13
81-147-1644
SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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

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SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

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I. SUMMARY

In October 1979, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate eye irritation in workers at an extruded rubber plant operated by Schlegel Tennessee, Inc. in Maryville, Tennessee. NIOSH investigators conducted a preliminary survey during November 20-21, 1979; an environmental/medical questionnaire survey during March 11-12, 1980; and follow-up environmental surveys on May 22, 1980, and February 18-19, 1981.

In the sponge and dense rubber production area, concentrations of carbon disulfide in 38 personal (breathing zone) air samples ranged from 0.2 to 14 mg/m^3 with a mean of 1.9 mg/m^3. Carbon disulfide concentrations in six of the 38 samples equaled or exceeded the NIOSH recommended criteria of 3.0 mg/m^3. During the production of neoprene rubber, 3 exposures to carbon disulfide ranged from 20 to 39 mg/m^3. None of the air concentrations of carbon disulfide for the 41 personal air samples exceeded the OSHA standard of 60 mg/m^3.

Of 522 air sample analyses for 38 compounds (e.g., see keywords on this page) other than carbon disulfide, 354 (68%) indicated non-detectable air concentrations,and none of the personal (breathing zone) air samples exceeded the evaluation criteria used for this report. However, several compounds capable of causing the type of eye irritation seen among the workers were detected: hydrogen sulfide, dimethylamine and triethylamine. Bulk samples of talc showed non-detectable asbestos and free silica. Bulk samples of carbon black showed minor amounts of cyclohexane solubles and polynuclear aromatic hydrocarbons.

Ophthalmologist-diagnosed cases of keratitis and conjunctivitis had occurred among employees since rubber production began in 1976. Sharp increases in the frequency of eye conditions occurred in January 1976 and during August-October 1979. In a medical questionnaire survey, 70 cases of keratitis/conjunctivitis during August-October 1979 (incidence of 45%) were reported among 156 production workers. In contrast, only 2 cases were reported among 23 office workers. The highest incidence (54%) occurred among workers exposed to rubber immediately after it left the ovens. In March 1980, with ovens operating at normal temperatures and after the partial installation of new ventilation systems, the prevalence rate among production workers was 25%. The keratitis/conjunctivitis cases could not be explained by factors such as wearing contact lenses, having a history of hayfever, smoking or age.

The air sample results indicate that certain employees were overexposed to carbon disulfide as judged by the NIOSH recommended criteria. The exact cause of the keratitis/conjunctivitis among production employees was not determined but carbon disulfide exposure was suggested as a risk factor. Medical, environmental, and work practice recommendations are included in this report.

KEYWORDS: SIC 2822 (Synthetic Rubber), carbon disulfide, hydrogen sulfide, solvents, toluene, nitrosamines, particulates, aliphatic amines, dimethylamine, trimethylamine, triethylamine, N,N-dimethylformamide, keratitis, conjunctivitis, eye irritation, polynuclear aromatics.

II. INTRODUCTION

In October 1979, at the suggestion of Tennessee OSHA and because of union and management concerns, NIOSH received a request from the management of Schlegel Tennessee, Inc. for a health hazard evaluation. The request stated that employees at the extruded rubber plant had experienced eye irritation from an unknown source for the previous three years.

In response to the health hazard evaluation request (HE 80-13), NIOSH conducted a preliminary survey during November 20-21, 1979, and an environmental/medical survey during March 11-12, 1980. Because of process and ventilation changes, additional environmental sampling was conducted on May 22, 1980. During February 18-19, 1981, a third environmental survey was conducted at management request (HE 81-147) to provide a test of the heating/ventilation systems during cold weather.

An interim report based on the preliminary survey and including observations, findings, and recommendations, was sent to the company and union on December 10, 1979. Letters, transmitting environmental data, were sent to the company and union on May 2, 1980, June 23, 1980, and July 16, 1980.

III. BACKGROUND

Schlegel Tennessee, Inc., began rubber production in 1975. In 1976, an outbreak of keratitis and conjunctivitis occurred among a large portion of the work force. For the next several years sporadic cases of keratitis and conjunctivitis were reported. In August 1979, a new production line was opened. Shortly thereafter, increased reports of keratitis and conjunctivitis occurred. In October 1979, it was discovered that some production lines may have been running at increased temperatures. After lowering operating temperatures, the reports of keratitis and conjunctivitis began to decrease.

Schlegel Tennessee, Inc., employs approximately 370 production and 130 administrative, research, and engineering employees (including a full-time nurse) who work on a 3-shift per day 5-days per week basis. The plant is a one story facility of about 115,000 sq. ft. with ceilings of about 25 feet. Most of the production is sponge and dense rubbers which are ethylene propylene-diene monomer based. Neoprene rubber, which is chloroprene based, amounts to less than 10% of total production. Several tons of rubber products, primarily weather stripping, are produced per day.

The process begins in the Mill Area (front end process) where various accelerators, activators, fillers, polymers, etc., are hand weighed and fed into a Banbury mixer by the compounder. After mixing, each batch (about 400 pounds) is discharged at an elevated temperature to a large rolling mill for rolling to a desired thickness. After rolling, the product is coated with a talc powder (to avoid sticking), cut to the desired width, air cooled on a conveyor line, placed on pallets, and stored for 24 hours in the "curing room".

The Extrusion Department and the Finishing Department are both located on the production floor. The Extrusion Department consists of nine similar automated extrusion lines (Lines 1-5 and 7-10) for fabricating the rubber parts. Line 7 is used for experimental products and those produced sporadically, e.g. neoprene. After extruding, the dense and sponge strips are combined in the "cross head" machine. The moldings are then vulcanized in an enclosed ventilated fluidized ballantini bed of small heated glass beads or in microwave ovens. Some lines use both processes. The vulcanized moldings are brushed, washed (for cooling), drilled with holes if required, formed in the final post form machine, and cut to length in the product cut-off machine.

Some moldings are packaged in the Extrusion Department. Others are moved a short distance to the Finishing Department where they are spliced together with cement and the application of heat in one of 18 presses.

For sponge rubber, about 90 percent of the composition is ethylene propylenediene terpolymer (EPDM), carbon black, hydrated magnesium silicate, paraffinic oil, and hydrated aluminum silicate. For dense rubber, about 90 percent of the composition is ethylene propylenediene terpolymer, carbon black, calcium carbonate, and paraffinic oil. The neoprene rubber consists primarily of polychloroprene rubber, carbon black, calcium carbonate, and aromatic oil. Because they are proprietary, the minor ingredients for the sponge, dense, and neoprene rubber are not cited.

There are about 120 production employees per shift distributed as follows:

1. Mill Area (front end process) - about 10 employees
2. Extrusion Department (vulcanizing process)- nine production lines with one operator and one to two assistant operators per line. Two to six employees work as finishing operators doing plugging, packaging, etc.
3. Finishing Department (molding and ancillary support operations) - about 40 employees
4. Maintenance - about 10 employees

IV. EVALUATION METHODS

A. Environmental

During November 20-21, 1979, a preliminary survey was conducted at the plant to familiarize the NIOSH industrial hygienist with plant processes, potential exposures, number of exposed persons, etc. During this survey, a number of bulk samples of process materials and bulk air samples were collected for laboratory analysis.

During March 11-12, 1980, the first environmental survey was conducted. Based upon the bulk sample analyses of the preliminary survey, and the findings of other NIOSH studies, personal and area air

samples for carbon disulfide, cyclohexane solubles, polynuclear aromatic hydrocarbons (PNA's), nitrosamines, particulates, copper, zinc, sulfur, mercaptobenzothiazole, benzothiazolyl disulfide, methylene chloride, perchloroethylene, 1,1,1-trichloroethyane, methyl ethyl ketone, benzene, toluene, cellosolve, xylene, benzene, trimethyl benzenes, ethyl benzene, phenyl isothiocyanate, benzothiazole, triethylamine, trimethylamine, dimethylamine, aniline and N,N-dimethylformamide were obtained. Bulk samples of carbon black were collected for cyclohexane solubles and PNA analyses. Bulk samples of talc were collected for asbestos and free silica determinations.

On May 22, 1980, during the second environmental survey, additional sampling was conducted for carbon disulfide with several samples for particulates and sulfur and a bulk sample of talc for free silica analysis. Because of problems in the field sampling and in the analytical laboratory, the results of the May 22, 1980, sampling are not considered reliable and are not further discussed in this report.

During February 18-19, 1981, the third environmental survey was conducted at management request to provide "a more severe test" of the heating and ventilating systems during the colder weather. The sampling strategy of this survey was similar to the March 11-12, 1980, survey, with many of the air sample analytes being the same, including a number of samples for carbon disulfide.

The air sampling and analytical methodologies for the different contaminants are shown in Table 1.[1-7] Included for each substance are the collection device, the pump flow rate, the analysis method, the analytical detection limit, and where available, the NIOSH reference for the detailed sampling and analytical method. Personal air samples are those for which the worker wears the air sampler with the collection device attached to his/her shirt lapel or collar so as to obtain air samples representative of what he/she is breathing. The fixed location or area samples are obtained by placing the sampling apparatus either in general work areas or in positions thought to have air quality similar to that to which the workers are exposed.

B. Medical

Three sources of information were used to evaluate the occurrence of conjunctivitis and/or keratitis: 1) OSHA Report of Injury records for eye conditions (including keratitis, conjunctivitis, iritis, foreign body and other); 2) medical records from ophthalmologists for eye conditions associated with OSHA Report of Injury records; and 3) data from a standardized questionnaire for eye symptoms.

