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APRIL 1990
A.E. STALEY MANUFACTURING COMPANY
HOULTON, MAINE

NIOSH INVESTIGATOR:
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I. SUMMARY

In August 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate exposures to propylene oxide, starch dust, phosphorus oxychloride, and the potential explosion hazard from starch dust at A.E. Staley Manufacturing Company in Houlton, Maine.

NIOSH investigators conducted a site visit on October 11, 1988, and on June 13-15, 1989, to monitor workers' exposure to propylene oxide and starch dust. Propylene oxide air concentrations ranged from less than 0.1 to 6.0 parts per million (ppm) in 89 samples collected in the reactor room and other areas of the plant. Most of the propylene oxide is released into the reactor room air during the pumping of propylene oxide into two reactor vessels. Propylene oxide vapor is most likely escaping through the seals on the agitator shaft or on the hatch doors. Twenty-six personal breathing zone samples were collected from two operators and a laboratory technician on two work shifts over three consecutive days. The operators had 8-hour time-weighted average (TWA) exposures ranging from 0.1 to 0.7 ppm. The highest short term exposure (77 minutes) was 1.9 ppm which occurred when the operator was in the reactor room and briefly in the propylene oxide weighing building. The laboratory technician had 8-hour TWA exposures ranging from less than 0.1 to 0.4 ppm. The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for propylene oxide are 20 ppm as an 8-hour TWA. NIOSH recommends that propylene oxide be considered a potential occupational carcinogen and worker exposures be reduced to the lowest feasible concentrations.

Five personal breathing zone air samples for total nuisance dust (starch dust) ranged from an 8-hour TWA of 4.61 to 12.51 milligrams per cubic meter of air (mg/m^3). Four area air samples ranged from 0.29 to 0.77 mg/m^3. The OSHA 8-hour PEL for total nuisance dust is 15 mg/m^3. The ACGIH TLV for starch is 10 mg/m^3. In many areas of the plant starch dust is present on surfaces as well as in the air.

Phosphrous oxychloride is pumped directly into the reactor vessel and does not present an exposure potential to the operators.

Although propylene oxide concentrations are well below the OSHA PEL, detectable levels were present in the reactor room and other areas of the plant; these should be reduced to the lowest feasible concentration. Improved engineering controls such as improving the tightness of seals should reduce propylene oxide emissions. The presence of even a fine layer of starch dust on surfaces is a potential fire or explosion hazard. Starch dust emissions into the work area should also be reduced to the lowest feasible levels.

KEYWORDS: SIC 2046, wet corn milling, propylene oxide, starch, phosphrous oxychloride, tapioca

II. INTRODUCTION

On August 3, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from the American Federation of Grain Millers (AFGM) to evaluate exposures to propylene oxide, starch dust, phosphorus oxychloride, and the potential explosion hazard from starch dust at A.E. Staley Manufacturing Company in Houlton, Maine.

III. BACKGROUND

The facility was built in 1960-1961 and purchased by A.E. Staley in 1967. Originally potatoes were ground at the plant through the 1973 season. Both potato and tapioca starches, (food and industrial), were produced through this period. After 1973 the facility became a food starch speciality plant with imported tapioca as the main raw material. Currently the plant employs 44 hourly and 7 salary and clerical full time employees. Production occurs on three shifts.

One of the main chemicals used in the production of speciality starches is propylene oxide. The propylene oxide is stored outside the processing building in an underground tank covered with earth. The tank is enclosed in a small building known as the "weighing building". From here, propylene oxide is pumped to a weighing tank also located in this building. When the weighed propylene oxide is needed, it is pumped to one of four reactor vessels (vats B, C, D, and E) containing the tapioca starch slurry in the reactor room. Once the propylene oxide is added, the slurry is heated and mixed for several days. Afterwards the reaction is stopped by automatically pumping phosphorus oxychloride, sodium hydroxide, sulfuric acid, and sodium carbonate into the vat. At this step the concentration of propylene oxide in the starch slurry should be less than 10 ppm. The starch slurry is then pumped to the wet room for the filtering and washing steps. From the wet room, the starch is sent to the drum dryer room and packaging area.

