NIOSH-0011588

50277-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. TA-76-90	2. NA	3. Recipient's Accession No. PB83 NA 10690

4. Title and Subtitle
Hazard Evaluation and Technical Assistance Report No. TA-76-90

5. Report Date
January 1978

6. NA

7. Author(s)
Hollett, B. A., and J. Schloemer

8. Performing Organization
NA

9. Performing Organization Name and Address
Hazard Evaluation and Technial Assistance Branch, Division of Surveillance, Hazard Evaluations, and Field Studies, NIOSH, Cincinnati, Ohio

10. Project/Task/Work Unit
NA

11. Contract(C) or Grant(G)
(C)
(G)

12. Sponsoring Organization Name and Address
Same as Above

13. Type of Report & Period
Technical Assista
September 21-23,

14. NA

15. Supplementary Notes
NA

16. Abstract (Limit: 200 words)

Worker exposures to chemical and physical hazards at Newport Industrial Products, Firestone Tire and Rubber Company (SIC-3011), in Newport, Tennessee were surveyed on September 22 and 23, 1976. An evaluation was requested by a representative of the United Rubber, Cork, Linoleum, and Plastic Workers of America, International Union on behalf of 260 workers. No measurable physiological strain appeared in the preshift and postshift medical tests given to 41 of the factory personnel. Wet bulb globe temperatures exceeded American Conference of Governmental and Industrial Hygienists (ACGIH) Threshold Limit Values for permissible heat exposure. Concentrations of 1,1,1-trichloroethane (71556), 2-nitropropane (76469), methylchloride (74873), dioxane (123911), and methylethyl-ketone (78933) were below respective OSHA standards of 350, 25, 500, 200 and 100 parts per million (ppm). Rubber solvent and 5 to 8 carbon chain alkanes were below the ACGIH standard of 400ppm and the NIOSH standard of 350 milligrams per cubic meter, respectively. Parts of the ventilation system were inadequate. The authors recommend continuing surveillance to avoid excessive heat stress and to minimize rubber process emissions exposures, including preplacement and periodic medical examinations, health and safety education concerning heat acclimatization, use of appropriate clothing, exposure reduction for periods of high heat stress, provision of adequate ventilation, availability of salt, drinking water, emergency supplies, and scales to measure daily weight loss from dehydration.

17. Document Analysis a. Descriptors
Hazards-unconfirmed, Organic-solvents, Heat-stress, Industrial-hygiene, Chemical-exposu

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement
Available to Public

19. Security Class (This Report)
NA

20. Security Class (This Page)

21. No. of Pages
51

I. SUMMARY

The original request to evaluate the alleged "heat stress and heat strain problem" at Newport Industrial Products was received from the United Rubber Cork, Linoleum, and Plastic Workers of America International Union. However, it was decided to evaluate the working environment as a service to both the Newport Industrial Products-Firestone Tire and Rubber Co. and the representing union.

The National Institute for Occupational Safety and Health (NIOSH) conducted a survey of Newport Industrial Products, on September 22 and 23, 1976. An interim report was transmitted in October, 1976. The preliminary final report was sent to the employer in November, 1977, for review for trade secrets and inadvertent technical inaccuracies in accordance with Title 42, Chapter 1, Subpart G, Part 85a of the Code of Federal Regulations. Comments submitted by the employer in a letter dated December 8, 1977, assisted NIOSH in the preparation of this final report.

Based on the measurements of temperature, evaporative cooling, and radiant heat loading and upon monitoring of workers' temperatures and pulses, and a review of corporate records, confidential interviews with workers, and observations of work practices and environmental controls, it has been determined that heat stress was not present during the first day of our visit, however, on the second day, September 23, elevated heat stress levels were observed. It is judged that during more severe local weather conditions of high temperature and humidity, there would be a very stressful exposure which would require close monitoring of conditions and proper management of personnel to avoid excessive heat stress. Further recommendations on this are included in the body of this report.

Limited measurements were taken of environmental exposures to rubber solvent, 1,1,1-trichloroethane, 2-nitropropane, methylene chloride, methyl ethyl ketone and other hydrocarbons C_5 to C_8, and also volatiles and particulates released during curing. No exposures above accepted levels of known contaminants were observed. A discussion of these limited findings are included in the body of this report. This is not an unqualified negative finding. There are a number of studies underway in the rubber industry which should produce a better definition of the potential hazards in tire curing, buildup, extruding and milling. With the limited information available on this industry's toxic hazards, it is considered prudent to provide optimum control of exposures to rubber process emissions. This judgment is based on epidemiological findings in the rubber industry.[1-13] Further recommendations are included in the body of this report.

II. TECHNICAL ASSISTANCE EVALUATION

A. Process Description

This facility has produced semi-pneumatic tires since 1968. It employs 260 persons. This involves processing bales of rubber by milling, extruding, splicing, fabricating and vulcanizing. Fifteen rubber formulations are used to produce tires with several hundred different size and tread designs.

The normal production rate is in excess of seventy thousand pounds of rubber compound per day which equates in excess of forty-five thousand tires. They range in size from a one-inch thick, six-inch diameter tire to a seven-inch thick, 24-inch diameter tire. The various rubber compounds are comprised of a minor percentage of synthetic and natural rubber with the remainder being filler and additives.

Bulk rubber stalk is manually fed by mill operators into mills that heat and shape it into sheets which are sliced into long ribbons feeding into a series of tube extrusion, cutting and splicing lines where various sized donut stock is produced. This stock is supplied to vulcanizers for the final formation and curing process.

The larger tires such as the All Terrain Vehicle tire (ATV) require the use of solvents and adhesive to build up tires from sheet stock. The ATV workers use code 332 (rubber solvent) and rubber cement 1072 (actually Chemlock 205 which is primarily methyl ethyl ketone), another rubber cement NV069 is a natural rubber compound dissolved in methyl ethyl ketone (MEK).

The vulcanizing presses are operated with steam pressure and air curing cycles. Each press contains molds producing one or several tires in each mold. The appropriate spliced donut stock is placed in each mold and the pressure and cure cycle runs automatically. The operator then removes each tire, replaces it with new stock, and begins using a knife to clean up the newly formed tires while the next heat and cure cycle takes place. Each operator tends several presses depending on the duty cycles and numbers of molds in each.

New workers are expected to start out at about one third of the normal work pace and build up to full capacity by the end of the first month. Drinking fountains and salt are provided in the work area. Pre-employment physicals are given with special testing by a contracted physician.

There are two scheduled ten minute breaks in mid-morning and afternoon and a 20 minute lunch break, this leaves 7 hours and 20 minutes of work time each day. With the exception of these breaks, the press operators remain at their presses throughout the work period with little chance for rest or removal from the proximity of the heat sources.

Packers work in an isle between and behind two rows of about fifty vulcanization presses each (line A and line B). The packers are required to reach or climb into large crates to stack the vulcanized tires as they come off the presses. The isle area receives discharged steam and volatiles from the presses as well as from the hot tires. Packers are in and out of the area intermittently. They have a complicated duty cycle which would require a detailed time study to assess a heat stress exposure.

Hot molds were sprayed by one employee twice each day with a mold release compound Frekote 33H which contains odorless mineral spirits, LS-100 high aeromatics, perchloroethylene, and methylene chloride. Cold molds are sprayed with Frekote 33C. This compound has contained significant quantities of methylene chloride, 1,1,1-trichloroethane, and 2-nitropropane. The manufacturer of Frekote has changed the 33C formulation to delete the 2-nitropropane. The new composition contains 1,1,1-trichloroethane, dioxane, perchloroethylene, and methylene chloride. The December 8, 1978 letter communicating with the plant manager indicates that these mold release compounds have since been replaced with a water base substitute.

Ventilation is provided by a combination of ceiling and wall exhaust fans and makeup air blowers and louvered windows. As can be seen in Figure II, there are five fans and five 12 X 4 feet louvered windows on the south wall behind "A" line. As shown, two are exhaust fans and three makeup fans. At the time of the survey there were seven large roof fans above the packing area between "A" and "B" lines. A curtain (shroud) was hung from the ceiling around the curing area to improve the air circulation pattern. This was done in 1975 following the recommendations of a ventilation study conducted by the University of Tennessee. The large makeup air unit was relocated at the west end of the curing area from the north wall about the same time.

There are four roof fans along the center line of the building from east to west. There are three roof fans above the splicers. There are five louvered makeup air inlets along the north wall and three large makeup air units which force air toward the ceiling. A large number of air circulating fans were in intermittent use during the survey. Eleven fans mounted about 12 feet above "A" line and three five foot high pedestal fans directed air on press operators. There was air movement from a large warehouse door approximately 9 feet X 12 feet toward the east end of "A" line. "B" line had nine overhead fans and seven pedestal fans. Neither the wall fans nor the air circulating fans operated consistently. Pedestal fans were particularly subject to frequent relocation and/or reorientation.

The December 8, 1977 letter of communications from the Plant Manager described several ventilation modifications that have been made since the survey. As is shown in Figure II, the shroud has been extended to enclose each press line separately, thereby reducing the heat and contaminants in the packing area. These fans were relocated and an additional fan purchased to provide exhaust directly over the lines. The question of possible short circuiting of the air flow to the remaining packing area ceiling exhaust fans through the newly created "roof vents" where fans had formerly been, was raised in telephone communications with the Plant Manager on January 18, 1978. This should be evaluated and if a problem, the roof vents could be used as a source for replacement air for low level cooling in the packers isle by dropping a duct from each vent to the working level below 10 feet. If this is not practical, closing these vents when the exhaust fans are in use would eliminate the short circuiting effect. The December 8, 1977 letter also described the installation of a hood and exhaust system over the 84 inch mill since the survey.

B. Evaluation Design

A walk-thru survey of the entire Newport plant identified and ranked probable heat exposures from the most exposed to the least exposed worker: 1) Press Operator, B line; 2) Press Operator, A line; 3) Tire Packer; 4) Maintenance on the Press Line; 5) Splicer; and 6) others. Forty-one of forty-five workers were chosen for participation in this study because of their work activities in a hot environment. This number comprised all but four of the workers who were in and around these areas on the day shift September 22 and 23, 1976, at the time that the survey took place.

Of the four workers not included in the survey, one did not complete the health testing due to illness and taking sick leave during the day; another reported to work ill with a significantly elevated temperature; a third had just returned to work after a long absence due to extensive surgery with many confounding symptoms, and the fourth worker did not return for the post-shift testing.

Medical observations of workers temperatures and pulse rates for physiological signs of heat strain were accomplished pre and post shift. Each worker was given a non-directed occupational illness and smoking history questionnaire followed by a directed questionnaire with specific symptoms known to be associated with heat stress and possible confounding etiologies.

Environmental perameters measured were dry bulb temp, wet bulb temp, and black globe temp. From these values a Wet Bulb Globe Temperature (WBGT) Index is computed which is used as a guide in determining heat stress exposures. Other environmental samples were collected to identify any exposures to airborne contaminants which might affect tolerance to heat stress or have other adverse health effects. Samples for particulates, organic vapors, and volatiles from the vulcanization process were collected in the workers' breathing zone.

C. Evaluation Methods

Environmental: The WBGT parameters were measured with mercury thermometers incorporated in apparatus as specified in reference 14. Each worker's exposures was to several presses, however, it is impractical to move the apparatus with the worker. A series of measurements were taken at representative work stations during the course of a shift. "A" line measurements were taken on September 22, and "B" line on September 23. The apparatus was positioned just above waist level about midway between two press work stations. This placed the thermometers at about arm's length from the press molds and adjacent to the work surfaces in front of the presses. Stacks of hot tires were occasionally placed in close proximity to the apparatus, these conditions are representative of the worker's exposure. Two to four measurements were taken along a press operator's work position. Several measurements were taken in the packers work area as well.

