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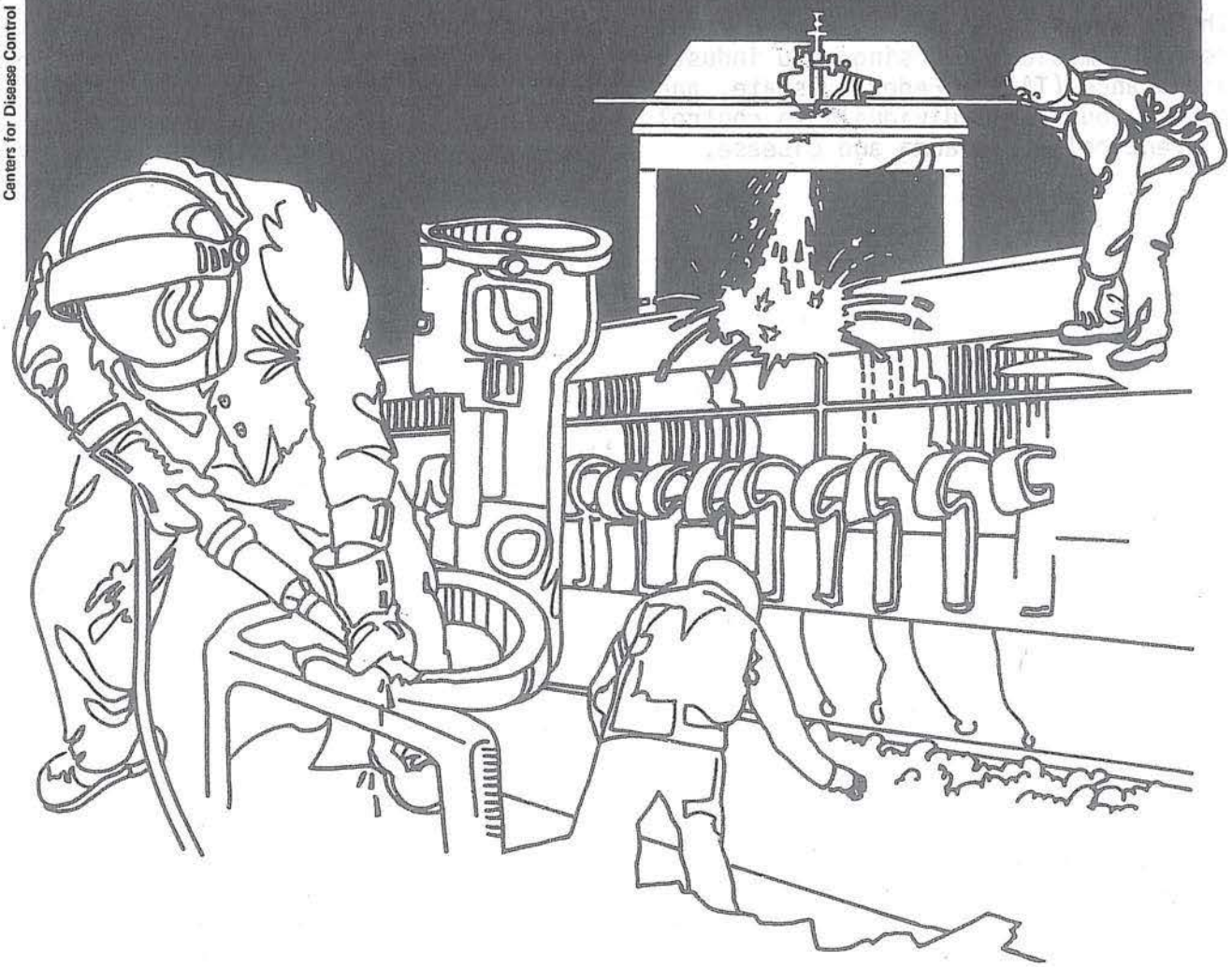

Health Hazard Evaluation Report

HETA 80-256-1386
RALSTON PURINA COMPANY
BLOOMINGTON, ILLINOIS

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 80-256-1386
NOVEMBER 1983
RALSTON PURINA COMPANY
BLOOMINGTON, ILLINOIS

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I. SUMMARY

On September 22, 1980, NIOSH received a request for a health hazard evaluation at the Ralston Purina Company, Soybean Division, Bloomington, Illinois. The request concerned employee exposure to hexane vapors in the extraction building. Leakage from pipes and process vessels was cited as a possible source of hexane exposure. Employees potentially exposed included one extraction operator on each shift and maintenance personnel who periodically work in the extraction building during the day shift.

