National Strategy for Personal Protective Technologies Research for the Agriculture, Forestry, and Fishing Sector

A DRAFT Prepared for NIOSH

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This draft is formatted into four parts: an overview, assessment, research plan, and appendixes. The assessment is structured using the five questions that NIOSH is using for its NORA town hall meetings, and the research plan is structured similar to the White House strategy for preventing a pandemic.

Contents

Overview ... 3
Assessment ... 4
1. Who is most at risk? ... 4
Injuries ... 5
Illnesses ... 6
2. How serious is the issue? ... 6
Fatalities ... 6
Farming ... 6
Fishing ... 9
Logging ... 9
3. What research is needed? ... 10
Surveillance ... 10
Technology Assessments ... 11
Intervention Research ... 12
PPE Program Effectiveness ... 12
4. Who are our partners? ... 12
PPE Manufacturing Industry ... 12
Professional and Standard-setting Organizations ... 13
Trade Organizations and Unions ... 14
Governmental Agencies ... 14
5. How can we make a difference? ... 15
Survival Equipment ... 15
First Decade NORA Priorities ... 15
PPE Design ... 16
PPE Program Design ... 16
Research Plan ... 16
Pillar 1. Surveillance ... 17
Goal: To set priorities for further surveillance and research. ... 17
Pillar 2. Standardization and Certification ... 17
Goal: To develop and validate performance-based specifications and standards for PPE. 18
Goal: To establish voluntary standards or 42 CFR certification programs for PPE. ... 18
Pillar 3. Product Development and Evaluation ... 18
Goal: To incorporate advanced protective technologies into fully-integrated, intelligent, and reliable ensembles. ... 18
Goal: To collaborate with partners in the development of PPE to protect workers from high risk, frequency, and/or severity hazards. ... 18
Pillar 4. Education, Training, and Feedback ... 18
Goal: To improve and implement PPE training programs, guidelines, and products for optimum use and acceptance by workers. ... 19
Appendix 1: Agriculture, Forestry, and Fishing Subsector Descriptions ... 20
Appendix 2: Applicable Standards and Standards Setting Organizations ... 22
References ... 25

National Strategy for Personal Protective Technologies Research for the Agriculture, Forestry, and Fishing Sector

"Providing National and World Leadership to Prevent Illnesses and Injuries"

Overview

Every day, in nearly every type of U.S. work setting, personal protective technologies are used to reduce workers' risk of job-related injury, illness, and death. These technologies include personal protective devices such as respirators, chemical-resistant clothing, hearing protectors, and safety goggles and glasses that provide a barrier between the worker and an occupational safety or health risk. In particular, respirators are a required component of many occupational safety and health programs, and may represent a worker's last line of defense against exposure to toxic fumes, vapors, or dust. More generally, personal protective equipment (PPE) is a last line defense after engineering controls.

PPE are tools that ensure the basic health protection and safety of users. PPE is any device designed to be worn by an individual when exposed to one or more safety and health hazards. PPE includes all clothing and other work accessories designed to create a barrier against or restraints from workplace hazards, and using PPE requires hazard awareness and training on the part of the user. Employees must be aware that the equipment does not eliminate the hazard; and if the equipment fails, exposure will occur. To reduce the possibility of failure, equipment must be properly fitted and maintained in a clean and serviceable condition. Personal protective technologies also include devices that provide a worker with early warning of a hazard or otherwise help keep the worker safe from harm, such as sensors that detect toxic atmospheres and communication devices used for safe deployment of emergency workers.

At the request of the Congress, the National Institute for Occupational Safety and Health (NIOSH) established the National Personal Protective Technology Laboratory (NPPTL) in Pittsburgh, PA in 1999.[1] NPPTL focuses expertise from many scientific disciplines to advance federal research on respirators and other personal protective technologies for workers. NPPTL's efforts are essential for applying state-of-the-art science to meet the increasingly complex occupational safety and health challenges of the 21st Century. NPPTL's strategic research program ensures that the development of new PPE keeps pace with employer and worker needs as work settings and workforces change and new technologies emerge. NPPTL research also responds to the need for effective protective technologies for first responders in terrorist events and other disasters. NPPTL incorporates NIOSH's longstanding program for testing and approving respirators for use in traditional work settings.

The NPPTL mission is to prevent work-related illness and injury by ensuring the development, certification, deployment, and use of PPE and fully integrated, intelligent ensembles. This will be accomplished through the advancement and application of personal protective technology standards.

Assessment

1. Who is most at risk?

The agricultural, forestry, and fishing sector covers five major subsectors based upon the North American Industry Classification System: (1) crop production, (1) animal production, (3) forestry and logging, (4) fishing, hunting and trapping, and (5) support activities for agriculture and forestry. The forestry subsector includes logging and wildland fire fighting. This sector presents a new challenge for NPPTL for, worker personal protective equipment (PPE) performance criteria and standards are not clearly defined as other sectors.[2] Using protective equipment, such as seat belts on tractors, and personal protective equipment (such as safety gloves, coveralls, boots, hats, aprons, goggles, face shields) could significantly reduce farming injuries.[3]

OSHA has determined that over the last 20 years agriculture has emerged from the third to the most hazardous industry. The *Occupational Outlook Handbook* published by the U.S. Department of Labor described the following types of employment in the agricultural, forestry, and fishing sector.

