

PB84154160

SAFETY INFORMATION PROFILE

Mobile Earth Moving Equipment - Non-Mining

Darrell B. Hunt
Radian Corporation
Occupational Safety and Health Division
1864 South State Street, #200
Salt Lake City, Utah 84115

210-78-0130-0000

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Division of Safety Research
Morgantown, West Virginia 26505

April, 1979

PREFACE

The information in this profile was prepared in accordance with the provisions of NIOSH Contract #210-78-0130-0000 and is only one of twenty-seven Industry Profiles profiles prepared under the contract. The reader should understand that this study is not intended to be an in-depth analysis, but rather, a limited overview of the industry. Each individual profile was prepared by a Profile Manager utilizing approximately 45 hours of professional time. Each profile is a reflection of the available literature, and other information obtained from industry, government, and labor contacts. Information Profiles are primarily intended for use in determining future study needs, priorities and directions. From this preliminary study may come various in-depth studies such as criteria documents, technology assessments, epidemiological studies, etc.

Radian gratefully acknowledges the guidance and direction of Mr. Ted Pettit, Project Officer, and Ms. Pat Gussey, Assistant Project Officer. Radian also thanks the many industry labor and government officials who provided information and assistance on short notice.

Table of Contents

	<u>Page</u>
Title Page	
Preface	
Table of Contents	
Executive Summary	1
A. Standard Industrial Classifications Included	2
B. Process Descriptions	4
C. Potential Hazards	6
D. Existing Hazard Controls	10
E. Accident and Illness Statistics	13
F. Exposure Levels	16
G. Related Studies	22
H. Industry Trends	23
I. Existing Standards	24
J. Names of Industry Associations and Other Interested Parties	29
K. Names and Addresses of Companies	30
L. Summary Analysis of Data	33
References and Sources	34
Appendix	37

EXECUTIVE SUMMARY

Information and data relating to earthmoving equipment operations is lacking and only a minimal amount of study has taken place. Most of the available data and information is extremely out of date and is probably not relative to the industry today. More detailed data is necessary to make an adequate assessment of the extent and magnitude of the hazard to personnel.

The major types of injuries experienced in heavy equipment operations are "strains and sprains". It has been reported that falls while getting on and off the equipment are the major causes of the injuries.

Accidents involving equipment roll-overs have historically been one of the most severe hazards associated with heavy equipment operations. Since the requirement for roll-over protective structures was introduced for earthmoving equipment, the fatality rate has decreased significantly, in fact, a reduction of over 50% in California.

MOBILE EARTHMOVING EQUIPMENT - NON-MINING

A. Standard Industrial Classifications Included

The topic of this profile has been restricted to operations of mobile heavy earthmoving equipment (non-mining) operations. Primarily, the emphasis has been placed on those pieces of equipment used in the heavy construction industry and excludes trenching and excavation.

There are a number of Standard Industrial Classifications (SIC's) listed that possess earthmoving operations as a facet of the total process.(1) These include SIC 1611 - "Highway and Street Construction, Except Elevated Highways"; SIC 1629 - "Heavy Construction, Not Elsewhere Classified (Excluding Highway Construction)"; and SIC 1794 - "Excavating and Foundation Work". There is no SIC code that pertains strictly to earthmoving operations, therefore the use of SIC codes in evaluating the industry from a statistical viewpoint would be virtually a waste of time. The one SIC code that will most often be referred to is SIC 1629 - "Heavy Construction (Except Highways), Not Elsewhere Classified". SIC 1629 includes as a subcategory earthmoving, not connected with building construction. This would include major earthmoving operations in dam construction, dike construction, land leveling and drainage, and reservoir construction.

The types of equipment that have been considered in the study are: scrapers, loaders, bulldozers, off-highway trucks, and graders. Although these pieces of equipment will be referred to specifically on occasion in this document, the majority of the text will deal with earthmoving equipment operations in general.

The numbers of persons involved in earthmoving equipment operations were unpublished in the literature reviewed. The International Union of Operating Engineers has roughly estimated that the number of personnel involved may be somewhere near 200,000.(2)

B. Process Descriptions

Primarily, the term earthmoving operations refers to that of leveling or grading the geography into a flat or sloping surface; removing earth to form a depressed area; building up earth to form a berm, dam, or dike; hauling earth from an unwanted area to that where it is needed; and general clearing and grading of the land to remove rocks and stumps.

Scrapers are used for removing large volumes of earth to another area and rough grading the area that is being lowered or raised. The scraper is pulled by a tractor and consists generally of a bed for collection of the removed earth and a blade extended downward from the front of the scraper bed, which scoops up a set layer of earth and projects it into the scraper bed. Some scrapers (elevator scrapers) are equipped with a conveyor device which transports the removed earth from the blade to the top and rear of the bed.

Loaders may be of the front-end or rear-end mounted bucket. Either way, they are equipped with a hydraulically operated bucket which can scoop up loose earth and load it into a transport truck or hauler. Loaders can also be used to transport small volumes of earth for short distances. The hydraulic mechanics, which control the bucket, allow the bucket to be set at different angles of pitch and also allow the bucket to be lifted

from ground level to a higher elevation. Some models are configured in two separate sections with articulated steering to provide for a tighter turning radius.

Bulldozers are primarily used as clearing equipment for dislodging stumps and rocks and for pushing small volumes of earth around and performing minor rough leveling. The bulldozer is usually a crawler or track type vehicle with a blade mounted in front with limited mobility.

Graders are generally used for leveling or finely grading land that is or has been roughly leveled. A grader is equipped with a blade suspended under the chassis which can be set mechanically to grade with any selected slope or can be set to grade a path of variable widths.

Off highway trucks are large tractor-tired type vehicles which are used to haul removed earth from one location to another. These trucks are usually loaded with a front-end type loader and are emptied at their destination through a rear gate or one in the bottom of the bed.

C. Potential Hazards

(1) Safety

One of the major hazards at a site where a great amount of earthmoving work is done is that of the equipment striking other pieces of equipment or running over personnel on the ground. Equipment moving fast and operating in an unorderly fashion are likely to collide. The potential exists for the equipment to be thrown out of control, especially if the terrain is rough. This is a point to be emphasized for the loader/haulers, because of their proneness to bounce. Bucket loaders are a considerable hazard from the standpoint that the bucket can be moved in any direction. The bucket can potentially hit another piece of equipment and injure the operator or hit a person on the ground. There is a constant danger that any person on the ground near massive earthmoving equipment might be run over, especially when the equipment is being operated in reverse.