Environmental sampling was conducted on November 24-25, 1980. A total of six personal breathing zone and seven area airborne hexane samples were collected. Exposure concentrations ranged from 4.4 to 13.2 parts hexane per million parts of air (ppm) for personal samples and from 13.2 to 26.9 ppm for area samples. By comparison, the NIOSH exposure criterion is 100 ppm and the OSHA permissible exposure limit is 500 ppm. A series of grab samples indicated a potential problem due to leaks from process equipment. Detector tube readings taken from one to six inches from the surface of sight glasses indicated hexane concentrations ranging from <100 ppm to greater than 3000 ppm.

A questionnaire survey of 17 operators and 10 maintenance workers showed the most frequently reported symptoms associated with the extraction process to be dizziness, giddiness, and lightheadedness (each reported by 74% of the participants), followed by nasal irritation (59%), eye irritation (56%), headache (56%), weakness (52%), and muscle aches (48%). Operators had higher prevalences of sleepiness (41% vs. 0%, p=0.026) and dry or irritated skin (65% vs. 20%, p=0.046) than maintenance workers.

Based on the results of this investigation, NIOSH has determined that employees were not exposed to hazardous levels of hexane on the days the health hazard evaluation was conducted. However, detector tubes used to collect grab samples detected leaks from some process equipment, and extraction building maintenance workers have had symptoms consistent with acute exposure to high levels of hexane. Recommendations are made (Section VIII) to improve the respiratory protection and confined space entry programs.

KEYWORDS: SIC 2075 (Soybean Oil Mill) Hexane, n-hexane, hexane-extraction, desolventizer

II. INTRODUCTION

On September 22, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation at the Ralston Purina Company, Soybean Division, Bloomington, Illinois. The request concerned employee exposure to hexane vapors in the extraction building. Leakage from pipes and process vessels was cited as a possible source of hexane exposure. Employees potentially exposed included one extraction operator on each shift and maintenance personnel who periodically worked in the extraction building during the day shift.

On November 24-26, 1980, NIOSH conducted environmental and medical surveys at the Bloomington facility. An opening conference and subsequent initial walk-through survey was performed with representatives of management, union, and NIOSH. Interviews were conducted with management and union representatives by NIOSH environmental and medical personnel.

While at the Bloomington facility, NIOSH personnel reviewed the Ralston Purina Policy and Procedure Manual, plant and corporate respiratory protection programs, the written procedure for confined space entry and OSHA Reports of Injuries and Illnesses. In addition, respirators and an oxygen meter were inspected.

Interim report no. 1 was distributed in May, 1981. The report discussed findings to date, future action, and recommendations resulting from the initial plant visit. Interim report no. 2, presenting the hexane air sampling results, was distributed in November, 1981.

III. BACKGROUND

The Bloomington facility began operations in 1949. The plant is divided into two divisions - soybean and animal feed (CHOW) with a total workforce of approximately 120 employees. The soybean division includes 40 hourly and 15 salaried employees. A separate process called the Flake Desolventizing System (FDS) was added to the extraction building in 1977. This system is designed to produce soybean meal suitable for human consumption. This process is noncontinuous and operates an average of two to three days per week.

Soybeans come into the facility by truck. They are unloaded at dumping stations and stored in silos. When ready for processing the soybeans are dried and returned to the silos for ten days to allow for moisture equilibration. Following equilibration, the soybeans are sent to the prep building where they are crushed and cleaned (removing hulls and debris) by air separation. Hulls are then ground, toasted, and sold as animal feed. Soybean meats which remain following air separation are

sent to the rotary furnace to be heated and subsequently sent to the flaking rolls where they are compressed into flakes approximately 15/1000 inch thick. This action causes oil cells within the seedmeats to rupture. From the flaking rolls, flakes are sent to the rotocell extractor. In the extractor the flakes are washed with hexane. Hexane removes soybean oil from the flakes forming a mixture called miscella (approximately 25% oil and 75% hexane). Miscella and soybean flakes are separated in the rotocell extractor and sent through separate pathways for final processing.

