II. OCCUPATIONAL HAZARDS

Occupational hazards in rendering plants can be divided into three categories: those resulting in mechanical injury, those resulting from physical agents, and those resulting from exposure to, or contact with, biologic and chemical agents.

Hazards Resulting in Mechanical Injury

According to the Bureau of Labor Statistics, the injury and illness incidence rate for the Animal and Marine Fats and Oils Industry (SIC code 2077) in 1977 was 25.0 cases/100 full-time workers (see Table II-1) [7]. Injury and illness rates in these establishments averaged approximately 1.9 times as much and lost workday cases about 2.7 times as much than their respective rates for the manufacturing industries sector between 1972 and 1977.

Although the number of lost-workday cases per 100 full-time workers was higher in animal and marine fats and oils establishments than comparable rates for the manufacturing industries sector, the average number of lost workdays per lost-workday case in these same establishments was lower. Table II-2 shows injury and illness rates for workers in animal and marine fats and oils establishments for 1972-1977. In each of these years, injuries accounted for approximately 96-98% of all reported cases.

The BLS has also recently developed the Supplemental Data System, which has as its source of data the first report of injury or illness submitted by employers and insurance carriers to worker compensation agencies of various states [12]. The source, type of accident, and nature of injury are described for compensable cases in 1977 for animal and marine fats and oils establishments in five states (Tables II-3, II-4, and II-5) [13]. (States with 50 or more total cases a year were selected to establish more reliably the leading causes of injury.) Cross-tabulation of source of injury and accident type, nature of injury with part of body affected, nature and source of injury, and nature of injury and accident type has been provided by these states [14]. These tables allow a more detailed analysis of the accident circumstances. Since the definition of a compensable case differs slightly from state to state, only general conclusions can be made concerning the sources, types of accidents, and natures of injuries in this industry. However, the summary data can help identify the areas in which engineering controls and safety activities need to be intensified and help pinpoint problems that must be solved.

(a) Walking-Working Surfaces

In rendering plants, walking-working surfaces were listed as the source of about 14% of the compensable injuries in the five states (Table

TABLE II-1

OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES PER 100 FULL-TIME WORKERS FOR SELECTED INDUSTRIES, 1972-77

Industry	SIC Code**	Total Cases***	Lost Workday Cases	Nonfatal Cases Without Lost Workdays	Lost Workdays per Lost Workday Case
Manufacturing					
1972		15.6	4.2	11.4	14.9
1973		15.3	4.5	10.8	15.2
1974		14.6	4.7	9.9	15.5
1975		13.0	4.5	8.5	16.8
1976		13.2	4.8	8.3	16.6
1977		13.1	5.1	8.0	16.1
Fats and Oils	207				
1975		19.2	7.9	11.2	19.2
1976		20.9	8.0	12.8	16.7
1977		21.9	9.1	12.8	15.4
Animal and Marine Fats and Oils					
1972	2094	27.2	12.1	15.1	15.0
1973	2094	29.8	12.7	17.1	13.7
1974	2094	28.8	13.5	15.3	14.0
1975	2077	23.8	11.2	12.3	17.4
1976	2077	27.1	13.2	13.8	13.8
1977	2077	25.0	11.7	13.3	14.2

*Incidence rates represent the number of injuries and illnesses or lost workdays per 100 full-time workers and were calculated as (N/EH) x 200,000 where:
N = number of injuries and illnesses or lost workdays
EH = total hours worked by all workers during the calendar year
200,000 = base for 100 full-time-equivalent workers (working 40 hours per week, 50 weeks per year)

**The Standard Industrial Classification Manual--1967 edition was used to categorize the 1972-1974 data; 1972 edition was used for the 1975-1977 data. SIC 2077 became the four digit classification for animal and marine fats and oils.

***Because of rounding and fatality cases there may be a difference between the total and the sum of the rates for lost workday cases and nonfatal cases without lost workdays.

Adapted from references 7-11

II-3), with falls being the most common type of accident resulting from this source (Table II-4). The major factor in this type of accident is the amount of friction between the shoe sole and the working surface. Shoe/working surface friction is affected by floor conditions, floor surface material, and shoe sole composition.

TABLE II-2

OCCUPATIONAL INJURY AND ILLNESS RATES IN ANIMAL AND MARINE FATS AND OILS ESTABLISHMENTS

		Incidence Rates per 100 Full-Time Workers					
		Injuries			Illnesses		
Year	Average Number of Workers (x 1,000)	Total cases**	Lost Work-day Cases	Nonfatal Cases Without Lost Workdays	Total Cases**	Lost Work-day Cases	Nonfatal Cases Without Lost Workdays
1972	NA*	26.3	11.8	14.5	0.9	0.3	0.6
1973	"	29.0	12.4	16.6	0.8	0.3	0.5
1974	"	28.3	13.3	14.9	0.5	0.2	0.3
1975	"	23.3	11.0	12.1	0.5	0.2	0.3
1976	11.2	26.2	12.7	13.5	0.9	0.5	0.3
1977	NA	24.1	11.4	12.7	0.9	0.3	0.6

*NA = Not available

**Because of rounding and fatality cases there may be a difference between the total and the sum of the rates for lost workday cases and nonfatal cases without lost workdays.

Adapted from references 7-11

Grease buildup is the major contributor to unsafe walking and working surfaces. The extent of the hazard depends upon the specific rendering process being employed and the extent to which fat and grease particles are confined within the equipment. While continuous rendering systems are able to confine the fat and grease particles, batch cooker operations are not, especially when the animal material is dumped from the cooker to the perc pan. In this situation exhaust ventilation is needed to pick up and remove the airborne fat particles and water vapor before they settle. NIOSH observed that in plants with grease buildup, the second level floor surface where the fat and grease particles settled was more slippery than the first level floor surface [15].