Agricultural Workers

- Duties and working conditions vary widely, from raising plants in greenhouses, to harvesting crops and tending to livestock outdoors.
- Farmworkers learn through short-term on-the-job training.
- Most farmworkers receive low pay and perform strenuous work outdoors in all kinds of weather.

Fishers and Fishing Vessel Operators

- More than 50 percent of all workers are self-employed, among the highest proportion in the workforce.
- Many jobs require strenuous work and long hours and provide only seasonal employment.

Forest and Logging Workers

- Workers spend all their time outdoors, sometimes in poor weather and often in isolated areas.
- Most jobs are physically demanding and can be hazardous.

Grounds Maintenance Workers

- Work is seasonal or variable has a significant job turnover.
- Many beginning jobs have low earnings and are physically demanding.

Animal Care and Service Workers

- The work can be unpleasant, physically and emotionally demanding, and sometimes dangerous.
- Most workers are trained on the job, but employers generally prefer to hire people who have some experience with animals.

Injury and illness rates provide a measure of the success of worker protection strategies. Those portions of industry with the highest rates indicate failures in protection and opportunities for

intervention research to improve the safety and health of these workers. Using 2004 data, Table 1 shows the agriculture, forestry, and fishing industry injury and illness rates.

Farmers are at very high risk for fatal and nonfatal injuries. Farming is one of the few industries in which the families (who often share the work and live on the premises) are also at risk for fatal and nonfatal injuries. Approximately 1,859,000 full-time workers were employed in production agriculture in the U.S. in 2003. In an average year, 110 American farm workers are crushed to death by tractor overturns (1992-2000). Every day, about 228 agricultural workers suffer lost-work-time injuries, and about 5% of these result in permanent impairment.

Table 1. List of Agriculture, Forestry, and Fishing Subsectors*

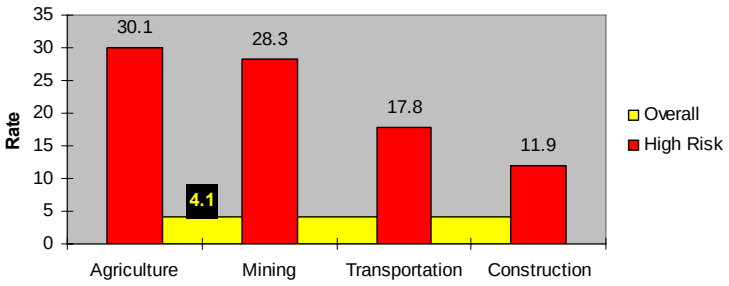
NAICS Code*	Agriculture, Forestry, and Fishing Subsector	Employment 2003	Rates, 2004‡	
			Injury	Illness
111	Crop Production	430,800	5.4	65.7
112	Animal Production	139,300	7.8	31.9
113	Forestry and Logging	72,800	6.0	23.7
114	Fishing, Hunting and Trapping	10,100	1.5	44.0
115	Support Activities for Agriculture and Forestry	311,900	5.1	31.3
11	Total	965,000	5.8	46.3
	All		4.7	30.7

*Excludes farms with fewer than 11 employees; also excludes self-employed workers.
The total employment in this sector in 2003 was 2,209,000.
Red shading indicates above average risk within the sector.

Injuries

In 2003, the agricultural, forestry, and fishing sector experienced 713 occupational fatalities, which was 13% of the total number of occupational fatalities for the Nation.[4] As shown in Figure 1, Agriculture is the highest risk sector for occupational fatalities in the United States.[5] According to a 1993 survey of farms by NIOSH, beef, hog, or sheep operations were found to have the highest number of lost-time work injuries (84,736 injuries) and restricted workdays (1,869,561 restricted workdays). Indeed, in 2004, hog and pig farming had highest occupational injury incidence rate in the nation of all occupations at 10.6 injuries per 100 full-time workers. The average for the nation was 2.5 injuries per 100 employees.[6] Cash grain operations had the second highest number of injuries (33,481 injuries); followed by vegetable, fruit, or nut operations (21,406 injuries). Cash grains operations had the second highest number of restricted workdays (607,160 restricted workdays); followed by dairy operations (318,711 restricted workdays); and vegetable, fruit, or nut operations (204,412 restricted workdays). Workers 30 to 39 years of age reported the highest number of injuries (21.7%).[7]

Figure 1. Occupational Fatality Rate, 2004 (per 100,000 employees)



Illnesses

As shown in Table 2, at or above average rates of illnesses occurred in the crop production subsector. Skin conditions in this subsector were nearly double the average rate for the whole sector. Support activities were above average for respiratory illnesses for the whole sector.

Table 2. Illness Rates per 10,000 Employees in the, 2003

Subsector	Total	skin	respiratory	poisonings	other
Crop Production	65.7	31.0	2.1	3.9	28.7
Agriculture, Forestry & Fishing	46.3	18.5	2.1	2.2	23.5
Fishing, Hunting & Trapping	44.0				
Animal Production	31.9	9.9	1.4		19.9
Support Activities	31.3	9.2	3.1	0.7	18.3
Forestry & Logging	23.7				21.7

Red shading indicates above average risk within the sector.