Particulate air samples were collected on tared VM-1 filter paper within closed face cassettes using a MSA Model G personal sampling pump at a flow rate of one lpm. These acted as prefilters for the 1 lpm charcoal tube samples on press operators and packers. Air contaminant samples were collected on charcoal tubes using Sipin pumps at a flow rate of 50 cc/min, or using MSA pumps at 1 lpm when preceeded by a particulate prefilter.

Weights were measured using a Perkins Elmer AD-2 Auto Balance. Limits of detection are 0.01 mg per filter.

MEK and solvents C_5 and C_8 were desorbed with carbon disulfide and analyzed by gas chromatography according to NIOSH Method P&CAM #127. Limits of detection were .01 mg of solvent or MEK. A Free Fattie Acid Phase (FFAP) column at 80^{o}C was used.

1,1,1-Trichloroethane, methylene chloride, 2-nitropropane were analyzed by the same method using a 12 foot FFAP column temperature programed from 50^{o}C to 80^{o}C. Limits of detection were .01 mg for each.

Nine charcoal tubes were analyzed by gas chromatography and mass spectrometry. Some were desorbed with carbon disulfide and some with hexadecane. For further discussion of analytical methods for volatiles released in rubber vulcanization, see References 15 and 16.

Medical: The workers reported to the First Aid Room pre-shift and immediately post-shift, where initial baseline (resting) temperature and pulse rate determinations were made. A screening technique was utilized taking four minute and eight minute post-shift recovery heart rate determinations. Since only two medical team members were available to perform the testing of forty-five workers during a two day period, it was impractical to take 1, 2, and 3 minute recovery pulses as recommended by Brouha.

The thermometer was placed under each worker's tongue with ensured mouth enclosure.[18] A stopwatch was started, and during each four minute period the pulse was taken, and the thermometer read and recorded at the end of each four minute period. The thermometer was then shaken down and placed in the alcohol water bath. This same procedure for measurement of oral temperature and heart rate was utilized throughout both days of the survey.[18] Day 2 of the survey, September 23, was a much warmer day as compared with Day 1, September 22, and so the day of testing became an additional significant variable. Analysis of data included: 1) distribution of symptoms by job day, sex and smoker; 2) the mean change in temperature and pulse rate determinations for Day 1 as compared with Day 2; and 3) the comparison of the 4 minute to 8 minute (recovery) post-shift temperature and pulse rate determinations. Oral temperatures were obtained by means of a standard 3 minute clinical Bureau of Standards standardized oral glass thermometer. An alcohol water bath surrounded with blue ice packs was used to contain the shaken down oral thermometers until their use. This was done to control their exposure to the ambient environment. Apical pulses were obtained by use of a stethoscope for a thirty second count multiplied by two. This data was interpreted using the NIOSH Heat Stress Criteria Document and Brouha's method for assessment of physiologic stress.[14,17]

D. Evaluation Criteria

1. Medical

Heat stress criteria are based on biological norms. Fluctuations in body temperature beyond a narrow range can result in serious alterations in health, functional efficiency and performance capacity. A resting body temperature of about 37°C (98.6°F) is accepted as "normal" but individual variation may be as much as 1°C (1.8°F) above or below this value. Each individual also has a variation in body temperature of ±0.5°C (.9°F) with the highest values in early afternoon and the lowest values in the early morning hours. When physical work is performed, the body temperature will be higher than at rest. However, whenever the body temperature exceeds 38°C (100.4°F) the cause for the increased temperature should be sought. Body temperatures above 39°C (102.2°F) are not acceptable for long periods and may be associated with serious health consequences. Acute heat disorders can be expected when the body temperature exceeds 39°C (102.2°F) and temperatures above 41°C (105.8°F) are intolerable. One hundred percent survival is limited to a range of body temperatures from 33°C (91.4°F) to 39°C (102.2°F).[19] A 99.6°F (37.5°C) oral temperature corresponds to the permissible limit for deep body temperature as recommended in the TLV.[18]

It has been well recognized that recovery heart rates can be used as an indicator of physical stress and of the individual's physical fitness. Johnson and Brouha at the Harvard Fatigue Laboratory reported measurements of the pulse rate within 3 minutes at three distinct times following work stress. They were able to predict the exponential recovery curve of the heart rate from the work rate back to the resting level. Their obtained values represented heart rates at the end of work at 1 minute, 2 minutes, and 3 minutes following work. Also the worker reported to the observer before starting each shift to obtain the resting pulse.[18] Based on Brouha's work, the recommended TLV for recovery heart rates is 110 beats per minute by the end of the first minute, taken from 30 to 60 seconds, with a decrease of 10 beats/minute between the first and third minutes.[17,19]

2. Environmental

Heat stress criteria are expressed in two ways. The work practices which are essential for monitoring and control are stated in the NIOSH Criteria for a Recommended Standard, Occupational Exposure to Hot Environments.[14] The Threshold Limit Values (TLV's) guides to be used in limiting the environmental exposure to tolerable levels.[20] The work practice procedures are intended to prevent acute or chronic heat disorders and illnesses and heat induced unsafe acts, and will reduce the risk of harmful effects due to the interactions between excessive heat and toxic chemicals and physical agents. The TLV's shown in Table 1 are based on the assumption that nearly all acclimitized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (100.4°F).[21]

Work practices are to be implemented if the Wet Bulb Globe Temperature (WBGT) Index may exceed 76°F for women or 79°F for men. The WBGT is an index combining environmental factors to quantify the heat stress conditions. It is computed from the shaded dry bulb, the black globe, and the natural wet bulb temperatures used in the equation ($WBGT = .7\ WB + .2\ GT + .1\ DB$). This index of measureable environmental factors is the simplest and most suitable technique to measure heat stress. The measurement of deep body temperature is the true indicator of heat strain on the body, however, it is impractical for monitoring the workers' heat load. Due to the wide range of individual heat tolerance among workers it is essential that work practices include a screening for possible limitations in heat stress adaptability. The practice must provide close surveillance of newly assigned workers to insure time for acclimatization. Work practices should include surveillance of WBGT to limit exposure within the TLV's during unusual climatic conditions. The recommended TLV's are valid for acclimatized workers who are physically fit, who are wearing light summer clothing. If special clothing is required for performing a particular job and this clothing is heavier or it impedes sweat evaporation or has higher insulation values, the worker's heat tolerance is reduced and the permissible heat exposure limits in Table 1 are not applicable. For each job where special clothing is required, the exposure limits shall be established by an expert.[20]

The best indicator of a workers' ability to tolerate heat stress is a work history. Higher heat exposures than those shown in Table 1 are permissible if the worker has been undergoing medical surveillance and it has been established that he is more tolerant to work in heat than the average worker. However, when working at such extremes, extra caution must be used so that no worker is permitted to continue their exposure when their deep body temperature exceeds 100.4°F.[20]

The permissible exposure limits for continuous work are applicable where there is a work rest regimen of a 5 day work week and an 8-hour work day with a short morning and afternoon break (approximately 15 minutes) and a longer lunch break (approximately 30 minutes). The TWA WBGT for such an exposure is computed over a 60 minute period by the equation:

$$\text{AV WBGT} = \frac{(\text{WBGT}_1)\ t_1 + (\text{WBGT}_2)\ t_2 \ldots + (\text{WBGT}_n)\ t_n}{t_1 + t_2 + \ldots t_n}$$

Where $WBGT_1$, $WBGT_2$, etc. are calculated for the various work and rest areas occupied during time periods t_1, t_2, etc. which are the elapsed times in minutes spent in the corresponding areas. Where the exposure is intermittent the time weighted average shall be calculated for a 120 minute period.[20]

Workers should monitor their daily body weight loss. A drop of 1.5 percent after one day's work shows excessive dehydration and an accompanying loss of alertness and increased accident potential. In sedentary jobs where continuous unimpaired mental performance is required, no employee shall be exposed to conditions which exceed the limits set forth in Figure 1.[14]

The assessment of work load categories is necessary when referring to the TLV in Table I, since the heat produced by the body and the environmental heat together determine the total heat load. The workload may be ranked in one of three categories; light, medium and heavy on the basis of type of operation.[20]

1) light work (up to 200 K Cal/hr): e.g. sitting or standing to control machines, performing light hand or arm work.

2) moderate work (200-350 K Cal/hr): e.g. walking about with moderate lifting and pushing.

3) heavy work (350-500 K Cal/hr): e.g. pick & shovel work.

When WBGT exposures exceed the 76° for women and 79° for men, then a combination of the work practices stated in Reference 14 and outlined briefly below shall be initiated to insure that employees' deep body temperature do not exceed 100.4°F.

1) Acclimitization policies should be established to include schedules of gradual work load increases for:

   a) Unacclimitized employees
   b) Acclimitized employees returning from 9 or more consecutive calendar days leave
   c) Acclimitized employees returning from 4 or more consecutive days of illness

2) A schedule of daily activities and work load to minimize peaks of physical strain.

3) Provide for hourly breaks for employees to get water and replace salt.

4) Implement environmental controls to reduce heat loading.

5) Measuring to ensure WBGT TLV's are not exceeded.

6) Provide medical preplacement screening and periodic physical examinations.

7) Appraisal of employees of hazards from exposure to heat stress, including training in health and safety procedures such as recognition of heat stress disorders, information on water and salt replacement, and the importance of acclimitization and of daily weighing before and after work. A one day loss of 1.5 percent of body weight or more shows excessive dehydration.

8) Information on special caution that shall be exercised in situations where employees are exposed to toxic agents and other stressful physical agents which may be present in addition to and simultaneously with heat.

9) Record keeping of medical and environmental data which have been stipulated above.

3. Effects

The three major clinical disorders resulting from excessive heat stress are: 1) heat stroke, a failure of the thermoregulatory center which constitutes a medical emergency; 2) heat exhaustion, from depletion of body water and/or salt; 3) heat cramps, from salt loss and depletion of body water. Other medical clinical entities from heat effects are heat syncope, heat rash, anhidrotic heat exhaustion, heat fatigue-transient and heat fatigue-chronic.[14]

Heat stroke is manifested by the three cardinal signs of: 1) hot dry skin which is red, mottled or cyanotic; 2) hyperthermia, a body temperature of 106°F or higher and rising; and 3) brain disorders with accompanying mental confusion, delirium, loss of consciousness, convulsions and coma. The clinical signs and symptoms of heat exhaustion include: weakness, extreme fatigue, giddiness, nausea, headache, clammy moist skin, pale or flushed skin, a normal or low oral temperature with elevated rectal temperature (between 99.5 to 101°F), fainting weak thready pulse, low blood pressure, prominent thirst, a small volume highly concentrated urine or urine more dilute with a larger volume, absence of chlorides, and elevated or below normal blood electrolytes. The diagnostic characteristic of heat cramps is painful spasms in the skeletal muscles.[14]

4. Toxicity Criteria of Atmospheric Contaminants

There are a number of atmospheric contaminants found in the rubber vulcanizing, tube extruding, milling, and tire buildup environments. Many of them are of unknown or poorly defined toxicity. There are some for which a number of criteria are available to assess the potential toxicity. The criteria with widest usage are the NIOSH Criteria Document Recommendations, the Threshold Limit Values (TLV) recommended by the American Conference of Governmental and Industrial Hygienists, and the Code of Federal Regulations, Title 29, Part 1910.1000 used in the enforcement of the Occupational Safety and Health Act. These three criteria are included here in Table 2. Their comparison can be made only with an understanding of the differences in methods of measurement and intended degree of protection. The criteria which in the author's opinion represents the best health protection has been applied.