Miscella goes into the vacuum flash unit where it is heated under pressure. The combination of heat and pressure drive off the hexane vapors. Two additional process vessels, the rising film evaporator and the oil stripper, are used to enhance the recovery of hexane. After cooling, soybean oil is sent to storage tanks.

Extracted flakes have two potential pathways from the rotocell extractor. The primary pathway is to send extracted flakes into the desolventizer toaster where steam is used to drive off any solvent remaining in the flakes. The desolventizer toaster also toasts the flakes. Flakes are then dried, cooled, ground, cleaned, and sold as meal. The second pathway is the FDS system. Extracted flakes go from the rotocell extractor to the FDS loop and then through the FDS stripper.

These units remove any remaining solvent using superheated hexane vapors instead of steam. From the stripper, flakes are sent to storage. This material will be shipped to a facility for final processing as soybean meal suitable for human consumption. The process operation is outlined in Figure I.

The extraction building covers six floors with the five upper decks consisting of grid flooring. There are two exhaust fans located on the 1st floor. The design is based on a theory of hexane vapors settling to the ground floor where the exhaust fans pick up the vapors and exhaust them above the roof. There are windows on each floor which are normally open due to heat from the extraction process.

The extraction process is enclosed and if maintained properly, should not result in high exposures to employees during normal operations. Potential sources of exposure include leaks in the processing equipment and interruptions in the normal process, such as, equipment malfunction and cleaning of process equipment.

IV. MATERIALS AND METHODS

A. Environmental

Environmental sampling was conducted during the second shift on November 24, and the first shift on November 25, 1980. Sampling trains consisting of a charcoal tube attached via flexible tubing to a battery operated pump calibrated at 50 cubic centimeters per minute were utilized to collect area and personal samples of airborne hexane. The charcoal tubes were separated into A and B portions and desorbed in 1 milliliter of carbon disulfide containing 1 microliter per milliliter ethyl benzene as an internal standard. The samples were analyzed according to NIOSH method P&CAM 127[1] (modified) using a Hewlett-Packard 5830A gas chromatograph equipped with a flame ionization detector. The hexane was quantitated using a stainless steel column packed with 20% SP-2100, 0.1% Carbowax 1500 on 100/120 Supelcoport with temperature programming from 70°C to 160°C. The limit of detection for hexane was 0.01 milligram.

Certified direct reading indicator tubes with an operating range of 100 to 3000 parts hexane per million parts of air were utilized to check for hexane leaks and to collect grab samples of airborne hexane concentrations. Employee work practices were observed while the extractor operator was conducting gauge and equipment checks. The operator conducts these checks a minimum of four times each shift.

B. Medical

The NIOSH medical investigator interviewed all available operators and maintenance personnel using a questionnaire that addressed current occupational and medical histories and a variety of symptoms potentially related to hexane exposure.

V. EVALUATION CRITERIA

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

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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

n-Hexane

Hexane is a clear, volatile liquid at room temperature. It is insoluble in water, but miscible with most organic solvents, and quite soluble in alcohol. Commercial hexane is a mixture of hexane isomers with small amounts of cyclopentane, cyclohexane, and pentane and heptane isomers. It may contain as little as 20%, or as much as 80%, of n-hexane. Commerical grades of hexane are used as solvents for vegetable oils, adhesives and as denaturants for alcohol.[2] It has been estimated that 2.5 million workers are potentially exposed to this substance.[3]

n-Hexane is a mild upper respiratory irritant and causes central nervous system depression; chronic exposure causes peripheral neuropathy.[4] Nausea, headache, and eye and throat irritation occur among persons exposed to concentrations of 1400 to 1500 parts per million (ppm). Dizziness and other central nervous system symptoms can occur at lower concentrations.

The present environmental criteria for n-hexane exposure are 100 ppm for the National Institute for Occupational Safety and Health (NIOSH) and 50 ppm for the American Conference of Governmental Industrial Hygienists (ACGIH). The Occupational Safety and Health Administration (OSHA) Standard is 500 ppm.[3,5,6] The NIOSH and ACGIH criteria are intended to prevent chronic neurologic effects; the OSHA standard is based on the former ACGIH TLV, which was designed to prevent the acute effects. NIOSH also recommends a ceiling concentration of 510 ppm for a 15 minute period.[3]