Injuries from falls were usually sprains and strains, but there were also contusions, fractures, and lacerations (Table II-5) [13,14].

A review of the 1979 First Reports of injury or illness from the five selected states indicated that many slips and falls occurred when workers unloaded grease barrels or dead stock from trucks [16]. Spillage from these barrels during their movement to the hot room caused the smooth metal surfaces of the trucks and the loading dock to become slippery. Secure lids for these barrels would minimize the grease buildup from the spillage. Sometimes grease was dumped onto the floor of the hot room before it was melted; when this occurred the boots of workers spread the grease and, therefore, the hazard to other areas.

The hide processing area was also identified by these reports as another location in rendering plants where there is an increased risk of slips and falls. Workers there lift hides and heavy bags of salt for the curing process.

Good housekeeping will also help minimize the hazards presented by spilled or settled materials that characterize the work environment in some rendering plants. Employer adherence to the general regulations for walking and working surfaces, listed in 29 CFR 1910.22, will reduce hazards by providing for clean, dry, orderly, and sanitary surfaces in addition to sufficiently safe clearances in aisleways where mechanical equipment is used. These aisleways should be kept clear and dry.

Spillage can be minimized by ensuring that scrap carts, conveyors, and containers are not overloaded. Leaking pumps, pipes, and valves should be repaired promptly. When spills occur, the bulk of the fat and other solids may be removed with a shovel, and then the floor should be cleaned with water. As an alternative, absorbents can be used to absorb the grease and fat, and then swept up and discarded. Cleansers should be used to remove any remaining fat and grease. Subsequently, any remaining water or liquid should be mopped up and the surface dried as completely as possible.

The type of floor surface can contribute to unsafe walking and working conditions. Independent rendering plants visited by NIOSH usually used smooth metal floors at the grease barrel unloading dock. While these floors provide the strength to resist damage from 204-kg (450-lb) barrels, they offer little slip resistance [15].

Much use is made of metal plates, of either solid, expanded, or serrated metal, as flooring, stairs, loading dock areas, walkways, and catwalks. The walking-working surface of the solid plate can be finished in a raised pattern to increase its slip-resistance. However, at one rendering plant where an abrasive material was incorporated onto the steel floor to provide more traction, the grease barrels destroyed the finish after only a few days. If the slip-resistant surfaces are vulnerable to barrel abuse, then conveyors or other automatic barrel movers should be considered. At another plant, the plant manager was thinking of installing tracks so he could roll the barrels from the trucks to the hot room, thus avoiding damage to the floor surface [15].

One type of solid rolled steel flooring has impregnated aluminum oxide particles. As the surface wears down, particles of the aluminum oxide are continually exposed to the walking-working surface. This type of plate material may be used as a structural component or laid down over existing flooring of all types [17].

Concrete surfaces, especially those with broom finishes, provide traction in other areas of the plant until they are worn smooth. Concrete floors have marginal wear resistance. Brick floor surfaces present a reasonably slip-resistant surface. Floor brick with a cast-abrasive surface is even better [18].

BLS data and the First Reports suggest that stairs in some rendering plants are particularly hazardous, involving 14 of the 55 working surface cases reported by four of the five states. At the independent rendering plants visited by NIOSH, the stairs always seemed hazardous to climb because they were slippery. At one plant, however, the stairs were made of corrugated metal that provided better traction [15].

The type of footwear worn by workers can contribute to slips and falls. Shoe-working surface friction is affected by the shoe sole and heel composition and contact area [17]. Most neoprene sole and heel materials provide a high degree of slip resistance and are resistant to leaking. Since most areas of (independent) rendering plants present some hazard of slips and falls, workers should be required to wear rubber or neoprene boots, preferably with safety toes. The material from which boot soles are constructed is more important than the sole pattern. A highly slip-resistant material with very little pattern is the safest type of footwear, as it provides greater contact with the floor surface [18].

Adherence to regulations for covers and guardrails will protect workers from the various hazards associated with open pits, tanks, bins, and vats (29 CFR 1910.23). In independent rendering plants, the raw-materials receiving pit is often more than 4 feet (1.2 m) deep and is routinely equipped with conveyors or augers at the bottom to move the material into the grinding system. Raw material is dumped into the pits from dump trucks, flatbed trucks, barrels, and wheelbarrows. Standard guarding is necessary protection at these openings; however, special modifications of a toeboard on the charging side of the opening may be appropriate so it will not interfere with cleanup of raw materials spilled during the charging operation.

TABLE II-3

SOURCE OF INJURY OR ILLNESS (SIC CODE 2077)

Number of Cases Within a State / Percent of Cases Within a State

State:Year	Boxes, Barrels, Containers	Chemicals	Hand Tools	Machines	Metal Items	Vehicles	Wood Items	Working Surfaces	All Other classifiable	Non-classifiable	Total
California: 1977	28	2	8	2	12	16	-	17	42	3	130
	21.5	1.5	6.2	1.5	9.2	12.3	-	13.1	32.3	2.3	100.0
Idaho: 1977	9	4	10	-	10	5	1	13	24	1	77
	11.7	5.2	13.0	-	13.0	6.5	1.3	16.9	31.2	1.3	100.0
Missouri: 1977	12	4	6	1	22	12	1	17	27	12	114
	10.5	3.5	5.3	0.9	19.3	10.5	0.9	14.9	23.7	10.5	100.0
Nebraska: 1977	7	1	16	-	1	2	1	8	24	1	61
	11.5	1.6	26.2	-	1.6	3.3	1.6	13.1	39.3	1.6	100.0
Wisconsin: 1977	5	3	18	2	7	6	3	14	34	4	96
	5.2	3.1	18.8	2.1	7.3	6.3	3.1	14.6	35.4	4.2	100.0
Percent weighted average by source*	12.8	2.9	12.1	1.0	10.9	8.6	1.3	14.4	31.6	4.4	100.0

