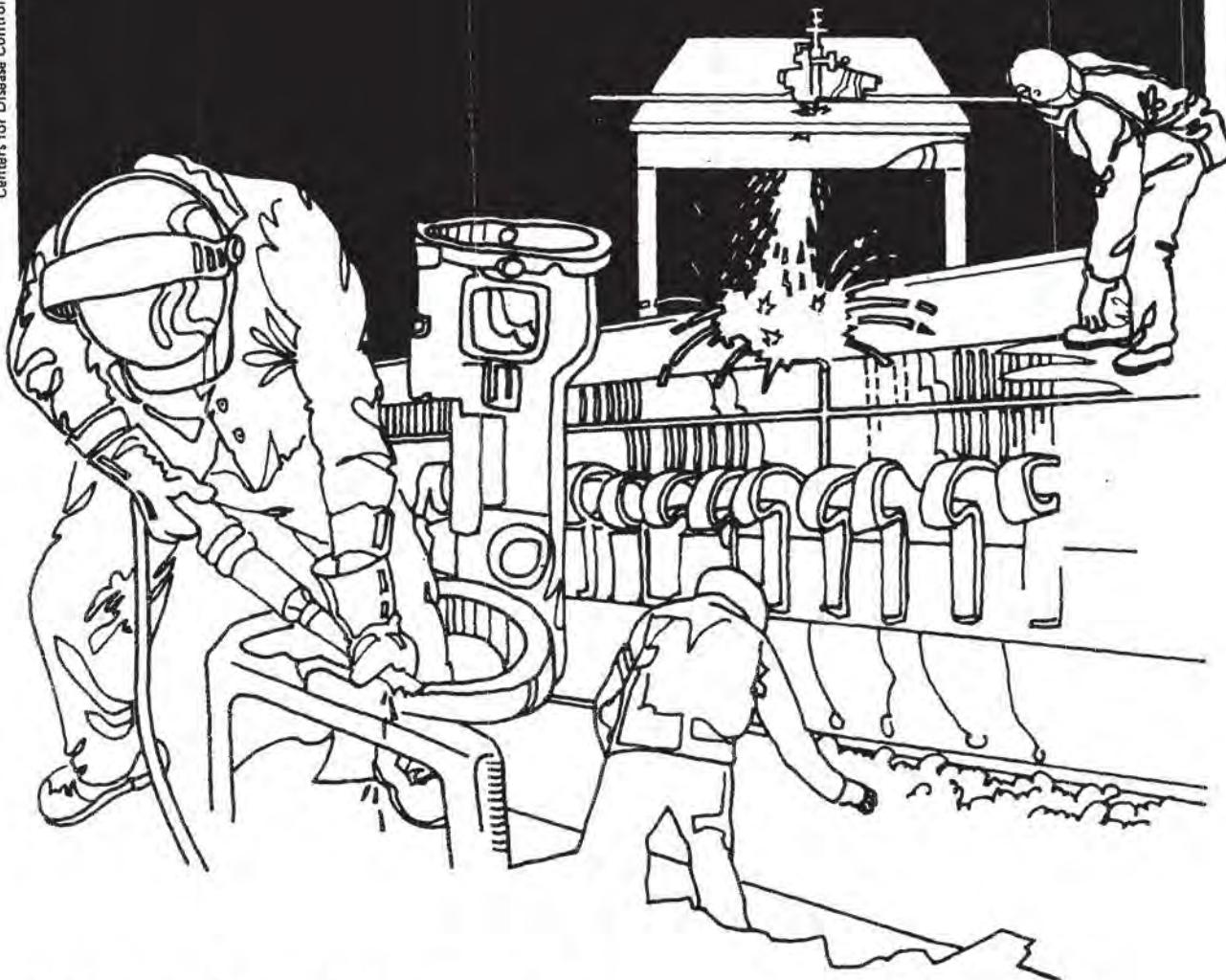


NIOSH



Health Hazard Evaluation Report

HETA 80-106-1065
DANA CORPORATION
RICHMOND, INDIANA

PREFACE

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

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

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 80-106-1065
MARCH 1982
DANA CORPORATION
RICHMOND, INDIANA

NIOSH INVESTIGATOR:
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I. SUMMARY

On August 8, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from Dana Corporation, to assist in the evaluation of their Plastigage® process. Plastigage is a thin strip of elastomer used to gauge the clearance of bearings, etc. The concern was in potential health hazards from exposure to heated process materials including chlorinated naphthalenes, butyl rubbers, and polyethylene. No health complaints were reported by workers. New facility design criteria were sought.

The process was divided in two locations: The Richmond Technical Center mixing process requires one employee for about one day to mix a one-month supply for the Tipton facility production line. All of the Richmond heated process materials are handled in a large exhaust hood. Process temperatures ranged from 100 to 156°C. The Tipton process runs five 8-hour shifts per week with two employees. It has three activities: billet making, extruding, and packaging. The melt pot is kept in a small hood and operated at approximately 150°C. The extruder presses a billet through a die heated to 45°C. Packaging is cutting the product and hand inserting into envelopes. Talc is used to avoid sticking.