The criteria used in this evaluation are discussed in detail in the references given below. The limited information presented here is intended to provide laymen with a general knowledge of the basis of these exposure criteria.

a) Tire vulcanization emissions are poorly defined and the toxicity of many are unknown.[2,7,15,16] However, based on epidemiology findings to date there is sufficient evidence of increased risk of illness to recommend reduction of exposures to these contaminants to the extent feasible.[5]

b) Rubber solvent should be controlled so that no employee is exposed to a concentration greater than 350 mg/cu m of air, determined as a TWA concentration. In addition, no employee shall be exposed to a ceiling concentration greater than 1,800 mg/cu m as determined by a sampling time of 15 minutes. Benzene content should be monitored to insure no incidental exposures to this contaminant.[22]

c) 1,1,1-trichloroethane should be controlled so that workers are not exposed at greater than a ceiling concentration of 350 ppm as determined by a 15 minute sample. Occupational exposures above 200 ppm require adherence to all of the sections of the NIOSH criteria document. The standard should prevent adverse central nervous system as well as chronic effects on workers.[23]

There has been reported an unconfirmed positive response in the mutagenicity assay of a microbial system by a laboratory working under EPA contract, administered by the Toxicology Assessment Branch, LSD, HERL, Cincinnati, Ohio.

d) 2-Nitropropane should be handled in the workplace as if it were a human carcinogen. Since there is only animal test data, no safe level for human exposure can be determined with the available information. Therefore, this potential carcinogen should be removed from the workplace or controlled to insure that no exposures occur. The NIOSH Current Intelligence Bulletin dated April 15, 1977, on this chemical has been included in this report as Appendix I.

e) The NIOSH recommended methylene chloride criteria is 75 ppm Time Weighted Average (TWA) in the absence of occupational exposure to carbon monoxide at or above 9 ppm (TWA) for a ten hour day. The reason for this conditional limit is that the toxic effects are additive.[25]

f) Methyl ethyl ketone has a TLV of 200 ppm (TWA) control of workers' exposure to this level should prevent any injurious effects and minimize complaints about odor and irritation.[24]

g) The alkanes C_5 to C_8 NIOSH criteria documents recommended control so that no employee is exposed to concentrations greater than 350 mg/M^3 (TWA). This is equal to about 120 ppm of pentane, 100 ppm hexane, 85 ppm heptane, and 75 ppm octane. In addition, no employee shall be exposed to ceiling concentrations greater than 1,800 mg/M^3 as determined over a sampling time of 15 minutes. This standard should prevent adverse effects of pentane, hexane, heptane, and octane on the health and safety of employees. Although the workplace environmental limits are considered to be safe levels based on current information, they should be regarded as upper boundaries of permissible exposure and every effort should be made to maintain the exposure as low as is technically feasible.[26]

h) The Dioxane Criteria Document recommends control so that no employee is exposed to concentrations greater than 1 ppm based on a 30 minute sample at a sampling rate of one liter/minute. This is the lowest concentration reliably measurable over a short sampling period. This limit is based on the belief that dioxane can cause tumors in exposed workers and on the belief that information allowing the derivation of a safe exposure limit is not now available.[27]

5. Toxic effects of environmental exposures in the rubber industry have been documented in recent epidemiological studies being conducted by the Harvard School of Public Health and by the School of Public Health of the University of North Carolina. These studies are being funded under a joint effort by the United Rubber Workers Union and six major rubber manufacturing companies. They have not yet reached the point where specific chemical agents can be identified as the cause of the observed excesses in certain types of morbidity and mortality findings. There has been an effort to identify the work exposures which are most frequently found to have a high rate of death or illness of some specific type. Findings to date are not conclusive, however, in tire manufacturing they do indicate an association with higher incidence of acute and chronic bronchitis[1,4,7] as well as excesses in certain types of neoplasms.[3,7,8,9,10,15] The brain, lungs, bronchus, stomach, prostate, uterine, and lymphatic and hematopoietic tissues have been implicated in various studies. Based on these findings it is concluded that emissions from rubber processing are potentially harmful and that safe exposure levels are not known.

E. Evaluation Results and Discussion

1. Environmental Findings

The WBGT index observed during this survey are presented in Table 3. Climatological data considered to be most representative of Newport was obtained from the National Climatic Center in Ashville North Carolina.[28-30] The nearest observation stations would be Knoxville WSO Airport and the Newport Utilities Board station, one mile north west of Newport. Weather data for June thru September 1976 is presented in Table 4.

Normal weather conditions are considered to be hot and humid during the months of June, July, August and September average and maximum values are provided in Tables 5 and 6. The conditions on September 22 and 23, are not considered representative of the more severe conditions where heat stress would most probably manifest itself. The high and low temperatures for a 24-hour period beginning at 0900 on September 22 and 23, were a high of 72 and 79^{o}F and a low of 38 and 40^{o}F, respectively.[29]

Average temperatures normally range from a low in the lower 60's to highs in the upper 80's during the three hottest months of June, July and August. On the average there are 36 days during this period with highs above 90^{o}. September is normally cooler with an average high of 83^{o} and an average low of 57^{o} and an average of 6 days above 90^{o}.

The 1976 data show that the summer was not as hot as normal. In September the average high was 77^{o} and the low was 52.7^{o} and the temperature never exceeded 90^{o}. During the three hottest months of June, July and August, the average highs and lows were about three degrees lower than normal and the temperature exceeded 90^{o} only 17 days less than half the normal frequency.

Relative humidity data is not maintained at Newport, however the Knoxville WSO Airport station is at about the same elevation, has a similar temperature and rainfall history, is approximately 40 miles away and does report relative humidity data comparison of the historical monthly averages, and the 1976 monthly averages show that in June, July and September there was one or two percent higher relative humidity than average and that August was about average.

These climatic conditions are reflected in the relatively low WBGT levels recorded on September 22, and the slightly higher levels recorded on September 23.

The workload representing press operators is judged to be moderate to heavy. Packers workloads should be evaluated thoroughly to determine the proper category. From Figure 1, it is seen that a Threshold Limit Value for continuous work in the moderate workload category is 80°F WBGT and 77°F for the heavy workload category. Data presented in Table 3 shows that no excessive WBGT's were observed on September 22, 1977. However, on September 23, these limits were exceeded in most of the measurements taken after 11 o'clock. The mid to upper 80° WBGT levels observed late in the shift were significantly above the TLV.

Additional WBGT data was provided by the corporate industrial hygienist for January 21 and 22, 1973; July 24, 1973; August 13 and 14, 1973; July 10, 1974; October 23, 1974; August 24, 1976 (see Table 7). The higher levels observed in July and August are reported to have been purposely taken during very hot weather. Thus these measurements are assumed to represent the most severe heat stress conditions and not the average plant conditions. While there are undoubtedly some differences in the survey technique, it is unquestionably clear from this data that very high heat stress conditions would prevail in the press and packing areas during unfavorable climatic conditions of high heat and humidity.

The ventilation readings were highly variable and fluctuate considerably. This is due to large numbers of entry points for make-up air and the large number of portable air circulating fans.

The ventilation system for the A-line appeared adequate; this does not appear to be true for the B-line; particularly for the east end. The reason for this is that the make-up air sources located along the north and west walls are too far away and the system is short circuited by roof exhaust fans located between the B-line and the air sources.

The "apparently adequate" ventilation system for the A-line may be creating a problem for the packers. Volatiles released from the curing process are drawn past the packers by the 7 roof exhaust fans located above their work area.

Exposures to air contaminants measured during this survey are presented in Tables 8 and 9. There were no excessive levels measured for any of the known contaminants. It should be noted that these measurements were not sufficient to determine the daily time weighted average exposures but rather were short term measurements to identify any high levels of general contamination which could be present. There is a lack of information regarding rubber tire process emissions, which leaves an element of uncertainty regarding the adequacy of controls and the potential risk to long term employees. This is further complicated by the presence of a high heat stress factor during summer months which has the potential for interacting with chemical hazards to increase the risk to the exposed worker.

It was learned subsequent to the survey that the formulation of a mold release compound, Frekote 33C, has been changed to delete 2-nitropropane. The new formulation does contain dioxane. Since this was not known at the time of the survey no environmental data was taken. However, the criteria and toxicity data is provided in this report. The company has indicated that a non-toxic water based mold release has been substituted for Frekote 33C.

Nine charcoal tubes were submitted for gas chromatograph and mass spectrometer (GC/MS) identification of volatiles collected from the breathing zones of press operators and packers. Most of the sample volumes were 200 liters or more and were preceeded by a filter. Three samples from press operators and one blank were desorbed with carbon disulfide CS_2 solvent. Only two of these had peaks at sufficient concentrations that they could be identified by GC/MS. Even though these sample volumes were 384 and 246 liters, respectively, analysis of the backup section revealed no breakthrough. Further GC/MS work on these two samples, one for later peaks and one for earlier peaks, was accomplished using two different modes of mass spectrometry to elicit both compound type and molecular weight where possible. Since most of the observed peaks eluted around the CS_2 solvent, the other five samples were desorbed with hexadecane to allow better identification of these early peaks. Two of these samples, from packers, had peaks at sufficient concentrations that they could be identified by GC/MS. Further GC/MS analysis similar to that described above was accomplished on the larger volume, 265 liter, sample. A summary of the GC/MS identification is given in Table 8. For more positive identification and quantification a comprehensive study of the specific types of rubber used, accelerators, and additives would be needed.

2. Medical Findings

As can be seen in Table 10, a total of 41 workers, 31 females and 10 males, were interviewed and had pre-shift (resting) and 4 minute and 8 minute (recovery) post-shift oral temperatures and apical pulses taken for clinical evidence of heat stress during this evaluation. The age range was 19-56 years with a mean of 35 years. Employment history (Table 11), at Newport Industrial Products extended from its beginning in 1968, which included 18 of the 41 workers tested, to 1976 with only 2 new workers. Thirty-eight of the 41 workers tested were hired between the years of 1968 to 1973. It can also be seen by examining Table 12, that 18 of 41 workers interviewed gave a present history of smoking.

Thirty-three of 41 workers (81 percent) gave a history of symptomatology possibly related to work on either the non-directive and/or directive questionnaire (Tables 13-1,2,3). Eighteen of the 41 workers (44 percent) responded "yes" on the non-directive questionnaire to having a positive history of one or more health problems related to work. The 15 health problems are listed in Table 13-1, and include: six of 41 interviewed reported headache; four of 41 experienced eye irritation; three of 41 reported fatigue; while two of 41 noted weakness and skin irritation, and there was one complaint each of thirst, difficulty in breathing, hoarseness, irritability, nervousness, jock itch, joint pain, sinusitis, hernia and hysterectomy. It is not possible to directly relate all of these reported complaints to occupational exposures.

As illustrated in Table 13-2, 33 of the 41 workers (81 percent) interviewed with a directive questionnaire of symptoms of heat stress answered "yes" to having had one or more symptoms. The 11 symptoms of heat stress and responses of 41 workers queried include: feelings of intense heat and thirst - 22; breathlessness and palpitation - 19; headache - 19; fatigue - 19; weakness - 17; tingling and numbness of extremities - 16; dizziness - 14; diarrhea - 12; nausea - 8; muscle cramps - 7; and vomiting - 3.

Upon closer questioning, however, 15 of these 33 workers had symptoms which could possibly be related to other causes as well as to heat stress (see Table 13-3). Possible confounding etiologies include: nine of 41 workers had histories of bronchitis, asthma, TB or hay fever; eight hypertension or anemia; three hypertension or heart disease; and five had experienced pain or chest tightness.

Analysis by chi-square tests, of the distribution and association of symptoms by job, day, sex and smoker was not found to be statistically significant (Table 14). However, it is important to note, that workers with anemia, chronic respiratory, cardiovascular and other medical problems are affected more quickly and with greater severity because their diseases are aggravated by heat stress. Therefore, heat stress poses a greater potential danger to those with pre-existing health conditions.