*The sum of cases from a specific source (column) for the five reported states divided by the sum of cases from all sources for the five reported states, expressed as percentage

Adapted from reference 13

TABLE II-4

TYPE OF ACCIDENT OR EXPOSURE (SIC CODE 2077)

Number of Cases Within a State / Percent of Cases Within a State

State:Year	Struck By or Struck Against	Fall	Caught In or Between	Rubbed or Abraded	Over-Exertion	Contact With Extreme Temperatures	Contact with Radiation, Caustics, etc	Motor Vehicle Accident	All Other Classifiable	Non-classifiable	Total
California: 1977	29	21	11	6	34	13	4	4	7	1	130
	22.3	16.2	8.5	4.6	26.2	10.0	3.1	3.1	5.4	.8	100.0
Idaho: 1977	40	9	6	-	10	4	4	2	2	-	77
	51.9	11.7	7.8	-	13.0	5.2	5.2	2.6	2.6	-	100.0
Missouri: 1977	46	21	6	3	6	8	5	5	6	8	114
	40.4	18.4	5.3	2.6	5.3	7.0	4.4	4.4	5.3	7.0	100.0
Nebraska: 1977	18	9	1	6	12	2	5	1	7	-	61
	20.5	14.8	1.6	9.8	19.4	3.3	8.2	1.6	11.5	-	100.0
Wisconsin: 1977	36	15	3	4	16	2	12	2	4	2	96
	37.5	15.6	3.1	4.2	16.7	2.1	12.5	2.1	4.2	2.1	100.0
Percent weighted average by type of accident*	35.4	15.7	5.6	4.0	16.3	6.1	6.3	2.9	5.4	2.3	100.0

*The sum of cases from a specific source (column) for the five reported states divided by the sum of cases from all sources for the five reported states, expressed as percentage

Adapted from reference 13

TABLE II-5

NATURE OF INJURY OR ILLNESS (SIC CODE 2077)

State:Year	Amputations	Burns	Contusions, Bruises	Cuts, Lacerations	Fractures	Scratches, Abrasions	Sprains, Strains	Occupational diseases	All Other Classifiable	All Non-classifiable	Total
					Number of Cases Within a State / Percent of Cases Within a State						
California: 1977	-	15	10	22	10	4	51	2	1	15	130
	-	11.5	7.7	16.9	7.7	3.1	39.2	1.5	.8	11.5	100.0
Idaho: 1977	-	7	16	19	4	10	17	-	4	-	77
	-	9.1	20.8	24.7	5.2	13.0	22.1	-	5.2	-	100.0
Missouri: 1977	-	8	17	20	7	1	24	4	25	8	114
	-	7.0	14.9	17.5	6.1	0.9	21.1	3.5	21.9	7.0	100.0
Nebraska: 1977	-	4	1	16	7	-	23	3	7	-	61
	-	6.6	1.6	26.2	11.5	-	37.7	4.9	11.5	-	100.0
Wisconsin: 1977	-	3	10	23	7	3	23	16	6	5	96
	-	3.1	10.4	24.0	7.3	3.1	24.0	16.7	6.3	5.2	100.0
Percent weighted average by nature of injury*	0	7.7	11.3	20.9	7.3	3.8	28.9	5.2	9.0	5.9	100.0

*The sum of cases from a specific source (column) for the five reported states divided by the sum of cases from all sources for the five reported states, expressed as percentage

Adapted from reference 13

(b) Boxes, Barrels, Containers, and Dead Stock

In the five selected states, about 13% of the injuries listed were attributed to work with boxes, barrels, and other containers. Another 4% could be attributed to animal products such as carcasses, bones, and hides. Approximately 16% of all accidents were listed as overexertion (Table II-4), which most frequently involves lifting, pulling, or throwing of objects. The most common injury involved sprains and strains, frequently to the back [14].

Rendering plants that process restaurant grease will handle many heavy barrels, and plants that process hides and pet food will handle more dead stock than other plants. Many plants do not handle any dead stock, but plants in the west and midwest process more dead stock than those in other parts of the country. In plants that process hides, lifting, pulling, and throwing injuries involving hides and heavy bags of salt are problems.

A work practice guide for manual lifting has been developed by NIOSH [19]. This guide makes recommendations for controlling various hazards related to unaided symmetric (two-handed) lifting of an object of known weight and size. Quantitative recommendations regarding the safe load weight, size, location, and frequency of handling are presented. In addition to recommendations for the selection and training of workers who must manually handle materials, the guide presents some engineering and administrative controls. The guide will help employers determine which lifting tasks being performed in their plants are unacceptable without engineering controls (above a maximum permissible limit (MPL)); unacceptable without administrative or engineering controls (between the action level (AL) and the MPL) and which are acceptable (below the action level). More detailed information on the maximum permissible limits and action levels can be found in the NIOSH work practice guide for manual lifting [19].

Employers should ensure that hazardous pushing, pulling, and lifting tasks not covered by the NIOSH guide are either performed with the aid of some mechanical device, such as a hoist, or redesigned so that they can be performed safely. While a hoist will reduce the physical hazards associated with manual pushing, pulling, and lifting, it could introduce new physical hazards unless operational guidelines are developed and followed. In some rendering plants, workers clean up under perc pans held up by hoists. Inspection of hoists and their ceiling connections for possible corrosion should be performed frequently. Employers should also consider the use of jacks or posts as safety supports for perc pans.