The vats all have welded steel covers with an agitator shaft entering from the top of the vessel with a graphite seal. There is also a hatch door on the top of each vessel to collect samples. The hatches all have rubber seals on the edges to prevent propylene oxide vapors from escaping. Before pumping the propylene oxide, the lines to the vat are purged with nitrogen to prevent an explosive mixture of oxygen and propylene oxide vapor from forming. The head spaces of the vats are also blanketed with nitrogen during the reaction cycle to limit oxygen concentrations to below 10%. Fans located at the top of each vat exhaust vapors from the head space to outside the building whenever the hatch is opened.

IV. METHODS

NIOSH investigators conducted an initial evaluation of the Houlton, Maine facility on October 11, 1988. The investigation began with a meeting with management and union representatives on potential health problems within the plant. During this meeting, copies of industrial hygiene records, the OSHA Log and Summary of Occupational Injuries and Illness, a list of employees, flow-through diagrams of the process, a diagram of the plant layout, and a list of all chemicals used in the process were obtained. Following the meeting, a walk-through survey of the starch modification processes was conducted.

Upon review of the company records and completion of the walk-through inspection the investigators concluded that there is a potential employee exposure to propylene oxide. Therefore, a return visit to monitor employees' exposures to this compound was scheduled.

On June 13-15, 1989, environmental monitoring was performed for propylene oxide as well as limited sampling for starch dust.

A. Propylene oxide

Personal and area monitoring was performed in the reactor room, laboratory, and propylene oxide weighing building. Other area samples were collected in the wet room, dry bagging area, and packaging area. Numerous short term as well as full-shift samples were collected in the reactor room. In addition, consecutive short-term samples identified short-term exposures associated with process and job activities.

Sampling began on June 13, 1989 at 0705 hours. At this time, vats D and E each contained a batch of starch slurry to which propylene oxide had been added on June 12th. On June 13th between 0825 and 0845 a batch of propylene oxide was weighted in the weighing building. At 1305 operator 1 began pumping propylene oxide into vat B which lasted until 1618. On June 14th, a second batch was weighed and pumped to vat C between 1345 and 1557. On June 15th, a third batch was weighed and pumped to vat E between 1630 and 1830.

The propylene oxide was collected on 50/100 mg charcoal tubes at a flow-rate of 0.2 liters per minute. All samples were stored below 0°C until analysis. Samples were desorbed with carbon disulfide and analyzed by gas chromatography according to NIOSH Method No. 1612.(1) The limit of detection was 0.01 mg per sample.

B. Total Dust

On June 13th, personal breathing zone monitoring was conducted for total nuisance dust from five employees who worked in the warehouse. Their duties included: bagging dry starch, transporting the starch with forklifts, and sweeping spilled starch.

On June 14, area monitoring was performed for total nuisance dust in the warehouse and the drum dryer room. All samples were collected on pre-weighed 37-mm, 5-um pore size, polyvinyl chloride membrane filters at a flow rate of 2 liters per minute. Gravimetric analysis of the samples was performed according to NIOSH Method 0500.(1)

C. Phosphrous Oxychloride

Unlike the propylene oxide, only a few pounds of phosphrous oxychloride are pumped directly into the reactor vessel. Since there was no apparent employee exposure to this compound, air monitoring was not performed.

V. EVALUATION CRITERIA

A. Propylene Oxide

Skin contact with liquid propylene oxide can cause contact dermatitis. Exposure to propylene oxide vapor can cause irritation of the eyes, nose, throat, and lungs. In one report, humans exposed to propylene oxide vapor received corneal burns.(2) Exposure to propylene oxide can also result in a reduced capacity to repair DNA lesions. Twenty-three workers exposed to propylene oxide in a factory producing alkylated starch had reduced capacity for unscheduled DNA synthesis following the in vitro induction for DNA damage to their blood lymphocytes.(3) Unscheduled DNA synthesis is a step in the enzymatic repair of DNA damage. Studies on the carcinogenic effect of propylene oxide in laboratory animals performed by the National Toxicology Program and by other researchers have concluded that there is evidence that propylene oxide is an animal carcinogen.(4) Based on this research, NIOSH therefore recommends that propylene oxide be considered a potential occupational carcinogen in conformance with the OSHA Cancer Policy. The excess cancer risk for workers exposed to propylene oxide has not yet been established, but the probability of developing cancer should be decreased by minimizing exposure. As a matter of prudent public health policy, employers should assess the conditions under which workers may be exposed to propylene oxide and take

reasonable precautions (such as appropriate engineering and work practices controls) to reduce exposures to the lowest feasible concentrations.(5)