VI. RESULTS

A. Environmental

Sampling

Results of environmental sampling for airborne hexane are included in Table I. A total of six personal and seven area samples were collected. Exposure concentrations ranged from 4.4 ppm to 13.2 ppm for personal samples worn by Ralston Purina personnel, and from 13.2 ppm to 26.9 ppm for area samples. All values are below the current environmental criteria. Higher values for personal samples were obtained with sampling trains worn by the NIOSH industrial hygienist. On both shifts sampled, the NIOSH industrial hygienist spent 5-6 hours in the extraction building. This would approximate time spent in the extraction building by the extraction operator who had a slightly lower exposure on each shift. Higher values obtained for samples worn by the NIOSH industrial hygienist may have been due to the time spent evaluating hexane leaks.

Results of grab samples collected using certified direct reading detector tubes are presented in Table II. Airborne concentrations ranged from less than 100 ppm to in excess of 3000 ppm. Hexane was always detected for samples collected in the extraction building but often at concentrations below the limit of quantitation of the indicator tube (100 ppm). Most samples collected in the general work area were below 100 ppm. The exceptions to this were samples taken above a waste water tank and near the FDS scrubber as it was flushed with waste water. High airborne concentrations (1000 and 3000 ppm)

were measured in both locations. In addition, high airborne hexane concentrations were detected at several sight glasses on the rotocell extractor. Detector tube readings taken approximately one inch from the surface of sight glasses indicated hexane concentrations ranging from less than 100 ppm to greater than 3000 ppm. Hexane concentrations decreased rapidly as detector tube readings were taken farther away from the sight glass. In one instance a reading taken one inch from a sight glass indicated a hexane concentration of 1000 ppm, while a subsequent reading taken six inches from the sight glass indicated a level below 100 ppm. Extraction operators conducting normal rounds in the extraction building look through the sight glasses to insure the rotocell is operating properly. The operator looks through 15 sight glasses for 10-15 seconds during each round. This results in the operator spending approximately 15 minutes each shift looking through sight glasses. This may expose the operators to high hexane concentrations because their nose and mouth are within one to two inches of the sight glass.

These results indicate that in general hexane concentrations are below 100 ppm but that some work activities (flushing the FDS scrubber, looking through sight glasses) result in very high airborne concentrations (1000 to greater than 3000 ppm).

General Observations

Production during the survey was estimated to be running at the normal rate on the evening shift and slightly above normal during the day shift for the main extraction building. The FDS system was not operating during the NIOSH visit. The reason, according to employees, was that the FDS storage bins were full. Most employees questioned, believed that hexane exposure was worse when the FDS system was operating.

There was a lot of water on the first floor in the extraction building. Steam leaks appeared to be responsible for at least some of the water via condensation on process equipment and/or structural supports. The water presents a slip/fall hazard to employees working in the extraction building.

Two process vessels (the rotocell and desolventizer toaster) may require entry to conduct maintenance and or cleaning. The rotocell is the only vessel that requires entry on a regular basis (2-4 times/year). The desolventizer toaster can usually be cleaned or repaired without entry.

If employees need to enter process equipment it is emptied, if possible, and then purged with air. The supervisor has responsibility for checking the atmosphere before the employee enters. The employees work in three member teams with one employee entering the equipment and the other two remaining by the entrance. The employee who enters is equipped with either a self contained breathing apparatus (SCBA) for short periods (up to 15 minutes) or a hose masked attached to a hand operated blower for longer periods. The atmosphere is evaluated with hexane detector tubes or a combustible gas meter. This technique should be modified by using an oxygen meter in conjunction with a combustible gas meter calibrated for hexane.

The respiratory protection program should also be improved with emphasis on the type of respiratory protection used, and storage and maintenance of the respirators. One of the respirators evaluated was found to be in an unsanitary condition. The respirator was dirty and some metal components were rusty. The respirator, consisted of a hand operated air blower connected to a hose mask (Bureau of Mines approval 1905 A). Hose mask respirators are not approved by NIOSH for atmospheres immediately dangerous to life and health (IDLH).[7,8] This particular respirator is not curently approved by NIOSH for any use.[8,9]

The confined space entry program was thorough in many respects. Some changes are needed however, so that the program meets the requirements of the NIOSH recommended standard for confined space entry. In addition to changing the testing of the confined space's atmosphere, a written emergency rescue procedure should be added to the written program. After being established the procedure should be practiced initially to insure it is feasible and practiced periodically thereafter (at least annually) so that individuals responsible for performing the rescue are proficient at it.[10]

B. Medical

Seventeen operators and 10 maintenance personnel participated in the medical survey; all were men. They ranged in age from 19 to 63 years, but there were two distinct age groups. Nine workers were under 30, and the other 18 were over 45. Time at current job ranged from 1/2 year to 31 1/2 years, with a median of four. Time at the company ranged from one year and two months to 31 1/2 years. Again, there were two distinct groups: 15 employees had been at the company 28 or more years, and the other 12 had been there 16 or fewer years, nine of them five or fewer.