Historically, one of the most severe hazards has been the equipment rolling over and crushing the operator while operating on unlevel ground. This hazard is more specific toward tire and wheel type equipment and especially those with higher centers of gravity. The two major causes of turnovers are from operating across too steep of a grade or too near the edge of a trench or embankment. On a steep grade, a wheeled vehicle operating across the slope may hit a bump or hole or the wheels on the downhill side may dig into the ground if the soil is soft, this may cause the center of gravity to shift downhill creating the potential for the vehicle to roll over. Some water trucks have an extremely high center

of gravity when fully loaded, the same holds true for loader/haulers with the full bucket lifted overhead.

Another hazard to operators of earthmoving equipment is running into overhead obstruction such as trees, powerlines, roofs, and earthen overhangs (this is especially relative to loader/haulers). Running into such an obstruction may cause the operator to be injured from a falling object, the cab being ripped off, or electrical shock. Also included in this category is the threat of running over or cutting into an explosive container, natural gas line, or electrical cable buried or partially buried in the ground.

Operators and others on the ground may be injured by falling or flying objects. Equipment operators working under overhanging ledges are susceptible to falling rocks and clods, and in some cases to cave-ins from undercutting the bank too much. Front-end loader operators on equipment without canopies may be struck by dirt and rocks falling from raised buckets, as may persons working close by on the ground. Additionally, equipment without fenders or flaps may throw rocks or clods striking employees in the vicinity.

Injuries occurring while the equipment is sitting still or being mechanically inspected are common. According to safety personnel of the Tennessee Valley Authority the number one cause of injuries among their equipment operators are personnel slipping or tripping while getting on or off the equipment.(3) This may be due to slippery surfaces, inadequate stepping points, or improper hand holds. Other hazards include the bucket or blade falling and crushing the

worker, while performing maintenance or adjustments; a worker being caught in a pinch point of the hydraulic system or the articulated steering system; explosions from static electricity created while refueling; and workers being struck by locking wheel rings that may fly off with great force while a worker is airing the tire.

(2) Health

Health hazards include exposure to both chemical and physical agents. The potential chemical hazards are exposure to engine exhaust gases and the dusts stirred up by the equipment. In the operation of some equipment the exhaust gases are blown out of the stack almost directly into the face of the operator. In most cases the fuel is diesel and the potentially hazardous emissions include carbon monoxide, nitrogen oxides, oxides of sulfur, and particulates, with special attention to the polycyclic hydrocarbon (PAH) class of compounds. PAH compounds in the form of benzo-a-pyrene, a known cancer causing agent, have been identified in diesel exhaust gases.(4)

The main hazard involved with exposure to dusts is the development of silicosis. Silicosis is a fibrotic formation in the lungs resultant from inhalation of silica dust. Silica exposures have been found to be especially significant for push cat operators and some scraper operators.(5) It has been suggested that mechanics may be exposed to asbestos, while working on the brakes of heavy equipment, because the dust created from wearing down of asbestos brake shoes.(2) Asbestosis, a disease resulting from asbestos inhalation, is also a pulmonary fibrotic disease.

The physical agents that may present a hazard to the operators of earth-moving equipment and surrounding workers are noise, heat, and vibration. Most heavy equipment operators are exposed to high levels of engine and other mechanical noise. The major source of noise in the past was identified as straight exhaust pipes. Exposure for long periods of time to high levels of noise may cause hearing damage. Exposure to high levels of heat resulting from the ambient temperature and the heat generated from the engine may cause equipment operators to experience heat exhaustion, heat cramps, or heat stroke. The hazard is most extreme to older, over-weight, and unacclimated persons. It has been suggested that heavy equipment operators may also be exposed to hazards of whole body vibration transferred to the body from the operating equipment. The chronic effects of whole body vibration are not adequately known; however, some studies have reported changes in many physiological functions such as a change in enzyme secretions and nerve conduction velocities.(6)

D. Existing Hazard Controls

Incidents involving a piece of equipment striking another vehicle or person can be limited by several means. Busy operations where there are a number of vehicles operating should have a traffic control plan laid out and should have signals or signal men to control the traffic flow. The speed of equipment can be limited through administrative controls or the use of governors. Loaded equipment should always be given the right of way. Equipment with bi-directional capabilities should be equipped with audible warning signals to alert personnel on the ground of their approach. Audible backing alarms are required for reverse operation or a spotter person must be available. Equipment also should not be started and put into motion until the operator has checked to assure that there are no personnel hidden underneath, in the bucket, or within danger of a pinch point in the mechanical or hydraulic systems.

Controls that exist to prevent severe injury or death from a wheeled vehicle rolling over are reinforced structures built around the operator's position and the use of seat belts on most equipment. Roll-over protective structures (ROPS) are of little use if seat belts are not worn, since the operator would probably be thrown outside of the cage if he was not belted in. Other controls include the training of personnel in proper driving techniques, including limitations of the terrain that may be scaled, techniques to avoid turnovers on slopes near 45°, and avoidance of operating near the edge of trenches and drop-offs. ROPS may also be useful in preventing injury from running into overhead obstructions.

An exhausted effort should be made to identify any underground utilities or any past uses of the land that may have allowed for the burial of hazardous waste. If possible, areas with overhead power lines should be avoided, the power should be shut off, or the equipment operators should be warned and the lines marked or provided with warning signs.

Canopies built over the operators position on the equipment may protect him from objects which could potentially fall from an overhanging ledge or from a loader bucket raised overhead. All operators and ground personnel should wear protective head gear to prevent serious injury. Injury from objects kicked up by the tires or tracks of equipment may be limited by requiring fenders and mud flaps on all equipment and requiring personnel to wear protective clothing (especially safety glasses and hard hats).

Each piece of equipment should be equipped with all stepping or standing surfaces covered with skid free material and proper hand hold bars should be provided. Anytime the equipment is stopped, left unattended, or undergoes repair or inspection the blade or bucket should be rested on the ground and all pinch points should be guarded or locked, e.g., articulated steering frame. Tires on vehicles equipped with locking rings should only be pneumatically pressurized using an extended airchuck with the worker standing off to one side. Refueling by starting the fuel flow only after the nozzle has made contact with the metal filler will eliminate the potential for a static spark and possible explosion or fire. Gloves, safety glasses or goggles, hard hats, and safety shoes are recommended for all operators.

Exposure to exhaust gases in the open environment is totally unnecessary and can be prevented by extending the exhaust stack or relocating the exit point above and behind the operators cab. Exposure to silica can be reduced through enclosing the cab around the operator and providing it with filtered air. Asbestos exposure for equipment mechanics could be reduced through the use of non-asbestos substances in the production of brake shoes. For any of the above inhalation hazards, personnel may be issued respirators temporarily, until permanent controls are completed.