The Occupational Safety and Health Administration (OSHA) has recently established an 8-hour time-weighted average (TWA) of 20 parts per million (ppm) for propylene oxide to protect workers against the risk of primary irritation and central nervous system depression.(6) However, during the OSHA rule-making process, NIOSH disagreed with the proposed permissible exposure limit (PEL), recommending that propylene oxide be designated as a potential occupational carcinogen.(7)

The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) is 20 ppm as an 8-hour TWA.(8) The ACGIH TLV is based on the acute toxicity of propylene oxide and its "lesser toxicity in relation to ethylene oxide".(9)

B. Total Nuisance Dusts (corn, tapioca, and potato starches)

Airborne nuisance dusts, which include corn, tapioca, and potato starches, are supposedly dusts which have little adverse effects on the lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. OSHA's 8-hour PEL for nuisance dust is 5 mg/m^3 for respirable dust and 15 mg/m^3 for total dust.(8) The ACGIH recommends that exposure to starch not exceed 10 mg/m^3.(9)

Although starches are considered non-toxic, starch dust is a fire and explosion hazard. The Bureau of Mines has classified most starches as having a "severe" explosion potential. The National Fire Protection Association has detailed standards for the manufacturing and handling of starch.(10) The standards include requirements for structural features, ventilation, explosion protection, equipment, starch dryers, dust control, house keeping, electrical, fire protection, cutting, welding, spark-operations, and other topics.

VI. RESULTS

A. Propylene Oxide

Twenty-six personal breathing zone samples were collected from two operators and a laboratory technician on two work shifts over three consecutive days (Table 1). The operators had 8-hour TWA propylene oxide exposures ranging from 0.1 to 0.7 ppm. The highest short term exposure was 1.9 ppm which occurred on June 13th between 0705 and 0822. This was the period when the operator was in the reactor room, and briefly in the propylene weighing room preparing to weigh a batch. The laboratory technician had an 8-hour TWA propylene oxide exposure ranging from less than 0.1 to 0.4 ppm.

Eighty-nine area air samples were collected between June 13th and June 15th. Most samples were collected on top of the vats where there is a potential for propylene oxide vapor to leak from either the seal around the the agitator shaft or at the door to the vat. Sample Vat E, 1st floor was collected on the side of Vat E at a height of 5 feet from the 1st floor. Propylene oxide air concentrations ranged from less than 0.1 to 6.0 ppm in the reactor room (Tables 2 and 3). Table 2 presents the area air sample results according to the time the samples were collected. Table 3 presents the same results according to location. From this data it can be seen that air concentrations of propylene oxide increase at the top of Vat B and Vat C with the pumping of propylene oxide into those vats. The levels were steady during the pumping then dropped off within an hour of the end of pumping. Monitoring around Vat E during pumping showed no increase in propylene oxide air concentration.

When operational procedures are followed in the reactor room, the final concentration of propylene oxide in the slurry is less than 10 ppm. At this concentration there should be very low levels of propylene oxide in the air of the Wet room. An area sample collected in the Wet room contained 1.9 ppm propylene oxide and a sample from the Packing area was 0.3 ppm. Two samples collected in the drum dry room were

non-detectable. A portion of the propylene oxide detected in the Wet room and the Packing room may be from air movement form the Reactor room. However, unreacted propylene oxide in the slurry may be a source of propylene oxide in the Wet room.

B. Total Nuisance Dust

Five personal breathing zone samples for total nuisance dust ranged from an 8-hour TWA of 4.61 to 12.51 mg/m^3 (Table 4). Two of these samples are in excess of the ACGIH TLV of 10 mg/m^3. Four area samples for total nuisance dust ranged from 0.29 to 0.77 mg/m^3 (Table 5) Exposures were greatest during the bagging of the starch.

VII. CONCLUSIONS

Propylene oxide vapor is present in the weighing building during batch weighing, reactor room, laboratory, packaging area, wet room, and above vats B and C during the addition of propylene oxide. The propylene oxide concentrations above vats B and C are most likely due to vapor escaping from within the vat through the agitator shaft seal or the hatch door. The seal on vat E appears to be controlling the propylene oxide vapor.

Although propylene oxide concentrations are well below the OSHA PEL, there are still low levels present in the work area. Since propylene oxide is considered by NIOSH to be a potential occupational carcinogen, employee exposures should be reduced to the lowest feasible level.