2. How serious is the issue?

Fatalities

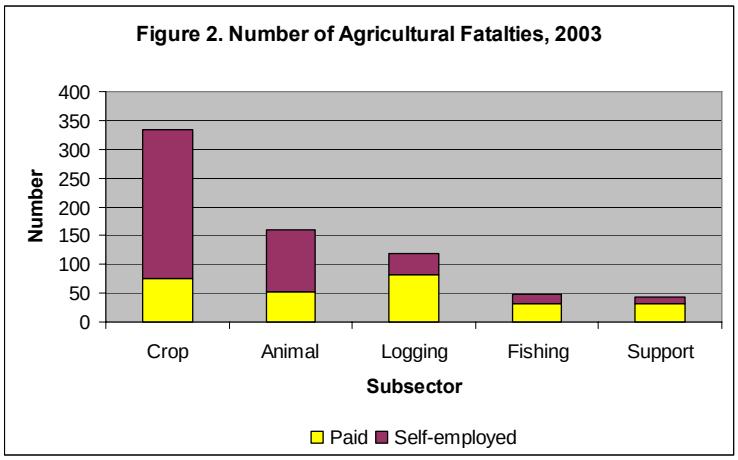
As discussed earlier, this sector now has the highest fatality rate in workplace in the nation. Figure 2 shows the distribution of fatalities by subsector. Crop production has the highest number of deaths with 47% of the total fatalities in the sector, followed by animal production at 22%, then by forestry and logging (logging represents 90% of this subsector) at 17 %, and with the remainder of the fatalities occurring in the fishing and support services subsectors.

In 2003, the fatality rate among all private employees was 4.6 per 100,000 workers in contrast with the fatality rate among workers in farming, fishing and forestry of 31.2 per 100,000 workers—the highest of all occupational categories. When the separate occupations within the category are observed, crop production, animal production, logging, fishing, and support activities had a fatality rate of 36.4, 16.0, 99.2, 99.2, and 25.1 deaths per 100,000 workers, respectively.[8] Pilots that support agriculture have three-times the fatality rate of all pilots based upon hours of flight time,[9] and helicopter logging operations pose significant hazards to not only the pilots but also the loggers that transported by the helicopters to remote sites.[10]

Farming

Self-employed Workers

As shown in Figure 2, most of the workers in the agriculture, forestry, and fishing sector are self-employed. This population of self-employed is not regulated by the government. Moreover, any farm that employs less than 11 workers is not inspected by Federal OSHA compliance officers. More than 70% of the

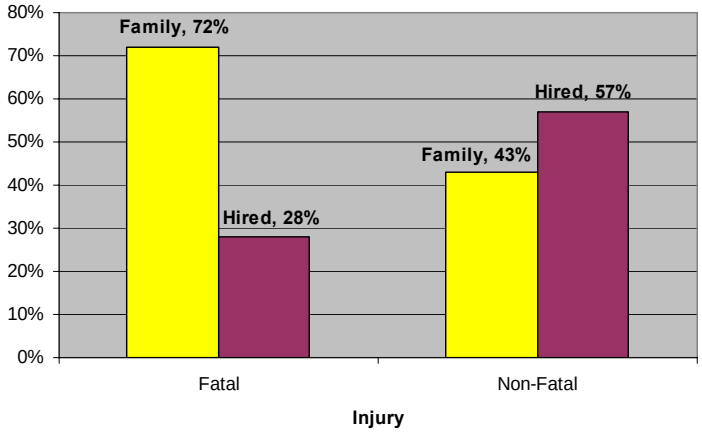


fatalities in this sector occur to self-employed workers as shown in Figure 3. There were 705 incidences of fatal injuries and 50,544 incidences of nonfatal injuries on U.S. farms in 1997. Operators and family members accounted for about 72 percent of the fatal injuries and 43 percent of the nonfatal ones. In terms of injuries per farm, operators and family members were killed at a rate of 0.27 per 1,000 farms and were injured at a rate of 11.4 per 1,000 farms. In comparison, hired laborers were killed at a rate of 0.30 per 1,000 farms reporting hired labor expenditures and injured at a rate of 44.2 per 1,000 farms reporting hired labor expenditures.[11] Family workers accounted for more injuries (131,694 injuries) and more restricted workdays (2,757,223 restricted workdays) than hired workers (59,888 injuries resulting in 606,542 restricted workdays). Family members had higher injury rates than hired workers on most types of farm operations, except nursery, poultry, and dairy operations.

Fatalities

A higher proportion of occupational fatalities occur with farm family members than among hired workers as shown in Figure 3. The deaths on farms (crop and animal production) are associated with the causes shown in Table 3. Farm tractors are responsible for more than half of the fatalities on American farms.

Figure 3. Fatal and Nonfatal Injury by Family Member and Hired Worker, 1997



Days Off Work

Figure 4 shows the higher level of total days off work per 10,000 employees experienced by the agricultural, forestry, and fishing sector as compared to all occupations. Consistently, this sector has a higher lost-time injury rate than the average working population in the United States.

Table 3. Distribution of 542 farm deaths by causative agent

Death Percentage	Causative Agent	Comments (breakdown within agent)
51%	Farm tractors	57% overturns; 9% fall-offs/runovers
11%	Buildings & structures	33% grain suffocation; 13% silo-gas
6%	Farm trucks	Mostly non-highway accidents
4%	Barnyard equipment	e.g. augers, skid loaders
4%	PTO/ power take-off	Drives attachable implements
3%	Electrocutions	Overhead wires only
3%	Haying equipment	Entanglement, especially in round balers
3%	Farm animals	Mostly bulls and horses
15%	Other	

Adapted from Skromme AB. *The First Annual US Farm Accident Report-1986*. Moline, IL, 1988.