Twenty-five (93%) of the 27 participants reported exposure to grain dust, and 21 (78%) reported exposure to hexane. Twenty-two (81%) reported using a respirator at least occasionally. All but one of

the nine younger employees were operators, whereas half of the 18 older employees were maintenance workers. The younger workers were similar to the older workers with respect to alcohol consumption, but differed with respect to cigarette smoking, the younger workers having a substantially higher ratio of current to former smokers (Table 3).

The most frequently reported symptoms associated (by the respondent) with the extraction process were dizziness, giddiness, and lightheadedness, followed by nasal irritation, eye irritation, headache, weakness, muscle aches, and dry or irritated skin (Table 3). Two workers had numbness of the hands, one had numbness of the feet, and two had numbness in both locations. There was no pattern to the differences in the prevalences of symptoms between younger and older employees, and none of the individual symptom differences was statistically significant. Operators had significantly higher prevalences of sleepiness (41% vs. 0%) and dry or irritated skin (65% vs. 20%) than maintenance workers, but had generally comparable prevalences of other symptoms (Table 4). The questions about symptoms specified no calendar time frame. Indeed, some workers told the interviewers that symptoms occurred only in the past because they have learned to avoid hexane exposure. Symptom frequencies thus represent cumulative prevalences over different periods of time. This may have contributed to the seemingly high prevalence of many of the symptoms.

VII. DISCUSSION AND CONCLUSIONS

Employees working in the extraction building were not exposed to airborne hexane vapors above present environmental criteria on the days this survey was conducted. The extraction operators had the highest exposure. The concentrations obtained during the NIOSH survey are due in part to hexane leaks from process equipment. Correcting these leaks should reduce airborne hexane concentrations. Employees may be exposed to excessively high hexane concentrations during entry into confined process vessels and/or maintenance of process equipment. The most frequently reported symptoms were those consistent with acute exposure to n-hexane.

A study of hexane exposure in another soybean extraction plant was recently conducted by NIOSH. The environmental and medical findings of that study are similar to the results of this investigation.[11]

VIII. RECOMMENDATIONS

1. The respiratory protection program needs to be improved with emphasis on the type of respirators available, and storage and maintenance of respirators. In addition, all respirators should be certified by NIOSH for the atmospheres in which they will be used (i.e. hexane).

2. The FDS system should be evaluated environmentally when operating to determine employee exposure to hexane. If employees are exposed to excessive hexane concentrations, NIOSH approved respirators should be issued to any employee working in the extraction building until hexane levels are reduced to an acceptable level (see recommendation no. 3).

3. Chemical cartridge respirators approved for use in atmospheres containing hexane vapors should be made available to all employees who work in the extraction building. These respirators would be suitable for use during short periods when hexane concentrations are above environmental criteria, and at other times when employees request respirators. These respirators are not suitable for atmospheres containing high hexane concentrations (atmospheres containing more than 1000 ppm hexane/m^3) or in oxygen deficient atmospheres (atmospheres containing less than 19.5% oxygen).[3,10]

4. Management should ensure that the confined space entry program meets the requirements of the NIOSH Recommended Standard for Working in Confined Spaces.[10] In addition, the requirements for respiratory protection presented in A Guide to Industrial Respiratory Protection and the criteria for working in hexane atmospheres (Criteria For a Recommended...Occupational Exposure to Alakanes (C5-C8)) must be maintained.[3,7] Needed changes to the program include:

   a. A new technique to evaluate the atmosphere of the confined space prior to an employee's entry. The hexane detector tubes only establish approximate hexane levels, and give no indication of the oxygen concentration present. The procedure should incorporate the use of a combustible gas meter (calibrated for hexane) in conjunction with an oxygen meter.

   b. A written emergency rescue procedure should be developed and added to the written program.

   c. When the atmosphere in the confined space is IDLH the only respiratory protection accepted by NIOSH is an SCBA or a combination airline and SCBA that always maintains possitive air pressure inside the respiratory-inlet covering.