Noise exposure can be controlled by reduction at the source (quiet mechanical noises, install mufflers in the exhaust line, and relocate the exhaust port away from the operator), isolation of the worker (enclose the operator in an insulated cab), provide the operator with earplugs or muffs temporarily, or limit the operator's time of exposure administratively.

The best defense against heat stress is a requirement for healthy acclimated operators. Beyond that, the operator could be placed in an air conditioned cab, provided a salt and water solution for drinking, or given rest breaks routinely to break up his exposure.

Whole body vibration is best reduced by damping the source or isolation of the operator from the source. The vibration source and the operators platform may be separated and only connected by flexible joints, thus reducing the transfer of the vibration through the operators platform and to his body.

E. Accident and Illness Statistics

In data released from the Bureau of Labor Statistics (BLS) covering the year 1975, the heavy construction industry had 62 fatalities per 100,000 full-time workers, nearly 8 times higher than that for workers in other industries.(7) This does not necessarily reflect heavy equipment related fatalities, but it does reflect the severity of the industry that heavy earthmoving operations are a large part of.

Statistical data for illness and injury experienced in heavy earthmoving equipment operations is practically non-existent on a national level, because no single SIC applies. Localized state studies and accident and illness statistics provide us with almost all of the available information.

1977 Oregon work injury and illness statistics reported that 0.2% of all industrial workmen's compensation claims were attributed to earthmoving and highway construction machinery as a major source of injury or illness.(8) The nature of these injuries by decreasing prominence were "sprains and strains" (47%), "bruises and minor crushes" (23%), and "major crushes" (18%). Operators of bulldozers, and excavation or road equipment experienced sprains and strains more than any other injury type (approximately 50% of all injuries). Injuries sustained by these operators were attributed to working surfaces as the major source of injury, while vehicles and machines were listed as the second and third most prominent sources. Heavy equipment mechanics also showed sprains and strains as the largest category of injuries with metal items and working surfaces as the two most popular sources. Tennessee Valley Authority representatives have indicated that falls getting off

and on equipment are the major cause of injuries, which confirms strains and sprains being the major injury type and working surfaces being the major injury source.(9)

A four-year study of fatalities involving bucket loaders (primarily front-end loaders) reported that 29 California workers had been killed by such vehicles between 1964 and 1967.(10) Thirteen deaths occurred in accidents where the loader overturned and twelve of those vehicles were equipped with rubber tires. It is suggested that nearly all of these deaths could have been prevented by ROPS. Five more of the deaths occurred while working under or near overhanging obstructions, again pointing out the need for overhead protection.

Another study conducted in California of roll-over related deaths between 1960 and 1975 showed the following trend in fatalities:(11)

<u>Year</u>	<u>Deaths</u>
1960	13
1961	18
1962	17
1963	18
1964	17
1965	17
1966	23
1967	18
1968	12

1969	15
1970	16
1971	17
1972	10
1973	6
1974	5
1975	7

A safety order was released in 1977 requiring ROPS and safety belts on some types of heavy construction equipment. Looking at the above table it can be seen that a decreasing trend has occurred since 1971.

F. Exposure Levels

Exposure data that was obtained during the course of this project is limited to noise and dust.

Noise and audiometric data were collected at 16 different work sites by the U.S. Public Health Service in 1965.(12) The noise samples that were produced by the various types of equipment studied were collected during normal operation at the operators position. The levels recorded are shown in Figures 1-3. The overall noise levels ranged from 90-120 dB SPL. The scraper-loaders and tractor-dozers produced the highest overall noise measurements. The audiometric (hearing) examinations of the operators showed that their hearing was poorer than that reported for age-matched non-exposed persons, and the loss in acuity increased in magnitude as a function of years of employment, even when age corrected.

Another study performed by the State of Hawaii in 1972 involved the measurement of noise levels on all types of construction equipment.(13) All bulldozers, and front-end loaders produced operator exposure levels greater than 90 dBA. Bulldozers evidenced mean levels in excess of 100 dBA. Noise levels measured are shown in Table 1.

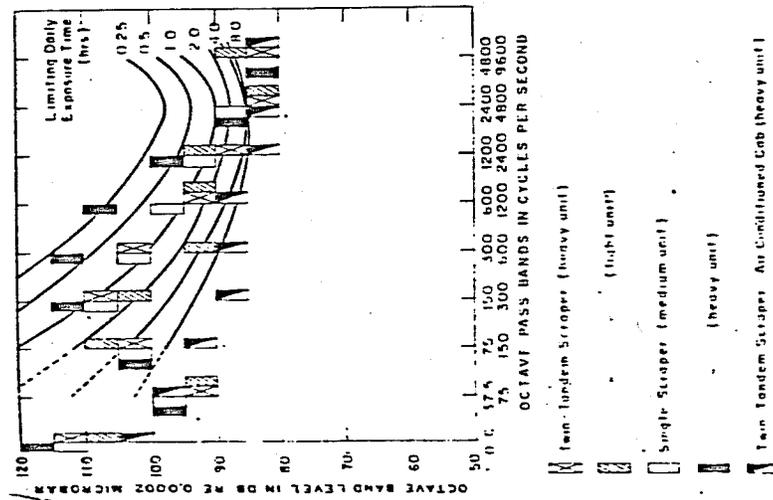


FIGURE 1. Over-all and octave-band levels of operational noise from scraper-loader equipment compared with a proposed safe noise exposure criterion. (12)

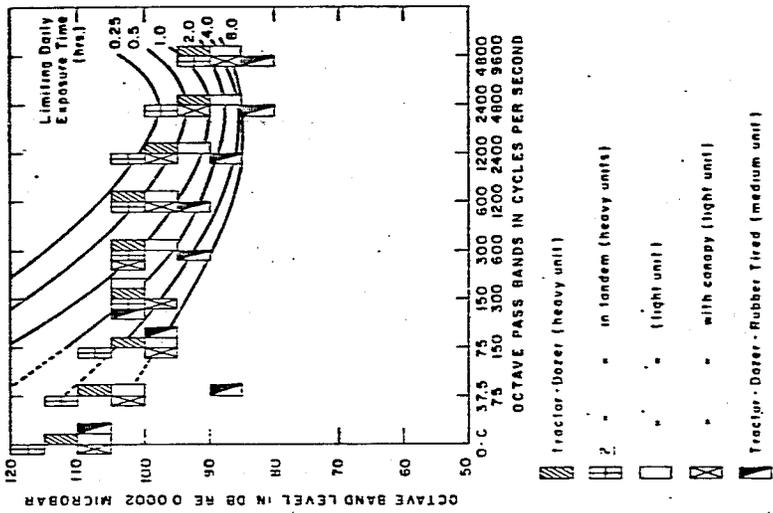


FIGURE 2. Over-all and octave-band levels of operational noise from tractor-dozers equipment compared with a proposed safe noise exposure criterion. (12)