Seasonal Nature of Work

Table 4 depicts the intrinsically seasonal nature of many segments of agriculture that not only causes the size of this workforce to vary temporally and often geographically via migrant work groups,[1] but usually has major effects on the nature and intensity of the work itself. The mechanized commodities require minimum manual tending while growing and are also highly automated during harvest. Bush and tree crops require relatively low labor during their growing phases, but require high manual labor during harvest. Raising and tending livestock tends to require frequent labor inputs but has no harvest peak. And row crops are usually labor intensive throughout most of their growing and harvest phases. These generalizations demonstrate agriculture's distinctively wide diversity in intensity and temporal frequency of exposure to hazards, which makes it difficult to generalize about agriculture as a whole.

Figure 4. Days Off Work Because of Injury, Agriculture Compared to All Occupations, Annual Cases per 10,000 Workers, 2003 (BLS data)

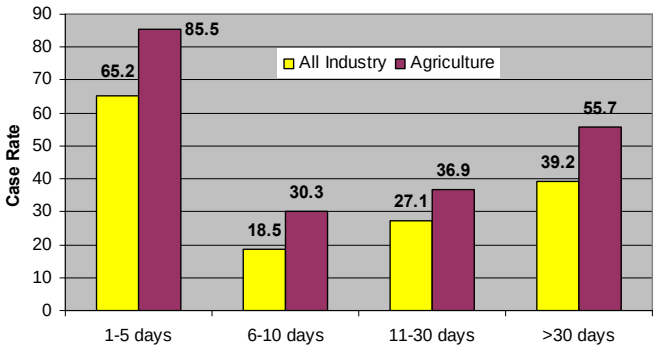


Table 4. Labor Intensity While Growing vs. During Harvest in Production Agriculture

		Labor Intensity During Harvest	
		Low	**High**
Labor Intensity While Growing	**Low**	**Mechanized Crops** (e.g. cotton, grain, processed tomatoes, and nut crops)	**Bush & Tree Crops** (e.g. tobacco, stone fruit, and citrus)
	High	**Livestock** (e.g. cattle, swine, poultry)	**Row Fruits & Vegetables** (e.g. strawberries, lettuce, and flowers)

Source: http://www.osha.gov/SLTC/agriculturaloperations/tables.html#table1

Injury by Event

According to data for the period, 1995 to 1999, 4,093 fatalities has occurred in the agriculture, fishing, and forestry sector at an average annual rate of 23.0 per 100,000 workers. The leading events for these fatalities—horticulture excluded-- among farmers farmworkers, and managers was non-highway transportation events. For groundkeepers and gardeners, the leading event was falls to another elevation, and the leading event for fishers was water vehicle event.[12] For the whole sector, 51% of the fatalities were associated with both highway (12%) and non-highway transportation events, followed by 23% from contact with objects and equipment (12% stuck by object), 10% exposure to harmful substances and environments, and 7% each for falls and violent acts. Two percent were associated with fires or explosions and the remaining 1% was classified as other.

[1] Martin PL, Olmstead AL. The Agricultural Mechanization Controversy. *Science* 227(1985): 601-606.

Children on Farms

An estimated 1.08 million children and adolescents under 20 years of age resided on farms in 2001, with about 593,000 of these youth performing work on the farms. In addition to the youth who live on farms, over 400,000 children and adolescents were hired to work on U.S. farms in 2001. On average, 103 children are killed annually on farms (1990-1996). Approximately 40 percent of these deaths were work-related. In 2001, an estimated 22,600 children and adolescents were injured on farms; 8,400 of these injuries were due to farm work. Children as members of farm families or migrant worker families are potentially exposed to the same hazards as other farmworkers as shown in Table 5.

Table 5. Farmworkers – including farm families and migrant workers – are exposed to several potential hazards

▪ Chemicals/Pesticides	▪ Manure pits
▪ Cold	▪ Mud
▪ Dust	▪ Noise
▪ Electricity	▪ Ponds
▪ Falls	▪ Silos
▪ Grain bins	▪ Slips/Trips
▪ Hand tools	▪ Sun/Heat
▪ Highway traffic	▪ Toxic gases
▪ Lifting	▪ Tractors
▪ Livestock handling	▪ Wells
▪ Machinery/Equipment	

Source: http://www.osha.gov/OshDoc/data_General_Facts/farm-facts-factsheet.html

Fishing

Alaska's commercial fishermen work in one of the world's harshest environments. They endure isolated fishing grounds, high winds, seasonal darkness, very cold water and icing, and short fishing seasons, where very long work days are the norm. Fatigue, physical stress, and financial pressures face most Alaska fishermen through their careers. he hazardous work conditions faced by fishermen have a strong impact on their safety. Out of 862 work-related deaths that took place in Alaska during 1990-2004, one-third (281 cases) occurred to fishermen. This is equivalent to an estimated annual fatality rate of 111 per100,000 workers annually. This fatality rate is 24 times that of the overall US occupational fatality rate of 4.6 per100,000 workers annually for the same time period. Since 1990, there has been a 76 percent decline in deaths to commercial fishermen in Alaska due in part to the U.S. Coast Guard implementing new safety requirements in the early 1990s. These safety requirements contributed to 96 percent of the commercial fishermen surviving vessel sinkings/capsizings in 2004, whereas in 1991, only 73 percent survived. There is a continuing pattern of losing 20 to 40 vessels every year in Alaska with about 100 fishermen who are rescued each year.