At one rendering plant visited by NIOSH, workers responsible for unloading grease barrels were aided by a conveyor that moved the grease barrels from the unloading dock to the hot room. After the grease was melted the barrels were automatically turned upside down and emptied. This greatly reduced the manual pushing, pulling, and lifting performed at this plant [15].

NIOSH visited two other rendering plants that handled barrels of restaurant grease. At one of these, workers used hand trucks to move the barrels; at the other plant, because the hoist was inoperative, the workers moved the barrels manually. Minimizing the distance required to move the barrels will also reduce the amount of pushing, pulling, and lifting [15].

Any worker involved in lifting, pushing, or pulling should be required to wear safety-toe footwear. Since these jobs are usually performed on slippery surfaces, the safety footwear should have soles made of slip-resistant material. Safety-toe footwear of the proper type is effective in reducing material handling injuries as well as slips and falls. Recommendations for safety-toe footwear are presented in ANSI Z41.1-1967.

The lids of barrels and other containers are often rough, and cuts and lacerations may result from handling them if gloves are not worn. Workers should be required to wear gloves when handling barrels and other containers.

(c) Hand Tools

Hand tools were listed as the source of about 12% of the compensable injuries in rendering plants in the five states (Table II-3). Renderers use knives and axes, as well as maintenance tools such as wrenches, hammers, and small hand-held power tools including drills, welding torches, and small saws. Cuts and lacerations, most frequently of the fingers and hands, are caused often by hand tools.

The most frequent hand tool accidents in many rendering plants involve knives. In some rendering plants knives are used to skin, gut, and bone carcasses and trim hides. Skinners of dead stock have often injured fingers, hands, arms, thighs, knees, legs, and feet [16]. According to the 1979 First Reports, hide trimmers had similar accidents. These rendering plants should have a knife safety program that includes the use of personal protective equipment and training. The First Reports cited above indicate that when a worker was cutting a carcass every part of his body was vulnerable to knife wounds. The use of personal protective equipment should, therefore, be as extensive as possible.

Other frequent causes of hand tool injuries result from cleavers, axes, and large knives used to reduce the animal carcasses to a size that is amenable to the rendering plant's equipment. Protective equipment including mesh gloves, arm protectors, and abdominal protectors should be used by workers cutting up the carcasses. Knives used in this task should have maximally guarded handles, designed to prevent the hand from slipping onto the blade.

Hand tool-related injuries during maintenance operations can be reduced by the use of personal protective equipment such as safety shoes and gloves and by training workers in the proper use of tools. General industry standards for the use of hand tools are listed in 29 CFR 1910.241-1910.247. Hand saws and other powered tools must be properly grounded, insulated, or enclosed because of the wet conditions that often exist during their use. Powered equipment that uses a constant pressure switch must be chosen, when available, in order to shut off the power when the operator releases the pressure. To protect the eyes from flying particles when grinding, cutting, or sawing, workers should wear appropriate eye protection, such as face shields, safety glasses with side shields, goggles, or a combination.

(d) Powered Industrial Trucks

Vehicles were reported to be involved in about 9% of the injuries (Table II-3). All vehicles used in the industry were included, such as raw material pickup trucks, forklift trucks, and front-end loaders. Vehicle-related accidents occur both in the collection of raw material from butcher shops, restaurants, and meatpacking plants (activities not included in the scope of this document), and in the rendering plants themselves.

Adherence to the regulations for powered industrial trucks listed in 29 CFR 1910.178 will reduce these injuries. They require safety training of operators, installation of mirrors at blind corners, inspection of vehicles prior to use, and the use of only properly maintained equipment.

(e) Metal Items

Metal items such as shafts, discs, and pulleys were involved in about 11% of all compensable injuries in the selected states (Table II-3); most injuries were cuts, lacerations, and contusions [14]. Metal-item-related injuries occurred primarily in the handling of these objects during maintenance in tight quarters and around hot equipment in an uncomfortable (hot and humid) environment. These injuries can be prevented by the use of protective equipment such as safety shoes, gloves, and head protection (hard hats) and the training of workers in proper materials handling techniques.

(f) Machines and Conveyors

Machines such as grinders, cookers, presses, and centrifuges were the source of about 1% of the compensable injuries (Table II-3). These machines are a relatively minor source of compensable injuries in the rendering process. Adherence to the general regulations for machine guarding listed in 29 CFR 1910 Subpart O will continue to protect the operator and other workers from the moving parts of machines.

Rendering plants use screw conveyors (augers) to move material through the process. To prevent workers from coming into contact with moving parts, conveyors should be provided with covers that are either bolted on or electrically interlocked, which ensures that the conveyor will not be operated without proper guards in place. Where screw conveyors cannot be fully enclosed (receiving points and some points of discharge), they should be hooded or guarded by location or other suitable barrier. Start and stop controls should be located and guarded to prevent accidental operation, and a sufficient number of controls should be provided throughout the process area to stop the conveyors in an emergency.

Plant machines and conveyors require maintenance, inspection, cleaning, adjusting, and servicing. Work that requires entrance into, or close contact with, machines or conveyors should not begin until lockout/tagout procedures are followed. NIOSH is preparing a document on controlling maintenance hazards that result from the presence of energy [20]. The recommendations of this document are applicable to industries that use hazardous levels of energy for machines or processes and where maintenance activities could bring workers close to resulting hazards. In these instances, maintenance should only be performed after the energy is eliminated or controlled in accordance with the recommendations.

The employer should be aware of the Federal regulations (29 CFR 1910.179) for the operation of cranes used to repair rendering equipment. Regulations also exist (29 CFR 1910.184) for the selection and inspection of chains used for hoisting. Workers should never attempt to unkink a chain that is under stress.

