U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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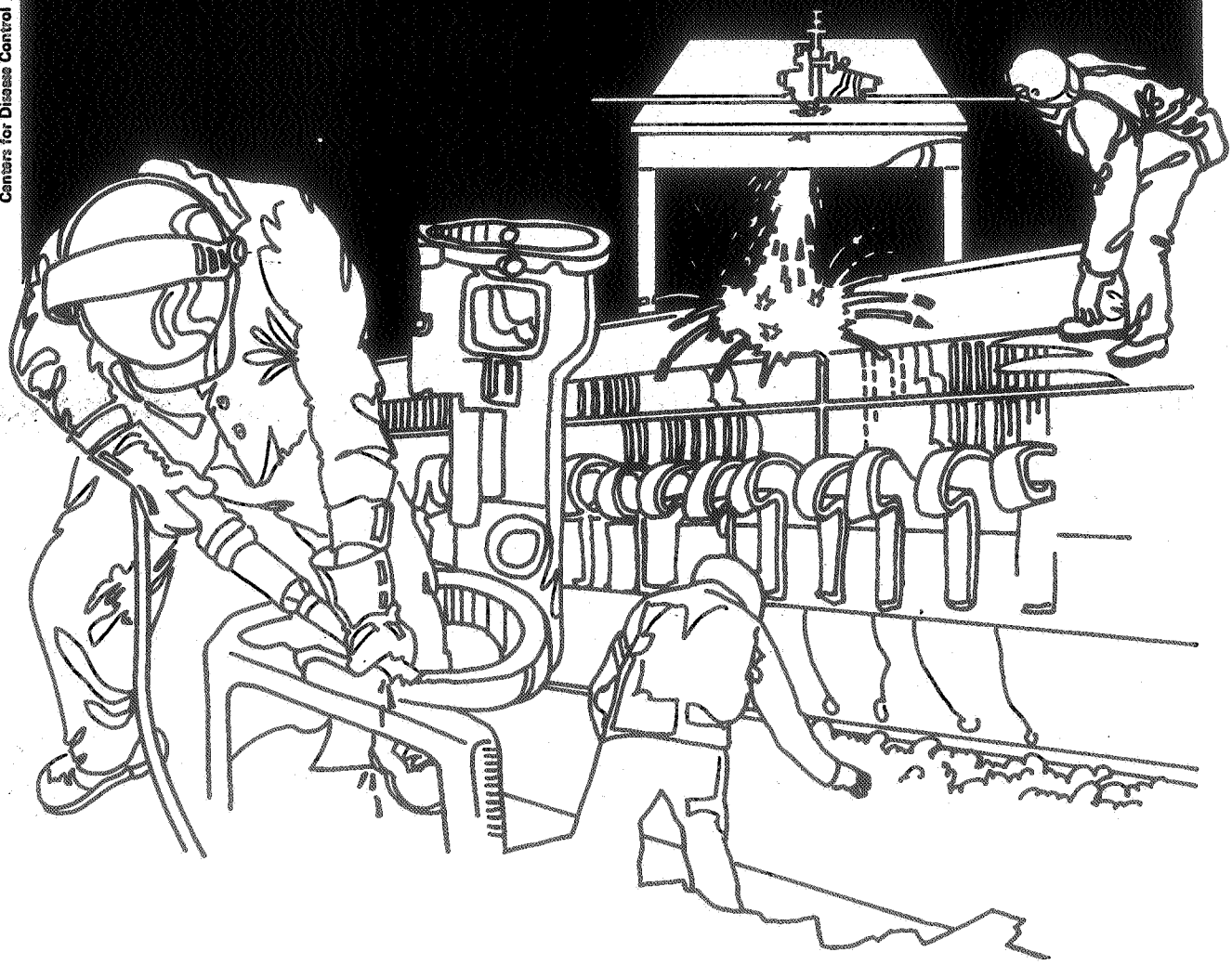
NIOSH



Health Hazard Evaluation Report

HETA 83-417-1357
U.S. ENVIRONMENTAL PROTECTION AGENCY
TRIANGLE CHEMICAL SITE
BRIDGE CITY, TEXAS

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.

HETA 83-417-1357
AUGUST 1983
U.S. ENVIRONMENTAL PROTECTION AGENCY
TRIANGLE CHEMICAL SITE
BRIDGE CITY, TEXAS

NIOSH INVESTIGATORS:
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1. SUMMARY

In July 1982, the National Institute for Occupational Safety and Health (NIOSH) was requested by the U.S. Environmental Protection Agency (as part of an Interagency Agreement) to evaluate the health and safety conditions for EPA employees and EPA contract employees at the Triangle Chemical site in Bridge City, Texas.

On August 18-20, 1982, NIOSH investigators collected 24 air samples which were analyzed on site and made 20 direct reading indicator measurements. 84 additional air samples were collected and more than 170 analyses were completed. Volatile organic vapors were detected in nearly all of the samples, but at very low concentrations (toluene in 22 of 24 samples at a mean concentration of 476 ug/M^3; xylene in 3 of the six samples at a mean concentration of 215 ug/M^3; and hydrocarbons, other than toluene and xylene, in 19 of 24 samples at a mean concentration of 605 ug/M^3). The highest concentration of a single substance measured was 12.7 mg/M^3 of acetone in the laboratory trailer. The NIOSH recommended criteria and OSHA regulatory standard for these materials are 375,000 and 750,000 for toluene, and 435,000 ug/M^3 for xylene. There were no detectable airborne nitrosamines, particulate glycols, or aliphatic amines at this site. Chloride anions, detected in 4 of 8 samples; nitrate ion, detected in one of eight samples; and sulfate ions detected in 3 of 8 samples suggest low level exposures to the corresponding acids which were being handled on the site. Samples analyzed in the laboratory confirmed the "real time" analyses completed on-site by NIOSH chemists during the survey.