Logging

Over the 10-year period 1980-89, 1,492 or more deaths occurred in the logging industry, where the average annual fatality rate is more than 23 times that for all U.S. workers (164 deaths per 100,000 workers compared with 7 per 100,000). Most of these logging deaths occurred in four occupational groups: logging occupations (for example, fellers, limbers, buckers, and choker setters), truck drivers, general laborers, and material machine operators. An estimated 59% of all logging-related deaths occurred when workers were struck by falling or flying objects or were caught in or between objects. Approximately 90% of these fatalities involved trees, logs, snags,

or limbs.[13] Logging operations are associated with felling and moving trees and logs from the stump to the point of delivery, and may include marking danger trees, felling, limbing, bucking, debarking, chipping, yarding, loading, unloading, storing, and transporting machines, equipment and personnel to, from and between logging sites. The tools and equipment used in logging, such as chain saws and logging machines pose hazards wherever they are used. As loggers use their tools and equipment, they are dealing with massive weights and irresistible momentum of falling, rolling, and sliding trees and logs. The hazards are even more acute when dangerous environmental conditions are factored in, such as uneven, unstable or rough terrain; inclement weather including rain, snow, lightning, winds, and extreme cold and/or remote and isolated work sites where health care facilities are not immediately accessible. The combination of these hazards presents a significant risk to employees working in logging operations throughout the country, regardless of the type of timber being logged, where it is logged, or the end use of the wood. OSHA and NIOSH (http://www.cdc.gov/niosh/injury/traumalog.html) have information on their web sites related to forestry/logging that includes injury and fatality reports. The forestry and logging subsector has 159 annual lost-time cases of sprains and strains per 10,000 workers as compared to 69 cases for agricultural, forestry, and fishing sector and 64 cases for all occupations.

3. What research is needed?

Surveillance

There is a need to identify and prioritize agriculture, fishing, and forestry technologies for PPE research. More detailed investigations through surveillance methods are needed to identify and prioritize agricultural, forestry, and fishing technologies for research. These investigations include disaggregating the high risk areas in agriculture, fishing, and forestry by the various conditions indicated in Tables 1 and 2. An important part of the surveillance activity is to collect data on self-employed workers as well as employees.

PPE interventions can be identified by conducting case studies of investigation reports by OSHA and by NIOSH in their Health Hazard Evaluations (HHE's) and Fatality Assessment and Control Evaluation (FACE) Programs. In addition, National Transportation Safety Board and U.S. Coast Guard investigation reports are resources available for identifying PPE needs.

OSHA provides a rich source of recorded injuries that could be prevented with the use of PPE. As an example, a dairy farmworker lost a fingertip from a valve actuating.[14] An example of an HHE is an investigation of workers exposed to airborne microorganisms from compost.[15] The NIOSH FACE program investigates occupational fatalities, many of which could be prevented by the use of functional PPE. An example of a FACE report is the asphyxiation of a farmer for lack oxygen in a silo.[16]

U.S. Coast Guard produces investigation reports of marine casualties. On March 15, 2006, the Coast Guard rescued three fishers in the North Atlantic; all three were wearing survival suits and were able to board a life raft after their vessel sank in 15 waves and 40 degree F water.[17]

Technology Assessments

Respiratory protective equipment technologies and products available to this sector are well defined. Materials technology for protective garments for pesticide application is an area needing investigation, hazard assessment, materials development, design configuration, prototyping, laboratory human subject testing, field evaluation and standards development. Dermal hazards from pesticides are an area needing investigation. Currently available worker protective garments for continual and one-time use are not appropriately designed for agricultural workers in warm/humid climates.[18] Woven fabrics were evaluated against three pesticide mixtures of atrazine and pendimethalin and showed that fabric thickness, cover factor, yarn twist factor and yarn packing factor can be used to estimate air permeability of woven fabric.[19] Hydrogen cyanamide is used in agriculture as a plant growth regulator and personal protection research is needed to prevent severe irritation and ulceration of the eyes, skin, and respiratory tract while applying this chemical to vegetation.[20] Agriculture, forestry, and fishing have replaced manufacturing in recording the highest incidence of occupational skin disease since 1996.[21]

Workplace deaths related to commercial fishing involve mostly falls overboard (drowning and hypothermia) and from trauma caused by equipment on deck. Hospitalized injuries are often related to falls on deck, entanglement in machinery, or being struck by an object.[22] The use of personal floatation devices, particularly immersion suits, in surviving cold-water events indicates that many deaths in commercial fishing could have been survivable.[23]

The complex farm environment presents a continuous threat to the lungs, which has worsened with the increased use of confinement buildings for poultry, hogs, and cattle.[24] The dairy industry is in need of protective equipment to prevent falls on slippery surfaces and to protect eyes, face, and hands during the application of strong detergents.[25] In a study of the severity of construction falls, fatal injuries occurred predominantly on farms without the use of passive personal fall protective equipment (safety net, lifeline, etc.).[26] Women working 1 to 20 hours per week have been found to be less likely to wear seat belts on tractors; using hearing, eye, or breathing protection; and wearing gloves or boots than women working more than 20 hours per week.[27] Noise hazards identified on farms included tractors without cabs, workshop tools, small motors (e.g., chainsaws, augers, pumps), manual handling of pigs, shearing sheds, older tractors, and heavy machinery such as harvesters, bulldozers, and cotton module presses.[28] Restraint devices such as seatbelts on tractors for keeping operators in their seats during overturns, collisions, or rough conditions have been borrowed from automobile technology, and have not been designed for the conditions found in farming.[29]

Wildland fire fighting operations include the activities of fire suppression and property conservation in forest, bush, grass, and ground cover that is not within structures but involved with fire. Wildland fire fighting PPE is more specialized in the area of protective ensembles. Respiratory protection for wildland fire fighting has been a topic of controversy. NIOSH is presently conducting respiratory effects research related to wildland fire fighting. The development of respiratory protective equipment that provides inhalation protection, and is acceptable to wildland firefighting community, is a technical challenge. Protective ensemble materials technologies and design improvements are similar to the other sectors. Protective garments offering required physical protection and flame/heat resistance, while enhancing

breathability to minimize the negative effects of heat stress, is a research and development opportunity.