Other comments related by workers include the feelings of intense heat and thirst, breathlessness and palpitation, weakness and fatigue were specific problems related to the summer months, especially July. Tingling and numbness of extremities was mentioned by several press operators as being an arm positioning problem. The process called for constant intermittent upward reaching with a stick to pry the small rubber tires from their molds. This process required the arms to be above the head for much of the day with pressure placed on the fingers in prying loose the tires. This position and pressure resulted in numbness and tingling of the fingers due to gravity, stasis and compression.

Table 15 contains the pre-shift (resting) and 4 minute and 8 minute (recovery) post-shift oral temperature and apical pulse rate determinations that were found as a result of this investigation. The range of resting pre-shift oral body temperatures was from 96°F to 98.8°F, with eleven of 41 below the "normal" variation of 96.8°F to 100.4°F. The 4 minute post-shift oral body temperatures ranged from 97.6°F to 99.8°F, with two below the .9°F variation of 97.7° to 101.3°F oral afternoon high body temperature, and one above at 99.8°F the 99.6°F oral deep body temperature limit recommended TLV. The 8 minute recovery temperature range was within the normal limits with a range of 98°F to 99.8°F. However, 18 of the 41 workers' temperatures had not crested within the 4 to 8 minute post-shift period, but continued to rise, therefore, true recovery temperatures were not obtained on 44 percent of the workers.

The pre-shift apical pulse range was from 54 to 116 with 3 workers having resting pulse rates elevated over 100 beats per minute. Two of the three workers' pulses actually decreased with work, while the third worker in the other category (non-hot job) increased to 112 beats per minute. Possible explanations for the increased resting pulse rates of these two workers were histories of: 1) a nervous condition, and 2) of hypertension. The third worker had no history of health problems, nor did he work in a hot job category; thus the etiology was unknown. The post-shift 4 minute apical pulse range was within normal limits with the exception of the two workers previously mentioned who had gone from 116 to 114 and 100 to 112, respectively.

The existence of three of 41 workers with elevated apical pulse rates cannot be attributed to heat stress as all three were elevated above 100 beats per minute prior to beginning work. While two workers pulses went down with work, the third, a worker from a non-hot job, continued to rise but fell to 110 beats per minute within the 8 minutes. Comparison of the 4 minute to 8 minute (recovery) post-shift temperature and pulse rates were both statistically and practically non-significant.

There were no significant differences in oral temperatures or pulse rates when comparing Day 1 and Day 2 measurements.

3. Discussion

It is apparent from the pre and post-shift medical tests that no measurable physiological strain from heat stress was observed during this study. This is not surprising since the weather was relatively cool when compared to the previous three summer months record. This would have acclimatized the workers to heat stress levels well above those observed. There may be significant variations in work site temperatures. A hot spell or unusual rise in humidity may create overly stressful conditions for a few hours or days in the summer. Non-essential tasks should be postponed during such emergency periods, in accordance with a pre-arranged plan. Rescheduling hot work to a cooler period of the day or night can help. Also, assignment of extra helpers can reduce heat exposure by allowing more frequent rest periods. However, there is danger in this practice if unacclimatized novices are utilized. The highly motivated individual, particularly the novice who desires acceptance, is at great risk. In the same spirit, foreman should respect the opinion of an employee when he reports that he does not feel up to work in the heat at a particular time. Non-job personal factors such as low grade infection, a sleepless night, or diarrhea (dehydration affects sweating) which would not affect performance on most jobs, may adversely affect heat tolerance.[14]

Exposure to hot environmental conditions can lead to primary heat illnesses, to unsafe acts, or to increased susceptibility to toxic chemicals and physical substances. Through the application of basic health and safety procedures, the individual may by proper precautions reduce the likelihood of ill effects from a hot work environment. It has been established that both heat tolerance and also physical work capacity decline with age.[14] Employees over 45 years of age and new employees should not be assigned to hot jobs where the environmental conditions exceed 79°F WBGT for men and 76°F WBGT for women until they are acclimatized.[14]

Special attention during the pre-placement examination and after age forty-five should be directed to history and/or physical examination findings of chronic functional or organic impairments of the cardiovascular, renal, endocrine and respiratory systems and of the liver and skin. Significant disease of any of these systems should be disqualifying for new employment on jobs involving severe heat exposure, as well as contraindicated on jobs if the disease is progressive despite treatment.[14]

Careful histories should be taken on use of drugs, especially hypotensive agents, diuretics, antispasmodics, sedatives, tranquilizers, antidepressants, as well as abuse of anphetamines, hard narcotics and alcohol. Many of these drugs impair normal responses to heat stress and others alter behavior, thus exposing a worker or fellow workers to health and safety hazards. Evidence of therapeutic use of one or more of these categories of drugs or personal abuse of alcohol and other drugs should be disqualifying.[14]

Workers employed on jobs which regularly expose them to levels of heat stress which have been determined to approach or equal permissable limits prescribed by the heat standard should be examined periodically on an annual basis, or more frequently if indicated. The examination should be conducted in the summer season.[14]

In the preparation of this report it has become increasingly clear that there is a need for a much better definition of the toxic exposure to rubber processing workers.[2,7,15] The evidence available gives the impression that there is a problem with carcinogenesis primarily in those processes where solvents or adhesives are used and/or where heated processing causes emissions. There is a need for continued emphasis in researching the emissions of various rubber vulcanization processes.[2,7,15,16]

This must be followed by a study of the carcinogenic properties of these emissions. With a better understanding of the source of toxic exposure appropriate process changes or controls can be implemented. In the interim, measures must be taken to minimize overall exposures whenever possible; by use of process modifications, engineering controls, and personal protective equipment only when necessary.

III. RECOMMENDATIONS

There is a clear need for continuing surveillance of this work environment to avoid excessive heat stress exposures and to minimize rubber process emissions exposures. Implementation of the work practice standard as outlined in this report should provide the necessary controls to meet this requirement. Careful monitoring of workers' exposure during extreme climatic conditions and judicious use of the appropriate combination of administrative and engineering modifications, will ensure an environment safe from excessive heat stress. Administrative controls should include:

1. Pre-placement medical evaluation with assessment of the individual's heat tolerance should be conducted with special emphasis on the cardiovascular, renal, hepatic, endocrine and respiratory systems and the skin.

2. Periodic medical examinations should be given yearly for those over 45 years of age and every two years below that age to all employees working in conditions of extreme heat exposure or with heavy workloads.

3. Employees should be educated in health and safety practices concerning heat acclimatization, water intake and salt replacement, and how to recognize symptoms of heat disorders and illnesses.

4. Employees should be informed of the possible combined effects of heat and one or more of the following: alcoholic beverages, prescription or non-prescription drugs, toxic agents, and other physical agents.

5. Employees should be informed as to the use of appropriate clothing.

6. Employers should include a period of acclimatization for each new employee or employee returning to work after a work absence.

7. A pre-planned exposure reduction schedule for high heat stress periods should be developed.

8. A monitoring procedure including action levels for implementing closer surveillance and exposure reduction measures.

Other actions to be taken should include insuring:

1. Adequate ventilation of work and rest areas to aid in evaporative cooling as well as remove potentially harmful contaminants.

2. The removal of a suspect human carcinogen from the work environment by substitution whenever possible or by controls as outlined in Appendix I for 2-Nitropropane.

3. Availability of drinking water and salt.

4. Availability of scales in employees' dressing areas to measure daily weight loss.

5. Availability of emergency supplies for treatment of heat stress casualties.

For a more detailed listing and discussion of recommended work practices see reference 14.

IV. REFERENCES

1. Chronic Respiratory Symptoms and Job Types Within the Rubber Industry, A.J. McMichael, et. al., J. Occup. Med. 18:611-617, Sept. 1976, 10 refs.

2. Mortality Experience of a Cohort of Rubber Workers, 1964-1973, D. Andjelkonic, et. al. J. Occup. Med. 18:387-394, June 1976, 18 refs.

3. Mortality Among Rubber Workers: Relationship to Specific Jobs, A.M. McMichael, et. al. J. Occup. Med. 18:178-185, March 1976, 16 refs.

4. Respiratory Morbidity in Rubber Workers -- I. Prevalence of Respiratory Symptoms and Disease in Curing Workers, L.J. Fine and J.M. Peters. Arch. Environ. Health, 31:5-9, January/February, 1976, 7 refs.

5. Respiratory Morbidity in Rubber Workers -- II. Pulmonary Function in Curing Workers, L.J. Fine and J.M. Peters, Arch. Environ. Health, 31:10-14, January/February, 1976, 7 refs.

6. Studies of Respiratory Morbidity in Rubber Workers -- III. Respiratory Morbidity in Processing Workers, L.J. Fine and J.M. Peters, Arch. Environ. Health, 31:136-140, May/June, 1976, 6 refs.

7. Mortality Among Rubber Workers - - I. White Male Union Employees in Akron, Ohio, R.R. Monson and K.K. Nakano, Am. J. Epidemiol., 103:284-296, March 1976, 25 refs.

8. Mortality Among Rubber Workers - - II. Other Employees, R.R. Monson and K.K. Nakano, Am. J. Epidemiol., 103:297-303, March 1976, 6 refs.

9. A Survey of Occupational Cancer in the Rubber and Cablemaking Industries: Results of Five Year Analysis, 1967-71, A.J. Fox, D.C. Lendars, and R. Aven, British J. Ind. Med. 3;:140-151, August 1974, 40 refs.

10. An Epidemiologic Study of Mortality Within a Cohort of Rubber Workers, 1964-72, A.J. McMichael, et. al. J. Occup. Med., 16:458-464, July, 1974.

11. Working Conditions and Health Status of Automobile Tire Vulcanizers, Yw.G. Shirkov, N.P. Sobaleva, S.T. Alimova, and L.E. Midkov, Gigigena Trude 16:16-19, 1970, Russian, CIS #2253-72.

12. Occupational Hygiene Problems Associated With Vulcanization Processes in the Rubber Industry, Z.A. Volkova and Z.M. Bagdinov, Gigiena I. Sanitarija, 34 No. 9: pg. 33-40, September, 1969, Russian, CIS#507-1970.

13. Cancer and Exposure to Mineral Oils, H.G. Parkes, Industrial Medicine, Vol. 39, No. 2, Pg. 51-54, February, 1970, 4 refs.

14. Criteria for a Recommended Standard ... Occupational Exposure to Hot Environments, HSM 72-10269, U.S. Dept. of Health, Education and Welfare, National Institute for Occupational Safety and Health, 1972.

15. Air Sampling and Analysis in a Rubber Vulcanization Area, S.M. Rappaport, and D.A. Fraser, Amer. Ind. Hyg. J. 38:, May, 1977, 15 refs.

16. Gas Chromatographic - Mass Spectrometric Identification of Volatiles Released from a Rubber Stock During Simulated Vulcanization, S.M. Rappaport and D.A. Fraser, Analytical Chem. 48, Nos:476-481, March, 1976, 45 refs.

17. The Industrial Environment - Its Evaluation and Control, Chapter 30, Physiology of Heat Stress, HEW, (NIOSH) Publication, 1973, 30 refs.

18. Standards for Occupational Exposure to Hot Environments Proceedings of Symposium, Ch. 9., Physiologic Monitoring of Heart Rate, Sweating Body Temperature, and Metabolic Cost During the Work Situation, Pg. 63-67, 170-177, HEW Publication No. (NIOSH) 76-100, January, 1976.

19. NIOSH Course Handbook - Recognition, Evaluation, and Control #549, Section V, Heat Stress.

20. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1976. American Conference of Governmental Industrial Hygienists, Box 1937, Cincinnati, Ohio 45201.

21. Heat Exposure Limits for Occupational Work, F. Dukes-Dubos and Austin Hanschel, ASHRAE J. 15 No. 9: September, 1976, 57-62, 27 refs.

22. Criteria for a Recommended Standard ... Occupational Exposure to Refined Petroleum Solvents, HEW Publication No. (NIOSH) 77-192, July, 1977.