(g) Hot Objects

Steam and hot water, fat products, and process equipment such as cookers and ring dryers are sources of burns in rendering plants. Burns were reported in about 8% of the compensable cases (Table II-5).

Steam and hot water are frequently used in some rendering plants to hose down equipment and greasy, slippery areas. In some First Reports, workers burned their legs and feet while using steam or hot water to clean their boots [16]. Some workers using cold water-steam mix hoses for hot water operations have been exposed to steam when they mix too much steam with water. Other workers have been burned by steam and hot water because they lost control of hoses during cleanup operations.

Steam and hot water lines should be marked and insulated. Hose used for cold water-steam mixes should be approved for use with steam. Cold water-steam mixes for obtaining hot water can be used only if suitable thermostatically-controlled mixing units are used. Mixing units need to withstand temperatures of 180 F (82 C) at a pressure of 150 psi. To discourage workers from using a hose with water temperatures ranging from 140 to 180 F (60 to 82 C) to wash personal equipment, equipment wash-off stations should be established in the plant. Water temperatures at these stations should be no higher than 120 F (49 C). To eliminate accidents occurring when workers lose control of a hose, steam and hot water hoses should be equipped with pressure-activated nozzles. These nozzles automatically shut off the steam or water when the worker lets go of the nozzle. To prevent hoses from rupturing, frequent inspections should be made to assess the condition of the hose. Mixing valves should also be inspected frequently.

(h) Repetitive Body Motion

When an injury is due to a worker's repetitive motion rather than to what he is doing with an object, bodily motion should be designated as the source of the injury. Research has shown that cumulative trauma disorders of the hand and wrist are a common problem for workers who perform repetitive manual work. In recent years, tendonitis and tenosynovitis have become significant occupational diseases in some industries. In rendering plants, some operations with knives and shovels are repetitive. In Nebraska, bodily motion was listed as the source of 8% of all rendering injuries. Sprains and strains are the most frequent type of injury resulting from bodily motion [14]. There are reports [16] of tenosynovitis in workers who skinned dead stock.

Hazards from Physical Agents

(a) Noise

Workers may be exposed to high noise levels in some rendering plants because boilers, pre-breakers, crushers, disintegrators, and grinding mills can generate noise exceeding 90 dBA (Table II-6).

In 1976, an OSHA inspection of an independent plant found that an operator at a control panel of the inedible rendering operation was exposed to a time-weighted average noise level of 91 dBA during an 8.5-hour exposure. The control panel in this plant was between two cookers, with a hogger (bone crusher) overhead.

Unsuccessful attempts to reduce the noise level included installing rubber pads under motor mounts, maintenance of bearings, installing a curtain to reduce the impact of ground bones on the side of the bin, and separating the metal parts of processing equipment with sound-deadening materials. The successful solution was to install a control booth. The booth is used by the operator to monitor the machinery control panel and to do paperwork. With the doors of the booth closed, readings of 72 to 75 dBA were obtained at times of highest noise generation. Noise levels in this plant are typical for a plant with similar equipment and equipment layout (D Mackenzie, written communication, January 1979).

During NIOSH visits [15] to two independent rendering plants with Duke rendering systems, noise measurements were made. The control panel in one plant was in front of two cookers and closely surrounded by the rest of the process equipment, except for the hammer mill which was in an adjacent room. Noise levels of 91 dBA and 96 dBA were recorded at the control panel and hammer mill, respectively. At the other plant where the hammer mill was completely isolated in a separate room, 81 dBA was measured at the control panel. A different layout of process equipment at this plant was also a factor in the lower noise measurements.

Noise measurements taken 6 feet (2 m) in front of hammer mills at four rendering plants visited by NIOSH ranged from 94 to 106 dBA. These levels contributed to background noise levels at work stations in the plant.

Information has been obtained concerning noise levels near process equipment (Anderson IBEC continuous system) at two rendering plants (A Phifer, written communication, June 1978). The data are presented in Table II-6. With the exception of one location, the reported area noise levels equaled or exceeded 90 dBA. In the boiler area, measurements of 97 and 98 dBA were recorded. The extent of worker exposure to noise at these levels was not recorded. Except for the boiler room, similar noise levels were obtained on a NIOSH plant site visit at another rendering plant with an Anderson system. Noise level measurements taken at cookers and expellers (presses) were usually greater than 85 dBA, but they always included background noise [15].

Engineering controls and preventive maintenance are important elements of noise control. Proper maintenance of bearings, drive gears, rollers, and other moving parts is important in minimizing noise generation. Some noisy equipment may be enclosed and insulated. At some rendering plants visited by NIOSH, the layout of the process equipment, including the complete isolation of the grinding mills in a separate room, provided a work environment without exposure to high noise levels. Mufflers may be used on steam or compressed-air exhausts. Soundproof booths or enclosed control rooms may also be provided for operators in a noisy environment. If noise levels or exposure periods cannot be reduced, warning signs should be posted in the exposure area, and workers in the area should wear hearing protection, such as ear muffs, rubber or foam earplugs, or fiber plugs. Various NIOSH publications contain information necessary for an effective noise control program [21-23]. Noise control should be considered when purchasing new equipment.

(b) Fire

Industry professionals have cited fire as a common danger in rendering plants. The fire hazard rating of rendering plants is high, according to Best's Loss Control Engineering Manual [24], which provides data on the insured loss (fire, workmen's compensation, product liability) of a broad cross-section of industry. Best's rating system is based on the average experience of insurance companies encompassing 90-98% of the premiums written. Batch rendering operations received a rating of 8 on a scale of 0 to 10, with 10 representing the greatest hazard of fires. Older batch plants are more susceptible because they were constructed with wood or other combustible materials. Continuous rendering operations were considered less hazardous, but no numerical ratings were given. Continuous systems are usually installed in new buildings constructed of steel and concrete block or other noncombustible materials (W Prokop, written communication, June 1978).