During the initial visit in November 1979, OSHA Report of Injury records were reviewed and copies obtained of all reports involving eye conditions since the plant began operation. Several workers on medical leave were interviewed for symptoms. Discussions were held with the plant nurse and with the ophthamologist to whom the majority of the workers had been referred for evaluation.

During the second visit in March 1980, all production employees working first or second shift in the Extrusion or Finishing Departments and all office workers were invited to participate in the questionnaire survey. For the third shift, only those production workers with OSHA Report of Injury records for eye conditions were eligible. Mill workers were not included in the study since no diagnoses of keratitis had been reported among this group.

After obtaining informed consent and consent for release of medical information, a standardized questionnaire was administered by trained interviewers. The questionnaire was reviewed by the National Eye Institute and included both symptoms reported during the initial visit and symptoms associated with keratitis. One unrelated question, "Did the color of your eyes change, like from brown to blue?" was included as an indicator of a tendency to respond affirmatively to any suggested symptom.

Information was collected on previous eye symptoms and job activities during the Aug.-Oct. 1979, outbreak and at the time of the survey. Questions were also included on previous eye injuries; potential confounding factors for eye symptoms such as hay fever, smoking and contact lenses; possible adaptive responses to eye symptoms such as wearing glasses with light sensitive or tinted lenses; and the presence of several non-eye symptoms such as dizziness, nose or throat dryness or irritation, nausea, nervousness, coughing and skin irritation.

Medical records were collected for all workers who reported seeing an ophthalmologist for an eye condition associated with an OSHA Report of Injury. Eye irritation symptoms for the August - October 1979, outbreak were reviewed for workers with diagnoses by ophthalmologists of either keratitis or conjunctivitis during this period. Since it was not possible to distinguish between individuals with keratitis or conjunctivitis on the basis of symptoms, a common case definition was constructed for "keratitis/conjunctivitis." A case of keratitis/conjunctivitis was defined as a "yes" response to at least five of six symptoms: burning or burning pain, bloodshot or very red eyes, film over the eyes or blurry vision, gritty or scratchy sensation, eyes more sensitive to light than other members of household, and bad headaches.

The study population consisted of production workers from the first and second shift who were either assigned to a specific line or who had a stationary job. Third shift participants were used only to establish the case definition of keratitis/conjunctivitis. The Extrusion Department was composed of workers assigned to a specific line and included the following job titles: Assistant Line Operator (before or during enclosed heating of the rubber), Finishing Operator (after heating - rubber exposed to air), and Line Operator (entire line). The Finishing Dept. consisted of two stationary jobs: Splicer - Molder (reheating rubber) and Finishing Operator. An office worker was defined as any worker who reported spending less than 5% of their time on the production floor.

V. EVALUATION CRITERIA

A. Environmental Criteria

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

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the levels set by the evaluation criteria. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. In reviewing the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 to meet those levels specified by OSHA standards.

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

The environmental evaluation criteria used for this study are presented in Table 2. Of the 39 substances sampled for during the study, five were present in other than non-detectable or trace concentrations. Listed in Table 2, for each of these five substances, are the recommended environmental limit, the source of the recommended limit, the principal or primary health effects underlying each recommended limit, and the current OSHA legal standard.[8-13]

Nitrosamines, as a class, are among the most potent and widespread of animal carcinogens. Although there is not a current OSHA standard for employee exposures to airborne N-nitrosamines, OSHA has a regulation regarding work practices and handling of liquid and solid N-nitrosodimethylamine in concentrations greater than 1%.[13] Since nitrosamines are potent carcinogens, it is prudent to eliminate or reduce exposures to nitrosamines to the lowest possible levels.

B. Medical

Carbon disulfide[15,16] vapor causes narcosis at high concentrations; repeated exposure to low concentrations causes damage to the central and peripheral nervous systems and may accelerate the development of, or worsen, coronary heart disease. Exposure of humans to 1150 ppm causes serious symptoms, and 4800 ppm for 30 minutes may be fatal. Repeated exposure to carbon disulfide at 186 ppm may cause sleep disturbances, fatigue, nervousness, anorexia, and weight loss; headache and dizziness have been reported at repeated exposure of 11 ppm. Psychosis and suicide are established risks of overexposure to carbon disulfide. Other reported effects include ocular changes, gastrointestinal disturbances, renal impairment, liver damage and reproductive disorders.

Hydrogen sulfide[14,15,16] gas is a rapidly acting systemic poison which causes respiratory paralysis with consequent asphyxia at high concentrations. Concentrations of 1000-2000 ppm may cause coma after a single breath and may be rapidly fatal. Prolonged exposure to 250 ppm may cause pulmonary edema. Rapid olfactory fatigue can occur at high concentrations. In low concentrations, hydrogen sulfide may cause headache, fatigue, irritability, insomnia, and gastrointestinal disturbances; in somewhat higher concentrations it affects the central nervous system, causing excitement and dizziness.

Exposure to concentrations of hydrogen sulfide above 50 ppm for one hour may produce eye irritation including acute conjunctivitis with pain, lacrimation, and photophobia. In the severe form this may progress to keratoconjunctivitis and vesiculation (blistering) of the corneal epithelium (keratitis superficialis punctata). At concentrations as low as 10 ppm (less than the current OSHA standard), the first symptoms of eye irritation may appear after 6-7 hours of exposure. Prolonged exposure to concentrations of hydrogen sulfide as low as 50 ppm may cause rhinitis, pharyngitis, bronchitis, and pneumonitis. Repeated exposure to hydrogen sulfide results in increased susceptibility, so that eye irritation, cough, and systemic effects may result from concentrations previously tolerated without any effect.

Synergism of Hydrogen Sulfide and Carbon Disulfide--Keratitis has frequently been reported in industrial operations with carbon disulfide exposure (e.g. rayon production). A series of animal experiments demonstrated that carbon disulfide does not, by itself, cause keratoconjunctivitis.[17] Another compound frequently present with carbon disulfide -- hydrogen sulfide -- was identified as the etiologic agent for keratitis in rayon mills. Carbon disulfide has been shown, however, to potentiate the effects of hydrogen sulfide in causing keratitis; i.e., keratitis appears at lower levels of exposure to hydrogen disulfide when carbon sulfide is also present.[16,17]

Aliphatic amines (e.g. triethylamine, dimethylamine, and trimethylamine) are irritating or damaging to the eye on contact. Dimethylamine has been reported to cause edema of the cornea, leading to photophobia and blurring of vision.[18] Triethylamine has been reported to cause opacity and edema of the cornea.[21] In animals, triethylamine has been reported to cause keratitis at 50 ppm.[21] Dimethylamine and trimethylamine have also been reported to cause keratitis in animals from direct application at high concentrations.[22] This same report attributes the cause of keratitis in workers unloading oil herring to these two methylamines. However, hydrogen sulfide is a predominant compound in gaseous degradation products of anaerobic putrafaction of oil herring and also causes keratitis.

VI. RESULTS

A. Environmental

Table 3 summarizes the results of the personal air sampling for carbon disulfide while Appendix 1 presents all of the individual air sample results (personal and area samples) for the surveys of March 1980 and February 1981. In March 1980, while sponge and dense rubber were being run, the 16 personal samples in the Extrusion and Finishing Departments ranged from 0.2 to 14 mg/m^3 with a mean of 2.0 mg/m^3. One of these 16 samples exceeded the evaluation criterion of 3.0 mg/m,^{3} but all were below the ACGIH TLV of 30 mg/m^3 and the OSHA standard of 60 mg/m^3. In February 1981, while sponge and dense rubber were being run, the 22 personal samples in the Extrusion and Finishing Departments ranged from 0.4 to 3.8 mg/m^3 with a mean of 1.9 mg/m^3. Four of these 22 samples were 3.0 mg/m^3 and one was 3.8 mg/m^3 as compared to the evaluation criterion of 3.0 mg/m^3. All 22 were below the ACGIH TLV of 30 mg/m^3 and the OSHA standard of 60 mg/m^3. Mean air concentrations in the Extrusion Department were lowest while the rubber was in the ovens (Asst. Line Operators, mean of 0.9 mg/m^3), intermediate for the mobile Line Operators (2.1 mg/m^3), and highest immediately after the rubber emerged from the ovens (Finishing Operators, mean of 2.6 mg/m^3). The overall mean air concentration in the Finishing Department (0.6 mg/m^3) was lower than in the Extrusion Department (2.2 mg/m^3).

During the March 1980 survey, three personal air samples for carbon disulfide were collected on Line 7 employees while neoprene rubber was being run (Table 3). Concentrations ranged from 20 to 39 mg/m^3 with a mean of 31 mg/m^3. All three samples exceeded the evaluation criterion of 3.0 mg/m^3, two exceeded the ACGIH TLV of 30 mg/m^3, and none exceeded the OSHA standard of 60 mg/m^3.

Table 4 summarizes the air sample results for 46 toluene, 10 cellosolve, 39 perchloroethylene, thirty-nine 1,1,1-trichloroethane, 7 xylene, 31 methylene chloride, 31 methyl ethyl ketone, 31 benzene, seven 1,3,5-trimethylbenzene, seven 1,2,3-trimethylbenzene, seven 1,2,4-trimethylbenzene, and 7 ethyl benzene analyses. The individual air sample results are presented in Appendices 2 and 3. Most (62%) of these air samples indicated non-detectable air concentrations and none exceeded either the evaluation criteria or the OSHA legal standards (see Table 4).