The NIOSH field survey on October 23-24, 1980, obtained process emissions samples and bulk samples of the materials used. A sample in the breathing zone of one operator was taken at the Tipton plant. In addition, ventilation controls were evaluated and work practices were observed.

Thermogravimetric analysis of bulk samples revealed onset of decomposition of the product around 140°C with 50% loss at 240°C. The chlorinated naphthalene components demonstrated onset at 132°C and 100% loss at 250°C.

Process air samples showed the presence of the chlorinated naphthalenes; hexane, cyclohexane, C₈-C₁₃ alkenes, and methylcyclopentane in the Richmond hood. Of these only the alkenes were found in the extruder process samples in Tipton, however, trichloroethylene, toluene, and 1,1,1-trichloroethane were also present. The breathing zone sample of the Tipton operator showed 3.0 mg/m³ of total chlorinated naphthalenes. Only the chlorinated naphthalenes approach the recommended exposure control limit which would be a Threshold Limit Value TLV® between 2.0 and 5.0 mg/m³ depending on the trichloro- and tetrachloronaphthalene vapor mixture.

Following the survey, the process was consolidated at the new location in the Tipton facility. They modified the process to eliminate the billet dipping procedure entirely. A lateral exhaust table and temperature limiting devices were installed to control emissions. This process is now scheduled for another move to a different plant.

The airborne exposure levels observed in the workers breathing zone on the day of the survey at Tipton were not hazardous, however, deficiencies in the ventilation system, and repeated hand contact with the product were identified as potentially hazardous at Tipton. The lack of temperature limiters on the heating pots at both facilities was also identified as potentially hazardous. Recommendations to eliminate these potential hazards are found in Section VII of this report.

KEYWORDS: SIC 3592/8911/3070 (Plastigage® manufacture), Chlorinated naphthalenes, Tetrachloronaphthalene, Trichloronaphthalene, Hexane, Cyclohexane, C₈-C₁₃ Alkenes, C₈-C₁₃ Alkanes, Polyisobutylene, Methylcyclopentane

II. INTRODUCTION

On August 8, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from Dana Corporation, to assist in the evaluation of their Plastigage® process. Plastigage is a thin strip of elastomer used to gauge the clearance of bearings, etc. The concern was based on a recent change in process materials and a planned relocation of the process. Primary interest was in potential health hazards from exposure to heated process materials. Management indicated that they had not received any health complaints from workers.

NIOSH conducted an environmental survey on October 23-24, 1980, at two facilities located in Richmond and Tipton Indiana. NIOSH distributed an Interim Report #1 in December 1980 after submittal for trade secret review on November 24, 1980.

III. BACKGROUND

The Plastigage process was divided in two parts: one is mixing the Plastigage material at the Richmond, Indiana Technical Center by one employee; the other is billet making and extrusion at the Tipton, Indiana plant by two employees.

The mixing activity was initiated in Richmond at the same time as the change in the chlorinated naphthalene process materials in July 1980. One employee has handled this process on a once a month basis as needed. The two Tipton production employees had only been on the job for a few weeks. They had been reassigned from other processes due to a major plant cutback.

The Richmond mixing process is infrequent. It requires about one day to mix a one-month supply for the production line. Mixing involves melting a number of components in sequence in an aluminum pot over an electric heat source. The mixture is stirred continuously by an electric motor after the initial melting of the first component. All heated process materials are handled in a large exhaust hood, which was originally used for plasma metal spraying. Each material is added incrementally and is allowed to melt before additional materials are added. Process temperatures ranged from 100 to 156°C. The major materials include chlorinated naphthalenes, butyl rubber, and polyethylene. This process is located in a room that is not normally occupied. The operator monitors the process intermittently throughout the day. The operator wears gloves and safety glasses when adding materials and also wears a half-face organic vapor cartridge respirator when he "pours" the molds.

The Tipton process runs eight hours a day, five days a week. It has three activities: billet making, extruding, and packaging. Billet making involves several steps: the melting of the Plastigage material; the addition of dye, for color coding; and the intermittent repeated

dipping of starter cores in the melt, to form a billet. Thus a billet is formed similar to a candle-making process. The melt pot is kept in a small hood and operated at approximately 150°C. The hot plate is manually adjusted based on the operators judgment of consistency, rather than a thermometer. Billets of three colors are stored in a 40°C oven for use in the extruding activity.

The extruder presses a billet through a die heated to 45°C. The dies are changed to form starter cores or any of the three gauges of Plastigage produced. The extruded product forms a coil below the die. The coil is coated with talc to avoid sticking together.

Packaging includes cutting the product into one-foot lengths. Each strip is hand inserted into an envelope. Workers hands are coated with talc. The two operators work at these three activities together on an incentive credit basis.

The Tipton plant activity is in a large area with a high bay ceiling. There were no other nearby processes, at the time, due to the plant shutdown. There was a plan to colocate the mixing process with the production process in a small room at the Tipton plant. Management was looking for guidance on ventilation and process controls needed for the new location.

IV. EVALUATION DESIGN AND METHODS

A. Design

The manufacturers of component materials were contacted to determine composition and likely decomposition characteristics under specified process conditions. This information was used in the preparation of a sampling protocol.