Cascade impactor data showed that only a small fraction of the airborne dust at this site, less than 10 microns in diameter, was respirable. The mean aerodynamic mass median diameter of the airborne particles was 14 microns. The mean concentration of respirable dust was 1.6 mg/M^3.

Exposure to chemicals were highest in the areas of active materials handling. The incidence of exposure to organic vapors and acid anions was greatest in the samples collected immediately adjacent to the bulking operations (60% positive samples) and the samples collected adjacent to the barrel crushing operation (100% positive results). Personnel directly involved with active materials handling (Barrel Samplers, Chemists, and the Barrel Grabber Operator) were exposed to airborne chemicals more frequently than other personnel.

To evaluate the potential for heat stress, the WBGT measured between 10 AM and 2 PM averaged 87.8°F on August 18th and 86.2°F on August 19th. These temperatures would indicate that normally clothed, heat-conditioned workers use either a 30 min-30 min work rest regimen for control of occupationally induced heat stress (Barrel Samplers) or a 45 min-15 minute regimen (Heavy Equipment Operators). There was no formal work rest regimen on the site; additionally workers wore impervious clothing (for chemical splash protection) which impaired normal body cooling mechanisms to combat heat stress.

Based on the environmental assessments of this investigation, NIOSH noted that control of heat stress was inadequate. No overexposures to airborne chemicals were measured. However, workers are potentially exposed to hazardous chemicals by accidental spills, splashing, and rupturing of chemical containers. The laboratory trailer lacked ventilation appropriate for handling unidentified hazardous substances. Newly developed air sampling methods applicable to hazardous waste sites and other recommendations are detailed on Pages 6-7.

KEYWORDS: SIC 9511 (Air and Water Resources and Solid Waste Management) and SIC 4783 (Packing Goods for Shipping), Hazardous Waste Sites, Heat Stress, Respiratory Protection, Air Sampling.

II. BACKGROUND

Under Interagency Agreement 82-40 with the U.S. Environmental Protection Agency (EPA), the National Institute for Occupational Safety and Health (NIOSH) conducted air monitoring to measure occupational chemical exposures during a removal action at the former site of Triangle Chemical Company in Bridge City, Texas between August 17 and August 20, 1982.

The facility, which was in bankruptcy, had been used for the production of antifreeze, windshield washer solvent, industrial cleaning compounds, hand cleaners, and brake fluids from 1970 to 1981. The site occupied 4.5 acres. The former administration building, warehouse, and storage facilities were located immediately off State Highway 62. Behind the administration and warehouse buildings the land inclined sharply downward and sloped into Coon Bayou (Figure 1). EPA documents indicated that a fish kill attributed to chemicals from the Triangle Site had occurred in the vicinity of Coon Bayou and Hoo Hoo Road (about one mile west of the site) in 1981.

During the survey about 950 drums, of which 250 were empty, were opened, sampled, labeled for compatibility and their contents transferred in solid or liquid bulk carriers. The primary worker job categories included: Barrel samplers, Chemists, and Heavy Equipment Operators. The empty barrels were crushed and removed from the site. There was no opportunity, during this study, to measure occupational exposures resulting from operations such as sampling 26 bulk storage tanks or removing contaminated soil.

This report will discuss the sampling results obtained during the week of August 17th. A previous report, which contained the Superfund Site Occupational Safety and Health Program Evaluation: Triangle Chemical Company Site, Bridge City, Texas; was forwarded to interested parties in October 1982.

III. METHODS

The documents furnished for planning this survey included:

1. The Procurement Request Rationale[1]
2. The Estimated Time Required for Removal of Hazardous Waste at the site[2]
3. A diagram of the Triangle Chemical/Redbird Chemical Site
4. A Location Map of the Surrounding Area
5. The Draft Contract for the Planned Removal Action
6. The Personal Protection Level Determination
7. The Draft Function Description for OSC Staff
8. The Site Safety Protocol
9. The Community Relations Plan

None of these documents contained the actual sampling data sheets, the laboratory reports of the results of on-site sampling, or a description of

the sampling conditions. The Procurement Request Rationale listed the chemicals that had been identified on site by the Texas Department of Water Resources.[1]

Ammonium hydroxide	Methylethylketone
Butanol	Nitric acid
Caustic (pH12)	p-Decyl-phenol
Dichlorobenzene	p-Nonyl-phenol
Diethanolamine	Phosphoric acid
Ethanol	Polypropylene
Glycol	Rust tem 200
Hydrochloric acid	Surfactant (pH 1)
Hydrofluoric acid	Toluene
Methanol	Trichloroethane
Methylethlamine	Xylenes

The estimate of the volume of hazardous waste at the site is given in Table 1.[2] Based on the information furnished, the percentage of the materials present is given in Table 2

The NIOSH air sampling scheme was developed after considering the available information. The industrial processes formally conducted on this site eliminated consideration of heavy metal, pesticides, PNA, and PCB contamination. Volatile solvents, acids (acid anions), alcohols, amines, and their possible reaction products, such as the nitrosamines were selected for evaluation. The sampling media, sample flow rates, and methods of analysis chosen are detailed in Appendix I.

There were four additional kinds of samples utilized.

(1) Particle size was measured with midget cascade impactors to determine the size distribution of the fugitative dusts originating from this site.

(2) The SDRITS (Simultaneous Direct Reading Indicator Tube System), a device that allows the simultaneous utilization of 10 direct reading indicator tubes was used to screen for unanticipated vaporous contaminants.