Table 5 summarizes the air sample results for 6 cyclohexane solubles, 6 benzo(a)pyrene, 6 chrysene, 6 pyrene, 6 benzo(a)anthracene, 6 fluoranthracene, 16 total particulates, 9 zinc-dimethyl-dithiocarbamate, 9 copper-dimethyl-dithiocarbamate, 6 sulfur, 2 toluene diisocyanate, 2 butyl mercaptan, 20 triethylamine, 20 dimethylamine, 10 trimethylamine, 11 phenylisothiocyanate, 11 benzothiazole, 7 N-nitrosodimethylamine, 7 N-nitrosopiperidine, 18 aniline, 18 N,N-dimethylformamide, 10 hydrogen sulfide, 7 sulfur dioxide, and 15 total hydrocarbon analyses. The individual air sample results are presented in Appendices 4 thru 11. With the exception of 1 sample for cyclohexane solubles, and 2 samples for dimethylamine, most (73%) of these air samples indicated non-detectable air concentrations and none exceeded either the evaluation criteria or the OSHA legal standards. One of the cyclohexane solubles samples exceeded the evaluation criteria of 0.10 mg/M^3 and 2 of the dimethylamine samples exceeded the evaluation criteria of 18 mg/M^3. However, these 3 samples were area samples and none reflect actual employee exposures. The 15 air samples for total hydrocarbons ranged from "non-detected" to 16 mg/M^3. Although there is not a recommended or legal standard for total hydrocarbons per se, the NIOSH recommended standard for such refined petroleum solvents as petroleum ether, rubber solvent, mineral spirits, and stoddard solvent is 350 mg/M^3 determined as an average concentration for up to a 10-hour work shift, 40 hour work week. This comparison is not intended to imply that the hydrocarbon measurements reflect refined petroleum solvent vapors solely, but is intended to serve as sort of a "yard-stick".

The analyses of two bulk talc samples showed no asbestos or free silica (quartz, cristobalite) at the laboratory detection limits.

The two carbon black samples analyzed for cyclohexane solubles and polynuclear aromatics showed minor amounts of the cyclohexane solubles, fluoranthene, and pyrene. Benzo(a)pyrene, chrysene, benzo(a)anthracene, and benzo(e)pyrene were not detected at the laboratory detection limits.

Short term breathing zone indicator tube samples for mercaptan (5 samples), triethylamine (8 samples), hydrogen sulfide (5 samples), ammonia (3 samples), and sulfur dioxide (5 samples) showed essentially non-detectable air concentrations (Appendix 13).

B. Medical

1. Recorded Eye Problems

Figure 1 shows the temporal distribution of eye problems reported in the OSHA Report of Injury records since the plant began operation in January 1976 through December 1979. There were 252 incidents, with several individuals having more than one incident. Two periods of increased incidence are apparent, one in January 1976 when approximately 23 OSHA reports of injury were filed per 100 workers and the other during August-October 1979 when approximately 6 reports were filed per 100 workers. Figure 2 shows the distribution of reports by week for the August-October 1979 outbreak. The histogram shows a steep rise coinciding with the opening of a new production line, reachng a maximum of approximately 14 reports per 100 workers during the week of August 13, 1979. The prevalence declines to approximately 5 reports per 100 workers in October 1979 and drops to background levels in November 1979 when vulcanizing temperatures were lowered.

2. Questionnaire

Keratitis/Conjunctivitis--August - October 1979. During the August-October 1979, outbreak there were 70 cases of keratitis/conjunctivitis among 156 production workers interviewed, an incidence rate of 45% (Table 6). Among 23 office workers there were two cases, an incidence rate of 9%. This difference was statistically significant ($X^2 = 10.9$, $p < 0.001$). For all twelve eye symptoms associated with keratitis or conjunctivitis, production workers had significantly higher rates than office workers (Table 7). These differences were statistically significant ($p < 0.05$) by either the X^2 or Fisher's Exact Test. For headache, production workers again reported a greater rate (60% vs. 39%), though this difference was not quite statistically significant ($X^2 = 3.45$, $p < 0.06$).

In response to the question unrelated to keratitis/conjunctivitis, "Have your eyes ever changed color, such as from brown to blue?," 5 (3%) of the production workers and 1 (4%) of the office workers responded "yes". This difference was not statistically significant (Two-sided Fisher's Exact Test, $p = 0.27$).

Incidence rates were similar for the Extrusion and Finishing Departments (Table 8). In both departments, however, the rates were highest in Finishing Operators, workers exposed to molding after it has been heated. Within the Extrusion Department, Finishing Operators exposed to molding immediately after it emerged from the ovens had the highest incidence rate; 23 of 43 (53%). Assistant Line Operators who work where molding is enclosed in the ovens had the lowest rate. This

difference was statistically significant (x^2=4.04, $p < 0.05$), 7 of 24 (29%) . Line Operators, who work the entire line (i.e., both the area covered by the Assistant Line Operators and the area covered by the Finishing Operators), had an intermediate rate, 9 of 21 (43%). When attack rates were computed by production line, the differences were not statistically significant ($X^2 = 5.305$, DF=8, p=0.72).

Keratitis/Conjunctivitis--March 1980. Workers were asked about current eye symptoms in March 1980 when ovens were operating at normal temperatures and after the new ventilation system had been partially installed. The prevalence of keratitis/conjunctivitis at this time among production workers was 25%.

Confounding Factors. Confounding factors for keratitis/conjunctivitis were examined for cases and non-cases of August-October 1979. Among cases, 3% wore contact lenses; among non-cases, the proportion was 2% (Table 9). This difference was not statistically significant (One-sided Fisher's Exact Test, p = 0.61). Among cases, 7% reported having hayfever; among non-cases the proportion was 5%. This difference was not statistically significant (One-sided Fisher's Exact Test, p = 0.37). Half (51%) of the cases were smokers; a greater proportion (65%) of the non-cases were smokers. This difference was almost statistically significant ($X^2 = 2.99$, p = 0.08), but the trend was the opposite of what would be expected if smoking were the cause of the eye symptoms reported. Mean age for cases was 33 years and for non-cases, 34 years.

Adaptive Responses. Among production workers for August-October 1979, 70% reported wearing light-sensitive or tinted glasses (suggestive of photophobia). Among cases the proportion was 86% and among non-cases, 65%. This difference was statistically significant ($X^2 = 6.91$, $p < 0.01$).

Other Symptoms. Among cases of keratitis/conjunctivitis in March 1980, the following non-eye symptoms were reported: nose irritation (96%), nervousness (72%), cough (70%), nausea (64%), skin irritation (46%), and dizziness (40%).

VII. DISCUSSION/CONCLUSIONS

A. Environmental

With the exception of carbon disulfide, the air sample results (including 26 short-term samples) generally indicated concentrations of contaminants well below their respective evaluation criteria, during what were judged to be normal operations. Of 522 sample analyses, for 38 compounds other than carbon disulfide, 354 (68%) indicated non-detectable air concentrations (at laboratory lower limit of quantitation) and none of the personal air samples showed a result in excess of the evaluation criteria, the ACGIH TLV, or the OSHA standard.

Although none of the air samples for particulates in the compounding area exceeded the evaluation criteria of 10 mg/m^3 for total particulates (nuisance dusts) a sense of security is not necessarily appropriate. A review of the list of proprietary ingredients would show several that could pose health risks at concentrations below the evaluation criteria of 10 mg/m^3 for total particulates. A lack of available sampling and analytical methods was the reason some of these potentially hazardous ingredients were not sampled for.

Nitrosoamines (N-nitrosodimethylamine, N-nitrosopiperidine) were detected at levels typical of what NIOSH has found in the rubber industry for plants with low levels. Although the small amounts found in the Schlegel plant are not unusual for this type of industry, because of nitrosamines' carcinogenic potential, employee exposures to should be minimized.

That the bulk samples of talc did not show detectable quantities of asbestos or free silica, indicates that it can be handled or controlled as if it were pure talc rather than as a carcinogen (asbestos) or a substance capable of silicosis potential (free silica). A similar conclusion can be made for carbon black, since the bulk sample analyses showed just minor amounts of the cyclohexane solubles and polynuclear aromatic hydrocarbons.

The highest exposures to carbon disulfide were seen during neoprene production when the three personal samples all exceeded the evaluation criterion. Lower exposures to carbon disulfide were seen during dense and sponge rubber production, with 4 of the 38 personal samples being equal to the evaluation criterion and 2 of the 38 personal samples being greater than the evaluation criterion. The mean concentration of carbon disulfide was similar in both the March 1980 and the February 1981 environmental surveys. None of the air samples for carbon disulfide exceeded the OSHA standard. Although the air concentrations were less than the OSHA standard, it is concluded that some employees may occasionally be over-exposed to carbon disulfide as judged by the evaluation criterion.

B. Medical

Several chemical compounds have been suggested as the cause of the keratitis documented among the Schlegel workers. Investigative reports prepared by company consultants have identified carbon monoxide, carbonyl sulfide, carbon disulfide, chloroprene, ammonia, and sulfur dioxide as being present during vulcanization and capable of causing eye irritation. Although these compounds may adversely affect the eye, including damage to the cornea,[18,19] none causes keratitis. Grant[18] notes that ammonia, carbon disulfide, and sulfur dioxide have all been reported to cause keratitis. In each instance, the reports have been erroneous or unreliable. Grant also notes that possibly methyl amines have been erroneously reported to cause keratitis. In most of these reports, hydrogen sulfide has also been present. An outbreak of keratitis reported at another plant using an identical

process was attributed to ethyl isothiocyanate.[20] This compound has not been detected at Schlegel Tennessee Inc., however. Ballantine (fine glass beads) which is present in some of the ovens has been suggested as the cause of the keratitis, but Ballantine would cause long straight scratches of the cornea, not the vesiculation or blistering as documented by ophthalmologists among Schlegel workers.