5. Monitoring of the confined space should continue throughout the entry period to ensure the atmosphere has not deteriorated (i.e. from nonflammable to flammable).

6. All sight glasses on the rotocell extractor should be inspected.

Any sight glass found to be leaking should be repaired. Other equipment in the extraction building should also be inspected for leaks and repaired if necessary.

7. The open wastewater barrel located on the first floor should be covered. Detector tubes used to evaluate hexane exposure indicated high airborne hexane concentrations above this barrel (Table II). This will help reduce airborne hexane concentrations.

8. Steam leaks from the various process equipment should be repaired to reduce the accumulation of water on the first floor of the extraction building. The water represents a slip/fall hazard for employees.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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Dissemination, 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.

1. Ralston Purina Company
2. Grain Millers Union, Local 303
3. Confidential Requestor
4. NIOSH, Region V
5. OSHA, Region V

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

TABLE I

RESULTS OF ENVIRONMENTAL SAMPLING FOR HEXANE
PERSONAL AND AREA SAMPLES

RALSTON PURINA COMPANY
BLOOMINGTON, ILLINOIS
HETA 80-256

November 24-25, 1980

Job and/or Location	Sample Type	Sample Time	Date	Volume (Liters)	Concentration (ppm)
Maintenance	Personal	0737-1553	11/25/80	24.8	4.5
Maintenance	Personal	0735-1558	11/25/80	25.2	4.4
Extraction Operator	Personal	1625-2348	11/24/80	22.2	13.2
Extraction Operator	Personal	0800-1550	11/25/80	23.5	12.6
NIOSH Industrial Hygienist	Personal	0748-1557	11/25/80	24.5	21.0
NIOSH Industrial Hygienist	Personal	1618-2353	11/24/80	22.8	18.3
1st Floor by Waste H_2O Tank	Area	0805-1630	11/25/80	25.3	15.9
6th Floor by Rotocell	Area	0822-1616	11/25/80	23.7	23.3
3rd Floor by D.T. Scrubber	Area	0812-1628	11/25/80	24.8	26.9
5th Floor by Rotocell	Area	0818-1625	11/25/80	24.4	22.6
1st Floor by Waste H_2O	Area	1637-0007	11/24/80	22.5	13.2
6th Floor by Rotocell	Area	1645-2355	11/24/80	22.3	24.1
3rd Floor by D.T. Scrubber	Area	1643-0002	11/24/80	22.0	14.9

Limit of Detection = 0.01 mg hexane per sample

Environmental Criteria (ppm) as an 8-hour or 10 hour (NIOSH) TWA: NIOSH - 100 ppm
ACGIH - 50 ppm
OSHA - 500 ppm

TABLE II

GRAB SAMPLES FOR HEXANE
USING CERTIFIED DIRECT READING DETECTOR TUBES

RALSTON PURINA COMPANY
BLOOMINGTON, ILLINOIS
HETA 80-256

November 24-25, 1980

Location	Time of Sample	Date	Concentration (ppm)
6th Floor, near rotocell	1825	11/24/80	<100
	1830	11/24/80	<100
	2205	11/24/80	<100
	2215	11/24/80	<100
Top of rotocell, at feed conveyor packing gland on drive end[1]	1835	11/24/80	<100
	1845	11/24/80	<100
	2225	11/24/80	<100
1st floor near waste H_2O tank	1950	11/24/80	<100
	1955	11/24/80	<100
	2230	11/24/80	<100
	2240	11/24/80	<100
6th floor by rotocell, north side at sight glass[1]	2040	11/24/80	>3000
	2045	11/24/80	>3000
6th floor by rotocell, south side at sight glass[1]	2050	11/24/80	850
	2055	11/24/80	600
Background sample taken in yard area	2105	11/24/80	ND
6th floor at rotocell, tube approximately one inch from sight glass[1]	1323	11/25/80	1000
Same as above except tube six inches from sight glass[1]	1325	11/25/80	<100
6th floor near rotocell	1340	11/25/80	<100

(continued)

TABLE II (continued)