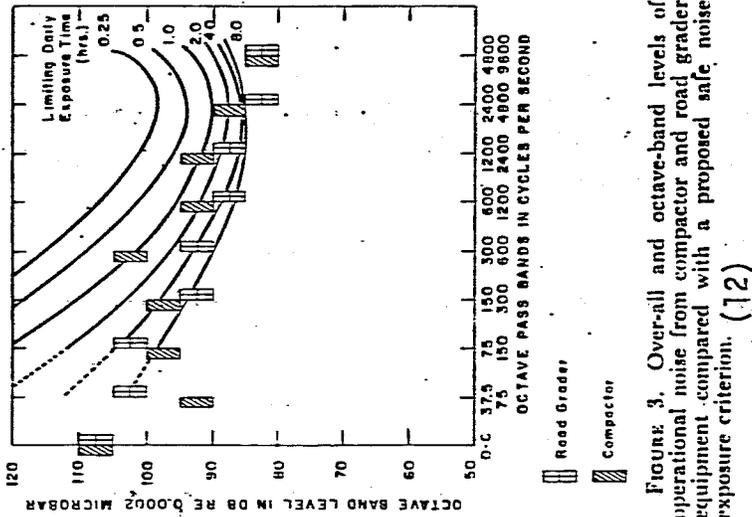


FIGURE 3. Over-all and octave-band levels of operational noise from compactor and road grader equipment compared with a proposed safe noise exposure criterion. (12)



Table 1
DECIBEL (dBA) READINGS OF CONSTRUCTION VEHICLES^a

<i>Category</i>	<i>Manufacturer and Model</i>	<i>Sample Size</i>	<i>Mean dBA</i>	<i>Standard Deviation dBA</i>	<i>P Value^b</i>
BULLDOZERS	Caterpillar D 9	4	108.0	2.94	**
	Caterpillar D 8	2	105.5	0.71	**
	International TD30	2	104.0	0.00	**
	International TD25, TD125 & 500	3	95.0	6.12	
	Total	11	103.3	6.18	**
FRONT LOADERS	GMC Rocker, Trojan 204A, Case 1150, and Hough 400	4	93.7	2.00	*
	Caterpillar 955R, 992 & 998	3	92.8	3.06	
	Total	7	93.0	2.48	**
BACKHOE LOADERS	Case 400	4	91.8	2.02	
	International 3000 & Ford 5500	2	88.8	1.75	
	Total	6	90.8	2.33	
GRADERS	Caterpillar 12E	3	89.7	3.08	
	Caterpillar 12F & John Deere 570	2	88.0	2.00	
	Total	5	88.7	2.66	
COMPACTORS	Caterpillar 825B & Rayon V002	2	98.8	1.06	*

^a All measurements were taken at operator stations unless stated otherwise.

^b P Value = probability or level of significance.

* readings were not significantly higher or lower than 90 dBA (P > .05)

* readings were significantly higher or lower than 90 dBA (0.01 < P < .05)

** readings were significantly higher than 90 dBA (P < .01)

(13)

**Reproduced from
best available copy**

Silica exposures were also measured by the Public Health Service at locations in California in 1965.(5) The levels measured are shown in Table 2 along with a description of the jobsite and the piece of equipment. Operators of pushcats were almost consistently exposed to high silica dust levels, while grader operators received very low exposures.

TABLE 2
RESULTS OF IMPINGER DUST SAMPLES (5)

Description of sample*	Free silica in soil %	Dust**		Description of jobsite
		Safe limit MPPCF	Sample result MPPCF	
1. Upwind air	--	--	0.4	Canal cut. Weather cool, light wind.
2. TSS-40 scraper	49	10	16.3	Water applied to cut and haul road.
3. D-9 Push-Cat	49	10	13.2	Dust barely visible in cut and moderate along haul road.
4. D-9 Ripper-Cat	49	10	10.2	
5. Grader, Cut and haul road	49	10	5.4	
6. Grader, finishing slope	49	10	4.1	
7. D-9 Ripper-Cat (wet soil)	49	10	2.4	
8. TS-14 scraper	49	10	17.4	
1. Tandem coupled D-9 ripper and pusher	29	10	2.6	Borrow pit. Weather cool, light wind. Soil damp from previous rain.
2. Cat 660 scraper	29	10	0.5	Water applied to cut and haul road.
3. Upwind air	--	--	0.5	Dust seldom visible.
1. D-7 dozer	15	20	288	Brush clearing job. Weather warm, visibly very dusty.
2. D-7 dozer	15	20	72	
1. Cat DW-20 scraper	15	20	9.6	Shallow cut. Weather cool, light wind. Water applied to cut and haul road. Dust barely visible.
2. Tandem coupled D-9 pusher and ripper	15	20	12.6	
1. WABCO B-70 scraper	38	10	1.0	Highway grade. Weather warm, light wind. Water applied to cut and haul road. Heavy visible dust near belt loader.
2. WABCO B-70 scraper	38	10	12.0	
3. Cat 660 scraper	38	10	6.0	
4. Front-end loader	38	10	5.0	
5. Cat D-8 pushing belt loader	38	10	48	
1. D-9 Push-Cat	27	10	31.6	Canal cut. Weather cool, light wind. Water applied to cut, fill and haul roads. Visible dust clouds around equipment.
2. Euclid TS-14 scraper	27	10	16.0	
3. D-9 Push-Cat	27	10	26.0	
1. John Deere 5010 scraper	10	20	7.4	Subdivision construction. Weather foggy with light wind. Soil damp, water applied to fill. Little visible dust.
2. D-9 Push-Cat	10	20	21.2	
3. Cat 641 scraper	10	20	5.2	

TABLE 2 (CONT.)
RESULTS OF IMPINGER DUST SAMPLES (5)