23. Criteria for a Recommended Standard ... Occupational Exposure to 1,1,1-trichloroethane (methyl chloroform), HEW Publication No. (NIOSH) 76-184, July, 1976.

24. Documentation of the Threshold Limit Values for Substances in Workroom Air, American Conference of Governmental Industrial Hygienists, 3rd Edition, 6th Printing, with supplements for additions and changes through 1975, Printed 1976.

25. Criteria for Recommended Standard ... Occupational Exposure to Methylene Chloride, HEW publication No. (NIOSH) 76-138, March, 1976.

26. Criteria for Recommended Standard ... Occupational Exposure to Alkanes C_5-C_8, HEW Publication No. (NIOSH) 77-151, March, 1977.

27. Criteria for a Recommended Standard ... Occupational Exposure to Dioxane, HEW Publication No. (NIOSH) 77-226, September, 1977.

28. Climatography of the United States No. 20, Climate of Newport, Tennessee, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Ashville, N.C., December, 1975.

29. Climatological Data, Tennessee, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Ashville, N.C., Vol. 18, No. 6,7,8 and 9.

30. Comparative Climatic Data Through 1976, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Ashville, N.C., April, 1977.

V. AUTHORSHIP AND ACKNOWLEDGMENTS

Originating Office:

Jerome P. Flesch
Acting Chief
Hazard Evaluations and Technical
Assistance Branch
Cincinnati, Ohio

ACKNOWLEDGMENTS

Environmental:

Raymond Rivera
Industrial Hygienist

Laboratory Analysis:

Dick Kupel
Research Chemist

Ardith Grote
Chemist

Statistical Analysis:

William Stringer
Statistician
Support Services Branch
Cincinnati, Ohio

Report Typed By:

Carol Goetz
Clerk Typist
Industrial Hygiene Section
Hazard Evaluations and Technical
Assistance Branch
Cincinnati, Ohio

Table 1

American Conference of Governmental and Industrial Hygienists
Permissible Heat Exposure Threshold Limit Values
(Values give in °C and °F WBGT)*

Work-Rest Regimen	Work Load: Light °C*	Light °F*	Moderate °C*	Moderate °F*	Heavy °C*	Heavy °F*
continuous	30.0	86	26.7	80	25.0	77
75% work 25% rest each hour	30.6	87	28	85	25.9	79
50% work 50% rest each hour	31.4	88.5	29.4	85	27.9	82
25% work 75% rest each hour	32.2	90	31.1	88	30	86

*WBGT = Wet Bulb Globe Temperature Index
= .7 Wet Bulb Temperature + .2 Block Globe Temperature + .1 Dry Bulb Temperature

See Section D 2 of this report for a discussion of criteria limitations.

Table 2

Toxicity Criteria

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennesse

September 1976

TOXIC MATERIAL	NIOSH[a] RECOMMENDED	ACGIH TLV[b] 1976 Book	Title 29[c] Part 1910.1000, Subpart C
Rubber Solvent	350 mg/M^3 (TWA) (C) 1,800 mg/M^3	400 ppm (TWA) No (PEL) Given	None Given
1-1-1 Trichloroethane	(C)[d]350	350 ppm (TWA) 450 ppm (PEL)[d]	350 ppm (TWA) (Table Z-1)
2-Nitropropane	Treat as a suspect human carcinogen (See Appendix I)	25 ppm (TWA) 25 ppm (PEL)	25 ppm (TWA) (Table Z-1)
Methylene Chloride	75 ppm (TWA) (C) 500 ppm in absence of CO> 9 ppm	200 ppm (TWA) 250 ppm (PEL)	500 ppm (TWA) (C) 1000 ppm 200 ppm Peak (Table Z-2)
Methyl Ethyl Ketone	None Given	200 ppm (TWA) 300 ppm (PEL)	200 ppm (TWA) (Table Z-1)
Alkanes C_5 - C_8	350 mg/m^3(TWA) (C) 1800 mg/m^3	None Given	None Given
Dioxane	(C) 1 ppm Skin[e] Suspect Human Carcinogen	50 ppm (TWA) skin No (PEL) Given	100 ppm (TWA) skin (Table Z-1)

(See Page 2 Notes)

MULTIPLE CRITERIA TABLE 2 - (cont)

a. All NIOSH recommended criteria cited here are time weighted averages (TWA) designed to protect the health and safety of workers for up to a 10-hour workday, 40 hour workweek over a working lifetime. Compliance with all sections of the applicable standard should prevent adverse effects on the health and safety of workers.

b. American Conference of Governmental Industrial Hygienists Threshold Limit Value's refer to time-weighted average concentrations for a 7- or 8-hour workday and 40-hour workweek. They represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effects. These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline.

c. From CFR Title 29 Part 1910.1000 Occupational Safety and Health Standards, Subpart C Occupational Health and Environmental Controls, air contaminants; any employee exposed to any material listed in Table Z-1, Z-2, or Z-3 of this section shall be limited in accordance with the requirements of the following paragraphs of this section. (See Code of Federal Regulations dated July 1, 1976 for full discussion). Criteria cited here from Tables Z-1, Z-2, and Z-3 all are based on an 8-hour work shift of a 40-hour workweek time weighted average exposure.

d. Ceiling concentrations (C) and Short Term Exposure Limits (STEL) are listed where available. These limits are based on various exposure control criteria and time limits which must be carefully studied before application to a specified working environment. Typical limits might be a 10 or 15 minute exposure once a day with a compensatory period of exposure below the TWA limit.

e. The "Skin" notation refers to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substance. Vehicles can alter skin absorption. This attention calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the TLV is not invalidated.

Table 3

WBGT's Determined in Press Operations' and Packers Work Environment
(Curing Dept.)

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

September 22, 1976

(Press Operators' Side of Line)

Location	WBGT	Time
Between Presses A-1 & A-2	61.5	0800
	70.5	1025
	72.0	1345
Right of Press A-6	72.0	0835
	70.5	1034
Between Presses A-19 & A-20	69.5	0810
	77.5	1415
Left of Press 19	74.5	1115
Left of Press A-25	72.0	1125
Left of Press A-26	72.5	0845
	77.0	1420
Between Presses A-30 & A-31	69.0	0915
	71.0	1448
Right of Press A-31	70.5	1230
Between Presses A-36 & A-37	70.5	0920
	75.5	1455
Right of Press A-37	73.0	1235
Between Presses A-41 & A-42	69.5	0950
	71.5	1305
Right of Press A-47	72.0	1310
Between Presses A-46 & A-47	70.0	0955
Between Presses A-12 & A-13	72.5	1055
Left of Press A-12	76.0	1350
Right of Press B-68	73.0	0820
	77.5	1000

Page 2 - TABLE 3 - Continuation

Location	WBGT	Time
Right of Press B-72	74.0	0910
September 23, 1976 (Press Operators' Side of Line)		
Between Presses B-96 & B-95	76.0	0740
	77.5	1035
	80.2	1435
Between Presses B-92 & B-93	67.0	0745
Between Presses B-93 & B-94	79.5	1110
Between Presses B-89 & B-90	68.5	0810
Left of Press B-86	72.0	0815
	82.5	1435
Right of Press B-88	83.5	1230
Between Presses B-84 & B-85	71.0	0850
Between Presses B-83 & B-84	82.5	1235
Between Presses B-81 & B-80	77.0	0855
	86.5	1503
Between Presses B-79 & B-80	86.5	1300
At Press B-77	88.5	1505
Between Presses B-75 & B-76	75.5	1305
Between Presses B-74 & B-75	68.5	0929
Between Presses B-65 & B-66	75.5	0925
Between Presses B-67 & B-68	80.5	1335
Between Presses B-71 & B-72	83.4	1405
Between Presses B-60 & B-59	73.0	1005
Between Presses B-59 & B-58	82.5	1340
Between Presses B-56 & B-57	84.5	1410
Between Presses B-55 & B-54	80.0	1025
Between Presses B-49 & B-50	77.5	1105
September 22, 1976 (Packing Area)		
Between Presses A-4 & A-5	69.5	1300
Between Presses A-16 & A-17	76.5	1302
	69.0	1509

Page 3 - TABLE 3 - Continuation

Location	WBGT	Time
Between Presses A-37 & A-38	76.5	1353
Between Presses A-26 & A-27	80.0	1029
	September 23, 1976 (Packing Area)	
Between Presses B-54 & B-53	67.0 73.0	1022 1445
Between Presses B-68 & B-69	62.0	0807
Between Presses B-67 & B-68	79.0	1350
Between Presses B-82 & B-83	71.0 81.5	0918 1221
	September 22, 1976 (Packing Area)	
Isle Opposite Press A-26	70.0	1102
Isle Opposite Press B-75 (no side)	67.5	? P.M.
	September 23, 1976 (Packing Area)	
Isle Between B-54 & A-6	66.0 71.0	0950 1512
Isle Between B-69 & A-21	68.5	0841
Isle Between B-68 & A-20	74.0	1415
Isle Between B-83 & A-35	71.0	0950
Isle Between B-82 & A-34	76.5	1312

NOTE: Temperature measurements in Packing Area were made between boxes used for Packing; measurements were made near the isle edge of the box. Temperatures measured in the isle were in the center of the isle.

Table 4

Climatological Data[29]
for Newport, Tennessee*

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

June - September 1976

	June	July	Aug.	Sept.
Average Maximum Temperature ^{o}F	83.5	85.4	85.2	77.1
Average Minimum Temperature ^{o}F	58.5	60.5	60.9	52.7
Average Temperature ^{o}F	71.2	73.0	73.1	64.9
Number of days 90^{o} for above	1	10	6	0

*Newport Utility Board Observer: location 1 mi NW, Elevation 1035 feet, Daily 24 hour observation period ending at 9 a.m.

Climatological Data[30]
for Knoxville WSO, AP. Tennessee*

June - September 1976

	June	July	Aug.	Sept.
Average Maximum Temperature	84.2	86.3	85.8	78.0
Average Minimum Temperature	63.5	66.1	64.0	57.4
Average Temperature	73.9	76.2	74.9	67.7
Number of days 90^{o} for above	2	10	5	0
Rel. humid average % 0100 hours	89	92	87	93
0700 hours	92	92	94	96
1300 hours	60	62	60	64
1900 hours	65	69	66	71

*National Weather Service Observer: location WSO Airport, Elevation 980 feet, Daily 24 hour observation period ending at midnight.