The NIOSH field survey on October 23-24, 1980, was directed at obtaining process emissions information and bulk samples of the materials used. In addition, ventilation controls were evaluated and work practices were observed.

1. Charcoal Tube Samples

All air samples taken were area or process samples with one exception - a breathing zone sample on a production worker. The samples were collected with DuPont 4000 pumps. Full-term samples were collected at a flow rate of 0.2 liters per minute while the short-term samples and the workers breathing zone sample were collected at 1.0 liters per minute.

2. Detector Tube Measurements

Direct reading detector tube measurements were also taken for carbon monoxide, carbon dioxide, hexane, and ethylene in the

mixing hood, mixing pot headspace, and production line area to aid the laboratory in preparing their analytical procedures. Similar measurements were made in the workers breathing zone.

3. Richmond Measurements

At the Richmond facility, the process air samples were collected on charcoal tubes placed inside the ventilation hood downstream of the heated emission source and in the head space of the melting pot. One downstream sample was taken during the full operation cycle and all other samples were taken sequentially during the phases of meltdown and mixing. The visible emissions were carried directly to the exhaust plenum in a well-defined exhaust stream. These samples were to identify the nature of emissions that must be dealt with in the design of a new facility.

4. Tipton Measurements

At the Tipton facility the process air samples were collected on charcoal tubes placed between the remelting hood and the extruder, over the workbench adjacent to the hood, and below the extruder where the product is discharged and collected. These were intended to identify process emission from the production activity as well as assess the effectiveness of the ventilation controls. The worker who conducted the hot process work for that day wore a charcoal tube sampler in his breathing zone. The other production worker was packaging the product at the bench where our area sampler was running and no personal monitoring was performed.

B. Analytical Method

Bulk samples of the product and the product components were collected for thermogravimetric analysis for weight loss. Analysis was accomplished on a DuPont Model 990 Analyzer equipped with a Model 950 Thermogravimetric Analyzer. Analysis was performed in air flowing at approximately 100 milliliters per minute. The temperature gradient was 20°C per minute.

Two bulk talc samples were analyzed for silica by X-ray diffraction (XRD). They were analyzed qualitatively by scanning 8 through 80 degrees 2θ using copper X-ray radiation. One sample was further analyzed by X-ray fluorescence (XRF) to determine the elements that were present in the sample.

The charcoal tube samples (including the fiberglass component) were desorbed in carbon disulfide and injected into a gas chromatograph equipped with a 10% SP-2100 column and a flame ionization detector (FID). Identities of analytes were confirmed by mass spectrometry.

Total chlorinated naphthalenes were quantitated using the bulk mixture of the component provided. These results should be considered as estimates as recovery tests show that the desorption efficiency for chlorinated naphthalenes on charcoal is less than 60%. Corrections for desorption efficiency were made. The lower limit of detection was 0.05 mg/sample.

The C₈-C₁₃ alkenes/cycloalkanes were quantitated collectively using diisobutylene as standard. These figures should be considered as estimates because the FID response varies for different compounds. The lower limit of detection was 0.05 mg/sample.

Methylcyclopentane, a C₆ cycloalkane, was quantitated using hexane as the standard for quantitation. Again, these figures should be considered approximations. The lower limit of detection was 0.01 mg/sample.

The lower limits of detection for 1,1,1,-trichloroethane and trichloroethylene was 0.05 mg/sample and for toluene was 0.01 mg/sample. The detector tubes lower limits of detection are 5.5 mg/m³ for carbon monoxide, 0.1% by volume for carbon dioxide, 340 mg/m³ for hexane, and 0.58 mg/m³ for ethylene.

V. EVALUATION CRITERIA

Criteria for limiting occupational exposures to toxic chemicals and physical agents considered in the evaluation include: the legal standards of Occupational Safety and Health Administration (OSHA); the National Institute for Occupational Safety and Health (NIOSH) recommended standards; and the American Conference of Governmental Industrial Hygienists Threshold Limit Values®. These criteria are presented for the substances evaluated in this report in Appendix I, along with the primary health effects.

The chlorinated naphthalenes can affect the body if they are inhaled, if they come in contact with the eyes or skin, or if they are swallowed. They may be absorbed through the skin. Exposures may cause an acne-like rash. They may also injure the liver, resulting in such effects as fatigue, dark urine, and yellow jaundice.¹

The American Conference of Governmental Industrial Hygienists has published Threshold Limit Values (TLV)® for tri- and tetra-chloronaphthalene. This criteria represent an 8-hour time weighted average exposure condition under which it is believed that nearly all workers may be repeatedly exposed for five 8-hour days a week for a working lifetime without adverse effect. The trichloronaphthalene has a TLV of 5.0 mg/m³ (milligrams per cubic meter of air). The more highly chlorinated naphthalenes are more toxic, therefore, the tetrachloronaphthalene has a TLV of 2.0 mg/m³.

Exposures to a mixture of these would require a control limit somewhere in between these two levels depending on the proportions of the two in the exposure.² For more detailed discussion of criteria see Appendix 1. The OSHA standard is the same as the TLV.