Description of sample*	Free silica in soil %	Dust**		Description of jobsite
		Safe limit MPPCF	Sample result MPPCF	
4. FWD-Wagner compactor	10	20	38.2	Subdivision construction. Weather foggy with light wind. Soil damp, water applied to fill. Little visible dust.
5. D-8 towing sheepsfoot	10	20	4.9	
1. HD-21 pusher	34	10	13	Subdivision construction. Weather foggy with light wind. Water applied to haul roads and fill. Moderate visible dust.
2. D-9 pusher	34	10	16.1	
3. AC-562 tandem scraper	34	10	17.9	
4. AC-562 yoked to sheepsfoot	34	10	10.8	
5. Upwind air	--	--	1.3	
1. D-8 pusher	26	10	3.2	Canal cut. Weather clear, light wind. Area heavily pre-wetted. No visible dust.
2. Euclid TS-14 scraper	26	10	2.5	
3. Euclid TS-14 scraper	26	10	0.8	
4. D-8 dozer	26	10	0.8	
1. D-9 pusher	19	20	46	Canal cut. Weather clear, light wind. Soil dry. Heavy dust in cut.
2. D-9 pusher	19	20	22.2	
3. Cat DW-21 scraper	19	20	4.0	
4. Cat DW-21 scraper	19	20	5.1	
1. Front-end loader working broken asphalt pavement	32	10	10.3	Miscellaneous--Weather clear, light wind, dry soil. Heavy visible dust on sample 2. Others, mild visible dust.
2. Front-end loader working loose dry dirt	32	10	61.6	
3. Front-end loader working crushed rock	39	10	24.0	
4. Power shovel working borrow area	23	20	16.8	

*Samples obtained at operator's breathing zone.

**Safe limit from California General Industry Safety Orders.
MPPCF--millions of dust particles per cubic foot of air.

G. Related Studies

Studies related to the material contained in this report have been limited, to those performed by the U.S. Public Health Service in California, as previously discussed. Communication with unions, trade associations, and government agencies indicated that no other studies have been initiated or planned in this occupational area.

H. Industry Trends

There was no available information regarding the specific subject of trends in the earthmoving industry. The earthmoving industry most likely follows the trend of the heavy construction industry, since most large earthmoving operations are directly related to large heavy construction projects. Therefore, the trends of the heavy construction industry are presented.

In 1978 new construction of all types (excluding home building) was up 10% in dollar value and an 8% growth is being forecast for 1979.(14) Heavy construction is expected to rise over last year. Flood control, hydro-electric, and irrigation work are expected to slow down, while sewerage and waterworks projects continue to grow. Waterworks plans have jumped over 200% in the Midwest and 150% in the Mid-Atlantic and Far West regions. Highway construction is expected to only experience a 3% surge in 1979.

Earthmoving equipment has become larger over the past few years and designs in controls for safety and health are being manufactured on the equipment according to statutory requirements.

I. Existing Standards

(1) OSHA Standards

In the past, the construction industry has been overwhelmed by conflicts over which OSHA regulations were applicable to their operations. The construction industry is subject to both 29 CFR 1910, "General Industry Standards", and 29 CFR 1926, "Construction Standards and Interpretations". The construction employer has been obligated to comply with general industry standards (from Part 1910) when specific construction standards (from Part 1910) were not available for an area of concern. This meant that construction employers had to constantly keep up with two sets of regulations and many conflicts arose between industry and OSHA.

A move is currently underway by OSHA to verticalize the standards by removing all applicable portions of 29 CFR 1910 and placing them in 29 CFR 1926. As the first phase of the "verticalization" process, a program directive was established, including a list of all applicable Part 1910 standards, and was endorsed by the Advisory Committee on Construction Safety and Health.(15) The program directive basically stated that OSHA compliance officers would continue to enforce Part 1926 Standards and that they would only enforce those Part 1910 standards that were endorsed as applicable to the industry as listed. Any citation deviating from the list must first be approved by the Regional and National OSHA Offices. A copy of the newly integrated list of applicable standards is provided in Appendix A.

Standards that are of importance to earthmoving operations are listed below:

- 1910.136 - Foot protection
- 1926.52 - Occupational noise exposure
- 1926.55 - Gases, vapors, fumes, dusts, and mists
- 1926.100 - Head protection
- 1926.101 - Hearing protection
- 1926.102 - Eye and face protection
- 1910.134 and
 - 1926.103- Respiratory protection
- 1926.201 - Signaling
- 1926.202 - Barricades
- 1926.601 - Motor vehicles
- 1926.602 - Material handling equipment
- 1926.1000- Rollover protective structures (ROPS) for material handling equipment
- 1926.1001- Minimum performance criteria for rollover protective structures for designated scrapers, loaders, dozers, graders, and crawler tractors
- 1926.1003- Overhead protection for operators of agricultural and industrial tractors
- 1910.1001- Asbestos

The Society of Automotive Engineers (SAE) has indicated that the old ROPS criteria may be inadequate for some heavy equipment, according to a discussion with the OSHA Construction Standards Office.(16) The OSHA standards do not reflect the new SAE criteria, but it was indicated that the standard will be updated.

(2) Environmental Protection Agency (EPA)

The Environmental Protection Agency promulgates standards for pollutants both for acceptable ambient levels and emission levels. Noise is considered a pollutant and attempt to limit the noise emitted would also enhance the protection for the workers against hearing loss. EPA regulations governing off-highway type wheel and crawler tractors are presented in 42 FR 3580-4, July 11, 1977 as reported by the TVA.(17) It was also reported that most of these requirements are being met by the equipment produced today.

(3) American National Standards Institute (ANSI)

The American National Standards Institute (ANSI) is a clearinghouse and coordinating body for voluntary standards activity on the national level.(18) Some 250 ANSI standards have been adopted or referenced in the OSHA standards. Others may simply be useful as standard procedures to follow in daily operations. ANSI standards that are pertinent to earthmoving operations are included within the OSHA standards.

(4) Society of Automotive Engineers (SAE)

The Society of Automotive Engineers (SAE) has published performance criteria for roll-over protective structures on various types of earthmoving equipment and also for seat belts that must be used in conjunction with ROPS.

The applicable standards, as adopted by OSHA are:

- SAE J320a - Minimum Performance Criteria for Roll-Over Protective Structure for Rubber-Tired Self-Propelled Scrapers
- SAE J394 - Minimum Performance Criteria for ROPS for Rubber-Tired Front End Loaders and Dozers
- SAE J395 - Minimum Performance Criteria for ROPS for Crawler Tractors and Loaders
- SAE J396 - Minimum Performance Criteria for ROPS for Motor Graders
- SAE J334 - Protective Frame Test Procedures and Performance Requirements

SAE J167 - Protective Frame with Overhead Protection -
Test Procedures and Performance Requirements

SAE J386 - Seat Belts for Construction Equipment

Additionally, standards have also been set for service braking systems as follows:

SAE J319b - Self-Propelled Scrapers

SAE J236 - Self-Propelled Graders

SAE J166 - Trucks and Wagons

SAE J237 - Front End Loaders and Dozers

(5) Construction Industry Manufacturers Association (CIMA)

The Construction Industry Manufacturers Association has developed voluntary guidelines for the safety of persons operating or maintaining earthmoving equipment. These booklets of guidelines include crawler tractor/loaders, off-highway trucks, wheel-type loaders/dozers, motor graders, and scrapers.