Hazards and PPE for agricultural, forestry, and fishing workers include;

- Lung and respiratory protection (inhalation) – dust/mold, chemicals/pesticides, fuel fumes, welding fumes, organic dust, manure gases, storage in bins, tanks and silos
- Skin and dermal protection – protective clothing and garments during application on toxic and irritating chemicals and pesticides and use of cleaning solvents
- Hand protection – job matched gloves and barrier creams
- Foot Protection – safety shoes and boots with non-slip soles and heels
- Head injuries and protection – hard hats, riding helmets
- Eye injuries and vision protection – protective eyewear, welding helmets
- Hearing protection – acoustic earmuffs and plugs
- Drowning protection – personal flotation devices, survival suits
- Electrical protection – insulated gloves, clothing, tools
- Rollover protection – restraint devices
- Fire protection – respiratory protection, survival cover, garments, boots, and gloves
- All-terrain vehicles – helmets, restraints
- Remote locations/working alone – emergency calling equipment, self-administered first-aid, survival equipment for harsh environments.
- Sprains and strains – musculoskeletal protective equipment.

Intervention Research

A need also exists for developing PPE interventions to address the gaps and develop efforts for broad adoption of successful PPE interventions in targeted agricultural, forestry, and fishing technologies. Table 6 gives an overview of injurious and physical agents, biological and chemical agents, and diseases of concern in agriculture. This array of agents and health hazards is characteristic of agriculture. The health implications of many chemical agents are already well known. However, for various reasons the traditional industrial hygiene phases of recognition, evaluation, and control of health and safety hazards in agriculture have lagged behind those in general industry.

PPE Program Effectiveness

Many of the injuries and illnesses in the agricultural, forestry, and fishing sector could be prevented through an effective PPE program. Thus, not only the improvement of PPE is important, but the use and maintenance of PPE is also important. PPE programs need to be improved including appropriate training of workers in PPE use and maintenance. Moreover, since such a high proportion of workers in this sector are self-employed and many are migrant workers, methods to access, inform, and serve self-employed workers is also needed.

4. Who are our partners?

PPE Manufacturing Industry

The International Safety Equipment Association represents the safety equipment manufacturing industry and promotes the increased use and awareness of PPE. Members

of the association include companies that design, manufacture, and supply safety equipment that is used in hazardous work environments. It also drafts national and international safety equipment performance standards, provides a forum for discussing industry issues such as non-proprietary technologies and e-commerce, and represents the industry's interests before governmental agencies. The *Best's Safety & Security Directory* also provides a compilation of PPE manufacturing and distribution companies,[30] which is a source for potential collaboration in specialty areas. A principle source to farmers for PPE is catalog services such as Gemplers at http://www.gemplers.com/.

Table 6. Alphabetical listing of recognized hazards and diseases related to agriculture.

Safety & Physical Agents	Biological & Chemical Agents	Agricultural Diseases
Commodity storage & transfer **Electricity** **Ergonomics** • Back injury • Lifting • Repetitive trauma **Farm machinery** • Balers • Chain saws • Combines • Power take-off (PTO) • Roll-over protection • Safety guards • Tractors **Fire** **Fuel storage (leaks and fires)** **Illumination (poor lighting)** **Lightning (shock and fire)** **Liquefied Propane [LP] gas** **Liquefied anhydrous ammonia** **Livestock handling injuries** **Physical/environmental hazards** • Noise • Thermal (heat and cold) • Ultraviolet (sun light) • Vibration • Psychological stress • Sanitation (field) • Transportation (on & off road) • Welding	**Asphyxiation/suffocation** • Confined space • Entrapment • Fumigation • Carbon Monoxide (combustion) • Silo gases (NO_2 and CO_2) **Detergents** **Diesel exhaust** • Disinfectants including • Chlorine • Quaternary ammonia compounds • Organic iodides • Cresol-based compounds • Formaldehyde emitters **Dusts** (inorganic aerosols) **Hydrogen sulfide** (a key manure gas) **Microbiologic organisms** • Infectious microbes • Mold spores (mycotoxins) • Noninfectious bioaerosols • Parasites **Nitrogen dioxide** (silos & welding) **Organic dusts** - e.g. • Cotton dust • Endotoxin (on many organic dusts) • Grain dust • Sugar cane (bagassosis) • Wood dust **Pesticides** (including application and harvest activities)	**Arthritis** **Dermatoses** - caused by • Heat • Irritant chemicals • Infectious microbes • Insects • Sensitizing chemicals • Sunlight **Noise Induced Hearing Loss** **Immunologic diseases** • Allergic rhinitis • Asthma • Dermatoses **Noninfectious diseases** • Cancer (is actually a low risk) • Hypertension and heart • Respiratory diseases • Asthma (also immunologic disease) • Bagassosis (from sugar cane) • Bronchitis • Byssinosis (from cotton dust) • Farmer's Lung (see also HP below) • Hypersensitivity pneumonitis • Organic dust toxic syndrome (ODTS) • Pneumoconiosis (e.g. silicosis) • Silo filler's disease (see also NO_2) **Organophosphate poisoning and sequelae** **Silo unloader's disease** **Zoonotic diseases**

Adapted from Popendorf W, Donham KJ. "Agricultural Hygiene." *Patty's Industrial Hygiene and Toxicology.* 4th ed. Volume 1, Part A. New York: John Wiley & Sons, 1991: 721-761.