When mean values for carbon disulfide were computed by job title, the highest mean values were seen after the rubber molding emerged from heating. This pattern was similar to that seen among keratitis/conjunctivitis cases.

The prevalence of non-eye symptoms among cases of kerato/conjunctivitis suggests the presence of an irritative compound in addition to carbon disulfide.[17] Although several of the non-eye symptoms may occur from exposure to carbon disulfide, two of the most prevalent, (nose irritation and cough) are not ordinarily seen with carbon disulfide. Hydrogen sulfide, an irritative compound detected at Schlegel Tennessee, Inc., causes keratitis and is potentiated in causing this health effect when accompanied by the presence of carbon disulfide.

Workers in the Extrusion and Finishing Departments at Schlegel Tennessee, Inc. had an increased risk of developing eye irritation including keratitis or conjunctivitis. The highest risk occurred among Extrusion Department Finishing Operators who had contact with molding immediately after it emerged from the vulcanizing ovens and is exposed to air. An increased risk of keratitis and conjunctivitis also occurred when the ovens were operated at elevated temperatures.

VIII. RECOMMENDATIONS

1. All engineering control systems should be periodically evaluated/modified to assure adequacy, maintenance, and proper utilization. Adequate local exhaust ventilation should be provided for any operation (e.g., compounding, cut-off, drilling) which may generate aerosols (dusts) resulting in hazardous employee exposures. This is particularly true in the compounding area where toxic substances are handled.

2. Because of the carcinogenic potential of nitrosamines, management should make a concerted effort to identify and eliminate the source(s) of these compounds.

3. The worker education program should include discussions of various process chemicals, hazards and toxic effects of these chemicals, and good work practices for reducing exposures.

4. The company should maintain a high degree of housekeeping within the plant. Containers holding various chemicals should have tight fitting lids and be appropriately labeled. Dusts should not be allowed to accumulate.

5. Work practices should be evaluated to ascertain if employees are being unnecessarily exposed to chemicals. Improper work practices (e.g., putting heads in ventilation hoods, leaning into or over drums of chemicals, handling hot extrusions with bare hands, unnecessarily creating dusts, etc.) should be corrected.

6. The wearing of proper protective clothing (e.g., long-sleeved shirts, respirators, gloves, etc.) should be established for certain operations, particularly those with higher exposure potentials such as compounding and cleaning dust collectors. Goggles should be worn by employees when there is a potential for airborne ballantine dusts such as opening of hood doors to fluidized bed and/or adding ballantine.

7. The respiratory protection program should comply with the OSHA requirements for a minimal acceptable program as described in Title 29 of the Code of Federal Regulations, Part 1910, Section 134.

8. Employees should continue to be referred to an ophthamologist when symptoms and physical examination suggest the possibility of keratitis.

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1. Schlegel Tennessee, Inc.
2. Amalgamated Clothing and Textile Workers International Union
3. Amalgamated Clothing and Textile Workers Local 1933
4. Tennessee Department of Labor
5. OSHA, Region IV, Atlanta, Georgia
6. NIOSH, Region IV, Atlanta, Georgia

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

TABLE 1

AIR SAMPLING AND ANALYSIS METHODOLOGY

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Substance	Collection Device	Flow Rate (LPM)	Analysis	Detection Limit (ug/sample)	NIOSH Reference
Benzene	Charcoal Tube	0.1-0.2	Gas Chromatograph	4,5	P&CAM 127
Benzothiazole	"	1.0	"	5	"
Carbon Disulfide	"	0.1	"	0.6	S-248 (modified)
Cellosolve	"	0.1-0.2	"	200	P&CAM 127
Ethyl Benzene	"	"	"	10	"
Methylene Chloride	"	"	"	10,20	"
Methyl Ethyl Ketone	"	"	"	80,200	"
Perchloroethylene	"	"	"	10	"
Phenyl Isothiocyanate	"	1.0	"	5	"
Toluene	"	0.1-0.2	"	10	"
1,1,1-Trichloroethane	"	"	"	10	"
1,3,5-Trimethylbenzene	"	"	"	10	"
1,2,3-Trimethylbenzene	"	"	"	10	"
1,2,4-Trimethylbenzene	"	"	"	10	"
Xylene	"	"	"	10	"
Aniline	Silica Gel Tube	0.2	Gas Chromatograph	10	S-310,255
Dimethylamine	"	0.1	"	10	P&CAM 220
N,N-dimethylformamide	"	0.2	"	10	S-310,255
Triethylamine	"	0.1	"	10	P&CAM 220
Trimethylamine	"	0.1	"	10	P&CAM 220
Copper	FWSB Filter	1.5	Atomic Absorption	2.0	P&CAM 173
Zinc	"	1.5	"	2.0	"
Total Particulates	"	1.5	Electrobalance	10.0	---
N-nitrosodimethylamine	Thermosorb Tube	1.0	GC&HPLC-TEA	0.1 ug/M^3	None Published
N-nitrosopiperidine	"	1.0	GC&HPLC-TEA	0.1 ug/M^3	None Published

TABLE 1 (continued)

AIR SAMPLING AND ANALYSIS METHODOLOGY

Substance	Collection Device	Flow Rate (LPM)	Analysis	Detection Limit (ug/sample)	NIOSH Reference
Cyclohexane Solubles	Glass Fiber Filter Ag. Memb. Filter Porus Polymer Tube	1.5	Cyclohexane Extraction	20	P&CAM 217
Polynuclear Aromatics					
Benzo(a)anthracene	"	1.5	HPLC-UV Detector	1.0	P&CAM 217
Benzo(a)pyrene	"	1.5	"	1.0	"
Chrysene	"	1.5	"	3.0	"
Fluoranthene	"	1.5	"	2.0	"
Pyrene	"	1.5	"	5.0	"
Toluene diisocyanate	Impinger	1.0	High Pess. Liq. Chro.	0.7	P&CAM N-240
Butyl Mercaptan	Chromosorb Tube	1.0	Gas Chromatograph	5	S350
Sulfur	Glass Fiber Filter	1.5	Gas Chromatograph	5	S-248 (modified)
Hydrogen Sulfide	Long Term Ind. Tube	0.02	Direct Reading	5 ul	Mfg. Data
Sulfur Dioxide	"	0.02	Direct Reading	5 ul	"

TABLE 2

ENVIRONMENTAL EVALUATION CRITERIA (see note)

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Substance	Recommended Environmental Limit (mg/M^3)	Source	Primary Health Effects	OSHA Standard (mg/M^3)
Carbon disulfide	3	NIOSH	Heart, nervous system, and reproductive effects	62
Cyclohexane (Benzene) Solubles	0.1	NIOSH	Lung and skin cancer	0.2
N-nitrosodimethylamine N-nitrosopiperidine	(nitrosoamines are potent animal carcinogens - exposures should be minimized)			
Total Particulates	10	ACGIH	Pulmonary Effects	15
Toluene	375	NIOSH	Central Nervous System Depressant	750

All air concentrations are time-weighted average exposures for a normal (8 to 10 hour) work day of a 40 hour work week unless otherwise designated.

NOTE: Criteria for cellosolve, dimethylamine, perchloroethylene, 1,1,1-trichloroethane, xylene, methylene chloride, methyl ethyl ketone, benzene, 1,3,5-trimethyl benzene, 1,2,3-trimethyl benzene, 1,2,4-trimethyl benzene, ethyl benzene, toluene diisocyanate, butyl mercaptan, zinc-dimethyl-dithiocarbamate, copper-dimethyl-dithiocarbamate, triethylamine, aniline, N,N-dimethylformamide, sulfur, phenylisothiocyanate, benzothiazole, hydrogen sufide, and sulfur dioxide are not presented in this table since these substances were either non-detectable or present in trace concentrations only.

TABLE 3

SUMMARY OF AIR SAMPLE RESULTS FOR CARBON DISULFIDE

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Organization	Number of Samples	Carbon Disulfide (mg/M^3) Air Concentration Mean	Carbon Disulfide (mg/M^3) Air Concentration Range
9/20/79	State of Tennessee Dept. of Labor	8	2.6	nd-12.1
3/11-12/80	NIOSH - Because of suspect samples, results not summarized			
5/22/80	NIOSH - Becuase of suspect samples, results not summarized			
6/16/80	Aetna Life & Casualty Co.	8	2.4	1.2-3.1
2/18-19/81	NIOSH	23	1.8	0.2-3.8
Survey Criteria			3	

TABLE 4

SUMMARY OF AIR SAMPLE RESULTS FOR SOLVENTS

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

March 11-12, 1980
February 18-19, 1981

Solvent	Total Samples	Number of Samples with Non-detectable Air Concentrations	Samples with Detectable Air Concentrations*			Survey Criteria* and Source
			Number	Air Conc.* Mean	Air Conc.* Range	
Toluene	46	2	44	16.0	0.1-260.0	375 (NIOSH)
Cellosolve	10	5	5	0.7	0.3-1.0	185 (ACGIH)
Perchloroethylene	39	29	10	1.3	0.1-4.0	LFL (NIOSH)
1,1,1-Trichloroethane	39	15	24	1.1	0.1-9.0	1910 (NIOSH)
Xylene	7	2	5	0.04	0.02-0.06	100 (NIOSH)
Methylene Chloride	31	26	5	0.4	0.1-0.9	261 (NIOSH)
Methyl Ethyl Ketone	31	30	1	0.3	---	590 (ACGIH)
Benzene	31	31	0	---	---	LFL (NIOSH)
1,3,5-Trimethylbenzene	7	7	0	---	---	125 (ACGIH)
1,2,3-Trimethylbenzene	7	6	1	0.04	---	125 (ACGIH)
1,2,4-Trimethylbenzene	7	4	3	0.05	0.03-0.07	125 (ACGIH)
Ethyl Benzene	7	6	1	0.03	---	435 (ACGIH)

LFL - Reduce exposures to lowest feasible limit.