A leading cause of industrial fires is defective electrical equipment and wiring [25]. Specific problems at rendering plants include improperly grounded equipment, frayed and bared wires, wet material around electrical outlets, and loose and corroded conduit connections. Electrical equipment and wiring should be installed and maintained in accordance with the latest National Electrical Codes. Because of the corrosive nature of the chemicals used and given off in rendering plants, all electrical equipment and wiring should be periodically inspected and tested to detect deficiencies and ensure continued satisfactory performance. Automatic sprinkler or foaming systems can be used effectively for fires in rendering plants, but they must be properly located for maximum efficiency.

TABLE II-6

NOISE-LEVEL MEASUREMENTS AT TWO RENDERING PLANTS*

Location of Noise Measurement	Decibels("A" scale reading)	
	Plant A	Plant B
Pre-breaker	95	93
Disintegrators	96	92
Expellers	93	90
Centrifuge	-	93
Operating floor	94	93
Filter press	-	90
Grinding mill	92	89
Two boilers	97 (1 on)	98 (2 on)
Boiler header steam leak	104	-

*Area measurements; personal monitoring was not performed.

Adapted from A Phifer, written communication, June 1978

Welding and thermal cutting pose a potential fire hazard in confined spaces and rendering plant areas in which grease and other combustible materials have accumulated (A Phifer, written communication, June 1978) [16]. They should be performed under maximum fire-safe working conditions. Grease or other combustible deposits must be removed from the working surface, and sparks should be contained. Fire extinguishing equipment suitable to the plant area should be available in adequate quantities within easy reach (A Phifer, written communication, June 1978).

Excessive heat generated by friction is another major source of fires. Such excessive heat may result from inadequate lubrication, misaligned bearings, and improperly adjusted belt-driven machinery. A program of preventive maintenance that includes frequent inspections can minimize the risk of fires from these sources. Spontaneous ignition may also occur in rendering plants, particularly in the perc pans of the batch cooker systems if rendered material, heated to temperatures above 120 C (250 F), is held in the pan for a prolonged period (eg, overnight) [26]. Fires of this type reportedly can be avoided if the material is processed within 8 to 12 hours after the fat is drained (W Prokop, written communication, December 1979).

Fat mists from cookers may coat the entire inside of a rendering plant. Although fats do not have a low flashpoint, they can be ignited by open flames used carelessly or by uncontrolled heating. If exhaust ventilation is used to prevent the settling of released fat aerosols, the exhaust ductwork must also be kept clean. Exhaust fans should be equipped for automatic shutoff in the event of fire.

Proper operation and maintenance of boilers and other pressure vessels are essential to their safe use. Boilers must be operated in strict conformance with local codes. At a minimum, all pressure vessels should be equipped with rupture discs and vents to prevent explosion.

(c) Heat

Some rendering plant workers (especially those working above hot process equipment) are exposed to hot and humid work environments, particularly during the summer [15,24]. Such exposure may result in heat stroke, heat exhaustion, heat cramps, heat rash, and heat fatigue.

A worker's ability to do his job is affected by working in hot environments. Heat tends to promote accidents due to the slipperiness of sweaty palms, dizziness, or the fogging of safety glasses. Since the frequency of accidents in general appears to be higher in hot environments, it is important to ensure that thermal stress does not make rendering jobs more dangerous [27].

Much heat is created in rendering plants by equipment such as cookers and dryers. Energy conservation efforts that insulate hot equipment and steam and condensate piping will help reduce the heat load in rendering plants. Local exhaust systems at heat sources and general plant ventilation systems can also remove heat and humidity from the work areas (A Phifer, written communication, June 1978) and increase air circulation.

If heat stress is suspected, various means can be used to alleviate it. These means seek to reduce heat storage by the body, either by limiting input heat load, limiting metabolic heat load, or limiting exposure duration. In practice this can be radiant heat shielding, forced air movement, clothing designed to minimize heat absorption and maximize evaporative cooling, and worker rest schedules designed to prevent body temperatures from increasing over the work shift [28].

Intake air, cooled by water-heat exchange, was directed at job stations for workers operating cookers at one plant visited by NIOSH [15]. A NIOSH criteria document on hot environments [28] recommended that newly exposed workers be acclimatized and that exposure time be short. A joint OSHA/NIOSH pamphlet, Hot Environments, is available to give employers and workers an overview of the health hazards of work in hot environments and to alert them to the precautions needed to avoid excessive heat stress [27].

Hazards from Biologic and Chemical Agents

(a) Acute Toxicants, Including Asphyxiants

The anaerobic decomposition of biologic material can produce gases that may accumulate in drains, sewers, tanks, and other confined or enclosed spaces. Fatalities reported by two rendering facilities resulted from an apparent accumulation of toxic gases in confined spaces [29,30]. Since this has not been widely recognized as a hazard in the rendering industry, these episodes are discussed here in detail.

In 1975, workers died at a rendering plant where they were exposed to gases thought to be the result of decomposition of animal material [29,31]. Six men were asphyxiated when a clogged drain was opened, presumably releasing lethal quantities of gaseous products into a confined space.

The animal materials had been delivered by truck, weighed, and dumped into a large holding pit for materials to be rendered [29,31]. After the trucks were unloaded, they were washed out, the drainage entering another pit (for waste collection) below the scales. This pit normally drained into a third, adjoining pit by gravity through a 6-inch drain pipe. However, the drain pipe was thought to have been clogged for 2 to 7 days [29,31].