Professional and Standard-setting Organizations

Professional organizations also provide viable partners in PPE research. These include the National Safety Council, American Conference of Governmental Industrial Hygienists, American Industrial Hygiene Association, American Society for Agricultural and Biological

Engineers (publishes the *Journal for Agricultural Safety and Health*), and American Society of Safety Engineers. Standard-setting organizations include the American National Standards Institute, American Society of Testing Materials, European Committee for Standardization, International Organization for Standardization, National Fire Protection Association, and Standards Council of Canada. Several PPE standards that apply to agricultural, forestry, and fishing industry workers are listed in Appendix 3. Even though the National Fire Protection Association (NFPA) respiratory committee does not address respiratory protection for wildland fire fighting operations, future cooperation is possible with the NFPA Technical Committee on Wildland Fire Fighting Protective Clothing and Equipment.

The National Safety Council's (http://www.nsc.org/library/facts/agrippe.htm) National Educational Center for Agricultural Safety is potential venue for PPE training. Two other professional organizations have emerged that encourage farm safety. These are the National Institute for Farm Safety (http://www.ag.ohio-state.edu/~agsafety/NIFS/nifs.htm), which grew out of a network of USDA safety extension agents, and the North American Agromedicine Consortium, which is a partnership between the local medical communities and state extension services and is responsible for publishing the *Journal of Agromedicine*. The NIOSH funded Centers for Agricultural Disease and Injury Research, Education, and Prevention have also established their association, which can offer a mix of research and outreach for PPE-based protection of farmers and farmworkers.

Trade Organizations and Unions

The Farm Bureau, Farmers Union, and National Grange represent American farmers. The Farm Bureau is not only a federation of farmers and ranchers, but it also represents a significant insurance organization, which at times encourages farm safety. In some states, the federation and insurance company are one, but in other states they operate separately. However, most farmers are involved in commodity organizations such as the American Corn Growers Association, American Soybean Association, American Sugar Alliance, Corn Refiners Association, National Association of Wheat Growers, National Corn Growers Association, National Cotton Council, National Grain and Feed Association, National Potato Council, National Pork Producers Council, National Broiler Council, National Cattlemen's Beef Association, and US Poultry and Egg Association. A commodity focus for safety and health could lead to partnering with such organizations.

The United Farm Workers' Union has long-held concerns regarding the health consequences of working in fields that were being treated with a variety of pesticides and fertilizers. These concerns include skin contact causing rashes and skin reactions and respiratory illnesses that affect them and their children.

Governmental Agencies

The U.S. Coast Guard is a potential partner for understanding and preventing injuries, illnesses, and death among fishers. OSHA is a potential partner in some aspects of fishing and in fish farming and in logging operations as well as large farming operations. EPA is a potential partner regarding PPE use to protect workers from pesticide exposures especially in their Certification and Worker Protection Branch, Office of Pesticides Programs. The U.S. Departments of Agriculture (USDA) and of Interior are potential partners in the application of PPE in forestry

and land management operations, and establishing protective policies for logging, ranching, hunting, trapping, and wildland firefighting on Federal lands. Moreover, USDA also operates farms on which PPE policies could be applied and evaluated, and they fund a Youth Farm Safety Education and Certification Program that offers an opportunity to reach children that work on farms. Regarding wildlands firefighting, specific opportunities for partnerships include the U.S. Forest Service's Technology and Development Center, the State of California's Department of Forestry and Fire Protection, the U.S. Bureau of Land Management, the Canadian Interagency Forest Fire Centre, and the Pennsylvania Bureau of Forestry.

5. How can we make a difference?

Survival Equipment

Some workers in this sector are exposed to extreme environments that require personal protection to survive the exposure. For example, firefighters attempting to control wildland fire need equipment to survive fires that overtake them, and fishers need survival gear to live through fishing vessel sinking, many of which are in cold water. In addition, occupant restraint technology (in combination with a rollover protective structure) needs to be improved so as to be more "user-friendly" for farmers who are exposed to tractor overturns.

First Decade NORA Priorities

An original NORA priority addressed chemical protective clothing, noise, respirators, and eye safety. NIOSH's Protective Clothing Program is aimed at protecting the skin from various health hazards that may be encountered in the workplace or during a terrorist attack. The program has evolved over the years to incorporate a broad range of studies of how chemicals seep through barrier materials, leak through small holes, or change the barrier material to reduce its protection.

Noise-induced hearing loss is 100 percent preventable but once acquired, hearing loss is permanent and irreversible. Non-linear hearing protectors (NLHPs) have been developed to provide improved communication and ability to hear warning signals while protecting workers from hazardous noise. However, the existing American and international standards for testing linear hearing protectors cannot address the performance and effectiveness of nonlinear (level dependent and active noise cancellation) devices. NIOSH is developing standardized laboratory test methods for acoustic and psycho-acoustic assessment of NLHPs, which addresses the shortcomings of current ANSI and ISO standards.