Two of the five employees who worked in the warehouse on June 13, 1989 were exposed to total nuisance dust levels in excess of the ACGIH TLV of 10 mg/m^3.

Starch dust on surfaces is common throughout most area of the plant. Although the complete removal of all fugitive starch is extremely difficult, the presence of even a fine layer of starch dust on surfaces is a potential fire or explosion hazard.

VIII. RECOMMENDATIONS

1. To further reduce propylene oxide exposures in the plant atmosphere, the following steps should be taken:

    a. The agitator shaft seals on vats B and C should be tightened or replaced followed by periodic inspections.
    b. The rubber seal on the hatch doors should be periodically checked.
    c. Enough time should be allowed for the propylene oxide in the starch slurry to be completely reacted before the slurry is pumped to the wet room.
    d. The weighing room should be periodically checked for propylene oxide leaks.
    e. The company policy of prohibiting all employees from the reactor room except for essential employees such as reactor room operators, laboratory technicians, and maintenance personnel was observed by the employees and should be maintained.

2. Starch dust levels should be reduced during bagging in the warehouse to levels below the ACGIH TLV of 10 mg/m^3. All efforts to reduce airborne starch dust will also reduce the potential for fire or explosion.

IX. REFERENCES

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2. McLaughlin RS: Chemical burns of the human cornea. Am J Ophthalmol 29: 1355-1362, 1946.

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4. NTP: Toxicology and carcinogenesis studies of propylene oxide in F344/N rats and B6C3F1 mice (inhalation studies). Research Triangle Park, NC: National Toxicology Program, NTP 83-020, 1985.

5. NIOSH Current Intelligence Bulletin 51: Carcinogenic Effects of Exposure to Propylene Oxide NIOSH, Cincinnati, OH, July 13, 1989.

6. OSHA: Air Contanimants - Permissible Exposure Limits (Title 29 Code of Federal Regulations Part 1910.1000) OSHA, US Dept. of Labor, Washington DC, 1989.

7. NIOSH: Testimony of the National Institute for Occupational Safety and Health on the Occupational Safety and Health Administration's Proposed Rule on Air Contaminants, 29 CFR Part 1910, Docket No. H-020. Presented at the OSHA informal public hearing, August 1, 1988. NIOSH policy statements. Cincinnati, OH: US Dept of Health and Human Services, CDC, NIOSH, 1988.

8. ACGIH: Threshold Limit Values and Biological Exposure Indices for 1989-1990. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 1989.

9. ACGIH: Documentation of the threshold limit values. 5th edition, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, p. 504, 1986.

10. National Fire Protection Association: Standard for Manufacturing and Handling Starch, NFPA No. 61A-1973, National Fire Codes, volume 5, Quincy, MA, 1981.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. A.E. Staley Manufacturing Company
2. American Federation of Grain Millers, Local 234
3. American Federation of Grain Millers, International
4. NIOSH, Boston Region
5. OSHA, Region I

In order to comply with NIOSH's regulations regarding informing affected employees (CFR, Title 42, Part 85a, Section 85.11), 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
Personal Breathing Zone Samples for Propylene Oxide
HETA 88-336

A. E. Staley, Inc.
Houlton, Maine

June 13-15, 1989

Job Title	Sample No.	Time-Hours	ppm	8-Hour TWA in ppm
June 13, 1989				
Lab Technician 1	C1	705-810	ND	
	C8	810-900	ND	
	C15	900-1006	ND	
	C24	1006-1110	ND	
	C30	1110-1210	ND	
	C48	1210-1321	ND	
	C61	1321-1450	ND	ND
Lab Technician 1	C49	705-1321	0.2	
	C62	1325-1451	ND	0.1
Operator 1	C7	705-822	1.9	
	C14	825-915	1.4	
	C18	915-1010	1.5	
	C23	1010-1109	ND	
	C31	1109-1213	0.3	
	C38	1213-1305	ND	
	C56	1305-1428	ND	0.7
Operator 1	C39	705-1305	0.8	
	C63	1305-1355	0.2	0.6
June 14, 1989				
Lab Technician 1	K4	740-1450	0.1	0.1
Operator 1	K3	814-1550	0.5	0.4
	K2	1347-1450	0.9	0.1
Operator 2	K13	1500-1605	0.3	0.1
	K21	1500-2240	0.2	0.2
June 15, 1989				
Lab Technician 1	T1	735-1545	0.4	0.4
Operator 1	T3	730-1455	0.3	0.2
Operator 2	T14	1255-2230	0.2	0.2

ND = non-detectable (less than 0.1 ppm)
OSHA PEL for propylene oxide is 20 ppm (parts per million) as an 8-hour TWA (time-weighted average).