Location	Time of Sample	Date	Concentration (ppm)
6th floor at rotocell sight glass on east side	1345	11/25/80	<100
1st floor, reading taken over barrel used to hold H_2O coming out of waste H_2O tanks	1530 1540	11/25/80 11/25/80	>3000 >3000
Same as above, except reading taken two feet from top of barrel	1545	11/25/80	<100
1st floor at end of n-hexane preheater	1310	11/25/80	<100
1st floor at drain for FDS scrubber, water/hexane mixture was being flushed through scrubber	1315	11/25/80	1000
Background sample taken southeast of extraction building by gate	1300	11/25/80	trace

ND = Nondetected, no discoloration of the indicating layer in the detector tube.
Trace = Slight discoloration of indicating layer in detector tube.
< = Less than, definite discoloration of indicating layer but length of discoloration below the limit of quantitation (100 ppm).
> = Greater than.
(1) = Readings taken to evaluate potential n-hexane leaks.

Environmental Criteria (ppm):	TWA	Ceiling (15 minute)
	NIOSH = 100 ACGIH = 50 OSHA = 500	NIOSH = 510

TABLE III

RESULTS OF QUESTIONNAIRE SURVEY OF EXTRACTION BUILDING

RALSTON PURINA COMPANY
BLOOMINGTON, ILLINOIS
HETA 80-256

November 24-25, 1980

	Workers under 30 years old		Workers over 45 years old		All Workers	
	Number	%	Number	%	Number	%
Number of workers	9	100	18	100	27	100
Maintenance workers	1	11	9	50	10	37
Cigarette smoking status						
Current smokers	5	56	7	39	12	44
Former smokers	1	11	11	61	12	44
Never smoked	3	33	0	0	3	11
Alcohol consumption						
≤5 drinks/week	5	56	10	56	15	56
6-15 drinks/week	3	33	5	28	8	30
>15 drinks/week	1	11	3	17	4	15
Symptoms						
Dizziness	5	56	15	83	20	74
Giddiness	6	67	14	52	20	74
Nausea or vomiting	0	0	4	22	4	15
Headache	6	67	9	50	15	56
Burning, tearing, or itching of eyes	5	55	10	56	15	56
Dry or sore throat	2	22	7	39	9	33
Sleepiness	3	33	4	22	7	26
Progressive weakness or weakness of legs	4	44	10	56	14	52
Numbness of hands or feet	1	11	4	22	5	19
Muscle aches	4	44	9	50	13	48
Lightheadedness	8	89	12	67	20	74
Nervousness	2	22	6	33	8	30
Itchy, dry, or runny nose	6	67	10	56	16	59
Nose bleeds	2	22	1	6	3	11
Dry or irritated skin	5	56	8	44	13	48
Skin rash*	1	11	3	18	4	15

* - The response to this symptom is absent from the questionnaire of one older worker.