There is no specific criteria for methylcyclopentane, however, it can be compared with the NIOSH recommended criteria for C₅-C₈ alkanes. This criteria is applicable to a general class of straight- or branched-chain saturated aliphatic hydrocarbons. The alkanes criteria references toxicity data for alkane mixtures including cycloalkane impurities and specifically methylcyclopentane in the 10 to 20% range. The authors note uncertainty about the contribution of these to the results. The Criteria Document expressed concern for benzene contaminants in these mixtures and for the potential for additive effects of mixtures of alkanes. They also note reports of neurological disorders from exposures to mixtures of alkanes. The recommended standard is based on the conclusion that acute intoxication by these alkanes involves a transient central nervous system depression and that chronic intoxication may involve a more persistent effect, polyneuropathy. A TWA concentration of 350 mg/m³ was recommended as the environmental limit.³

The C₈-C₁₃ alkenes/cycloalkanes mixture reported here can be compared to the NIOSH Recommended Criteria for Refined Petroleum Solvents although it does not specifically apply. This criteria is applicable to solvents with a total aromatic content of less than 20%, including petroleum ether, rubber solvent, varnish makers' and painters' naphtha, mineral spirits, Stoddard solvents, and Kerosene. This class of solvents are mixtures with varied boiling ranges and carbon chain length ranges from C₅ at the lower end up to C₁₂ at the upper. The criteria notes the potential for presence of alkanes discussed in the criteria above. It also cautions about the presence of benzene impurities in these mixtures and the potential for additive effects of these components. The recommended TWA control limit is 100 mg/m³ for kerosenes and 350 mg/m³ for the others with a ceiling concentration limit for the latter of 1800 mg/m³ to protect workers from 15-minute short-term exposures that might cause effects, such as vertigo or other adverse reactions, which could result in accidents.⁴

Hexane can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. Short-term overexposure to hexane may cause lightheadedness, giddiness, nausea, and headache. It may also cause irritation of the eyes and nose. Greater exposure may cause death. Long-term exposures have been associated with polyneuropathy.³

NIOSH has recommended that the OSHA permissible exposure limit for hexane be reduced from 1800 to 350 mg/m³ averaged over a work shift for up to 10 hours per day 40 hours per week, with a ceiling level of 1800 mg/m³ averaged over a 15-minute period.³ The 1981 ACGIH TLV's proposes a reduction to 180 mg/m³.

VI. RESULTS AND DISCUSSION

A. Results

1. Analytical

The quantitative analytical results of the process, area, and personal breathing zone air samples are presented in Table 1. The personal breathing zone sample of the Tipton production worker who handled the hot product showed no levels of exposure above the recommended criteria. However the chlorinated naphthalene level of 3.0 mg/m³ is in the range of the TLV.

Qualitative analysis of the Richmond mixing process data showed the presence of hexane, methylcyclopentane, C₈-C₁₃ alkenes, and possibly alkanes. Also dichloro-, trichloro-, and tetrachloronaphthalenes.

Qualitative analysis of the Tipton billet making and extruding process data showed the presence of C₈-C₁₃ alkenes beneath the extruder and 1,1,1-trichloroethane, trichloroethylene, and toluene beneath the extruder and between the extruder and the hood. The area process sample over the packaging bench contained trichloroethylene and toluene.

Direct reading detector tube measurements in the mixing hood, mixing pot headspace, and production line area were taken to aid the laboratory in preparing their analytical procedures. Positive indications for ethylene, n-hexane, and carbon monoxide were reported to the laboratory along with each sample's history of melt temperatures and melting activities. Detector tube measurements in the worker's breathing zone did not detect significant exposure levels.

Two talc materials were available for use as an antisticking powder. The one which had been used in the past and a new one which had been purchased locally when the original supplier stopped producing the old product. Qualitative XRD analysis of the old talc contained two peaks that coincided with the two most intense quartz peaks. The new talc contained one peak that coincided with the most intense quartz peak. In both cases, there is not enough evidence to conclude that quartz is present. If we assume that quartz is present, semi-qualitative results based on the most intense peak indicate that it would be in the 1-2% range.

The New talc sample contained mostly talc with a few minor impurities. The Old talc contained very little talc. The majority of it appeared to be a material other than talc. XRF analysis indicated the presence of high concentration of

silicon, and smaller concentrations of magnesium, iron, calcium, titanium, potassium, and copper. A computerized search/match identification of unknown compounds using the N.I.H. Computer system identified the major diffraction pattern in the Old talc sample as cristobalite. Further work would be necessary to positively identify cristobalite in this sample, but when additional samples of the material were requested it was learned that the supply had been exhausted and as stated previously it is no longer available on the market.

The thermogravimetric analysis results are presented in the following matrix;

THERMOGRAVIMETRIC ANALYSIS DEGREES CENTIGRADE

SUBSTANCE ANALYZED	% DECOMPOSITION		
	Onset	50 %	100 %
CHLORINATEDNAPHTHALENE	132°	216°	250°
POLYISOBUTYLENE	205°	357°	390°
PLASTIGAGE PRODUCT	140°	240°	415°

2. Ventilation

Ventilation measurements and smoke tube observations were made on both hoods. The Richmond plant mixing hood had an average face velocity of about 200 FPM, ranging from 160 FPM to 250 FPM. The total air volume exhausted was about 2000 CFM. Smoke tube observations showed good capture at all points of the hood face. They also showed that airflow was not turbulent. This hood was well positioned at the end of a small high ceiling room with little traffic and the supply air did not create cross drafts at the working face. Exhaust air was cleaned by a water scrubber before discharge. Under these favorable operating conditions, average hood face velocity of 100 FPM would be adequate as long as the flow pattern remained laminar.