Table 5

Climatological History for Newport, Tennessee(28)

LATITUDE N35 59
LONGITUDE W83 12

CLIMATOLOGICAL SUMMARY

MEANS AND EXTREMES FOR PERIOD 1951-1973

NEWPORT 1 NW, TN
ELEVATION 1039

MONTH	TEMPERATURE (°F)													PRECIPITATION TOTALS (INCHES)														
	MEANS			EXTREMES						MEAN NUMBER OF DAYS										SNOW, SLEET						MEAN NUMBER OF DAYS		
										MAX.		MIN.																
	DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	RECORD HIGHEST	YEAR	DAY	RECORD LOWEST	YEAR	DAY	90° AND ABOVE	32° AND BELOW	32° AND BELOW	0° AND BELOW	MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	MEAN	MAXIMUM MONTHLY	YEAR	GREATEST DEPTH	YEAR	DAY	.10 or MORE	.50 or MORE	1.00 or MORE
JAN	48.0	26.1	37.1	80	57	29	-14	66	31	0	3	22	1	3.94	10.77	54	3.02	54	16	5.2	15.5	66	9.0	62	10	9	2	1
FEB	51.6	28.4	40.0	74+	65	12	-5	66	1	0	2	18	0	3.96	8.31	57	2.15	57	1	3.4	11.5	60	10.0	60	14	8	3	1
MAR	60.2	34.7	47.5	87	54	25	7	60	5	0	0	14	0	4.78	10.82	63	3.85	63	12	1.1	10.0	60	6.0	54	1	9	3	1
APR	72.0	44.3	58.2	91+	57	27	25+	66	10	0	0	3	0	3.98	5.66	70	2.42	56	16	.1	2.0	71				8	3	1
MAY	79.6	52.6	66.1	95+	62	20	29	71	4	3	0	0	0	3.86	6.67	67	1.97	58	6	.0						8	3	1
JUN	86.1	60.9	73.5	105	52	28	36	66	1	9	0	0	0	3.86	7.89	57	3.30	53	22	.0						7	3	1
JULY	88.9	64.6	76.7	107+	52	28	47	61	10	14	0	0	0	4.46	7.70	71	2.81	60	11	.0						8	3	1
AUG	88.3	63.5	75.9	100	54	27	46	68	29	13	0	0	0	3.68	8.65	64	2.49	64	31	.0						7	2	1
SEPT	83.7	57.4	70.6	102+	54	5	32	67	30	6	0	0	0	2.88	5.78	62	2.25	62	17	.0						5	2	1
OCT	72.6	44.9	58.7	92+	53	1	22	52	30	0	0	4	0	2.65	5.61	59	2.20	64	17	.0						5	2	1
NOV	59.7	34.3	47.1	84	41	3	9	70	25	0	0	14	0	3.19	5.36	57	1.86	59	28	.5	3.5	63	4.0	63	30	7	2	1
DEC	50.6	28.4	39.5	82	51	7	-10+	62	14	0	1	21	0	3.48	7.85	61	2.35	61	12	2.4	8.8	62	5.0	62	12	7	2	1
YEAR	70.1	45.0	57.6	107+	JUL 52	28	-14	JAN 66	31	45	6	96	1	44.72	10.82	MAR 63	3.85	MAR 63	12	12.7	15.5	JAN 66	10.0	FEB 60	14	88	30	12

+ ALSO ON EARLIER DATES

MONTHLY NORMALS OF TEMPERATURE, PRECIPITATION AND HEATING AND COOLING DEGREE DAYS (1941-70)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
TEMPERATURE	38.3	40.6	47.7	56.5	66.9	74.3	77.2	76.2	70.3	59.2	47.2	39.1	58.0
PRECIPITATION	3.98	4.24	4.57	3.53	3.67	3.85	4.77	4.04	2.87	2.46	3.06	3.42	44.44
HEATING DEGREE DAY	828	683	547	213	31	5	0	0	18	216	534	803	3918
COOLING DEGREE DAY	0	0	10	18	120	284	378	347	177	36	0	0	1380

Table 6

Climatological History for Knoxville, Tennessee (30)

	Avg. Daily Temp.(1)			Extremes(2)		Avg.(1) Precip.	Heating	Cooling	Avg.(2) RH%	
	Max.	Min.	Mean	High	Low	(inches)	Deg. Days(1)	Deg. Days(1)	AM	PM
Jan.	48.9	32.2	40.6	72	-9	4.75	0	0	80	64
Feb.	52.0	33.5	42.8	75	0	4.43	0	0	78	60
Mar.	60.4	38.4	49.9	86	18	5.00	10	16	78	55
April	72.0	48.6	60.3	89	27	4.11	175	32	78	50
May	79.8	56.9	68.4	94	34	4.10	474	152	84	55
June	86.1	64.8	75.5	95	44	3.38	729	315	88	59
July	88.0	68.3	78.2	98	51	3.83	756	409	90	62
Aug.	87.3	67.2	77.3	99	53	3.24	630	361	92	61
Sept.	82.0	61.2	71.6	96	36	3.09	484	208	91	59
Oct.	71.8	50.0	60.9	85	25	2.16	173	48	88	55
Nov.	58.8	39.4	4(.2	83	13	3.46	47	0	83	58
Dec.	49.8	33.1	41.5	75	-2	4.45	0	0	81	64
Ann.	69.8	49.5	59.7	99	-9	46.0	3478	1569	84	59

(1) 30 year period 1941-1970
(2) 16 year period

Table 7

Operator Exposure, Press Lines

Corporate WBGT Measurements Operators Exposure, Press Line

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

Reference-October 26, 1976 letter from the Corporate Industrial Hygienist

January 21, 1973

Location	WBGT
B Line, Press #96	68.4
" " #90	72.2
" " #80	71.0
" " #70	73.0
" " #60	70.7

January 22, 1973

C Line, Press #116	77.4
" " #112	81.3
" " #105	77.4
A Line, Press # 45	66.7
" " # 35	65.0
" " # 25	65.8
" " # 15	67.3
" " # 5	67.2

July 24, 1973

C Line, Press #117	99.6
" " #114	99.2
" " #105	95.2
Between A & B Lines *	
(a) Opposite Press #10	103.6
(b) Opposite Press #22	104.2
(c) Opposite Press #30	99.4
(d) Opposite Press #43	98.2

August 13-14, 1973

84" Mill on 6" Line	86.0
Tire Splicer, 8" Line	81.6
" " 6" Line	83.6
" " Cold feed line	83.6
A Line, Press # 5	88.0
" " #15	89.2
" " #25	90.6
" " #35	88.0
" " #45	86.0
B Line, Press #60	90.6
" " #70	88.6
" " #80	89.2
" " #90	88.6
" " #96	86.0

Location	WBGT
July 10, 1974	
Between A & B Lines*	
(a) At Press A-16	84.0
(b) At Press A-34	89.0
A Line, Press #23	85.0
B Line, Press #61 & 62	85.0
C Line, Press #109	89.0
October 23, 1974	
C Line, Press#109	74.0
In aisle between Lines A & B*	78.6
B Line, Press #61	77.5
August 24, 1976	
Press #5	87.6
" #15	89.0
" #25	91.0
" #35	88.4
" #45	88.4
" #60	91.4
" #80	93.8
" #90	97.8
Crate Packing	90.0

CORPORATE INDUSTRIAL HYGIENIST

*Packing area (at end of table)

Table 8

Air Sample Results: Vulcanizing Department

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

September, 1976

Sample No.	Type	Period (hours)	Volume (Liters)	Results/Criteria	Possible Major Components	Other Tentative Identifications
Worker #1						
V-1671	Filter	6.4	384	.68 mg/M^3/10 mg/M^3		
CT-5	Charcoal tube with pre-filter	6.4	384		*	Toluene, tetrachloroethylene, ethyl benzene ar or xylene isomers. Substitute benzene (MW 12(such as methyl ethyl benzenes and trimethyl-benzenes. t-butyl isothiocyanate. Alkanes anc alkenes up to MW 170 or more. Diphenylhydrazi Largest peak could be a cycloalkene or an alaphatic disulfide.
CT-6	Charcoal tube	1.5	17.2	No identifiable peaks		
Worker #2						
V-1595	Filter	4.1	246	.98 mg/M^3/10 mg/M^3		
CT-12	Charcoal tube with pre-filter	4.1	246		heptane, methylcyclohexane	Toluene, ethyl benzene and/or xylene isomers. t-butyl isothiocyanate.
Worker #3						
V-1454	Pre-filter	3.8	232	.39 mg/M^3/10 mg/M^3		
CT-11	Charcoal tube with pre-filter	3.8	232	No identifiable peaks		
CT-10	Charcoal tube	3.8	20.6	No identifiable peaks		

CT-12 tentative identifications (continued):

Molecular Weight	Possible Type
84	cyclic (C_6H_{12})
86	(C_6H_{14})
98	(C_7H_{14})
100	(C_6H_{16})
112	(C_8H_{16})
114	(C_8H_{18})

34A

Table 8
Continued

Sample No.	Type	Period (hours)	Volume (Liters)	Results/Criteria	Possible Major Components	Other Tentative Identifications
Worker #4						
V-1566	Filter	6.7	400	.33 mg/M^3/10 mg/M^3		
CT-4	Charcoal tube with pre-filter	6.7	400	No identifiable peaks		
Worker #5						
V-1407	Filter	4.6	258	.66 mg/M^3/10 mg/M^3		
CT-15	Charcoal tube with pre-filter	4.6	258	See CT-17 From a similar sample location		
Worker #6						
V-1591	Filter	4.7	265	.26 mg/M^3/10 mg/M^3		
CT-17	Charcoal tube	4.7	265		Hexane***	
Worker #7						
CT-9	Charcoal tube	2.1	50.5	Methylene chloride 21.4 mg/M^3/270 mg/M^3 1,1,1-Trichloroethane <.2 mg/M^3/1900 mg/M^3 2-Nitropropane <.2 mg/M^3/suspect human carcinogen		
Worker #8						
CT-3	Charcoal tube	6.8	28.7	Methyl ethyl ketone <.3 mg/M^3/590 mg/M^3 Hydrocarbons C_5-C_8, Alkanes C_3-C_8 5.5 mg/M^3/350 mg/M^3		

*CS_2 desorbed -Therefore, an effort was made to identify later elutriating peaks. Concentrations were low so identification was not as conclusive as samples CT-12 and CT-17.
**CS_2 desorbed - The early peaks found in this sample were alaphatic straignt chain, branched, and cyclic hydrocarbons C_8 or below.
***Hexadodecane desorbed - The early peaks were similar to those described above for CT-12. Compounds such as pentane, methyl pentanes, cyclohexane, and dimethylcyclopentain are included in these groups.

Table 9

Air Sample Results: All Terrain Vehicle Department

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

September 1976

Sample	Type	Period (Hrs)	Volume	Results Methyl Ethyl Ketone mg/m^3	Alaphatic Hydrocarbons, C_5-C_8 mg/m^3
Worker #9 CT-2	Charcoal Tube	5.5	20.0L	<.5	5.0
Worker #10 CT-14		3.7	14.7L	<.7	3.0
CT-16		4.1	17.0L	<.6	4.0
Worker #11 CT-13		3.3	11.6L	<.8	10.0
CT-18		4.5	15.5L	<.6	7.5
Criteria				TLV 590 mg/M^3	NIOSH for Alkanes 350 mg/M^3

Table 10

Employee Age & Sex Profile

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

September 22-23, 1976

	Number Interviewed	Percent Interviewed	Age Range in Years	Mean Age Range in Years
Females	31	75.6%	19-55	34
Males	10	24.4%	23-56	37
Total	41	100.0%	19-56	35

Table 11

Employment History

Year Began Employment	Number of Workers Employed
1968	18
1969	6
1970	1
1971	4
1972	6
1973	3
1974	0
1975	1
1976	2
Total	41

Table 12

Employees Smoking Profile

	Smokers	Non-smokers	Total
Females	13	18	31
Males	5	5	10
Total	18	23	41

Table 13

*Health Problems Reported from Questionnaires
by Employees of Newport Industrial Products, Newport, Tennessee
on September 22-23, 1976

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

Table 13-1

Non-Directive Questionnaire on Health Problems Related to Work[a]

Health Problems	Total Numbers of Workers Interviewed Reporting Health Problems	Percent of Workers Interviewed Reporting Health Problems
1. Headaches	(6 of 41)	14%
2. Eye Irritation	(4 of 41)	10%
3. Fatigue	(3 of 41)	7%
4. Weak	(2 of 41)	5%
5. Skin Irritaiton	(2 of 41)	5%
6. Thirst	(1 of 41)	2%
7. Difficulty breathing due to fumes	(1 of 41)	2%
8. Hoarse	(1 of 41)	2%
9. Irritable	(1 of 41)	2%
10. Nervous	(1 of 41)	2%
11. Jock Itch	(1 of 41)	2%
12. Joint Pain	(1 of 41)	2%
13. Sinus	(1 of 41)	2%
14. Hernia	(1 of 41)	2%
15. Hysterectomy	(1 of 41)	2%

a. Eighteen of forty-one workers (44%) reported one or more of the above health problems when asked "Do you have any health problems at work or you feel might be related to your work.