* Air concentrations in mg/M^3

TABLE 5

SUMMARY OF AIR SAMPLE RESULTS FOR 24 MISC. ANALYTES

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Substance	Total Samples	Number of Samples with Non-detectable Air Concentrations	Samples with Detectable Air Concentrations			Survey Criteria (mg/M^3)
			Number	Air Conc.* Mean	Air Conc.* Range	
Cyclohexane Solubles	6	1	5	0.08	0.06-0.12	0.1
5-Polynuclear Aromatics*	6	6	---	---	---	minimize exposures
Total Particulates	16	0	16	1	0.1-3.4	10
Zinc Dimethyldithiocarbamate	9	0	9	0.4	0.01-0.9	none
Copper Dimethyldithiocarbamate	9	6	3	0.08	0.06-0.1	none
Sulfur	6	6	---	---	---	none
Toluene Diisocyanate	2	2	---	---	---	0.035
Butyl Mercaptan	2	2	---	---	---	1.5
Triethylamine	20	18	2	0.6	0.4-0.8	40
Dimethylamine	20	12	8	9*	0.1-35*	18
Trimethylamine	10	10	---	---	---	10
Phenylisothiocyanate	11	11	---	---	---	none
Benzothiazole	11	11	---	---	---	none
N-nitrosodimethylamine*	7	0	7	0.6	0.1-2.1	minimize exposures
N-nitrosopiperidine*	7	6	1	0.4	---	" "
Aniline	18	17	1	0.1	---	10
N,N-Dimethylformamide	18	12	6	0.2	0.02-0.5	30
Hydrogen Sulfide	10	10	---	---	---	15
Sulfur Dioxide	7	7	---	---	---	1.3
Total Hydrocarbons	15	10	5	5	1-16	none

* NOTES:
1. All air concentrations are in mg/M^3 except for N-nitrosodimethylamine and N-nitrosopiperidine in ug/M^3.
2. The five polynuclear aromatics were benzo(a)pyrene, chrysene, pyrene, benzo(a)anthracene, fluoranthene.
3. Results for dimethylamine include two area samples of 35 mg/M^3 (not of health significance).

TABLE 6

PREVALENCE OF KERATITIS/CONJUNCTIVITIS BY WORK AREA

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

AUGUST-OCTOBER 1979

	Cases	Noncases	Total
Production	70	86	156
Office	2	21	23

Statistically significant ($X^2 = 10.9$, $p < 0.001$)

TABLE 7

KERATITIS/CONJUNCTIVITIS SYMPTOMS BY WORK AREA

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

AUGUST-OCTOBER, 1979

	Production Workers Proportion	(Percent)	Office Workers Proportion	(Percent)	Statistics X^2	p
Eyes more sensitive to light than other members of household	101/145	(70%)	6/20	(30%)	12.1	< 0.001*
Bloodshot or very red eyes	99/150	(66%)	9/23	(39%)	6.14	< 0.01*
Bad headache	89/149	(60%)	9/23	(39%)	3.45	0.06
Film over the eyes which made things look cloudy or hazy	84/149	(56%)	3/22	(14%)	14.0	< 0.001*
Gritty or scratchy sensation that felt like sand in the eyes	83/151	(55%)	1/23	(4%)	20.5	< 0.001*
Blurry or out of focus vision (even with glasses)	74/152	(49%)	3/23	(13%)	10.3	< 0.001*
Burning or burning pain in the eyes	81/152	(53%)	4/23	(17%)	10.3	< 0.01*
Unusual or excessive watering or tearing of the eyes	75/154	(49%)	2/23	(9%)	13.0	< 0.001*
Pain or pressure in the back of the eyes	54/153	(35%)	2/23	(9%)	6.52	< 0.01*
Spasms or excessive twitching of the eyelids	51/149	(34%)	2/22	(9%)	5.66	< 0.05*
Swollen or puffy eyes	47/151	(31%)	2/23	(9%)	4.96	< 0.05*
Seeing of rainbow rings or halos around lights	35/149	(23%)	0/22	(0%)	6.50	< 0.01*
Blisters on the eyes	22/152	(14%)	0/23	(0%)	3.81	< 0.05*
Eyes changing color (e.g. brown to blue)	4/149	(3%)	1/23	(4%)	0.20	0.66

*Statistically significant

TABLE 8
KERATITIS/CONJUNCTIVITIS CASES BY JOB TITTLE

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147
AUGUST-OCTOBER 1979

	Cases	Noncases
Extrusion Department		
Asst. Line Operator	7 (29%)	17 (71%)
Line Operator	9 (43%)	12 (57%)
Finishing Operator	23 (53%)	20 (47%)
Total	39 (44%)	49 (56%)
Finishing Department		
Splicer - Molder	10 (43%)	13 (57%)
Finish Operator	21 (48%)	23 (52%)
Total	31 (46%)	36 (54%)

TABLE 9

CONFOUNDING FACTORS FOR KERATITIS/CONJUNCTIVITIS

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

AUGUST - OCTOBER 1979

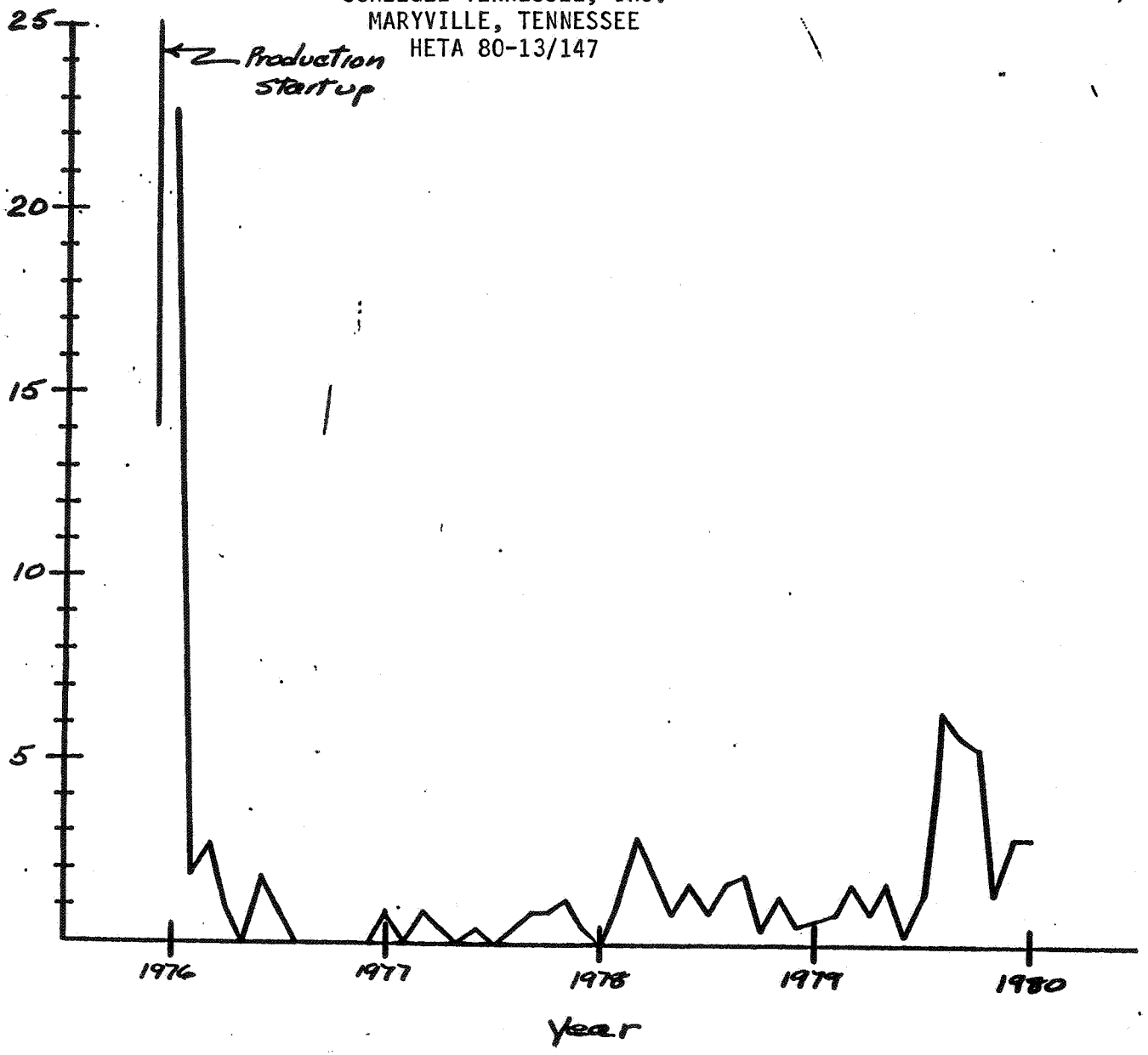
	Cases		Noncases		Statistics
	Proportion	(Percent)	Proportion	(Percent)	
Contact Lenses	2/70	(3%)	2/86	(2%)	Fishers, p = 0.61*
Hayfever	5/70	(7%)	4/86	(5%)	Fishers, p = 0.37*
Cigarette Smoker	36/70	(51%)	56/86	(65%)	$X^2 = 2.99$, p < 0.08*