The Tipton plant billet forming hood was not performing satisfactorily. It had a variable face velocity averaging less than 50 FPM. The flow was turbulent resulting in poor collection and retention of emissions. A 100 FPM average would be minimum for a good working environment with no cross drafting at the face and limited pedestrian traffic and a nonturbulent airflow. Emissions from billet dip plates, hung to dry on the lower edge of the hood face, were not controlled. This is an unreasonable expectation since hoods are not designed to capture emissions from in front of their face plane. The fan was located directly above the hood with the exhaust duct extending over 30 feet to the exterior wall. The duct was disconnected about 5 feet before the wall. This was apparently due to recent activities involving the removal

of overhead electric cables from this area. It was also noted that there had previously been a second fan at the wall exit point. It was observed that without a filter in place in the hood plenum the fan turbulence caused increased visible emissions from the hood face.

3. Protective Equipment

Production workers were not wearing gloves although management said that they had been made available. The chlorinated naphthalene component of this product is toxic by skin contact.

4. Process Controls

Overheating of process materials is a potential hazard. There were no safety devices to limit the temperatures of heating plates or the die, nor were there any temperature indicating devices in place on either melting process. The production hot plate is normally turned on early each morning to start the melt. The heat is increased by the operator to speed up the melt and then decreased until the dipping results are observed to be acceptable.

5. Employees Interviews

The mixing employee with the longest exposure period of three months had no health complaints. The production line employees were new to the job, two to four weeks. They commented on the unpleasant emissions from the poorly functioning hood, however, no specific health effects were noted.

B. Discussion

The primary objective of this survey was to identify potential environmental contaminants so that the new process could be properly designed to control them. Therefore, the process sample results reflect the presence of materials, however, the concentrations reported are not representative of the workroom environment; nor are they indicative of the amount of exposure to be expected since they are greatly affected by the volumes of air which is interacting with the source of the contaminant. In the case of the hood samples, the large air volume being drawn through would tend to dilute the contaminants; while the confinement of the head space in the mixing pot would tend to concentrate the contaminants.

The bench area sample and the personal breathing zone sample were representative of the exposure environment and an actual work activity exposure. The apparent deficiencies in the hood collection system and the work activities in front of the hood

would be expected to produce the worst case exposure for the remelt/billet-dipping activity in the circumstances present at the time of this survey. The sources of the chlorinated solvents on the Tipton samples were: a prestart-up cleaning of the melting pot and dye with 1,1,1-trichloroethane, and a trichloroethylene degreaser in the next room used in valve guide production. The toluene must also have been associated with the valve guide production, since it is not used in the Plastigage process.

The thermogravimetric results show that decomposition of the components and the materials will occur in the temperature range of the process melt and billet forming. Furthermore it shows extensive losses at slightly higher temperatures. Therefore, the mixing and melting processes must be accomplished with appropriate temperature and ventilation controls. The very efficient exhaust collection at the Richmond mixing facility provided good protection. As was discussed in the closing conference, there is a need for controls in the new facility.

The process was modified following this survey. The billet dipping procedure was eliminated. With the relocation of these activities to the area observed during the survey, formerly a quality control room. A lateral local exhaust ventilation system and heat control devices were installed. The only additional precautions required will be to avoid skin contact and practice good personal hygiene, i.e. no smoking in area, washing hands before eating or smoking, wearing clean work clothing daily, and showering at the end of the day.

VII. RECOMMENDATIONS

The recommendations which were previously stated in the December 1981 Interim Report are as follows:

1. Temperature monitoring and safety cut-off devices should be used on the heating plates and dies.
2. Local exhaust ventilation designs should be consistent with the ACGIH Manual of Practice for "Industrial Ventilation". For example, fans should be located at the exhaust end of the system and hoods should be located away from traffic patterns and cross drafts.⁵
3. The EPA has developed guidelines for performance of laboratory hoods which should be considered. They have found that the ability to adjust airflow in hoods through multiple slots can minimize turbulence effects. Their recommendations were provided to the requestor for his reference, i.e. Excerpts from EPA contract No. 68-01-4661 report dated January 15, 1978, by R.I. Chanberlin and J.E. Leahy.⁶