A maintenance man descended into the third pit to open the clogged drain, spending approximately 20 minutes in the pit with no apparent ill effects [31]. Later, he reentered the third pit to shut off a sump pump but collapsed while attempting to climb out. Five men attempting to rescue him also died after entering the pit. None wore respiratory protection of any kind.

Medical and autopsy findings showed signs of general hypoxia (stated as anoxia [29]) with acute edema of the brain and lungs. Four of the six victims had severe respiratory irritation, and one had a greenish discoloration of the viscera. Lung samples from five of the victims were analyzed by gas chromatograph for entrapped hydrogen sulfide; four lung samples from persons who had died from nonindustrial causes were analyzed as controls. Hydrogen sulfide was identified in all samples from the victims and in none from the controls. In addition, coins and keys in the pockets of some victims were darkened, and an analysis of them was positive for sulfur.

Sludge samples collected from the bottom of the pit were refrigerated on the night of the accident and tested qualitatively for hydrogen sulfide the next morning with lead acetate. The tests were positive [31]. On the day following the accident, lead acetate paper exposed 3 feet (0.9 m) above the sludge was positive for hydrogen sulfide. The toxicology department at Ohio State University collected a 40-liter air sample from the pit on the day after the accident, using a cadmium chloride solution in a midget impinger [31]. Approximately 15 ppm of hydrogen sulfide was found in the sample. Samples collected in Saran bags by NIOSH personnel 2 days after the accident showed traces of hydrogen sulfide (2-3 ppm), but were negative for methane, combustible gases, oxygen deficiency, and oxides of nitrogen.

The investigators interpreted the evidence as indicating that the deaths were probably caused by exposure to gases produced by decomposition of sulfur-containing organic material [29]. On the basis of the medical and environmental findings (symptomatology, pathologic findings, qualitative identification of gases in air and sludge) and of the operational circumstances and history of this episode, hydrogen sulfide alone or a combination of carbon dioxide, methane, and hydrogen sulfide was believed to be the most likely cause [29].

A similar episode was reported recently [30]. Two workers died in June 1980 at a rendering facility of a poultry processing plant where they were exposed to an oxygen-deficient environment or to gases that were thought to have resulted from decomposition of animal material. The two men were asphyxiated when they climbed to the bottom of a 15-foot (meat) overflow holding tank (#2) that possibly contained lethal quantities of gaseous products.

This overflow tank (#2) was filled with chicken parts (head, feet, and viscera) whenever the cooker and another overflow tank (#1) were full. The material placed in the overflow tanks was usually processed within 14 hours. Although the inside of overflow tank #1 was cleaned out at least three times per week, the inside of overflow tank #2, because of its location, was not cleaned out regularly. To give it a clean appearance, however, the outside was cleaned regularly.

The men were requested to enter the tank (#2) to remove roofing material that had fallen into the tank the day before. Both men collapsed and died while inside the tank, neither man wearing respiratory protection of any kind. No autopsies were performed. At high temperatures, the sulfur-containing amino acids in the poultry offal remaining in the overflow tank could have degraded and produced hydrogen sulfide. The roofing material clogged a drain at the bottom of the tank, allowing buildup of any gases that may have formed [30]. The evidence indicates that the deaths could have been caused by hydrogen sulfide exposure produced by decomposition of sulfur-containing organic material.

Details of the toxicologic effects of occupational exposure to hydrogen sulfide and carbon dioxide, and recommendations for workplace exposure limits are given in the respective NIOSH criteria documents [32,33]. Recommendations for entering, working in, and exiting from, confined spaces are given in the NIOSH criteria document Working in Confined Spaces [34]. Adherence to these recommendations will protect health and significantly reduce accidental injury and death associated with entering, working in, and exiting from confined spaces. It will also make the worker cognizant of the hazards associated with his work area and the safe work practices necessary to deal with these hazards.

(b) Infectious Diseases

Although infectious diseases have not been a major hazard in rendering plants in the United States, a few cases of brucellosis, psittacosis, Q-fever and anthrax have been reported. The agents for these diseases are introduced into the rendering environment by infected animal carcasses, but the rendered product is expected to be free of the disease agents because of the high temperature involved in the process. If infection with a zoonotic agent does occur, early diagnosis and treatment will tend to limit the duration and severity of the disease.

Brucellosis is a zoonotic disease transmitted by direct contact with diseased animals (cattle, swine, sheep, goats, horses, and reindeer), by conjunctival exposure, airborne droplet exposure, and ingestion of contaminated material. Brucellosis is characterized by malaise, chills, sweating, body aches, headache, loss of appetite, weight loss, and a fever of 101-104 F (38-40 C). Brucellosis has a fatality rate of 2%, and death is rare in persons with antibiotic treatment. Untreated cases may become chronic [35-37].

In the last 3 years for which data are available, independent rendering plant workers constituted 1.1% (3 of 271) of the brucellosis cases in the United States in 1976 [38], 1.7% (3 of 176) of the cases in 1977, and 5% (8 of 161) in 1978. Other cases may occur among the rendering workers of meat packing plants, but no details are available (M Potter, verbal communication, February 1979; A Kornblatt, verbal communication, February 1981).

Psittacosis is an infectious disease transmitted by direct contact with infected birds (eg, turkeys and pigeons) or the inhalation of dust from their droppings. This disease is characterized by an abrupt onset of shaking, chills, fever, headache, backache, photophobia, and loss of appetite [33-35]. Complications may result, but recovery is the usual outcome. Fatality is rare.