*Note: Thirty-three of fourty-one (81%) workers gave a history of symptomatology, either through directive or non-directive questionnaires, possibly related to work.

Table 13-2

Directive Questionnaire of Specific Symptomatology of Heat Stress[b]

Newport Industrial Products
Newport, Tennessee

September 22-23, 1976

Symptoms of Heat Stress	Number of Workers Interviewed Reporting Symptoms Without Confounding Etiology	Number of Workers Interviewed Reporting Symptoms With Confounding Etiology*	Number of Total Workers Interviewed Reporting Symptoms	Percent of Total Workers Interviewed Reporting Symptoms
Weakness	9	8	17	41%
Dizziness	6	8	14	34%
Fatigue	9	10	19	46%
Headache	11	8	19	46%
Vomiting	0	3	3	7%
Diarrhea	4	8	12	29%
Muscle Cramps	4	3	7	17%
Nausea	5	3	8	20%
Breathlessness and Palpitation	9	10	19	46%
Feeling of Intense Heat & Thirst	11	11	22	54%
Tingling and Numbness of Extremities	8	8	16	39%
Total Symptoms	76	80	156	

b. Thirty-three of fourty-one workers (81%) responded "yes" to having one or more of the above eleven symptoms of heat stress when asked "Have you experienced any of the following symptoms: Weakness, etc?"

*See Table 13-3

Table 13-3

Directive Questionnaire of
Confounding Diseases and Symptoms of Heat Stress[c]

Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee

September 22-23, 1976

Confounding Diseases and Symptoms	Total number of Workers Interviewed Reporting Confounding Diseases and Symptoms	Percentage of total Workers Interviewed Reporting Confounding Disease and Symptoms
1. Bronchitis, Asthma, TB, Hay fever	9 of 41	22%
2. Low Blood Pressure, Anemia	8 of 41	20%
3. High Blood Pressure, Heart Trouble	3 of 41	7%
4. Pain or Tight Chest	5 of 41	12%
** Total Symptoms	25	

c. Fifteen of forty-one workers responded yes, to having one or more of the ten confounding diseases and symptoms of heat stress listed in the four groups above, when asked, "Do you now have or have you ever had: Bronchitis, asthma, etc.?

** Number represents the total number of symptoms reported, some workers reported more than one symptom.

TABLE 14

Exposure Profile of Study Group
by Job Title, Sex and Day

Newport Industrial Products
Newport, Tennessee

September 22-23, 1976

Job Title	Female	Male	Total	Day 1	Day 2	Total
st Exposed - Hot Jobs						
Press Operator (B Line)	10		10		10	10
Press Operator (A Line)	11		11	11		11
Tire Packer		2	2	1	1	2
Maintenance (on Press Line)		2	2	2		2
Total - Most Exposed	21	4	25	14	11	25
ast Exposed - Non-Hot Jobs						
Splicer	10		10	3	7	10
Millman		2	2	2		2
Trucker on Press Line		2	2	2		2
Mold Cleaner		1	1		1	1
Tuber Operator		1	1		1	1
Total - Least Exposed	10	6	16	6	10	16
al - All Workers	31	10	41	20	21	41

TABLE 15

Pre-Shift and 4 and 8 Minute Post-Shift Oral Temperatures and Apical Pulse Rates

Newport Industrial Products
Newport, Tennessee

September 22-23, 1976

	TEMPERATURES			PULSES		
	Pre-Shift	Post-Shift 4 Minute	Post-Shift 8 Minute	Pre-Shift	Post-Shift 4 Minute	Post-Shift 8 Minute
Press Operators (B Line)						
1.	97.2	99	99	76	84	86
2.	96.6	99.4	99.6	80	86	82
3.	98.2	99.6	99.6	69	82	86
4.	97.4	98.8	98.8	69	84	86
5.	97.6	99.0	99.0	80	82	86
6.	96.8	98.6	99.0	70	68	72
7.	96.6	99.0	99.0	68	80	78
8.	96	98.4	98.6	68	66	66
9.	97.2	99.1	99.5	74	76	72
10.	97	98.2	98	72	86	86
Press Operators (A Line)						
11.	98	98.6	99	104	92	94
12.	98.8	99	99	70	76	80
13.	97.6	99.4	99.2	90	88	80
14.	97.8	98.6	98.6	80	70	72
15.	96	98.8	99.4	90	106	108
16.	97.8	98.6	98.2	70	84	76
17.	98.4	98.8	98.8	64	80	86
18.	97.6	98.6	98.8	68	82	88
19.	98.8	99.4	99.4	84	88	84
20.	97.4	98.4	98	68	72	78
21.	96.8	98	98.4	66	58	70
Tire Packers and Maintenance on the Press Line						
22.	95.2	98.8	99.0	54	62	66
23.	96.6	97.6	98.2	76	84	98
24.	97.2	99	99.2	60	96	92
Splicers						
25.	98.2	98.2	98.4	116	114	108
26.	97	99.0	98.8	72	82	80
27.	98.4	99.8	99.8	82	94	86
28.	97.8	99.4	99.4	90	81	84

TABLE 15 Cont'd.

Splicers, Cont'd.						
29.	96.6	98.2	98.2	78	96	96
30.	98.6	99.2	99.2	80	68	76
31.	97.4	99.4	99.2	66	88	82
Splicers,						
32.	97.8	97.8	98.6	72	70	70
33.	97.2	98.6	98.8	80	95	96
34.	97.0	98.2	98.4	62	66	64
Others						
35.	96.0	98.0	98.8	62	70	74
36.	96.2	98.6	98.8	66	80	80
37.	96.2	97.6	98	56	62	68
38.	97	98.8	98.6	68	94	82
39.	98.8	99	99	74	78	80
40.	97.6	99.2	99.4	100	112	110
41.	96	98.8	98.8	65	70	68

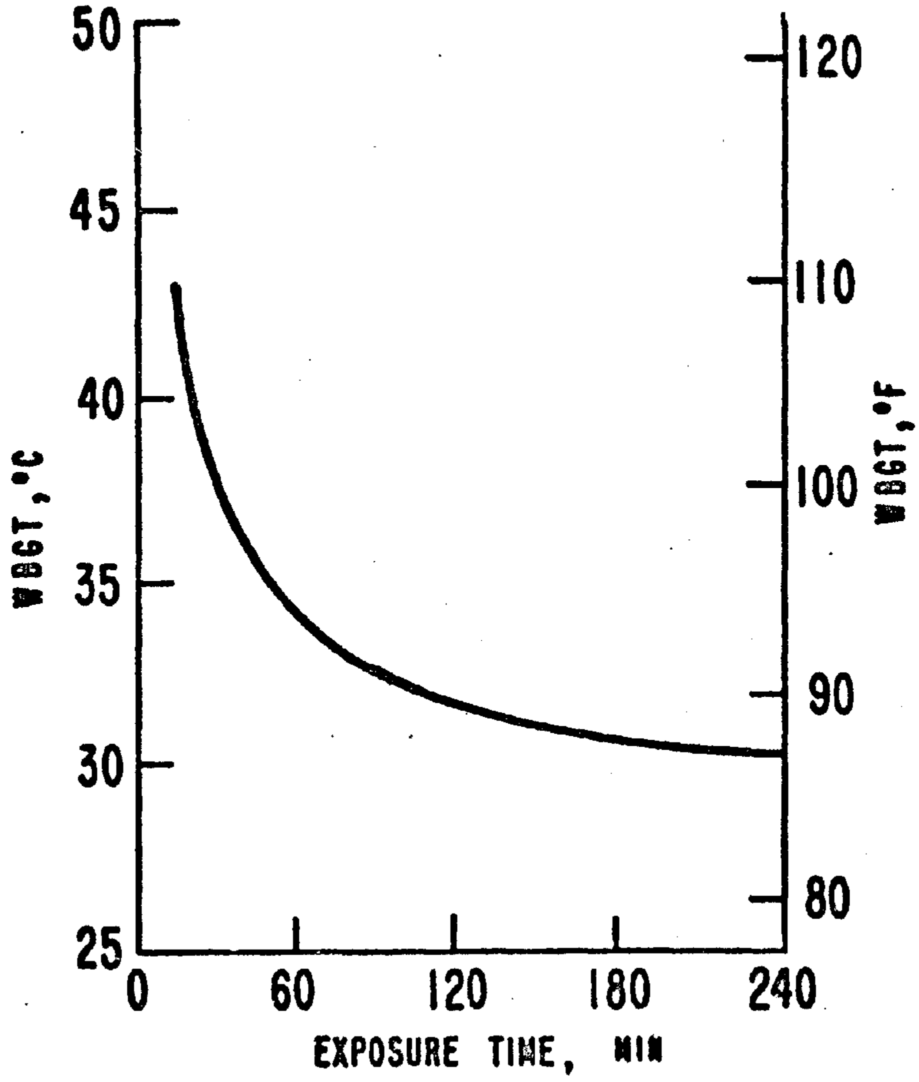
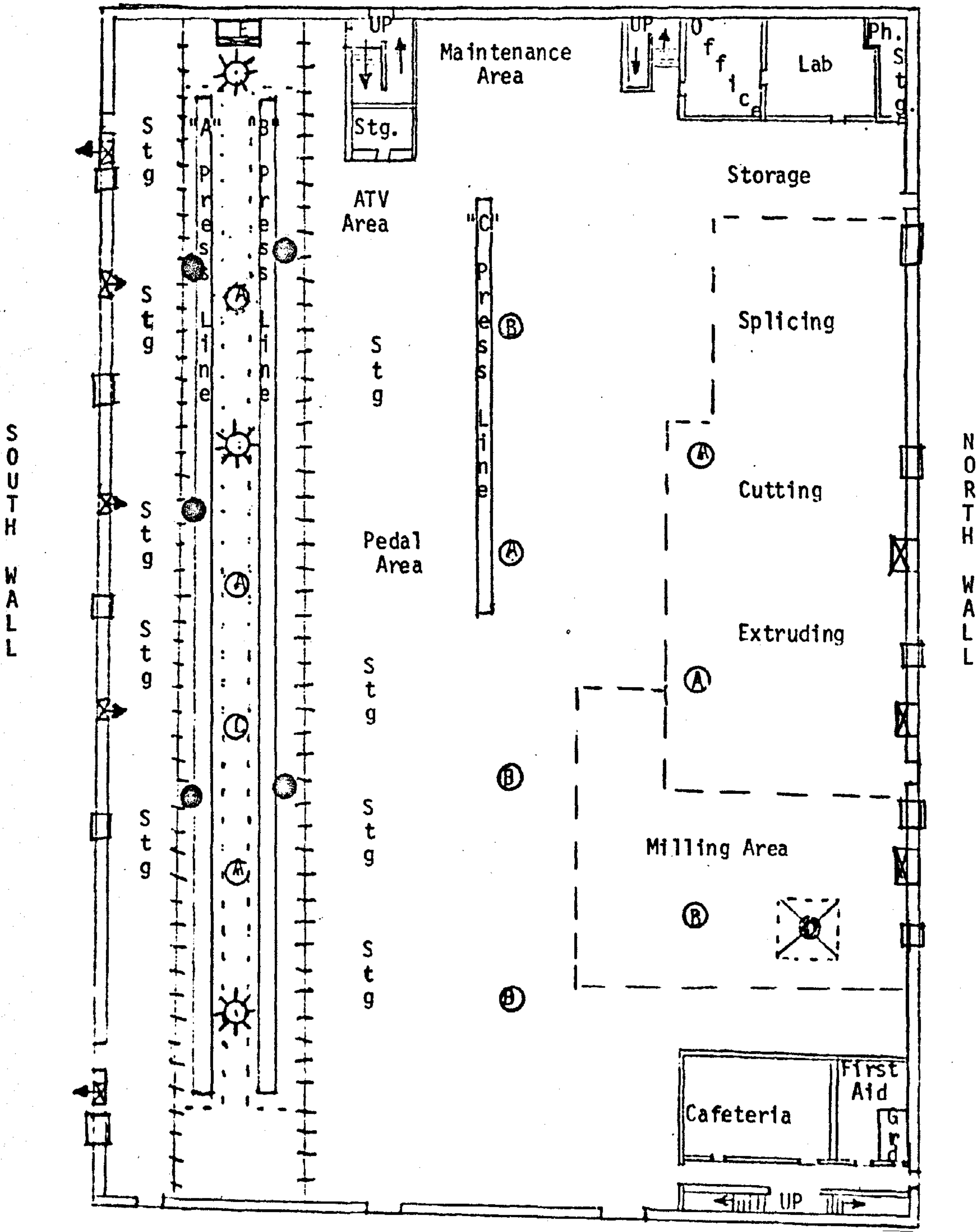