4. Consider using lateral exhaust over a pouring/drying table to minimize the exhaust air volume required.
5. Replacement air requirements and the effects of high-velocity room air currents on a local exhaust must be considered in the overall design of process ventilation. The choice of having the process area at positive versus negative pressure with respect to the surrounding work areas is an integral part of this design. The ultimate use of the adjacent unoccupied floor area must be considered in this choice. The possible need for filtration of exhaust air to reduce exhaust system maintenance should be considered.
6. Due to the "skin" toxicity from both contact and absorption, associated with the chlorinated naphthalene components of this product, it is prudent to emphasize good personal hygiene practices and to encourage the use of gloves or finger cots when handling this material on a continuous daily basis.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health (NIOSH)/Occupational Safety and Health Administration (OSHA). Occupational Health Guidelines for Chemical Hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health (NIOSH)/Occupational Safety and Health Administration (OSHA), 1981. (DHHS (NIOSH) Publication No. 81-123).
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6. Chamberlin, R.I. and Leahy J.E. Laboratory Fume Hood Standards, Recommended for the U.S. Environmental Protection Agency (Contract No. 687-01-4661). M.I.T. Cambridge, Massachusetts: 1978.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technical Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Manager Process Development, Dana Corporation
 2. NIOSH, Region V
 3. OSHA, Region V

For the purpose of informing the 3 affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

RESULTS OF AIR SAMPLES FOR HEXANE, METHYL CYCLOPENTANE,
CYCLOHEXANE, C₈-C₁₃ ALKENES, CHLORINATED NAPHTHALENES,
1,1,1-TRICHLOROETHANE, TRICHLOROETHYLENE, AND TOLUENE

DANA CORPORATION
RICHMOND/TIPTON, INDIANA
HETA 80-106

OCTOBER 23-24, 1980

LOC. #	JOB CLASSIFICATION	SAMPLE DATE	PERIOD START STOP	TIME (min)	RATE (lpm)	VOL. (l)	HEXANE mg/m ³	M-C-PENT mg/m ³	C-HEXANE mg/m ³	ALKENES mg/m ³	C1 Naphth mg/m ³	1,1,1,TC mg/m ³	TCE mg/m ³	TOLUENE mg/m ³	SAMPLE NOTES
R	MELT DOWN HOOD	10/23	8:50a.m. 10:00a.m.	70	1.0	70.0	< 0.14	< 0.14	< 0.14	< 0.71	0.71	< 0.71	< 0.71	< 0.14	
R	MELT DOWN HOOD	10/23	8:50a.m. 6:42p.m.	592	0.2	118.4	0.90	0.84	0.24	< 0.42	3.8	< 0.42	< 0.42	< 0.08	
R	MELT DOWN HOOD	10/23	10:00a.m. 11:39a.m.	99	1.0	99.0	< 0.10	< 0.10	< 0.10	< 0.51	0.51	< 0.51	< 0.51	< 0.10	
R	MELT DOWN HOOD	10/23	11:39a.m. 4:55p.m.	316	1.0	316.0	0.37	1.3	1.0	< 0.16	5.8	< 0.16	< 0.16	< 0.03	
R	MELT DOWN HOOD	10/23	4:55p.m. 6:42p.m.	107	1.0	107.0	0.18	< 0.09	< 0.09	< 0.47	0.47	< 0.47	< 0.47	< 0.09	
R	POT HEAD SPACE	10/23	3:20p.m. 4:45p.m.	85	1.0	85.0	34.	30.	8.1	8.8	82.	< 0.59	< 0.59	< 0.12	(1f)
R	POT HEAD SPACE	10/23	3:20p.m. 4:45p.m.	85	1.0	85.0	0.44	1.08	< 0.59	< 0.59	0.59	< 0.59	< 0.59	< 0.12	(1r)
R	POT HEAD SPACE	10/23	4:50p.m. 5:45p.m.	55	1.0	55.0	70.	33.	7.9	71.	10.	< 0.91	< 0.91	< 0.18	(2f)(a)
R	POT HEAD SPACE	10/23	4:50p.m. 5:45p.m.	55	1.0	55.0	43.	9.6	< 0.91	< 0.91	0.91	< 0.91	< 0.91	< 0.18	(2r)(a)
T	BETW HOOD&EXTRU	10/24	10:10a.m. 3:25p.m.	315	0.2	63.0	< 0.16	< 0.16	< 0.16	< 0.79	0.79	< 0.79	2.4	0.51	
T	OVER WORK BENCH	10/24	10:30a.m. 3:25p.m.	295	0.2	59.0	< 0.17	< 0.17	< 0.17	< 0.85	0.85	< 0.85	2.3	0.29	
T	WORKERS PBZ	10/24	10:10a.m. 3:20p.m.	310	1.0	310.0	0.06	< 0.03	< 0.03	0.78	3.0	0.43	2.9	0.59	
T	BELOW EXTRUDER	10/24	1:45p.m. 3:25p.m.	100	1.0	100.0	< 0.10	< 0.10	< 0.10	0.99	0.50	< 0.50	3.5	1.4	
LIMITS OF DETECTION: (units per sample)							0.01 mg/spl	0.01 mg/spl	0.01 mg/spl	0.05 mg/spl	0.05b mg/spl	0.05 mg/spl	0.05 mg/spl	0.01 mg/spl	

NOTES:

- < LESS THAN-These samples were below the detection limit and therefore the airborne concentration, if any, would be less than the value shown.
- a The sample tube was plugged with wax. These results reflect minimum possible concentrations if unrestricted flow for the full sample period.
- b This analysis was referenced to a mixture of tetra- and tri-chloronaphthalene bulk sample. The TLV's are 2.0 mg/m³ and 5.0 mg/m³ and the STEL's are 4.0 and 10.0 mg/m³ respectively. The manufacturers did not provide the relative amounts of each substance therefore the applicable criteria can only be stated to be between these two. The OSHA-PEL's are the same as the TLV's.
- f This is the front half of the sample tube analyzed separately. Add results to the back half for total sample results.
- r This is the back half of the sample tube analyzed separately. Add these results to the front half for total sample results.
- C1 NAPTH CHLORINATED NAPHTHALENE MIXTURE
- 1,1,1-TC 1,1,1,-TRICHLOROETHANE
- TCE TRICHLOROETHYLENE
- M-C-PENT METHYL CYCLOPENTANE, a C₆ Cycloalkane, was quantitated using hexane as the standard for quantitation. Again, these figures should be considered approximations.
- C-HEXANE CYCLOHEXANE
- ALKENES A MIXTURE. The C₈-C₁₃ alkenes/cycloalkanes were quantitated collectively using diisobutylene as standard. These figures should be considered as estimates because the FID response varies for different compounds.
- R The sampling location was in the Richmond plant.
- T The sampling location was in the Tipton plant.
- mg Milligram (1 mg = 0.001 grams)
- m³ Cubic Meter (In reference to concentration per cubic meter of air.)

APPENDIX 1
EXPOSURE CRITERIA AND HEALTH EFFECTS
HETA 80-106

DANA CORP.
RICHMOND, INDIANA
JANUARY 1982

This appendix is a brief overview of the principles and practices used by Industrial Hygienists and other qualified Occupational Health Professionals in applying exposure criteria. For a full understanding of any criteria, it is necessary to refer to the documentation used in making the criteria recommendation.

There are thousands of chemical and physical hazards in the workplace for which there are little or no information upon which to base a health effects exposure limit. There are a few hundred that have been sufficiently documented to be published by one or more professional groups or government agencies. Two of the most widely recognized are the American Conference of Governmental Industrial Hygienists list of Threshold Limit Values (TLVs®) and the National Institute for Occupational Safety and Health (NIOSH) Recommended Standards for Occupational Exposure. The Occupational Safety and Health Administration has promulgated a number of Permissible Exposure Limits (PELs) which, for the most part, were adopted from the 1968 TLV professional guides and are now standards. When available, all three of the above have been provided in these tables. The particular guide of choice depends on its intended use and limitations.

There are several general statements that can be made regarding the origin, limitations, and application of most of the exposure limit criteria:

Exposure criteria for chemical contaminants are given in units of airborne concentrations which is primarily related to toxic inhalation hazards. However, they may also be annotated as toxic by entry through the skin. This annotation warns of the need for precautions to avoid skin absorption which would invalidate the airborne exposure limit. Similarly in general there is a need to ensure that toxic exposures through ingestion are controlled by good personal hygiene, food handling, and contamination control.

These criteria are based on the best available information from industrial experience, from experimental human and animal studies, and when possible from a combination of all three. The basis on which the values are established may differ from substance to substance; protection against immediate impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress which could result in health effects may form the basis for others.

The amount and nature of the information available varies from substance to substance. Consequently, the precision of the estimated criteria is also subject to variation and the latest documentation should be consulted in order to assess the extent of the data available for a given substance.

The criteria represent exposure conditions under which it is believed that nearly all workers may be repeatedly exposed for five eight hour days a week for a working lifetime without adverse effect. Because of a wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the exposure limit; a smaller percentage may be effected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. In spite of the fact that serious injury is not believed likely as a result of exposures to the exposure limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

These criteria are for single-substance exposures and specified work schedules. Exposures to a combination of chemicals under a variety of physical conditions and work schedules requires adjustment of these criteria based on sound knowledge and professional judgment. This adjustment is more difficult when some of the exposures are to chemicals of unknown or poorly documented toxicity. These uncertainties add to the need to minimize exposure to atmospheric contaminants.

Threshold Limit Values for mixtures are addressed by the ACGIH as follows; "When two or more hazardous substances are present, their combined effect rather than that of either individually, would be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should be considered as additive..." It is also possible to have other effects from combined exposures such as synergistic action or potentiation. A synergistic effect is a combined toxicity greater than that expected from the two single toxicities added together. A potentiation effect is one which increases the toxic effect of a toxic hazard; potentiative and synergistic agents are not necessarily harmful by themselves. Potentiation effects are often caused by exposures other than inhalation, e.g. imbibed alcohol and inhaled narcotic (trichloroethylene).

Carcinogens, teratogens, and mutagens must be treated cautiously since unlike other toxicants the effect is a potentially serious disease irrespective of the exposure which caused it. However, the exposure level does appear to have a direct relationship on the likelihood of having these effects. Therefore to minimize the risk, it is prudent to minimize the exposure.

There are three categories of airborne exposure limits: the Time Weighted Average (TWA), the Short-Term Exposure Limit (STEL), and the Ceiling Limit (C).

The TWA is a calculated average exposure level for a specified period, typically eight to ten hours per day and fourty hours per week. TWA's

permit exposures above the limit provided they are compensated by equivalent excursions below the limit during the work period. There is a limit to the excursions that are permissible above the listed values. This limit is based on guidelines which take into account such factors as acute toxicity at higher concentrations, whether the effects are cumulative, the frequency of occurrence of peaks and their duration. All factors must be considered in making a judgment as to whether a hazardous condition exists.