In 1961 and 1973, Langmuir [39,40] reported on 26 cases of psittacosis among 38 workers (68.4%) of an independent rendering plant in Portland, Oregon, during the winter of 1955-1956. Infected turkeys had been chopped into small pieces and blown through a large duct into a vat for steam-pressure cooking. The disease occurred in workers in all job categories in the rendering plant except the truck drivers. The author [40] suggested that the disease was transmitted by the infective aerosol produced by the chopping and blowing of the infected material.

Q-fever is a zoonotic disease transmitted by direct contact with infected animals (eg, cattle, sheep, goats) or the inhalation of dust from their droppings. This disease is characterized by chilly sensations, retrobulbar headache, weakness, malaise, and severe sweating [35,36]. Pneumonitis occurs in most cases, with mild cough and chest pains. The fatality rate of untreated patients is less than 1%, and, for patients treated with antibiotics, it is negligible.

In 1947, Topping et al [41] reported an outbreak of Q-fever among workers in a cattle and hog meatpacking plant in which rendering was also performed. Of 97 workers, 31 (32%) had Q-fever, including 3 of the 4 workers in the lard and tankage areas associated with the rendering process. These workers also assisted in the slaughtering process; therefore, the area of the plant where the infection was acquired could not be established. Three of five workers in the hide-curing area also developed the disease. The remaining cases occurred in the slaughtering and dressing, boning, and sausage areas. The authors concluded that handling the tissues of freshly slaughtered animals in a meatpacking plant can carry a high risk of Q-fever infection.

Anthrax is a zoonotic disease transmitted by the inhalation of spores shed by infected animals (eg, cattle, sheep, horses, and pigs) or by direct contact with the animal. This disease is characterized by headache, nausea, vomiting, and fever [35,37]. Untreated cutaneous anthrax has a fatality rate of 5-20%; with effective antibiotic therapy, however, there are essentially no deaths.

The first case of human anthrax since 1955 was recorded in September 1980 in Colorado. It occurred in a 30-year-old man who had worked with animal carcasses. The man had assisted in skinning animal carcasses at a local rendering plant from August 26-31, during which time he was scratched on the arm by an animal hoof. A lesion and swelling developed; B anthracis was isolated from a wound culture. Surveillance of other workers at this plant has yielded no other cases in humans [42].

Other zoonoses, such as leptospirosis, could presumably occur in rendering plant workers; however, no cases of this disease have been reported in the United States. Several measures can reduce the risk of transmitting these infectious diseases in rendering plants. These include frequent washing of the hands, the provision of separate eating areas, and provision of ventilation control to isolate airflows from raw material or processing areas into final product areas. Wounds should be thoroughly cleaned and receive prompt first aid. Since minor cuts are relatively common in the rendering industry, tetanus immunizations should always be current.

Work areas in rendering plants should have conveniently located handwashing facilities with bowls large enough to minimize splashing. These areas should be supplied with hot and cold running water and should be directly connected to the drainage system. Smoking and eating in work areas of edible-rendering plants is prohibited by the US Department of Agriculture.

(c) Chemical Irritants Affecting the Skin, Eyes, and Mucous Membranes

Chemicals are used in rendering plants mostly for cleaning, to process animal material, treat waste water, and control odors, and in cooling towers and boilers (Table I-1). However, workers are usually only exposed to the chemicals used for cleaning, deodorizing, and water treatment. Generally, these chemicals are alkalies or oxidizing agents and may cause chemical burns or irritation. Inhalation of these agents may result in lung irritation and injury. Skin contact may result in dermatitis.

Injuries from mixing, storing, and applying these chemicals can be prevented if workers are trained to use personal protective equipment and the proper methods of handling chemicals. Full-face shields over chemical splash-type goggles, rubber gloves, rubber boots, rubber aprons, or rubber suits are examples of equipment that may be required. Where workers do their jobs in the presence of vapors or dust, there must be adequate ventilation. This may include a combination of general air ventilation and local exhaust ventilation. Respirators must be available for emergency protection where toxic vapors may be generated from some of the chemicals used in rendering plants (eg, chlorine). If a job requires a respirator, the employer must ensure that the worker is thoroughly trained in its use. Workers should be capable of and responsible for testing for leakage, proper fit, and proper operation of respirators.

If chlorine or other toxic chemicals are used in a rendering facility, special engineering controls and work practices may be necessary. Details concerning safe work practices and engineering controls are presented in the chlorine criteria document [43].

The employer should ensure that all compounds are used only in proper concentrations and in ways suitable for their intended purposes. Procedures must be established for mixing chemicals as recommended by the manufacturer or as developed by qualified plant personnel. In addition, employers should be familiar with all chemicals used, including their physical properties and any associated hazards. They must ensure that chemicals are kept in designated storage areas and that their use is accompanied by proper recordkeeping. Containers of chemicals should be tightly sealed and stored in a dry place. All chemical containers must be labeled.

As indicated in Table I-1, hydrazine may be used as an oxygen scavenger in boiler systems. Hydrazine deserves special attention because it may be absorbed through the skin, is toxic, and is judged by NIOSH to be a potential human carcinogen. A recommended standard, including work practices, is presented in the hydrazine criteria document [44]. Because other oxygen-scavenging chemicals may be used to remove oxygen, the use of hydrazine is unnecessary in rendering boiler systems (W Prokop, written communication, March 1979).

(d) Allergens

Rendering plant workers are exposed to a variety of animal danders, including those of the hair, skin, feathers, and other animal materials. Exposure to airborne animal-dander particles may result in asthma, inflammation of the nasal mucosa, and conjunctivitis. A scratch by a part of a carcass can cause a pruritic wheal and flare response (urticaria) at the site of contact. No data are available to assess the effects of worker exposure to allergens in rendering operations.