(3) Swipe samples were collected on the boots and gloves of personnel who had passed through the decomtamination line. These measured the effectiveness of the decontamination procedures.

(4) Nine or more heat stress measurement were made on-site August 18 and 19th. The monitoring equipment was located on an area of exposed soil typical of the site.

The eight man NIOSH field team was based in a 40 foot trailer. On-site sample analysis yielding qualitative contaminant information, quantitative

"range finding" information, and rapid feedback to responsible site safety personnel were performed. The available equipment included a gas chromatograph with flame ionization detectors (Shimadzu), an ion chromatograph with anion columns (Dionex Model 14), and a portable X-ray fluorescence device (Columbia Scientific Industries). The first two devices were selected based on the presence of significant quantities of volatile organic materials and acids at the site. The latter instrument was available on a stand-by basis to identify exposures to toxic metals if indicated.

Personal air samples were collected by attaching a battery operated air pump to the belt of the worker and positioning the collection medium in the breathing zone, roughly between the nose and the chin. Samples were also collected at fixed locations representative of the primary work station, such as the cab of heavy equipment. This technique allows the use of multiple pumps and sampling media to characterize exposure.

A number of spot tests for acids and bases (pH), Chloride/HCl (Silver nitrate), Fluoride/HF (Quinalizarin), Methyl ethyl ketone (nitroprusside), nitrate/HNO_3 (ferrous sulfate), phenol (antipyrene), and sulfide/H_2S (lead acetate) were also available.

IV. EVALUATION CRITERIA

There is very little air sampling information documenting occupational exposures during the cleanup of hazardous waste sites. The available literature suggests that the reported chemical injuries experienced by operators engaged in land disposal of hazardous chemicals tend to be acute. Keen and Mumford[3] list sudden dumping of toxic substances, entry into confined space (such as large tanks), and firefighting as the predominant chemical hazards at toxic waste landfills. The same authors were not able to demonstrate occupational overexposure to asbestos[4]. In another article, Lazar[5] describes a fatality caused by an explosion at an industrial landfill and another case of permanently disabling lung damage subsequent to inhaling a nematocide released from an improperly disposed pressurized container. Work at Chemical Control site during cleanup operations,[6,7] suggests that inhalation exposures at hazardous waste sites tend to be low. While air contaminant measurements at the Picillo Farm[8] are somewhat higher, they are not directly applicable to the Bridge City Site, since the Picillo cleanup involved removal of buried drummed materials and considerable operations below grade.

The NIOSH and ACGIH recommended standards as well as the OSHA standards for the specific chemical substances monitoried at the Bridge City Site are given in Appendix II. The criteria for assessment of heat stress are set forth in Appendices III and IV.

V. RESULTS

A. Field Sample Anaylses

The twelve wipe samples from the boots and gloves were extracted and analyzed on site for acid anions. These samples were collected to test the effectiveness of the decontamination procedures. Since results did not differ from the blanks, it was apparent that either there were no acid substances on the protective clothing or that the decontamination was effective at least as far as acids were concerned.

Twelve prewashed silica gel tubes were analyzed on site for HF, HCL, HNO_3, and H_3PO_4. There were no readings above blank levels indicating that the concentrations of these acids in air were less than 0.01 mg/M^3. The measured concentrations were well below the OSHA standards and NIOSH recommended standards for these substances.

The Simultaneous Direct Reading Indicator Tube System (SDRITS), was employed when a barrel, designated only as "Junk", was observed to be fuming when it was opened and its contents exposed to the ambient air (approximately 95°F, 80% RH). When the bung was closed, pressure inside the barrel increased. The SDRITS was operated while it was sitting on top of the opened barrel, with the results shown in Table 3. The vapors coming from the barrel were simultaneously sampled in 10 mL of distilled water in a bubbler; subsequent laboratory analysis by gas chromatography identified triethylamine in the sample. The color changes observed in the detector tubes were consistent with the presence of a high concentration of hydrazine and/or amines; the hydrazine detector tube changed from yellow to deep blue immediately, while only weak reactions, mainly in the precleanse layers, were seen in other detector tubes. This information was sufficient to suggest the need for laboratory testing of the barrel contents and the need for special precautionary procedures in handling this barrel.[9]

B. Off Site Laboratory Anaylses

The results of analyses performed in off-site laboratories are reported in Tables 4-10. All measured exposures were well below the Occupational Safety and Health Standards and the NIOSH Criteria for Recommended Standards. Volatile organic vapors were detected in nearly all of the samples (toluene in 22 of 24 samples at a mean concentration of 476 ug/M^3, xylene in 3 of 6 samples at a mean concentration of 215 ug/M^3, and hydrocarbons other than toluene and xylene in 19 of 24 samples at a mean concentration of 605 ug/M^3 (Table 5). Despite the presence of these materials in pre-cleanup samples, there were no detectable airborne particulate glycols or aliphatic amines at this site (Tables 6-8). Chloride anions were detected in 4 of 8 samples, nitrate in one of eight and sulfate ions in 3 of 8 samples (Table 9). One sample contained a small amount of a material with the same chromatographic retention time as fluoride.

While not exceeding evaluation criteria, the highest levels of contaminants were found in air samples collected in the contractor laboratory trailer. This appears to the be result of sample spillage, generally poor housekeeping, and a recirculating kitchen fan used for ventilation in the chemical handling area. Guidelines for laboratories handling hazardous materials have been developed by a number of agencies.[10,11]

The mean aerodynamic mass median diameter of the airborne particles collected at this site was 14 microns and the geometric standard deviation was 2 (Table 10). Using the plot, on log probability paper, of a distribution with a geometric mean of 14 and a geometric standard deviation of 2 it was estimated that only about 20% of the airborne dust particles were respirable, that is, between 1 and 10 microns in size, at this site.