The STEL is the maximal concentration to which a worker can be exposed for a period up to 15 minutes without suffering from 1) irritation, 2) chronic or irreversible tissue change, 3) narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least sixty minutes between exposure periods, and provided that the TWA-TLV is also not exceeded. The STEL should not be used as a design criteria.

The Ceiling Limit (C) is the concentration that should not be exceeded even instantaneously. The STEL is also to be considered a ceiling limit.

OSHA's Accepted Maximal Peak above the eight hour TWA specifies the applicable maximum duration for each substance so treated.

NIOSH Ceiling limits specify the short-term sampling period required for commonly available monitoring methods to detect the ceiling limit. This does not represent acceptance of a TWA excursion above the ceiling/peak exposure limit.

When referring to the following tables of criteria and effects, it is necessary to keep the principles and practices discussed above in mind. To interpret or apply these numbers to any particular set of environmental conditions, the advice and council of a qualified occupational health professional is necessary.

TABLE 1 OF APPENDIX 1

ENVIRONMENTAL CRITERIA AND PRINCIPAL HEALTH EFFECTS FOR AIRBORNE CONTAMINANTS
 [Please note: this table is not to be duplicated without Appendix 1 text.]

JANUARY 1982

UNITS ARE GIVEN IN BOTH: PARTS PER MILLION PARTS OF AIR BY VOLUME (ppm) / AND THE EQUIVALENT / MILLIGRAMS PER CUBIC METER OF AIR (mg/m³)

COMPOUNDS AND (SYNOMYS)	ACGIH (TLV)		OSHA (PEL)		NIOSH		PRINCIPAL HEALTH EFFECTS		NOTES
	TWA [ppm] mg/m ³	STEL [ppm] mg/m ³	TWA [ppm] mg/m ³	CEILING [ppm] mg/m ³	PEAK [ppm] mg/m ³	TWA [ppm] mg/m ³	CEILING [ppm] mg/m ³	TARGET ORGANS AND [REFERENCES]	
Cyclohexane (SYN:Benzene tetrahydride)	[300.0] 1050.0	[375.0] 1300.0	[300.0] 1050.0	----	----	----	----	Irritation of skin, eyes, and respiratory sys. also causes drowsiness	
n-Hexane (SYN:Hexyl hydride)	# [50.0] # 180.0	----	[500.0] 1,800.0	----	----	[100.0] 360.0	*[510.0] * 1,800	POLYNEUROPATHY-[NIOSH CRITERIA ALKANES] Lt.head ,giddy,nausea,headache, irr; eyes,nose, skin.	*15'
Tetra-chloronaphthalene (SYN: Halowax;See Kay wax)	----	2.0	4.0	*2.0	----	----	----	Skin and Liver injury. Acne-form dermatitis and jaundice,headache,dizzy,fatigue, and anorexia.	*SKIN
Tri-chloronaphthalene (SYN: Halowax;See Kay wax)	----	*5.0	10.0	*5.0	----	----	----	Skin and Liver injury. Acne-form dermatitis and jaundice,,headache,dizzy,fatigue, and anorexia.	*SKIN
1,1,1-Trichloroethane (SYN: Methyl chloroform)	350.0 1900.0	450.0 2450.0	350.0 1900.0	----	----	----	* 350.00 1900.0	Dermititis, Central nervous system depression, cardiovascular arrhythmia.	*15'
Trichloroethylene (SYN:Ethylene trichloride)	[#50.0] #270.0	[#150.0] #805.0	[100.0] 540.0	[200.0] 1080.0	[*300.0] *1620.0	[25.0] 135.0	[**100.0] **540.0	Potential Carcinogen-[NIOSH HAZARD REVIEW] Resp.Sys., heart, liver, kidneys, Ctl.Nerv.Sys.	**10' *5'/ 2 hrs
Toluene (Toluol) (SYN: Methyl benzene)	*[100.0] 375.0	[150.0] 560.0	[200.0] 750.0	[300.0] 1120.0	**[500.0] 1870.0	[100.0] 375.0	[200.0] ** 750.0	Effects central nervous system,liver, kidneys, &skin.Headache,euphoria,dizziness,insomnia,weak	*SKIN **10'

NOTES:

- (*, **) see notes in right column for each entry.
- # indicates that the following value is a proposed revision to the TLVs.
- C Designates a ceiling value not to be exceeded at any time.
- ACGIH American Conference of Governmental Industrial Hygienists.
- TLV® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes.
- STEL Short Term Exposure Limit - the maximal concentration to which workers can be exposed for a period up to 15 minutes continuously, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposures.
- TWA For ACGIH AND OSHA - The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- For NIOSH- The time weighted average concentration for a normal work period up to 10 hours per day and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- CEILING For ACGIH - The concentration that should not be exceeded even instantaneously.
- For OSHA - The permissible ceiling for an 8-hour day.
- PEAK For NIOSH - The concentration that should not be exceeded at any time and that should be measured over a specified short term sampling period.
- OSHA acceptable maximum peak above the ceiling for a specified maximum duration.

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