(6) Associated General Contractors of America (AGC)

The Associated General Contractors of America (AGC) have published a safety manual for all areas of construction. Chapter 18 of the AGC Manual of Accident Prevention in Construction is devoted to heavy earthmoving equipment operations.

J. Associations and Other Interested Parties

National Safety Council

444 North Michigan Ave.

Chicago, IL 60611

312-527-4800

International Union of Operating Engineers

1125 17th St. N.W.

Washington, D.C. 20036

202-347-8560

Construction Industry Manufacturers Association

Marine Plaza - 1700, 111 E. Wisconsin Ave.

Milwaukee, WI 53202

414-272-0943

Associated General Contractors of America

1957 E. St. N.W.

Washington, D.C. 20006

202-393-2040

American Federation of Labor and Congress of Industrial Organizations

815 16th St. N.W.

Washington, D.C. 20006

202-637-5000

K. Companies and Other Interested Parties

Kaiser Engineers Division

Kaiser Center

300 Lakeside Drive

Oakland, California 94666

415-271-4257

Houdaille-Duval-Wright Division of
Houdaille Industries, Inc.

998 Riverside Tr.

Jacksonville, Florida 32201

904-356-1951

Hardaway Company

300 East 11th Street

Columbus, Georgia 31902

404-322-3274

Johnson, AI Construction Company

1700 NW Financial Center

Minneapolis, Minn. 55431

612-831-8151

Smith Equipment Company

723 Kent Ave.

Brooklyn, New York 11211

212-522-7100

Steers J. Rich, Inc.

17 Battery Pl.

New York, New York 10014

212-943-3500

The Austin and Company

365 21 Mayfield Rd.

Cleveland, Ohio 44121

216-382-6600

Bently, A and Sons Company

201 Belmont Ave.

Toledo, Ohio 43695

419-244-5561

Drano Corporation - Eastern Construction Division

1800 - One Oliver Plaza

Pittsburgh, PA 15222

412-771-1200

Raymond International Inc.

2801 So. Post Oak

Houston, Texas 77027

713-623-1500

Arkansas Rock and Gravel Company

P.O. Box 6026

Texarkana, Texas 75501

214-838-7581

Basic Construction Company

80 29th Street

Newport News, VA 23607

804-244-7301

Drano Corporation, Western Construction Division

225 108 St. NE

Bellevue, Washington 98009

206-454-2049

L. Summary Analysis of Data

The heavy construction industry, of which earthmoving equipment operations is a part, has a fatality record nearly 8 times higher than the rest of private industry.

Based on 1977 Oregon statistics, approximately 0.2% of all workmen's compensation cases are attributed to earthmoving and highway construction equipment.

The major category of injuries sustained by personnel in earthmoving equipment operations is "strains and sprains". The majority of injuries result from falls getting on or off of the equipment.

Deaths from equipment roll-overs have been reduced by more than 50% since the mid-1960's. Roll-over protective structures are primarily given the credit for this reduction.

Comprehensive injury and illness data for earthmoving equipment operations are not available. It appears that additional work in this area is warranted.

REFERENCES AND SOURCES

- (1) Office of Management and Budget (1972), Standard Industrial Classification Manual, U.S. Government Printing Office, Washington, D.C., 1972, pp. 49,50,51,55.
- (2) Personal Communication with Mr. A. Bennett Hill, Assistant Director of Safety for the International Union of Operating Engineers, February 5, 1979.
- (3) Communication with Mr. David Groves, Assistant Director of the Division of Construction Safety for the TVA, January 11, 1979.
- (4) Environmental Health Associates (1978), "Health Effects of Diesel Exhaust Emissions", performed on contract to the American Mining Congress, Washington, D.C., January 1978, pp. vii,viii,46.
- (5) de Stwolinski (1969), "Occupational Health in the Construction Industry", Technical Report #105, Distributed by the Construction Institute, Stanford University, Stanford, California, May 1969, pp. 34,35,141.
- (6) National Institute for Occupational Safety and Health (1977), Occupational Diseases-A Guide to Their Recognition, U.S. Government Printing Office, Washington, D.C., June 1977, pp. 517,518.

- (7) Wang, Chaoling and Hilaski, Harvey J. (1975), "The Safety and Health Record in the Construction Industry", Monthly Labor Review, U.S. Department of Labor, BLS, March 1978, pp. 3-9.
- (8) ---(1977), "Oregon Work Injuries and Illnesses, 1977", State of Oregon Worker's Compensation Department, Research and Statistics Section, September 15, 1978, pp. 34,46, 71, 77, 78.
- (9) Communication with Mr. David Graves, Assistant Director of the Division of Construction Safety for the TVA, January 11, 1979.
- (10) White, V.L. (1971), "Roll-Over Protective Structures", American Society of Safety Engineers, Vol. 16, No. 7, July 1971, pp. 15-20.
- (11) --- (1976), "Work Fatalities Involving Roll-Over of Earthmoving Equipment", Work Injuries In California Quarterly, State of California Department of Industrial Relations, Division of Labor Statistics and Research, San Francisco, California, November 1976, pp. 1-7.
- (12) LaBenz, P., Cohen A., and Pearson B. (1965), "Noise and Hearing Survey of Earthmoving Equipment Operators", American Industrial Hygiene Association Journal, Vol. 28, No. 2, March-April 1967, pp. 117-127.

- (13) Wayshak, G. (1972), "Construction Equipment Noise is Above Ear Damaging Level". Journal of Environmental Health, Vol. 36, No. 2, October 1973, pp. 147-151.
- (14) --- (1978), "Construction Forecast '79", Construction Contracting, McGraw-Hill, Hightstown, N.J., Vol. 60, No. 12, December 1978, pp. 15-17.
- (15) U.S. Department of Labor Program Directive No. 200-88, October 10, 1978.
- (16) Communication with Mr. David Hadden of OSHA Construction Standards Division, November 1978.
- (17) Personal Communication with Mr. Dave Trayer of TVA, January 15, 1979.
- (18) American National Standards Institute (ANSI), American National Standards for Safety and Health, ANSI, New York, N.Y., October 1978, p. 1.