*All nonsignificant

FIGURE 1

PREVALENCE OF WORKERS WITH EYE CONDITIONS*
FROM OSHA REPORT OF INJURY RECORDS
1976 thru 1979

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

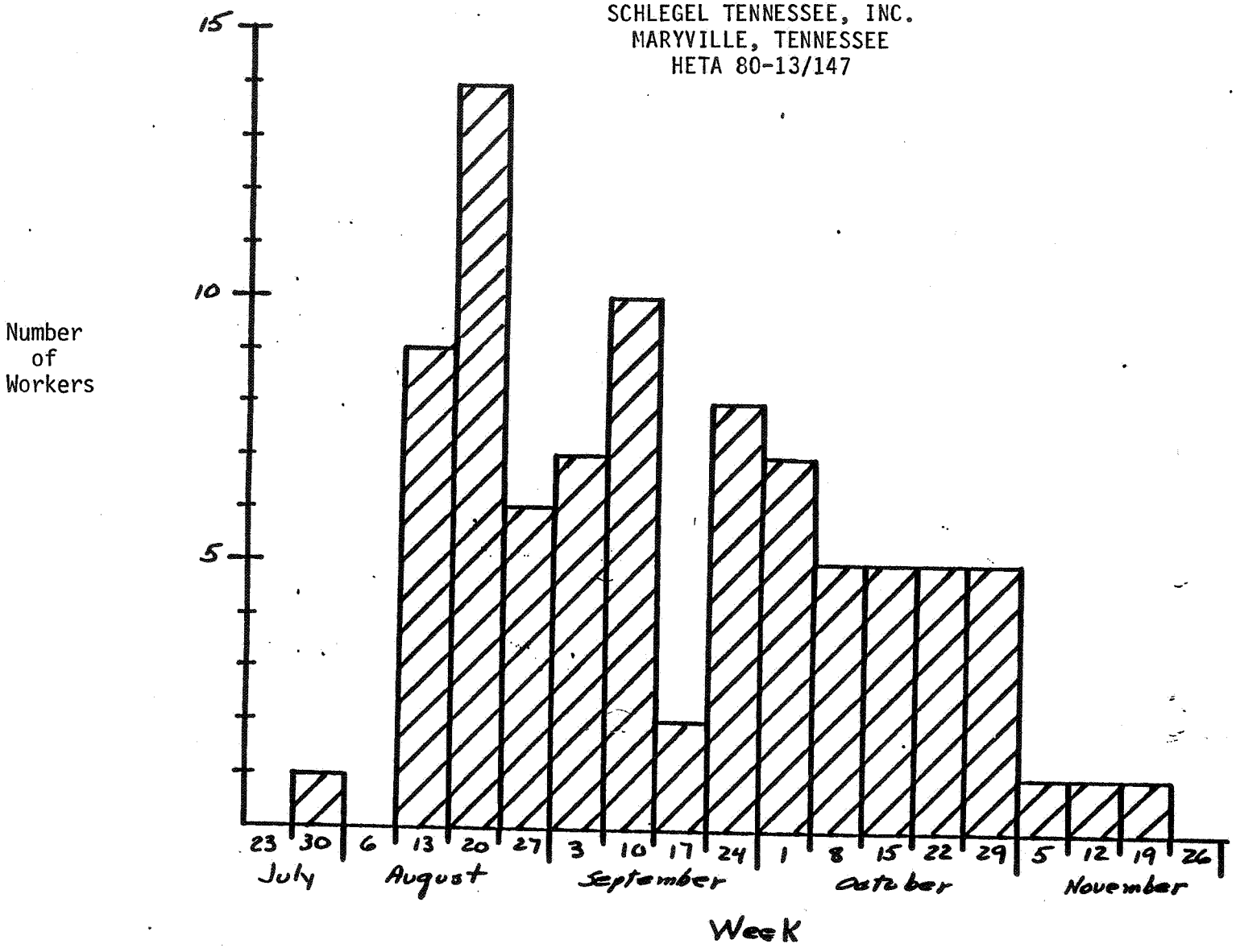


*Includes Keratitis, Conjunctivitis, Iritis, Foreign Body, Other

FIGURE 2

PREVALENCE OF WORKERS WITH EYE CONDITIONS*
FROM OSHA REPORT OF INJURY RECORDS
JULY 23 - NOVEMBER 26, 1979

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147



*Includes Keratitis, Conjunctivitis, Iritis, Foreign body, Other

APPENDIX 1

RESULTS OF AIR SAMPLING FOR CARBON DISULFIDE

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

March 11-12, 1980

Date	Time	Sample Type	Job or Location	Carbon Disulfide (mg/M^3)
3/11/80	0709-1432	Personal	Line 3 Operator	2.9
"	0716-1428	"	Line 3 Finisher	1.9
"	0721-1440	"	Line 5 Finisher	0.3
"	1535-1944	"	Line 5 Finisher	1.2
"	0905-1720	Area	Line 5 Operator	0.2
"	0721-1441	Personal	Line 7 Operator	33*
"	0924-1429	"	Line 7 Finisher	20*
"	0926-1428	"	Line 7 Finisher	39*
"	1355-1933	Area	Line 7 Finisher	51*
"	1531-1929	Personal	Line 8 Finisher	14*
"	0724-1445	"	Line 9 Operator	2.9
"	0738-1412	"	Line 9 Plugger	1.7
"	0852-1710	Area	Line 9 Finishing	1.2
"	0741-1409	Personal	Line 10 Plugger	1.7
"	0714-1438	"	Cement Mixer	0.5
"	0720-1437	"	Splice Molder	0.4
"	0726-1449	"	Finisher by Conveyor	0.2
"	0706-1333	"	Mill Operator	0.1
"	0915-1806	Area	Splice Molding #1	1.5
"	0819-1705	"	Cooling Mill Area	0.7
3/12/80	1042-1449	Personal	Line 4 Finishing	0.5
"	0842-1509	Area	Line 4 Brush-Off	1.2
"	0712-1446	Personal	Line 7 Operator	0.6
"	0719-1434	"	Line 7 Finisher	0.3
"	0717-1340	"	Line 7 Finisher	0.4
"	0851-1346	Area	Line 9 Drill Hole	2.1
"	1045-1446	Personal	Line 10 Finisher	1.9

Environmental Criteria (up to a 10 hour average daily exposure)	3.0
(15-minute ceiling exposure)	30.0

* Air level appears unreasonably elevated as compared to other samples. This might be a result of employee tampering.

APPENDIX 1 (continued)

RESULTS OF AIR SAMPLING FOR CARBON DISULFIDE

Survey of February 18-19, 1981

Date	Time	Sample Type	Job or Location	Carbon Disulfide (mg/M^3)
2/19/81	0721-1441	Personal	Line 5 Operator	1.8
"	0725-1441	"	Line 5 Asst. Operator	0.7
"	0720-1438	"	Line 5 Finisher	2.0
"	0716-1434	"	Line 5 Finisher	2.3
"	0718-1435	"	Line 5 Finisher	3.0
"	0713-1440	"	Line 5 Finisher	3.8
"	0824-1520	Area	Line 5 Finisher	2.4
2/18/81	0733-1446	Personal	Line 7 Asst. Operator	1.8
"	0737-1445	"	Line 7 Operator	1.6
"	0735-1447	"	Line 7 Finisher	2.5
"	0708-1445	"	Line 9 Operator	2.9
"	0711-1434	"	Line 9 Asst. Operator	0.8
"	0725-1429	"	Line 9 Finish Notcher	2.4
"	0717-1426	"	Line 9 Plugger Operator	3.0
"	0721-1431	"	Line 9 Finish Notcher	3.0
"	0715-1426	"	Line 9 Plugger Operator	3.0
2/19/81	0755-1436	"	Line 11 Asst. Operator	0.4
"	0803-1433	"	Line 11 Finisher	2.1
"	0750-1436	"	Line 11 Asst. Operator	0.9
"	0730-1445	"	Mold Operator	0.8
"	0745-1433	"	Mold Operator	1.1
"	0750-1401	"	Mixer Operator	0.2
"	0745-1431	"	Spray Operator	1.1
Survey Criteria (up to a 10 hour average daily exposure)				3.0

APPENDIX 1 (continued)