TABLE 2

Area Air Samples for Propylene Oxide

HETA 88-336

A. E. Staley, Inc.
Houlton, Maine

June 13-15, 1989

Location	Sample No.	Date	Time-Hours	ppm	Comments
Vat B	C2	June 13	720-813	ND*	
Vat E	C3	June 13	720-815	ND	
Vat D	C4	June 13	735-816	ND	
Vat C	C5	June 13	730-817	0.5	
Vat E 1st floor	C6	June 13	740-817	ND	
Vat B	C9	June 13	813-906	ND	
Vat E	C10	June 13	815-907	ND	
Vat D	C11	June 13	816-908	ND	
Vat C	C12	June 13	817-900	ND	
Vat E 1st floor	C13	June 13	817-910	ND	
Vat B	C16	June 13	900-1007	ND	
Vat E	C17	June 13	907-1010	ND	
Vat C	C19	June 13	909-1010	ND	
Vat D	C20	June 13	908-1012	ND	
Vat B	C25	June 13	1008-1112	ND	
Vat E	C26	June 13	1010-1113	ND	
Vat D	C27	June 13	1012-1115	0.3	
Vat C	C28	June 13	1012-1116	ND	
Vat B	C32	June 13	1112-1214	1.6	
Vat E	C33	June 13	1113-1218	ND	
Vat D	C34	June 13	1115-1219	0.6	
Vat C	C35	June 13	1116-1220	ND	
Vat E 1st floor	C36	June 13	1210-1302	ND	
Vat B	C40	June 13	1214-1310	0.4	1305-1618 PPO added to Vat B
Vat D	C45	June 13	1219-1318	ND	
Vat E	C46	June 13	1218-1319	ND	
Vat C	C42	June 13	1220-1340	ND	

*ND = non-detectable (less than 0.1 ppm)

TABLE 2 (continued)

Location	Sample No.	Date	Time-Hours	ppm	Comments
Vat E 1st floor	C37	June 13	740-1302	ND*	
Vat B	C41	June 13	720-1311	0.5	
Vat C	C43	June 13	730-1315	0.2	
Vat D	C44	June 13	735-1317	0.2	
Vat E	C47	June 13	720-1320	0.3	
Lab	C50	June 13	707-1326	0.2	
Lab	C51	June 13	707-1326	0.2	
Wet room	C52	June 13	740-1337	1.9	
Packing area	C53	June 13	750-1332	0.3	
Weighing building	C54	June 13	755-1343	6.0	0825-0845 PPO weighed
Vat E 1st floor	C55	June 13	1302-1425	ND	
Vat D	C57	June 13	1318-1430	ND	
Vat C	C58	June 13	1314-1432	0.3	
Vat E	C59	June 13	1319-1434	0.3	
Vat B	C60	June 13	1310-1435	0.5	
Vat B	C68	June 13	1435-1555	2.9	
Vat E	C69	June 13	1434-1555	1.2	
Vat C	C70	June 13	1432-1558	0.6	
Vat D	C71	June 13	1430-1600	0.5	
Lab	C72	June 13	1326-1600	0.2	
Lab	C73	June 13	1327-1600	0.2	
Weighing building	C75	June 13	1343-1915	1.9	
Vat D	C76	June 13	1318-1922	0.5	
Vat C	C77	June 13	1315-1920	0.5	
Vat B	C78	June 13	1555-1903	6.0	
Vat E	C79	June 13	1320-1904	2.0	
Vat D	C80	June 13	1600-1922	0.7	
Vat C	C81	June 13	1600-1920	0.5	
Vat E	C82	June 13	1555-1905	2.4	
Vat E 1st floor	C83	June 13	1555-1900	0.3	
Vat B	C85	June 13	1313-1903	4.5	
Vat E 1st floor	C86	June 13	1302-1900	0.2	
Lab	K5	June 14	741-1500	ND	1345-1557 PPO added to Vat C
Vat E	K7	June 14	745-1555	1.5	
Vat C	K8	June 14	746-1555	1.3	
Vat D	K9	June 14	746-1555	0.8	
Vat E 1st floor	K10	June 14	747-1600	0.2	
Drum dryer room	K11	June 14	755-1602	ND	
Vat B	K6	June 14	745-1914	2.2	