C. Heat Stress

Estimates of the work rate of the Barrel Samplers and Heavy Equipment Operators were made based on observed work practices (Table 11). While heat stress for workers in garments relatively impermeable to sweat, such as the coated Tyvek materials used at this site, cannot be adequately assessed by environmental measurements such as the WBGT, access to workers engaged in vigorous (non-supervisory) activities was restricted so no physiologic measurements could be made. The mean WBGT measurement between 10 AM and 2 PM was 87.8°F on August 18th and 86.2°F on August 19th (Table 12). Interpretation of the Heat Stress Criteria FOR NORMALLY CLOTHED WORKERS (Appendix IV) would indicate the use of a 30 min-30 min work rest regimen for Barrel Samplers on both August 18th and 19th. The same data would indicate a 45 min-15 minute regimen for Heavy Equipment Operators on August 18th and a continuous work regimen on August 19th. However, because of the use of protective clothing that inhibits free evaporation of sweat, the optimum work/rest regimen should be revised downward, that is to more stringent (less work and more rest) regimens.

VI. DISCUSSION AND CONCLUSIONS

1. Exposure patterns were highest in the areas of active materials handling. The incidence of all substances measured is given by location in Table 14. However, nitrosamines, ethylene glycols, and aromatic amines were not detected in any sample and are neglected in the following discussion. The pattern of incidence for substances for which there were positive analytical determinations can be derived from Table 14. The Area South samples, collected immediately adjacent to the bulking operations, have 60% positive samples, 12 positive determinations among 20 samples. The Area West samples, collected adjacent to the barrel crushing operation, have 100% positive results, 4 positive determinations among 4 samples. The incidence of the same substances in the relatively inactive areas of the site (the North and East Areas) is only 20%. Personnel directly involved with active materials handling (Barrel Samplers, Chemists, and the Barrel Grabber

Operator) were exposed to airborne chemicals more frequently than other personnel. The amount of data available from this study is insufficient for more extensive statistical analysis.

2. The utility and field ruggedness of the analytical instrumentation (gas and ion chromatographs and the X-ray fluoresence device) was demonstrated when the devices arrived in operational condition aboard the field study trailer. About one day was required to set up and prepare these devices in the field.

   The on-site availability of analytical instruments on site allowed health and safety personnel to make a rapid determination that workers were not being exposed to hazardous levels of contaminants.

3. The three major analytical instruments (IC, GC, and XRF) were chosen for this site based on the results of previous field samples. This appears to be a practical procedure.

4. The experience of this study suggests that the SDRITS sampler is a handy prescreening device for use in selecting the best method of field analysis, since the SDRITS enables field personnel to complete the 10 tube screening protocol suggested by Schneider[12] (Table 13) within eight minutes. Schneider's protocol was developed to detect the type and extent of unconfined dangerous chemicals or their reaction by-products, due to interaction with water, each other, or fire and is sufficiently sensitive to avoid acutely dangerous conditions. The "identification" is limited to definition of various substance groups, such as acid reacting substances, amines, and alcohols. An United Nations Identification Number is listed for each group of substances identified by the screening procedure. This information can be used to enter various emergency response schemes.[13,14] Substances not included in the Draeger scheme (such as hydrogen cyanide and hydrogen sulfide) can also be rapidly detected, either by deployment of a second sampling device or by serial screenings using a single device.

   A single test employing 10 detector tubes test generally can be completed within eight minutes. The short sampling time makes this device applicable to fire and hazardous material spill conditions where minimal operator exposure to dangerous conditions is desirable. Since the operator can watch the detector tubes as the sampling progresses, the device functions as a "real time" hazardous condition indicator. The rapidity of detection of hazardous conditions at the sampling point is limited only by the rate of color development in the detector tubes and the sequence of detector tubes utilized. For a single operator, the sampling time required is reduced by about a factor of 10, when compared to the sampling time required to make a similar number of measurements with a hand operated pump accommodating a single detector tube. The device is operated easily while wearing protective clothing and has been used successfully in a hazardous waste environment while wearing double

gloves, splash suits, and self-contained breathing apparatus (Figure 2). The utility of the SDRITS as a prescreening tool for field chromotagraphs was also demonstrated.

5. The utility of a trailer to serve as a mobile operational base at "unimproved sites" was clearly demonstrated. At this site there was no space available to house, assemble, or prepare industrial hygiene equipment for field use other than the NIOSH trailer. Further the trailer made it practical to transport bulky equipment (such as weather recording stations and laboratory size instruments) to the field. The use of such equipment to rapidly screen and report results in "near real time" effectively minimized the concern about serious airborne overexposures at this site.

6. The combination of techniques: screeing available data to select appropriate analytical instrument, rapid on-site screeing for a variety of substances using the SDRITS, and on-site sample analysis to document airborne contaimants and the effectiveness of decontamination procedures appears to offer an effective operating procedure for protecting workers who cleanup hazardous waste sites.

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report have been sent to:

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7. NIOSH Region VI

8. OSHA Region VI

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology 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 Road, Springfield, Virginia 22151. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address.