RESULTS OF AIR SAMPLING FOR CARBON DISULFIDE

Survey of May 21-23, 1980

Date	Time	Sample Type	Job or Location	Carbon Disulfide (mg/M^3)
5/22/80	0735-1428	Personal	Line 1 Finisher	3.6
"	0745-1449	"	Line 1 Asst. Operator	0.6
"	0737-1431	"	Line 1 Asst. Operator	0.3
"	0706-1442	"	Line 2 Operator	1.1
"	0740-1429	"	Line 2 Finisher	14*
"	0743-1431	"	Line 3 Finisher	3.8
"	0748-1127	"	Line 5 Finisher	6.5
"	0749-1358	"	Line 5 Finisher	2.5
"	0752-1438	"	Line 5 Asst. Operator	0.5
"	0730-1448	"	Line 7 Asst. Operator	0.6
"	0705-1451	"	Line 7 Operator	15*
"	0712-1228	"	Line 7 Finisher	2.9
"	0709-1228	"	Line 7 Finisher	67*
"	0703-1440	"	Line 7 Asst. Operator	56*
"	1237-1430	"	Line 7 Finisher	24*
"	1236-1452	"	Line 7 Finisher	1.5
"	0749-1443	"	Line 8 Asst. Operator	51*
"	0800-1438	Area	Line 8 Before Drilling	1.9
"	0805-1436	Personal	Line 8 Asst. Operator	23*
"	0718-1435	"	Line 9 Finisher	2.2
"	0725-1432	"	Line 9 Operator	2.1
"	0722-1434	"	Line 9 Finisher	3.1
"	0720-1001	"	Line 10 Operator	0.3
"	0714-1433	"	Line 10 Finisher	4.4
"	0726-1446	"	Line 10 Asst. Operator	0.8
"	1005-1445	"	Line 10 Operator	78*
"	1014-1445	Area	Sponge Storage Box	1.4

Environmental Criteria (up to a 10 hour average daily exposure) 3.0

* Air level appears unreasonably elevated as compared to other samples. This might be a result of employee tampering.

APPENDIX 2

RESULTS OF AIR SAMPLING FOR 12 SOLVENTS

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

March 11-12, 1980

Date	Time	Sample Type	Job or Location	Toluene (mg/M^3)	Perchloro-ethane (mg/M^3)	1,1,1-Trichloro-ethane (mg/M^3)
3/11/80	0915-1800	Area	Splice Molder	260	nd*	nd
"	0930-1809	"	Mixing Area	21	1.4	0.1
"	1519-1935	Personal	Mold Operator	76	nd	nd
"	1517-1955	"	Cement Mixer	50	nd	nd
"	1528-1937	"	Line 7 Finisher	nd	nd	nd
"	0924-1429	"	Line 7 Finisher	3	nd	nd
"	0924-1428	"	Line 7 Finisher	3	nd	0.3
"	0714-1438	"	Cement Mixer	32	nd	nd
"	0720-1437	"	Splice Molder	12	2	nd
"	0730-1440	"	Molder Back Area	30	nd	0.2
"	0722-1443	"	Spray Painter	15	nd	nd
"	0726-1449	"	Finisher-Molding	7	nd	0.2
"	0724-1441	"	Hot Melt Operator	5	nd	0.3
"	0738-1412	"	Line 9 Plugger	2	0.2	0.1
"	0741-1409	"	Line 10 Plugger	3	nd	0.3
"	0706-1333	"	Mill Operator	nd	0.3	3
"	0716-1428	"	Line 3 Finisher	2	nd	nd
"	0720-1440	"	Line 5 Operator	3	3	9
"	0721-1441	"	Line 7 Operator	5	4	nd
"	0819-1705	Area	Mill Area	0.1	na	na
"	0837-1713	"	Line 4 Finishing Hood	2	na	na
"	0854-1710	"	Line 9 Finishing	2	na	na
3/12/80	0734-1442	"	Line 7 Finishing	2	nd	nd
"	0729-1433	Personal	Cement Mixer	48	nd	0.2
"	0731-1437	"	Trimmer-Mold Area	10	nd	nd
"	0725-1436	"	Paint Sprayer	10	nd	nd
"	1048-1446	"	Line 4 Finisher	1	nd	nd
"	0756-1345	Area	Line 4 Brush-Off	2	nd	na
"	0750-1342	"	Line 10 Punch Hole	2	na	na
"	0847-1336	"	Line 4 Extruder	0.3	na	na
"	0850-1347	"	Line 9 Extruder	0.2	na	na
"	0750-1342	"	Line 9 Punch Hole	na	na	na
"	0840-1442	"	Line 7 Finishing	na	na	na
"	0734-1442	"	Line 9 Finishing	na	na	na
Environmental Criteria				375	339	1910

* NOTES:
1. na means not analyzed
2. nd means none detected at laboratory limit of quantitation
3. Xylene was present in trace quantities* in 5 of 7 of the above samples.
   Methyl Ethyl Ketone " " 1 of 31 "
   Benzene " " 0 of 31 "
   Ethyl Benzene " " 1 of 7 "
   1,3,5-Trimethylbenzene " " 0 of 7 "
   1,2,3-Trimethylbenzene " " 1 of 7 "
   1,2,4-Trimethylbenzene " " 3 of 7 "
   Cellosolve " " 5 of 10 "
   Methylene Chloride " " 5 of 31 "
4. Trace quantities means less than 1.0 mg/M^3

APPENDIX 3

RESULTS OF AIR SAMPLING FOR TOLUENE, PERCHLOROETHYLENE,
1,1,1-TRICHLOROETHANE, AND TOTAL HYDROCARBONS

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

February 18-19, 1981

Date	Time	Sample Type	Job or Location	Toluene (mg/M^3)	Perchloro-ethane (mg/M^3)	1,1,1-Trichloro-ethane (mg/M^3)	Total Hydrocarbons (mg/M^3)
2/18/81	0750-1401	Personal	Mixer Operator	79	nd*	2.2	16
2/19/81	0740-1444	"	Mixer Operator	7.0	nd	0.6	2.4
2/18/81	0745-1433	"	Mold Operator	0.6	nd	0.4	nd
2/19/81	0824-1520	Area	Line 5	0.7	nd	0.5	nd
"	0735-1443	"	Molding-Spray Operator	0.7	nd	0.7	nd
"	0721-1441	"	Line 5 Operator	0.5	1.0	3.1	nd
"	0720-1438	"	Line 5 Finisher	2.7	0.5	0.9	nd
"	0716-1434	"	Line 5 Finisher	2.3	0.1	0.8	1.2
"	0730-1445	Personal	Molding-Mold Operator	3.8	nd	1.0	nd
2/18/81	0731-1445	"	Line 7 Operator	0.3	nd	0.2	nd
2/19/81	0750-1436	"	Line 11 Asst. Operator	0.3	nd	0.3	nd
2/18/81	0735-1447	"	Line 7 Finisher	0.7	nd	nd	nd
"	0708-1445	"	Line 9 Operator	0.7	0.2	0.2	2
"	0721-1431	"	Line 9 Finisher Notcher	0.7	nd	0.3	nd
"	0715-1426	"	Line 9 Plugger Operator	0.8	nd	0.3	2
Environmental Criteria (up to 10 hour average daily exposure)				375	339	1910	none

NOTES: 1. "nd" means none detected at laboratory limit of quantitation

APPENDIX 4

RESULTS OF AIR SAMPLING FOR CYCLOHEXANE SOLUBLES
AND FIVE SPECIFIC POLYNUCLEAR AROMATIC HYDROCARBONS

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Location	Cyclohexane Solubles (mg/M^3)
3/12/80	0850-1609	Area	Cement Mixer	0.06
"	0837-1520	"	Cooling Mill	0.07
"	0852-1612	"	Line 9 Extruder	0.06
"	0844-1611	"	Line 9 Finishing	0.12
"	0853-1608	"	First Bay Splice Molder	0.09
"	0846-1612	"	Banbury Area	nd
Environmental Criteria				0.10

NOTE: Benzo(a)pyrene, chrysene, pyrene, benzo(a)anthracene, and fluoranthene were below the laboratory limit of quantitation for each of the above samples.

APPENDIX 5

RESULTS OF AIR SAMPLING FOR TOTAL PARTICULATES, COPPER, AND ZINC

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Job or Location	Particulates (mg/M^3)	Zinc-Dimethyl-dithiocarbamate* (mg/M^3)	Copper Dimethyl-dithiocarbamate* (mg/M^3)
			Survey of March 11-12, 1980			
3/11/80	0816-1704	Area	Compounding Cart	1.4	0.8	0.1
"	0700-1343	Personal	Compounder A	0.9	0.2	0.06
3/12/80	0742-1507	Area	Line 4 Extruder	0.1	0.01	nd
			Survey of February 18-19, 1981			
2/18/81	0805-1417	Personal	Compounder	1.7	0.89	nd
2/19/81	0753-1406	"	"	0.7	0.13	0.07
2/18/81	0810-1415	"	3rd Floor Operator	1.0	0.39	nd
2/19/81	0758-1406	"	"	3.4	0.56	nd
2/18/81	0809-1417	Area	Compounding	0.7	0.48	nd
"	0809-1417	"	"	0.2	0.05	nd
Survey Criteria (8-hour average daily exposure)				10.0	none	none

* Calculated from zinc and copper analyses, assuming theoretical proportions.