TABLE 2 (continued)

Location	Sample No.	Date	Time-Hours	ppm	Comments
Vat E 1st floor	K1	June 14	1350-1450	0.2	
Vat B	K12	June 14	1347-1604	3.6	
Vat E	K14	June 14	1348-1610	3.6	
Vat C	K15	June 14	1348-1610	3.6	
Vat D	K16	June 14	1347-1610	0.9	
Vat B	K17	June 14	1604-2236	1.2	
Vat C	K18	June 14	1610-2237	5.5	
Vat D	K19	June 14	1610-2237	0.5	
Vat E	K20	June 14	1606-2236	2.1	
Vat E	T2	June 15	732-1455	0.8	
Vat D	T4	June 15	734-1455	0.1	
Vat E 1st floor	T5	June 15	730-1455	0.1	
Vat C	T8	June 15	1435-1817	1.1	1630-1830 PPO added to Vat E
Vat E	T6	June 15	1635-1815	0.5	
Vat D	T7	June 15	1635-1816	ND	
Vat E 1st floor	T13	June 15	1636-2230	ND	
Vat B	T15	June 15	1635-2246	1.0	
Vat D	T16	June 15	1635-2247	0.1	
Vat E	T19	June 15	1635-2250	1.1	
Lab	T20	June 15	1636-2255	ND	
Drum dryer room	T12	June 15	1817-2248	ND	
Vat D	T17	June 15	1817-2248	0.2	
Vat E	T18	June 15	1817-2250	1.8	

ND = non-detectable (less than 0.1 ppm)

TABLE 3

Area Air Samples for Propylene Oxide

HETA 88-336

A. E. Staley, Inc.
Houlton, Maine

June 13-15, 1989

Location	Sample No.	Date	Time-Hours	ppm	Comments
Vat B	C2	June 13	720-813	ND	
Vat B	C9	June 13	813-906	ND	
Vat B	C16	June 13	900-1007	ND	
Vat B	C25	June 13	1008-1112	ND	
Vat B	C32	June 13	1112-1214	1.6	
Vat B	C40	June 13	1214-1310	0.4	
Vat B	C41	June 13	720-1311	0.5	
Vat B	C60	June 13	1310-1435	0.5	1305-1618 PPO
Vat B	C68	June 13	1435-1555	2.9	added to Vat B
Vat B	C78	June 13	1555-1903	6.0	
Vat B	C85	June 13	1313-1903	4.5	
Vat B	K6	June 14	745-1914	2.2	
Vat B	K12	June 14	1347-1604	3.6	
Vat B	K17	June 14	1604-2236	1.2	
Vat B	T15	June 15	1635-2246	1.0	
Vat C	C5	June 13	730-817	0.5	
Vat C	C12	June 13	817-090	ND	
Vat C	C19	June 13	909-1010	ND	
Vat C	C28	June 13	1012-1116	ND	
Vat C	C35	June 13	1116-1220	ND	
Vat C	C42	June 13	1220-1340	ND	
Vat C	C43	June 13	730-1315	0.2	
Vat C	C58	June 13	1314-1432	0.3	1345-1557 PPO
Vat C	C70	June 13	1432-1558	0.6	added to Vat C
Vat C	C77	June 13	1315-1920	0.5	
Vat C	C81	June 13	1600-1920	0.5	
Vat C	K8	June 14	746-1555	1.3	
Vat C	K15	June 14	1348-1610	3.6	
Vat C	K18	June 14	1610-2237	5.5	
Vat C	T8	June 15	1435-1817	1.1	

ND = non-detectable (less than 0.1 ppm)

TABLE 3 (continued)