Table 1

Estimated Volume of Chemicals[2]

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Number of Drums	Contents	Volume (gal)
260	Solvents	10,400
60	Acids	3,600
90	Bases	3,600
175	Alcohols	7,000
85	Ether	3,400
250	Empty	0
		28,000

Table 2

Estimated Frequency of Chemicals

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Category	Compounds	Relative Abundance
Solvents	Dichlorobenzene Toluene Trichlorethylene Xylenes Methylethylketone Orthodichlorobenzene	37%
Acids	Cresylic Acid Hydrochloric Acid Hydrofluoric Acid Surfactant (pH 1) Nitric Acid Phosphoric Acid	13%
Bases	Ammonium Hydroxide Caustic (pH 12) Diethanolamine Methylethylamine	13%
Alcohols	Butanol, P-decyl-phenol Ethanol, glycol Rust tem 200 Methanol P-nonylphenol	25%
Ethers	Ether	12%
Other	Polypropolyene	
		100%

Table 3
Examples of the Use of SDRITS

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Detector Tube	Examples of Reactions[1] A	B	C	D	E	F
1. Polytest	-	+	+	+	-	+
2. Ethyl acetate 200/a	-	-	+	+	-	-
3. Benzene 0.05	-	-	+	+	-	-[2]
4. Acetone 100/b	-	-	-	-	-	not used
5. Alcohol 100/a	-	-	-	-	-	-
6. Hydrocarbons 0.1%/b	-	-	-	+	-	-[2]
7. Carbon monoxide 10/b	-	-	-	+	-	-[2]
8. Methyl bromide 5/b	-	-	-	-	-	-
9. Hydrazine 0.25/a	-	-	-	-	+	+
10. Formic Acid 1/a	-	-	-	-	-	not used

Notes: 1 + means a color change; - means no color change
A = Hydrogen cyanide
B = Hydrogen sulfide
C = Benzene
D = Gasoline and Carbon monoxide
E = Triethylamine
F = "Junk" barrel

2 Indicated a discoloration in precleanse layer due to the high concentration of triethylamine.

Table 4
Quantitative Screening
for Volatile Organics
Chemistry Lab

Triangle Chemical Site
Bridge City, TX
August 19, 1982

Analyte	Concentration ug/M^3
Acetone	12725
Benzene	212
Hexane	400
Trichloroethylene	900
Toluene	1550
Xylene	237
Total Other HC	950

NOTE: The sample volume was 0.08 M^3 and the sample duration was 6+47.

TABLE 5

Organic Vapor Samples

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Sample Date	Sample Location	Sample Volume M^3 Time: HR+min	Toluene	Xylene ug/M^3	Total Other Hydrocarbons
8-19	Redbird Fence(N)	0.08/7+04	(62)	NA	450
8-20	Redbird Fence(N)	0.07/5+56	(43)	NA	(29)
8-19	Decon Trailer(E)	0.07/6+47	ND	ND	ND
8-20	Decon Trailer(E)	0.07/6+00	(128)	NA	ND
8-17	NIOSH Trailer(S)	0.02/	750	650	950
8-18	NIOSH Trailer(S)	0.05/4+10	(180)	ND	(180)
8-19	NIOSH Trailer(S)	0.09/7+04	233	NA	611
8-20	NIOSH Trailer(S)	0.06/5+21	(67)	NA	(67)
8-19	Barrel Crushing(W)	0.09/7+22	3578	NA	667
8-20	Barrel Crushing(W)	0.06/5+21	417	NA	617
8-18	Front End Loader	0.07/5+48	(86)	143	4457
8-19	Front End Loader	0.10/8+19	1730	NA	690
8-20	Front End Loader	0.07/6+00	(186)	NA	513
8-18	Barrel Grabber	0.07/5+51	ND	ND	1371
8-19	Barrel Grabber	0.10/8+22	(20)	NA	(30)
8-20	Barrel Grabber	0.07/6+00	(200)	NA	814
8-18	Barrel Sampler(P)	0.06/5+20	200	367	333
8-19	Barrel Sampler(P)	0.04/3+30	700	NA	600
8-20	Barrel Sampler(P)	0.07/5+48	(214)	NA	(57)
8-20	Chemist(P)	0.07/6+02	843	NA	1043
8-20	Photographer(P)	0.05/3+48	(60)	NA	ND
8-20	Safety Spec(P)	0.06	(33)	NA	ND
8-20	Supervisor(P)	0.05/4+20	(60)	NA	ND

NOTES:
1. ND means not detected.
2. NA means that the samples were not analyzed for the named substance.
3. (P) means personal sample i.e. the sampling train was physically attached to the person.
4. (N), (E), (S), and (W) gives the location of the samples with respect to the cardinal compass points.
5. When a result is enclosed in parentheses (), the analytical result was above the limit of detection but below the limit of accurate quantitation. The number is, at best, an estimate of the actual airborne concentration of the analyte.
6. The limit of detection for all substances included in this study is given in Appendix I.

TABLE 6
Nitrosamine Results

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Sample Date	Sample Location	Sample Volume M^3 Time: HR+min	NDMA*	NDEA**	NDELA***
8-18	Redbird Fence(N)	0.06/5+03	N.D.	N.D.	N.D.
8-20	Redbird Fence(N)	0.07/5+56	N.D.	N.D.	N.D.
8-19	Redbird Fence(N)	0.08/8+22	N.D.	N.D.	N.D.
8-18	Decon Trailer(E)	0.06/5+17	N.D.	N.D.	N.D.
8-18	NIOSH Trailer(S)	0.05/4+10	N.D.	N.D.	N.D.
8-20	NIOSH Trailer(S)	0.06/5+21	N.D.	N.D.	N.D.
8-19	NIOSH Trailer(S)	0.09/7+22	N.D.	N.D.	N.D.
8-18	Barrel Crushing(W)	0.05/4+06	N.D.	N.D.	N.D.
8-18	Barrel Grabber	0.07/5+51	N.D.	N.D.	N.D.
8-20	Barrel Grabber	0.07/6+00	N.D.	N.D.	N.D.
8-19	Barrel Grabber	0.10/8+22	N.D.	N.D.	N.D.
8-18	Front End Loader	0.07/5+48	N.D.	N.D.	N.D.
8-20	Front End Loader	0.07/6+00	N.D.	N.D.	N.D.
8-19	Front End Loader	0.10/8+19	N.D.	N.D.	N.D.