APPENDIX 6

RESULTS OF AIR SAMPLING FOR SULFUR AND TOTAL PARTICULATES

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE
HETA 80-13/147

March 11-12, 1980

Date	Time	Sample Type	Job or Location	Sulfur	Total Particulates (mg/M^3)
3/11/80	0700-1343	Personal	Compounder A	nd*	1.0
"	0703-1335	"	Compounder B	nd	---
"	0816-1709	Area	Compounding Cart	nd	0.7
3/12/80	0704-1421	Personal	Utility Man	---	1.1
"	0704-1421	"	"	---	1.7
"	0700-1515	Area	Mix Cart	---	0.6
"	0930-1432	Personal	Mixer	nd	1.2
"	0700-1515	Area	Mix Cart	nd	---
"	0721-1442	"	Line 7 Finishing	nd	0.1
Environmental Criteria for Nuisance Dust					10.0

* "nd" means none detected at laboratory limit of quantitation

APPENDIX 7

RESULTS OF AIR SAMPLING FOR TOLUENE DIISOCYANATE AND BUTYL MERCAPTAN

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Job or Location	TDI	Butyl Mercaptan
2/19/81	1040-1353	Area	Spray Booth	nd	ns
"	1041-1353	"	Spray Booth	nd	ns
2/18/81	1050-1576	Area	Line 7	ns	nd
"	1108-1527	"	Line 9	ns	nd
Survey Criteria				0.035 mg/M^3	1.5 mg/M^3

NOTE: 1. "nd" means none detected at laboratory lower limit of quantitation
2. "ns" means not sampled

APPENDIX 8

RESULTS OF AIR SAMPLING FOR TRIETHYLAMINE, DIMETHYLAMINE, AND TRIMETHYLAMINE

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Job or Location	Triethylamine (mg/M^3)	Dimethylamine (mg/M^3)	Trimethylamine (mg/M^3)
			Survey of March 11-12, 1980			
3/11/80	0842-1718	Area	Line 2 or 4 Finishing	nd*	0.3	nd
"	0719-1417	Personal	Line 4 Finisher	nd	nd	nd
3/12/80	0826-1337	Area	Line 4 Brush-off	0.4	1.6	nd
"	0809-1340	"	Line 4 Cutting Area	nd	0.1	nd
3/11/80	1535-1947	Personal	Line 5 Operator	nd	0.9	nd
"	1355-1932	Area	Line 7 Finishing	0.8	35	nd
3/12/80	0805-1442	"	Line 7 Finishing	nd	nd	nd
3/11/80	1527-1930	Personal	Line 9 Plugger	nd	nd	nd
"	0739-1414	"	Line 9 Plugger	nd	nd	nd
3/12/80	0814-1343	Area	Line 9 After Cutter	nd	0.1	nd
			Survey of February 18-19, 1981			
2/19/81	0725-1441	Personal	Line 5 Asst. Operator	nd	nd	ns*
"	0718-1435	"	Line 5 Finisher	nd	0.1	ns
"	0825-1520	Area	Line 5 Finishing	nd	nd	ns
2/18/80	1400-1448	"	Line 7 Inside Box Plugs	nd	35	ns
"	0711-1434	Personal	Line 9 Asst. Operator	nd	nd	ns
"	0717-1426	"	Line 9 Plugger	nd	nd	ns
"	0726-1429	"	Line 9 Plugger	nd	nd	ns
2/19/81	0755-1436	"	Line 11 Asst. Oper.	nd	nd	ns
"	0803-1433	"	Line 11 Finisher	nd	nd	ns
"	0735-1443	"	Line 11 Spray Operator	nd	nd	ns
Environmental Criteria				40	18	10

* "nd" means none detected at laboratory limit of quantitation
"ns" means not sampled

APPENDIX 9

RESULTS OF AIR SAMPLING FOR PHENYLISOCYANATE AND BENZOTHIAZOLE

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Job or Location	Phenylisothiocyanate	Benzothiazole
3/11/80	0845-1718	Area	Line 2 Finishing	nd*	nd
"	0837-1713	"	Line 4 Finishing	nd	nd
3/12/80	0810-1339	"	Line 4 After Brush-off	nd	nd
3/11/80	1355-1934	"	Line 7 Finishing	nd	nd
3/12/80	0802-1442	"	Line 7 Finishing	nd	nd
3/11/80	0724-1445	Personal	Line 9 Operator	nd	nd
3/12/80	0756-1345	Area	Line 9 After Brush-off	nd	nd
"	0753-1343	"	Line 9 Plugging	nd	nd
3/11/80	0900-1709	"	Line 10 Finishing	nd	nd
"	1337-1445	Personal	Cement Mixer	nd	nd
3/12/80	0846-1335	Area	Mill Area	nd	nd

* "nd" means none detected at laboratory limit of quantitation

APPENDIX 10

RESULTS OF FIXED LOCATION SAMPLING FOR NITROSAMINES

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Location	N-nitrosodimethylamine (ug/M^3)	N-nitrosopiperidine (ug/M^3)
		Survey of November 20-21, 1979		
11/20/79	1630-2009	Line 9 After Brush-off	2.1	0.4
"	1648-2012	Line 9 Plugging	0.4	nd
		Survey of March 11-12, 1980		
3/11/80	1325-1819	Line 7 Finishing	0.3	nd*
"	1319-1816	Line 8 Brush-off	0.5	nd
"	1321-1817	Line 8 Finishing	0.6	nd
"	1314-1815	Line 8 Extrusion	0.1	nd
"	1311-1813	Cooling Mill	0.1	nd

Survey Criteria - Exposures should be minimized
* "nd" means not detected at laboratory limit of quantitation

APPENDIX 11

RESULTS OF AIR SAMPLING FOR ANILINE AND N,N-DIMETHYLFORMAMIDE

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Job or Location	Aniline (mg/M^3)	N,N-Dimethylformamide (mg/M^3)
			Survey of March 11-12, 1980		
3/11/80	1540-1937	Personal	Line 2 Finisher	nd*	nd
"	0842-1718	Area	Line 2 or 4 Finishing	nd	0.02
"	0719-1417	Personal	Line 4 Finisher	nd	nd
3/12/80	0808-1340	Area	Line 4 Cutting	nd	nd
"	0824-1336	"	Line 4 Extruder	nd	nd
"	0826-1337	"	Line 4 Brush-off	0.1	0.13
3/11/80	1355-1933	"	Line 7 Finishing	nd	0.46
3/12/80	0805-1442	"	Line 7 Finishing	nd	0.03
3/11/80	0739-1414	Personal	Line 9 Plugger	nd	0.27
"	0852-1710	Area	Line 9 Finishing	nd	0.06
3/12/80	0814-1343	"	Line 9 After Cutter	nd	nd
			Survey of February 18-19, 1981		
2/19/81	0825-1520	Area	Line 5 Finishing	nd	nd
"	0713-1440	Personal	Line 5 Finisher	nd	nd
2/18/81	0733-1446	"	Line 7 Asst. Operator	nd	nd
"	1323-1400	Area	Line 7 Inside Box Plugs	nd	nd
"	0725-1429	Personal	Line 9 Finisher	nd	nd
"	0726-1429	"	Line 9 Plugger	nd	nd
2/19/81	0740-1444	"	Mixer	nd	nd
Survey Criteria (8 hour average daily exposure)				10	30

* "nd" means not detected at laboratory limit of quantitation

APPENDIX 12

RESULTS OF LONG TERM INDICATOR TUBE SAMPLING FOR
HYDROGEN SULFIDE (H_2S) AND SULFUR DIOXIDE (SO_2)

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Sample Type	Job or Location	H_2S (mg/M^3)	SO_2 (mg/M^3)
3/11/80	0820-1706	Area	Mill Area	<1.0	<1.0
"	0915-1803	"	Splice Molding	nd*	nd
"	0835-1717	"	Line 3 Finishing	<1.0	<1.0
"	0746-1408	Personal	Line 4 Plugger	<1.0	---
"	0905- ?	"	Line 5 Operator	<1.0	---
3/12/80	0900-1510	Area	Line 4 Vulcanizing	<1.0	<1.0
"	0858-1442	"	Line 7 Vulcanizing	<1.0	<1.0
3/11/80	0751-1418	Personal	Line 9 Finisher	<1.0	---
"	0849-1712	Area	Line 9 Finishing	<1.0	<1.0
3/12/80	0902-1512	"	Line 9 Finishing	<1.0	---
3/11/80	0915-1803	"	Splice Molding	---	nd
Survey Criteria (H_2S 15 minute ceiling; SO_2 8 hour average)				15	1.3

* "nd" means none detected at lower limit of quantitation

APPENDIX 13

RESULTS OF INDICATOR TUBE SAMPLING FOR MERCAPTAN, TRIETHYLAMINE, HYDROGEN SULFIDE, SULFUR DIOXIDE AND AMMONIA

SCHLEGEL TENNESSEE, INC.
MARYVILLE, TENNESSEE

HETA 80-13/147

Date	Time	Location	Mercaptan	Triethylamine	Hydrogen Sulfide	Sulfur Dioxide	Ammonia
3/11/80	11:00	Line #2 Cut-off	nd*	nd	nd	nd	
"	?	Line 5 Operator	nd	nd	nd	nd	
"	?	Line 7 Operator	nd	nd	nd	nd	
"	?	Line 7 By Microwave	nd	nd	nd	nd	
"	?	Line 9 Operator	nd	nd	nd	nd	
3/12/80	?	Line 1 Finisher		<1.0			<1.0
"	?	Line 9 Finisher		<1.0			<1.0
"	?	Line 10 Finisher		<1.0			<1.0
Survey Criteria:		Triethylamine (8 hour TWA)		40	15	1.3	35
		Hydrogen Sulfide (15 minute ceiling)					
		Sulfur Dioxide (8 hour TWA)					
		Ammonia (5 minute ceiling)					

* Air concentrations are in mg/M^3
* "nd" means none detected at laboratory limit of quantitation