APPENDIX

APPENDIX A

29 CFR 1926 SAFETY AND HEALTH REGULATIONS
AND 1910 STANDARDS IDENTIFIED AS APPLICABLE
TO CONSTRUCTION WORK

SUBPART A - GENERAL

- 1926.1 Purpose and scope
- 1926.2 Variances from safety and health standards
- 1926.3 Inspections-right of entry
- 1926.4 Rules of practice for administrative adjudications for enforcement of safety and health standards

SUBPART B - GENERAL INTERPRETATIONS

- 1926.10 Scope of subpart
- 1926.11 Coverage under section 103 of the act distinguished
- 1926.12 Reorganization Plan No. 14 of 1950
- 1926.13 Interpretations of statutory terms
- 1926.14 Federal contracts for "mixed" types of performance
- 1926.15 Relationship to the Service Contract Act; Walsh-Healey Public Contracts Act
- 1926.16 Rules of construction
- *1910.11 Applicability of Federal standards
- *1910.12 Construction standards - Part 1926
- *1910.16 Longshoring
- *1910.19 Application of 1910.1001 (Asbestos)

SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS

- 1926.20 General safety and health provisions
- 1926.21 Safety training and education
- 1926.22 Recording and reporting of injuries (Reserved)
- 1926.23 First aid and medical attention
- 1926.24 Fire protection and prevention
- 1926.25 Housekeeping
- 1926.26 Illumination
- 1926.27 Sanitation
- 1926.28 Personal protective equipment

*The 29 CFR 1910 standards identified in the document will be cited where appropriate.

- *1910.132(b)(c) - Employee owned and design of equipment
- *1910.136 Foot protection
- *1910.136 Footwear for employees

- 1926.29 Acceptable certifications
- 1926.30 Shipbuilding and ship repairing
- 1926.31 Incorporation by reference
- 1926.32 Definitions

SUBPART D - OCCUPATIONAL HEALTH AND
ENVIRONMENTAL CONTROLS

- 1926.50 Medical services and first aid
- 1926.51 Sanitation

- *1910.141(a)(2)(v) - Potable water
- *1910.141(a)(5) - Vermin control
- *1910.141(g)(2) - Eating and drinking areas
- *1910.141(h) - Food handling
- *1910.151 Medical services and first aid
- *1910.151(c) - Quick drenching or flushing of eyes

- 1926.52 Occupational noise exposure
- 1926.53 Ionizing radiation
- 1926.54 Nonionizing radiation
- 1926.55 Gases, vapors, fumes, dusts, and mists

- *1910.161(a), (2) - Safety requirements in using carbon dioxide

- 1926.56 Illumination
- 1926.57 Ventilation

SUBPART E - PERSONAL PROTECTIVE AND
LIFE SAVING EQUIPMENT

- 1926.100 Head protection
- 1926.101 Hearing protection
- 1926.102 Eye and face protection
- 1926.103 Respiratory protection

- *1910.94(a)(i)(ii), (5)(i)(ii)(b)(c), (8) - A continuous flow air-line respirator
- *1910.94(c)(3)(i), (4), (7) - Abrasive blasting
- *1910.134 Respiratory protection
- *1910.134(a), (b), (c), (d), (e)(f)(g) - Respiratory protection

- 1926.104 Safety belts, lifelines, and lanyards
- 1926.105 Safety nets
- 1926.106 Working over or near water
- 1926.107 Definitions applicable to this subpart

SUBPART F - FIRE PROTECTION AND PREVENTION

- 1926.150 Fire protection
- 1926.151 Fire prevention
- 1926.152 Flammable and combustible liquids

- *1910.106(a)(22) - Definition of marine service station
- *1910.106(g)(1)(i)(g) - Storage tanks
- *1910.106(g)(4) - Marine service stations

- 1926.153 Liquefied petroleum gas (LP-Gas)

- *1910.110(b)(5)(iii) - Marking container
- *1910.110(d)(1), (2) - Other than DOT specifications
- *1910.110(d)(7)(vii)(a-f) - Installation of storage containers
- *1910.110(d)(7)(viii) - Field welding
- *1910.110(d)(10) - Damage from vehicles

- 1926.154 Temporary heating devices
- 1926.155 Definitions applicable to this subpart

SUBPART G - SIGNS, SIGNALS, AND BARRICADES

- 1926.200 Accident prevention signs and tags
- 1926.201 Signaling
- 1926.202 Barricades
- 1926.203 Definitions applicable to this subpart

SUBPART H - MATERIALS HANDLING, STORAGE, USE,
AND DISPOSAL

1926.250 General requirements for storage

*1910.30(a)(1), (2), (4), (5) - Dockboard requirements

*1910.176(c) - Housekeeping

1926.251 Rigging equipment for material handling

*1910.184(c)(2), (3), (5), (7), (10), (11), (12) - Safe operating practices

*1910.184(e)(3)(i), (ii) - Inspection records

*1910.184(f)(2)(3), (4) - Wire rope slings

*1910.184(h)(2)(3)(iv)(v), (4), (5)(i-iv) - Natural and synthetic fiber rope slings

*1910.184(i)(2), (3), (4), (6), (7), (9) - Synthetic web slings

1926.252 Disposal of waste materials

SUBPART I - TOOLS - HAND AND POWER

1926.300 General requirements

*1910.212(a)(3)(i-iii) - General requirements for machine guards

*1910.212(a)(5) - Enclosure of blades

*1910.212(b) - Anchoring fixed machines

1926.301 Hand tools

1926.302 Power operated hand tools

*1910.244(b) - Abrasive blast cleaning nozzles

1926.303 Abrasive wheels and tools

1926.304 Woodworking tools

1926.305 Jacks - level and ratchet, screw and hydraulic

*1910.244(a)(2)(iii-vi) - Operation and maintenance of jacks

SUBPART J - WELDING AND CUTTING

- 1926.350 Gas welding and cutting
- 1926.351 Arc welding and cutting
- 1926.352 Fire prevention
- 1926.353 Ventilation and protection in welding, cutting, and heating
- 1926.354 Welding, cutting and heating in way of preservative coatings

SUBPART K - ELECTRICAL

- 1926.400 General requirements
- 1926.401 Grounding and bonding
- 1926.402 Equipment installation and maintenance
- 1926.403 Battery rooms and battery charging
- 1926.404 Hazardous locations
- 1926.405 Definitions applicable to this subpart