NOTES:
1. *NDMA means Nitrosodimethylamine. **NDEA means Nitrosodiethylamine. ***MDELA means Nitros diethanolamine.
2. ND means not detected.
3. (N), (E), (S), and (W) gives the location of the samples with respect to the cardinal compass points.
4. The limit of detection for all substances included in this study is given in Appendix I.

TABLE 7
Ethylene Glycol Results

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Sample Date	Sample Location	Sample Volume M^3 Time: HR+min	Ethylene Glycol
8-19	Redbird Fence(N)	0.01/0+58	N.D.
8-20	Redbird Fence(N)	0.07/5+56	N.D.
8-19	NIOSH Trailer(S)	0.07/5+28	N.D.
8-20	NIOSH Trailer(S)	0.06/5+21	N.D.
8-19	Chem Lab	0.07/5+28	N.D.
8-19	Barrel Sampler(P)	0.05/4+03	N.D.
8-19	Supervisor(P)	0.04/3+44	N.D.
8-19	Photographer(P)	0.05/4+07	N.D.

NOTES:
1. ND means not detected.
2. (N), (E), (S), and (W) gives the location of the samples with respect to the cardinal compass points.
3. (P) means personal sample i.e. the sampling train was physically attached to the person.
4. The limit of detection for all substances included in this study is given in Appendix I.

TABLE 8
Aliphatic Amine Results

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Sample Date	Sample Location	Sample Volume M^3 Time: HR+min	Aliphatic Amines
8-18	Redbird Fence(N)	0.06/5+03	N.D.
8-19	Redbird Fence(N)	0.08/7+04	N.D.
8-20	Redbird Fence(N)	0.07/5+56	N.D.
8-18	Decon Trailer(E)	0.06/5+17	N.D.
8-19	Decon Trailer(E)	0.08/7+04	N.D.
8-20	Decon Trailer(E)	0.07/6+00	N.D.
8-18	NIOSH Trailer(S)	0.05/4+10	N.D.
8-19	NIOSH Trailer(S)	0.09/7+22	N.D.
8-20	NIOSH Trailer(S)	0.06/5+21	N.D.
8-18	Barrel Crushing(W)	0.05/4+06	N.D.
8-19	Barrel Crushing(W)	0.09/6+29	N.D.
8-20	Barrel Crushing(W)	0.06/5+21	N.D.
8-18	Barrel Grabber	0.07/5+51	N.D.
8-19	Barrel Grabber	0.10/8+22	N.D.
8-20	Barrel Grabber	0.07/6+02	N.D.
8-18	Front End Loader	0.07/5+48	N.D.
8-19	Front End Loader	0.10/8+19	N.D.
8-20	Front End Loader	0.07/5+54	N.D.

NOTES:
1. ND means not detected. The limit of detection for all substances included in this study is given in Appendix I.
2. (N), (E), (S), and (W) gives the location of the samples with respect to the cardinal compass points.

TABLE 9
Acid Anions

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Sample Date	Sample Location	Sample Volume M^3 Time: HR+min	Chloride	Phosphate	Bromide	Nitrate	Sulfate
8-20	Redbird Fence(N)	0.07/5+56	N.D.	N.D.	N.D.	N.D.	N.D.
8-19	Redbird Fence(N)	0.08/7+04	N.D.	N.D.	N.D.	N.D.	N.D.
8-19	NIOSH Trailer(S)	0.06/5+21	(43)	N.D.	N.D.	N.D.	N.D.
8-19	NIOSH Trailer(S)	0.09/7+22	267	N.D.	N.D.	N.D.	644
8-20	Barrel Grabber	0.07/6+00	343	N.D.	N.D.	N.D.	1043
8-19	Barrel Grabber	0.10/8+22	(50)	N.D.	N.D.	257	(180)
8-19	Chem Lab	0.08/6+47	N.D.	N.D.	N.D.	N.D.	N.D.
8-20	Front End Loader	*					
8-19	Front End Loader	0.10/8+19	N.D.	N.D.	N.D.	N.D.	N.D.
8-19	Barrel Sampler(P)	**					

NOTES:
1. ND means not detected. The limit of detection for all substances included in this study is given in Appendix I.
2. *means that the sample was destroyed during transportation.
3. **means that the sample was destroyed during analysis.
4. (P) means personal sample i.e. the sampling train was physically attached to the person.
5. (N), (E), (S), and (W) gives the location of the samples with respect to the cardinal compass points.
6. When a result is enclosed in parentheses (), the analytical result was above the limit of detection but below the limit of accurate quantitation. The number is, at best, an estimate of the actual airborne concentration of the analyte.