FIGURE I . UPPER LIMITS OF EXPOSURE FOR UNIMPAIRED MENTAL PERFORMANCE

FIGURE II
PLANT LAYOUT AND VENTILATION
Newport Industrial Products
Firestone Tire and Rubber Company
Newport, Tennessee



45

FIGURE II LEGEND

○ Ceiling Exhaust Fan

Ⓐ- 15,000 CFM

Ⓑ- 30,000 CFM

Ⓒ- 50,000 CFM

Roof Vent - 50,000 CFM Fan Removed and Relocated Since Survey

● New/Relocated 50,000 CFM Fan Installed Since Survey

100,000 CFM Make-Up Air Units (4 ea)

Wall Louvers 8 ft. X 12 ft. (5 on N and S Walls)

New Exhaust Fan and Hood Installed Over Mill Since Survey

Wall Fan 15,000 CFM Supply or 20,000 CFM Exhaust as Shown by Vector)

Shroud Hung from Roof Existed at Time of Survey

New Shroud Added Since Survey (Surrounding A & B Press Lines Separately)

ATV - All Terrain Vehicle Fabrication

STG - Storage Area

GRD - Guard Room

PH - Phone Room

PEDAL - Pedal Production

NOTE: Drawing not to scale

APPENDIX I

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL

NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH
5600 FISHERS LANE
ROCKVILLE, MARYLAND 20852

CURRENT INTELLIGENCE BULLETIN:

2-NITROPROPANE

April 25, 1977

A recently completed inhalation study indicates that 2-nitropropane, a widely used solvent in industrial coatings and printing inks, causes liver cancer in rats. In this study sponsored by the National Institute for Occupational Safety and Health (NIOSH), all laboratory rats exposed to 207 ppm 2-nitropropane over a six month period developed hepatocellular carcinoma or hepatic adenoma. Although this study suggests that 2-nitropropane is carcinogenic, its carcinogenic potential in man has not yet been researched.

This Bulletin provides the results of this animal study along with other pertinent data, their implications for occupational health, and precautions for handling 2-nitropropane in the workplace.

Background

Solvent systems containing 2-nitropropane are used in coatings (e.g., vinyl, epoxy, nitrocellulose, and chlorinated rubber), printing inks, and adhesives. Occupational exposure to these products may occur in various industries including industrial construction and maintenance, printing (rotogravure and flexographic inks), highway maintenance (traffic markings), shipbuilding and maintenance (marine coatings), furniture, food packaging, and plastic products. NIOSH estimates that 100,000 workers are potentially exposed to 2-nitropropane in these and other industries.

Synonyms for 2-nitropropane include dimethylnitromethane, isonitropropane, nitroisopropane, and 2-NP. Trade names under which 2-nitropropane is marketed include NiPar S-20™ (commercial grade 2-nitropropane) and NiPar S-30™ (mixtures of 1- and 2-nitropropane). 2-Nitropropane (in concentrations ranging from approximately 5 to 25 percent) is used in a number of solvent systems to contribute desirable properties such as improved drying time, more complete solvent release, better flow and film integrity, retardation of blushing, greater wetting ability, improved electrostatic spraying, and increased pigment dispersion.

The sole known domestic producer of 2-nitropropane has been Commercial Solvents Corporation (recently acquired by International Minerals and Chemical Corporation, IMC). 2-Nitropropane has been manufactured at their Sterlington, Louisiana plant since 1955, and in a pilot plant in Peoria, Illinois from 1940 to 1955. Of the estimated thirty million pounds of 2-nitropropane produced annually, twelve million pounds per year are sold domestically; the remainder is either used internally at IMC or exported.

Toxicology

In an inhalation study conducted by Huntingdon Research Center under a NIOSH contract (HEW/NIOSH Project No. 210-75-0039), Sprague-Dawley male rats and New Zealand White male rabbits were exposed to commercial grade 2-nitropropane for seven hours per day, five days per week. One group of fifty rats and fifteen rabbits was exposed to 207 ppm 2-nitropropane; a second group of the same size was exposed to 27 ppm, while a third group was maintained as a control. Ten rats from each group were killed after exposure periods of two days, ten days, one month, three months, and six months. Liver neoplasms, described as hepatocellular carcinoma or hepatic adenoma, were observed in all ten rats killed after six months of exposure to 207 ppm 2-nitropropane. No tumors were observed in any other animals in this study, including controls. However, hepatocellular hypertrophy, hyperplasia, and necrosis were reported in rats exposed to 207 ppm 2-nitropropane for three months. In addition, elevated liver weights were found in rats exposed to 207 ppm 2-nitropropane for one, three, and six months. Liver histopathology, as well as the liver weights, of rats exposed to 27 ppm 2-nitropropane did not differ from controls.

Although certain shortcomings do exist in the conduct of this study,* the experiment is sufficient to merit the concern of the occupational health community. NIOSH has been advised that further investigation of the toxicity of 2-nitropropane has recently begun (April, 1977) under the sponsorship of the IMC Chemical Group, Inc.

* The fifty rats exposed to 207 ppm 2-nitropropane were weanling rats (younger and smaller than the other exposed rats and the control group) which were introduced to replace rats experiencing excess mortality during the first few days of exposure to 400 ppm 2-nitropropane. In addition, throughout the entire study, exposure to 2-nitropropane was conducted while food and water were present, thus introducing the potential for exposure by the oral route.

The effects of 2-nitropropane inhalation in laboratory animals have also been studied by Treon and Dutra (Arch. Ind. Hyg. and Occ. Med., 5:52, 1952). Five species of laboratory animals (2 animals of each species per exposure level) were exposed to various concentrations of 2-nitropropane. Acute exposures ranged up to 9000 ppm for short time periods (as low as one hour), while chronic exposure levels ranged down to 83 ppm 2-nitropropane for as long as 26 weeks. Treon and Dutra reported no histologic changes in the monkeys, rabbits, guinea pigs and rats exposed to 328 ppm or less regardless of exposure time.** However, both cats died within 17 days of exposure to 328 ppm and had severe liver damage and slight to moderate damage to the kidney and heart.

There are a number of published reports concerning acute health effects of occupational exposure to 2-nitropropane. One report of two workers attributes the death of one and liver damage in both workers to high level exposure to 2-nitropropane while painting the inside of a tank (Gaultier, M., et. al., Arch. d. Mal. Prof. 25:425, 1964). Another paper relates that continual exposure to concentrations of 20 to 45 ppm 2-nitropropane caused workers in one plant to experience nausea, vomiting, diarrhea, anorexia, and severe headaches (Skinner, J.B., Ind. Med. 16:441, 1947). A third report indicates that workers exposed to from 165 to 445 ppm mixed 1-and 2-nitropropane also experienced nausea, dizziness, headaches, and diarrhea (Documentation of Threshold Limit Values, American Conference of Governmental Industrial Hygienists, 1971). In addition, Williams, et. al., (New Eng. J. of Med., 291:1256, 1974) reported an excess of toxic hepatitis among construction workers applying epoxy resins to the walls of a nuclear power plant. Although the hepatitis in this case was attributed to exposure to a known hepatotoxin, p,p'-methylenedianiline (4,4'-diaminodiphenylmethane), these men were also observed to have used 2-nitropropane to remove the hardened resin from their skin.

**On subsequent examination by a NIOSH pathologist in March 1977, liver sections from two rats in this study which were exposed to about 300 ppm 2-nitropropane for seventeen exposures (7 hours each) showed clear cell foci. These and similar lesions are frequently seen prior to the development of hepatocellular carcinoma in rats exposed to known hepatic carcinogens. The lesions observed in the Treon and Dutra study are similar to those found in the liver sections of the rats in the Huntingdon study which were sacrificed after three months exposure to 207 ppm 2-nitropropane.

NIOSH Action and Recommendation

In order to characterize the potential for exposure to 2-nitropropane in the work environment, the National Institute for Occupational Safety and Health plans to conduct industrial hygiene surveys at facilities where 2-nitropropane is manufactured or consumed. In addition, an attempt will be made to identify a suitable worker population for epidemiologic studies.

The current Occupational Safety and Health Administration (OSHA) standard for occupational exposure to 2-nitropropane is 25 ppm. However, in light of the new information generated by the Huntingdon study, and while the carcinogenic potential of 2-nitropropane is being further evaluated, NIOSH believes that it would be prudent to handle 2-nitropropane in the workplace as if it were a human carcinogen. The attached interim recommended industrial hygiene practices were developed by NIOSH to help reduce occupational exposure to 2-nitropropane.

John F. Finklea, M.D.
John F. Finklea, M.D.
Director

Attachment

INDUSTRIAL HYGIENE PRACTICES TO REDUCE EXPOSURE TO 2-NITROPROPANE

The following are suggested good industrial hygiene practices that can help to reduce exposure to 2-nitropropane. The recent finding of liver cancer in laboratory rats exposed by inhalation to 207 ppm 2-nitropropane for six months has indicated a need to reduce worker exposure.

A. Regulated Area. Regulated areas should be established during manufacture, filling operations, use, release, handling or storage.

1. Access. Access should be restricted to employees who have been properly informed of the potential hazard of 2-nitropropane exposure and proper control measures.

2. Engineering Controls. The most effective control of any contaminant is control at the source of generation wherever possible. Effective engineering measures may include the use of walk-in hoods, or specific local exhaust ventilation. Suitable collectors should be used to prevent community air pollution.

   a. Due to the explosive potential of 2-nitropropane spark proof ventilation systems should be selected.

   b. Wherever possible the operations utilizing 2-nitropropane should be enclosed (with appropriate ventilation) to reduce exposures to the operators and others in the area.

3. Respirators. Personal respiratory protective devices should only be used as an interim measure while engineering controls are being installed, for non-routine use and during emergencies. Considering the carcinogenic potential of 2-nitropropane and the current Occupational Safety and Health Administration (OSHA) standard based on other toxicity, the appropriate personal respiratory protective measure is the use of a positive pressure supplied air respirator, or a positive pressure self-contained breathing apparatus.

4. Protective Clothing. Protective full body clothing should be provided and its use required for employees entering the regulated area. Upon exiting from the regulated area, the protective clothing should be left at the point of exit. With the last exit of the day, the protective clothing should be placed in a suitably marked and closed container for disposal or laundering. (Laundry personnel should be made aware of the potential hazard from handling contaminated clothing.)

5. Cleanliness. Employees should be required to wash all exposed areas of the body upon exiting from the regulated area.

6. Isolation. Any operations involving 2-nitropropane should be placed in an isolated area, in combination with other engineering controls, to reduce exposure to employees not directly concerned with the operations.

B. Medical Monitoring. All employees with a potential exposure to 2-nitropropane should be placed under a medical monitoring program including history and medical examinations with specific emphasis on liver function tests.

C. Substitution. The substitution of a solvent that does not contain 2-nitropropane is another possible control measure. Caution should be exercised in selecting a substitute for 2-nitropropane, giving full consideration to the possible toxic effects of the substitute.