TABLE IV

RESULTS OF QUESTIONNAIRE SURVEY OF EXTRACTION
OPERATORS AND MAINTENANCE WORKERS

RALSTON PURINA COMPANY
BLOOMINGTON, ILLINOIS
HETA 80-256

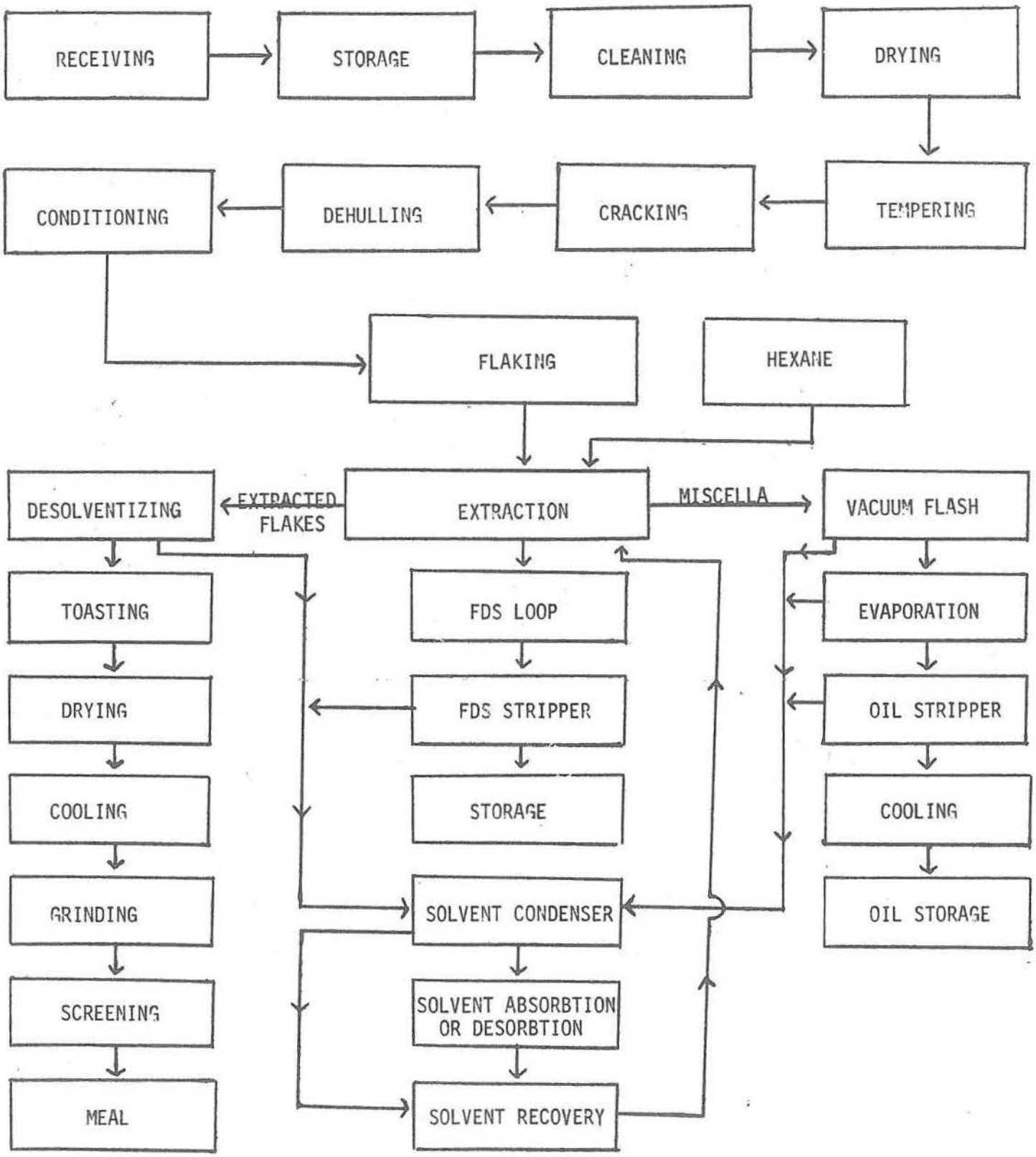
November 24-26, 1980

	Operators		Maintenance Workers		All Workers	
	Number	%	Number	%	Number	%
Number or workers	17	100	10	100	27	100
Cigarette smoking status						
Current smokers	9	53	3	30	12	44
Former smokers	5	29	7	70	12	44
Never smoked	3	18	0	0	3	11
Alcohol consumption						
≤5 drinks/week	9	53	6	60	15	56
6-15 drinks/week	6	35	2	20	8	30
>15 drinks/week	2	12	2	20	4	15
Symptoms						
Dizziness	12	71	8	80	20	74
Giddiness	12	71	8	80	20	74
Nausea or vomiting	3	18	1	10	4	15
Headache	8	47[A]	7	70[A]	15	56
Burning, tearing, or itching of eyes	10	59	5	50	15	56
Dry or sore throat	6	35	3	30	9	33
Sleepiness	7	41[B]	0	0[B]	7	26
Progressive weakness or weakness of legs	8	47	6	60	14	52
Numbness of hands or feet	4	24	1	10	5	19
Muscle aches	9	53	4	40	13	48
Lightheadedness	12	71	8	80	20	74
Nervousness	4	24	4	40	8	30
Itchy, dry, or runny nose	10	59	6	60	16	59
Nose bleeds	2	12	1	10	3	11
Dry or irritated skin	11	65[C]	2	20[C]	13	48
Skin rash*	2	13	2	20	4	15

A - p=0.42, Fisher's exact test, 2-tailed.
B - p=0.026, Fisher's exact test, 2-tailed.
C - p=0.046, Fisher's exact test, 2-tailed.
* - The response to this symptom is absent from the questionnaire of one operator

FIGURE 1

SOYBEAN SOLVENT EXTRACTION PROCESS



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