Table 10

Particle Size
Distributions

Triangle Chemical Site
Bridge City, TX
August 19, 1982

Sample Date	Sample Location	Sample Volume M^3 and Time: Hr+min	Mass Concentration mg/M^3	Aerodynamic Mass Median Diameter (microns)	Standard Deviation
8-18	Redbird Fence(N)	0.63/5+13	1.4	13	2.2
8-19	Redbird Fence(N)	0.78/6+29	1.1	14	1.8
8-20	Redbird Fence(N)	0.50/4+11	1.7	13	2.2
8-18	Decon Trailer(E)	0.63/5+12	1.5	13	2.5
8-19	Decon Trailer(E)	0.78/6+29	1.1	15	1.8
8-20	Decon Trailer(E)	0.51/4+15	1.7	15	1.9
8-18	NIOSH Trailer(S)	0.50/4+10	1.8	18	2.6
8-19	NIOSH Trailer(S)	0.79/6+35	1.3	15	1.9
8-20	NIOSH Trailer(S)	0.51/4+14	2.0	16	1.9
8-18	Barrel Crushing(W)	0.49/4+06	1.8	14	1.8
8-19	Barrel Crushing(W)	0.78/6+29	1.5	14	2.2
8-20	Barrel Crushing(W)	0.50/4+11	1.8	14	1.8

NOTE: The arithmetic mean of the 50 percent particle sizes is 14 microns.

Table 11

Estimated Work Loads

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Job Category	Activity	Estimated Work Load kcal/min	
Barrel Samplers			
	Body Position: Standing	0.6	
	Light Work-2 Arms	2.0	
	Basal Metabolism	1.0	
		3.6	= 216 kcal/hr (moderate work rate)
Heavy Equipment Operators	Body Position: Sitting	0.3	
	Light Work-2 Arms	1.5	
	Basal Metabolism	1.0	
		2.8	= 168 kcal/hr (light work rate)

Table 12

Heat Stress Measurements

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Date	Time of Observation	Dry Bulb T °F	Wet Bulb T °F	Globe T °F	WBGT °F/°C
8-18-83	10:23	94	80	106	86.6/30.3
	10:48	98	80	110	87.8/31.0
	11:18	100	80	117	89.4/31.9
	11:48	94	78	100	84.0/28.9
	12:21	101	81	120	90.8/32.7
	12:54	102	80	116	89.4/31.9
	14:05	98	79	108	86.7/30.4
	14:35	98	79	110	87.1/30.6
	15:05	101	81	115	89.8/32.1
	15:37	90	79	100	84.3/29.1
8-19-83	8:20	79	73	80	75.0/23.9
	8:52	82	77	93	80.7/27.1
	9:38	87	76	96	81.1/27.3
	10:21	89	76	99	81.9/27.2
	10:56	89	78	100	83.5/28.6
	11:36	91	79	100	84.4/29.1
	12:36	94	83	100	89.1/31.7
	13:06	96	82	110	89.0/31.7
	13:42	96	82	111	89.2/31.8
8-20-83	No measurements taken				

TABLE 13

Simultaneous Direct Reading Indicator Tube System (SDRITS)

	Detector Tube[1]	UN ID NUMBER	Pressure Drop in H_2O[2]	Manufacturer's Specifications Vol, L[3]	Flow Rate L/Min[4]	SDRITS[5] Vol L	t Min:sec	Positive Reaction Indicates Presence of	Detection Limit
1.	Polytest		20	0.5	N.S.[6]	0.5	1:40	2,3,4,5,6,7,8[7]	2 ppm (H_2S) 50 ppm (benzene) 2000 ppm (acetone)
2.	Ethyl acetate 200/a	1173	15	2	0.4-0.75	2.0	6:40	esters, 3,4,5	200 ppm
3.	Benzene 0.05	1114	>49	0.2-4	0.5-1	2.0	6:40	aromatic H/C	15 ppm
4.	Acetone 100/b	1090	>35	1	0.25-0.5	1.0	3:20	ketones	100 ppm
5.	Alcohol 100/a	1096	11	1	0.5-1	1.0	3:20	alcohols	100 ppm
6.	Hydrocarbons 0.1%/b	1114	14	0.3-1.5	0.5-1	1.5	5:00	aliphatic H/C	0.1% (butane)
7.	Carbon monoxide 10/b	1016	>46	1	0.2-0.4	1.0	3:20	carbon monoxide	10 ppm
8.	Methyl bromide 5/b	1062	>28	0.5	0.5-1	0.5	1:40	halogenated aliphatic H/C	5 ppm
9.	Hydrazine 0.25/a	1296	7	1	0.75-1.5	1.0	3:20	amines/ammonia	0.25 ppm
10.	Formic acid 1/a	1789	6	2	0.6-1.2	2.0	6:40	acid vapors	1 ppm

Notes:
1 As used in the Draeger scheme (Reference 15)
2 Pressure drop across the detector tube, measured at 0.3 L/min airflow.
3 V = S X B, where S = the number of recommended pump strokes and B = 0.1 L/stroke, the bellows' volume.
4 Q = B/t, where B = 0.1 L/stroke and t = the bellows' opening period, min/stroke.
5 The sample volume is the product of the flow rate (set at 0.3 L/min for all tubes) and the indicated sampling time.
6 N.S. = not specified.
7 A positive test also occurs for arsine, carbon disulfide, hydrogen sulfide, and nitric oxide.