Location	Sample No.	Date	Time-Hours	ppm	Comments
Vat D	C4	June 13	735-816	ND	
Vat D	C11	June 13	816-908	ND	
Vat D	C20	June 13	908-1012	ND	
Vat D	C27	June 13	1012-1115	0.3	
Vat D	C34	June 13	1115-1219	0.6	
Vat D	C57	June 13	1318-1430	ND	
Vat D	C71	June 13	1430-1600	0.5	
Vat D	C44	June 13	735-1317	0.2	
Vat D	C45	June 13	1219-1318	ND	
Vat D	C76	June 13	1318-1922	0.5	
Vat D	C80	June 13	1600-1922	0.7	
Vat D	K9	June 14	746-1555	0.8	
Vat D	K16	June 14	1347-1610	0.9	
Vat D	K19	June 14	1610-2237	0.5	
Vat D	T4	June 15	734-1455	0.1	
Vat D	T7	June 15	1635-1816	ND	
Vat D	T16	June 15	1635-2247	0.1	
Vat D	T17	June 15	1817-2248	0.2	
Vat E	C3	June 13	720-815	ND	
Vat E 1st floor	C6	June 13	740-817	ND	
Vat E	C10	June 13	815-907	ND	
Vat E 1st floor	C13	June 13	817-910	ND	
Vat E	C17	June 13	907-1010	ND	
Vat E	C26	June 13	1010-1113	ND	
Vat E	C33	June 13	1113-1218	ND	
Vat E 1st floor	C36	June 13	1210-1302	ND	
Vat E 1st floor	C37	June 13	740-1302	ND	
Vat E	C46	June 13	1218-1319	ND	
Vat E	C47	June 13	720-1320	0.3	
Vat E 1st floor	C55	June 13	1302-1425	ND	
Vat E	C59	June 13	1319-1434	0.3	
Vat E	C69	June 13	1434-1555	1.2	
Vat E	C79	June 13	1320-1904	2.0	
Vat E	C82	June 13	1555-1905	2.4	
Vat E 1st floor	C83	June 13	1555-1900	0.3	
Vat E 1st floor	C86	June 13	1302-1900	0.2	
Vat E 1st floor	K1	June 14	1350-1450	0.2	
Vat E	K7	June 14	745-1555	1.5	
Vat E 1st floor	K10	June 14	747-1600	0.2	
Vat E	K14	June 14	1348-1610	3.6	
Vat E	K20	June 14	1606-2236	2.1	
Vat E	T2	June 15	732-1455	0.8	
Vat E 1st floor	T5	June 15	730-1455	0.1	
Vat E	T6	June 15	1635-1815	0.5	1630-1830 PPO
Vat E 1st floor	T13	June 15	1636-2230	ND	added to Vat E
Vat E	T18	June 15	1817-2250	1.8	
Vat E	T19	June 15	1635-2250	1.1	

TABLE 3 (continued)

Location	Sample No.	Date	Time-Hours	ppm	Comments
Lab	C50	June 13	707-1326	0.2	
Lab	C51	June 13	707-1326	0.2	
Lab	C72	June 13	1326-1600	0.2	
Lab	C73	June 13	1327-1600	0.2	
Lab	K5	June 14	741-1500	ND	
Lab	T20	June 15	1636-2255	ND	
Weighing building	C54	June 13	755-1343	6.0	
Weighing building	C75	June 13	1343-1915	1.9	
Wet room	C52	June 13	740-1337	1.9	
Packing area	C53	June 13	750-1332	0.3	
Drum dryer room	K11	June 14	755-1602	ND	
Drum dryer room	T12	June 15	1817-2248	ND	

ND = non-detectable (less than 0.1 ppm)

TABLE 4

Personal Breathing Zone Samples for Total Nuisance Dust

HETA 88-336

A. E. Staley, Inc.
Houlton, Maine

June 13 & 14, 1989

Job Title	Time (minutes)	Actual mg/m^3	8-hour TWA mg/m^3
Loader 1	412	5.38	4.61
Loader 2	409	14.68	12.51
Loader 3	404	13.40	11.28
Loader 4	399	5.00	4.15
Loader 5	409	6.66	5.68

TWA = time-weighted average
The ACGIH TLV for total nuisance dust is 10 mg/m^3 as an 8-hour TWA (time-weighted average).

TABLE 5

Area Air Samples for Total Nuisance Dust

HETA 88-336

A. E. Staley, Inc.
Houlton, Maine

June 13 & 14, 1989

Location	Time (minutes)	mg/m^3
Hallway warehouse	300	0.63
Bagging area warehouse	300	0.60
Hallway on wall, warehouse	296	0.77
Drum Dryer bagging	290	0.29

TWA = time-weighted average
The ACGIH TLV for total nuisance dust is 10 mg/m^3 as an 8-hour TWA (time-weighted average).