SUBPART L - LADDERS AND SCAFFOLDING

- 1926.450 Ladders
- 1926.451 Scaffolding

- *1910.28(a)(15) - Material hoisted onto a scaffold
- *1910.28(a)(18) - Work on scaffolds during storms
- *1910.28(a)(20) - Tools, materials and debris accumulation
- *1910.29 Manually propelled mobile ladder stands and scaffolds (towers)
- *1910.29(a) - General requirements
- *1910.29(c)(1)-(7) - Mobile tubular welded section folding scaffolds

- 1926.452 Definitions applicable to this subpart

- *1910.21(g) - Definition of manually propelled mobile ladder stands and scaffold towers

SUBPART M - FLOORS AND WALL OPENINGS, AND
STAIRWAYS

- 1926.500 Guardrails, handrails, and covers

- *1910.23(b)(5) - Guarding of wall holes

- 1926.501 Stairways
- 1926.502 Definitions applicable to this subpart

*1910.21(a)(10) - Definition of wall hole

SUBPART N - CRANES, DERRICKS, HOISTS, ELEVATORS,
AND CONVEYORS

- 1926.550 Cranes and derricks
- 1926.551 Helicopters
- 1926.552 Material hoists, personnel hoists, and elevators
- 1926.553 Base-mounted drum hoists
- 1926.554 Overhead hoists
- 1926.555 Conveyors
- 1926.556 Aerial lifts

SUBPART O - MOTOR VEHICLES, MECHANIZED EQUIPMENT,
AND MARINE OPERATIONS

- 1926.600 Equipment

*1910.176(f) - Rolling railroad cars

*1910.169(a), (b) - General, installation and equipment requirements

- 1926.601 Motor vehicles
- 1926.602 Material handling equipment
- 1926.603 Pile driving equipment
- 1926.604 Site clearing
- 1926.605 Marine operations and equipment
- 1926.606 Definitions applicable to this subpart

SUBPART P - EXCAVATIONS, TRENCHING, AND SHORING

- 1926.650 General protection requirements
- 1926.651 Specific excavation requirements
- 1926.652 Specific trenching requirements
- 1926.653 Definitions applicable to this subpart

SUBPART Q - CONCRETE, CONCRETE FORMS, AND SHORING

- 1926.700 General provisions
- 1926.701 Forms and shoring
- 1926.702 Definitions applicable to this subpart

SUBPART R - STEEL ERECTION

- 1926.750 Flooring requirements
- 1926.751 Structural steel assembly
- 1926.752 Bolting, riveting, fitting-up, and plumbing-up

SUBPART S - TUNNELS AND SHAFTS, CAISSONS, COFFERDAMS,
AND COMPRESSED AIR

- 1926.800 Tunnels and shafts
- 1926.801 Caissons
- 1926.802 Cofferdams
- 1926.803 Compressed air
- 1926.804 Definitions applicable to this subpart

SUBPART T - DEMOLITION

- 1926.850 Preparatory operations
- 1926.851 Stairs, passageways, and ladders
- 1926.852 Chutes
- 1926.853 Removal of materials through floor holes
- 1926.854 Removal of walls, masonry sections, and chimneys
- 1926.855 Manual removal of floors
- 1926.856 Removal of walls, floors, and material with equipment
- 1926.857 Storage
- 1926.858 Removal of steel construction
- 1926.859 Mechanical demolition
- 1926.860 Selective demolition by explosives

SUBPART U - BLASTING AND USE OF EXPLOSIVES

- 1926.900 General provisions

*1910.109(g)(2)(ii)(a-f) - Blasting agents

*1910.109(h)(3)(ii)(a-f) - Slurry mixing fixed location

- 1926.901 Blaster qualification
- 1926.902 Surface transportation of explosives
- 1926.903 Underground transportation of explosives
- 1926.901 Storage of explosives or blasting agents

*1910.109(e)(3)(iii) - Pneumatic loading

- 1926.906 Initiation of explosive charged - electric blasting
- 1926.907 Use of safety fuse
- 1926.908 Use of detonating cord
- 1926.909 Firing the blast
- 1926.910 Inspection after blasting
- 1926.911 Misfires
- 1926.912 Underwater blasting
- 1926.913 Blasting in excavation work under compressed air
- 1926.914 Definitions applicable to this subpart

*1910.109(a)(12) - Definition

SUBPART V - POWER TRANSMISSION AND DISTRIBUTION

- 1926.950 General requirements
- 1926.951 Tools and protective equipment
- 1926.952 Mechanical equipment
- 1926.953 Material handling
- 1926.954 Grounding for protection of employees
- 1926.955 Overhead lines
- 1926.956 Underground lines
- 1926.957 Construction in energized substations
- 1926.958 External load helicopters
- 1926.959 Lineman's body belts, safety straps, and lanyards
- 1926.960 Definitions applicable to this subpart

SUBPART W - ROLLOVER PROTECTIVE STRUCTURES; OVERHEAD PROTECTION

- 1926.1000 Rollover protective structures (ROPS) for material handling equipment
- 1926.1001 Minimum performance criteria for rollover protective structures for designated scrapers, loaders, dozers, graders, and crawler tractors
- 1926.1002 Protective frame (ROPS) test procedures and performance requirements for wheel-type agricultural and industrial tractors used in construction
- 1926.1003 Overhead protection for operators of agricultural and industrial tractors

SUBPART X - EFFECTIVE DATES

1926.1050 Effective dates (general)
1926.1051 Effective dates (specific)

SUBPART INDEX FOR PART 1926

Safety and Health Regulations for Construction

- * - 1910.401-441 Commercial Diving Operations
- * - 1910.1001-1046 Toxic and Hazardous Substances

- *1910.1001 Asbestos
- *1910.1002 Coal tar pitch volatiles; interpretation of term
- *1910.1003 4-Nitrobiphenyl
- *1910.1004 alpha-Naphthylamine
- *1910.1006 Methyl chloromethyl ether
- *1910.1007 3,3' -Dichlorobenzidine (and its salts)
- *1910.1008 bis-Chloromethyl ether
- *1910.1009 beta-Naphthylamine
- *1910.1010 Benzidine
- *1910.1011 4-Aminodiphenyl
- *1910.1012 Ethyleneimine
- *1910.1013 beta-Propiolactone
- *1910.1014 2-Acetylaminofluorene
- *1910.1015 4-Dimethylaminoazobenzene
- *1910.1016 N-Nitrosodimethylamine
- *1910.1017 Vinyl Chloride
- *1910.1018 Inorganic arsenic
- *1910.1028 Benzene
- *1910.1029 Coke Oven Emissions
- *1910.1043 Cotton dust
- *1910.1044 1,2-dibromo-3-chloropropane
- *1910.1045 Acrylonitrile
- *1910.1046(a) Exposure to cotton dust in cotton gins