TABLE 14
Summary of Analytes by Location

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Locations	Toluene	Xylene	Other HC	NDMA	NDEA	NDELA	Ethylene Glycol	Aliphatic Amines	Cl	PO_4	Br	NO_3	SO_4
Overall	22/24 630	3/6 215	19/24 605	0/14	0/14	0/14	0/8	0/18	4/8	0/8	0/8	0/8	3/8
Area Samples													
Redbird Fence(N)	2/2 53	-	2/2 240	0/3	0/3	0/3	0/2	0/3	0/2	0/2	0/2	0/2	0/2
Decon Trailer(E)	1/2 64	0/1	0/2	0/1	0/1	0/1	-	0/3	-	-	-	-	-
NIOSH Trailer(S)	4/4 408	1/2 325	4/4 452	0/3	0/3	0/3	0/2	0/3	2/2 155	0/2	0/2	0/2	1/2 322
Barrel Crushing (W)	2/2 1998	-	2/2 642	0/1	0/1	0/1	-	0/3	-	-	-	-	-
Pseudo Personal Samples													
Barrel Grabber	3/3 667	1/1 143	3/3 1887	0/3	0/3	0/3	-	0/3	2/2 196	0/2	0/2	1/2 129	2/2 611
Front End Loader	2/3 110	0/1	3/3 738	0/3	0/3	0/3	-	0/3	0/2	0/2	0/2	0/2	0/2
Chem Lab	1/1 1550	1/1 237	1/1 15187	-	-	-	0/1	-	0/1	0/1	0/1	0/1	0/1
Personal Samples													
Barrel Sampler	3/3 371	-	3/3 1043	-	-	-	0/1	-	-	-	-	-	-
Chemist	1/1 843	-	1/1 1043	-	-	-	-	-	-	-	-	-	-
EPA Employees	3/3 51	-	0/3	-	-	-	0/2	-	-	-	-	-	-

NOTES: 1. The ratios give the number of positive analytical determinations for an analyte divided by the total number of analysis for samples collected at the specified location.
2. The number beneath the ratios are the mean concentrations for the specified location expressed in ug/M^3.

APPENDIX I

Sampling and Analysis Methodology

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Substance	Collection Device	Flow Rate (lpm)	Duration (hr)	Analytic Method	LOD ug	Reference
Aliphatic Amines	Silica Gel*	0.2	5-8	CG/NPD	10	16
Bromide	Prewashed Silica Gel	0.2	5-8	IC	4.4	17
Chloride	Prewashed Silica Gel	0.2	5-8	IC	1.8	17
Ethylene Glycol	GF Filters	0.2	5-8	GC/FID	4.4	18
Nitrate	Prewashed Silica Gel	0.2	5-8	IC	4	17
Nitrosamines	Thermosorb/N	0.2	5-8	GC-HECD	0.01	19
Particle Size Distribution	Cascade Impacter	2.0	5-8	Gravimetric		20
Phosphate	Prewashed Silica Gel	0.2	5-8	IC	2.7	17
Sulfate	Prewashed Silica Gel	0.2	5-8	IC	7	17
Toluene	Charcoal Tube	0.2	5-8	GC/MS	2-5	21,22
Total Other Hydrocarbons	Charcoal Tube	0.2	5-8	GC/MS	2-5	21,22
Xylene	Charcoal Tube	0.2	5-8	GC/MS	5	21

NOTES:
1. GC/MS means gas chromatography and mass spectrometry; IC means ion chromatography; NPD means nitrogen/phosphorus detector; FID means flame ionization detector; GC-HECD means gas chromatography using a Hall Electrical Conductivity Detector.
2. *One short term impinger sample using distilled water was collected at a flow rate of 2.0 lpm.
3. A modification of NIOSH Method P&CAM 339 was used for acid anions; a modification of P&CAM 221 was used for aliphatic amines; and a modification of P&CAM 338 was used for ethylene glycol.

APPENDIX II

Environmental Evaluation Crtieria

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

COMPOUND	AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS		OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION			NATIONAL INSTITUTE FOR OCCUPATIONAL AND HEALTH	
	TWA	STEL	TWA	CEILING	PEAK	TWA	CEILING
	All Units are Expressed in $\mu g/M^3$						
Acetone	1,780,000	2,375,000	2,400,000			590,000	
Benzene	30,000	75,000	30,000	75,000	150,000	3200	
Ethylene Glycol (Particulate)	10,000	20,000					
n-Hexane	180,000		1,800,000				
Toluene	375,000	560,000	750,000	1,120,000	1,870,000	375,000	750,000
Trichloroethylene	270,000	805,000	540,000	1,080,000	1,620,000	540,000	810,000
Xylene(o-,m-,p-isomers)	435,000	655,000	435,000			435,000	870,000

NOTES: 1. There are no specific standards for Aliphatic amines, Bromide, Chloride, Nitrate, Nitrosamines, Particle size distribution, Phosphate, and Sulfate.

Appendix III

Criteria for Assessment of Work Load[21]

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Body position and movement:	Work Load kcal/Minute
Standing	0.6
Sitting	0.3
Walking	2.0-3.0

Work	Energy Expendature Kcal/Minute Typical	Minimum	Maximum
Type of work:			
Hand work:			
Light	0.4	0.2	1.2
Heavy	0.9		
Arm work, one	1.0	0.7	2.5
Light			
Heavy	1.8		
Arm work, two arms			
Light	1.5	1.0	3.5
Heavy	2.5		
Work with body			
Light	3.5	2.5	15.0
Moderate	5.0		
Heavy	7.0		
Very Heavy	9.0		

Appendix IV

Heat Stress Evaluation Criteria21
WBGT Temperature for Various Work Loads

Triangle Chemical Site
Bridge City, TX
August 17-20, 1982

Work-Rest Regimen	WORK LOAD Light	Moderate	Heavy
Continuous Work	30.0/86	26.7/80.1	25.0/77
45 Min Work- 15 Min Rest, Each Hour	30.6/87.1	28.0/82.4	25.9/78.6
30 Min Work- 30 Min Rest, Each Hour	31.4/88.5	29.4/84.9	27.9/82.2
15 Min Work- 45 Min Rest, Each Hour	32.2/90.0	31.1/88.0	30.0/86.0

NOTE: 1. Data is for normally clothed individuals. Heat Stress for individuals wearing impervious clothing that inhibits free evaporation of sweat is greater than indicated by this table.
2. The ratios express the maximum WBGT temperature for the work load and work/rest regimen. The units are $^{o}C/^{o}F$.

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