Respirators protect the user in two basic ways. The first is by the removal of contaminants from the air. Respirators of this type include particulate respirators, which filter out airborne particles; and "gas masks" which filter out chemicals and gases. Other respirators protect by supplying clean respirable air from another source. Respirators that fall into this category include airline respirators, which use compressed air from a remote source; and self-contained breathing apparatus, which include their own air supply

Personal protective eyewear, such as goggles, face shields, safety glasses, or full face respirators must also be used when an eye hazard exists. The eye protection chosen for specific work situations depends upon the nature and extent of the hazard, the circumstances of exposure, other protective equipment used, and personal vision needs. Eye protection should be fit to an

individual or adjustable to provide appropriate coverage. It should be comfortable and allow for sufficient peripheral vision. Selection of protective eyewear appropriate for a given task should be made based on a hazard assessment of each activity, including regulatory requirements when applicable.

Strains and sprains are caused by excessive reaching, bending, lifting, gripping, squatting, or twisting of hands, shoulders, or body. In general, any work performed with high force, with many repetitions, or in a position that feels awkward is risky. Even a motion that is harmless in and of itself, like stretching out the arm to grasp an object, or squeezing a tool, may put the worker at risk of injury if it is repeated over and over. PPE to protect workers from strains and sprains are not typically considered in the domain for such equipment, but some equipment can reduce these exposures. For example, providing seats for jobs reduces the strain on the lower back and legs, whereas standing causes legs to swell (more than walking does); floor mats for standing work stations reduce fatigue, and a spring return on hand tools to maintain an open position reduces wrist strains.[31]

PPE Design

The design of PPE in this sector involves several unique challenges. Many working conditions are harsh regarding weather, high seas, fire, solar radiation, cold, and heat. The wear and tear in the variety of natural environments presents a variety of exposures with which to contend. PPE may be difficult to replace because of the lack of access to PPE venders. The workforce is made up of children, women, disabled farmers, and non-English speaking workers, which requires special fitting and training considerations. Not only must PPE protect against exposures, it must also provide personal restraints to keep the workers from being crushed in tractor or ATV overturns. In addition, protection against strains and sprains also present an emerging issue to be addressed by PPE.[32]

PPE Program Design

PPE programs for employers in this sector vary little from the program design criteria in other sectors. However, self-employed farmers present several challenges. They have little access to formal training except regarding pesticide application. They may also have little access to the purchase of PPE except through catalog services.[33] In addition, children provide labor on many farms, and their involvement in PPE programs are unique compared to other industrial sectors. Furthermore, many farmers continue farming after a permanent disability and require special consideration regarding their PPE needs.[34] This workforce also includes persons with fatalistic and independent attitudes.

Research Plan

In addition to the above assessment, an important aspect of this *Research Plan* is to provide a framework for future U.S. Government planning efforts that the nation must have a system of plans at all levels of government and in all sectors outside of government that can be integrated to address the threat of emergencies whether small or catastrophic. It is guided by the following principles:

● Engineering control or inherently safer systems should be used to negate the need for PPE. PPE should only be used as a "last line of defense" when engineering control systems or hazard elimination are not feasible.
● Employers should have credible preparedness plans to respond to PPE needs within their workplaces. Individual workers should be prepared for the use of PPE and be trained in the use of PPE for their particular working conditions.
● The private sector should play an integral role in PPE research and development and should be part of national deployment of PPE technologies.
● Partnerships will be leveraged to address the threat of uncontrolled hazards, especially the threat of terrorist attacks or natural disasters.
● Three criteria are important in assessing the need for PPE research:
  ► Frequency of the occupational safety and health problem.
  ► Severity of the occupational safety and health problem.
  ► The preventability of the problem with PPE.

The *Research Plan* addresses the full spectrum of the agriculture, fishing, and forestry sector with nearly all work conducted outdoors under extreme or intense weather or disaster (e.g., wildland fire) conditions. While the circumstances of these conditions can vary considerably in temperature and wet or windy conditions, our strategic principles remain relevant. Four pillars of the *Research Plan* are described below:

Pillar 1. Surveillance

Occupational health surveillance can be viewed as tracking occupational injuries, illnesses, hazards, and exposures. Occupational surveillance data are used to guide efforts to improve worker safety and health, and to monitor trends and progress over time. This effort will analyze and interpret existing data, undertake data collection efforts to fill gaps in surveillance data, provide support to state agencies to conduct occupational surveillance and associated prevention efforts, and work with Federal, State, and private sector partners to improve occupational health surveillance.

Goal: To set priorities for further surveillance and research.

Priorities under this goal include:

■ ***Investigate high risk subsectors and populations for injuries and illnesses that can be prevented with PPE.***

■ ***Review and monitor HHEs, FACE, and OSHA as well as NTSB and Coast Guard inspection reports regarding*** **agriculture, fishing, and forestry** ***to identify the circumstances of severe injuries and illnesses that PPE could prevent; and PPE failures to protect workers.***

■ ***Evaluate new technologies for both potential hazards as well as use in PPE.***

Pillar 2. Standardization and Certification

NIOSH is developing appropriate standards and test procedures for PPE used to protect workers in hazardous environments. This development work includes the validation of performance-based PPE specifications including shelf life. Concepts, standards (when fully developed), and

other documents will be posted when they become available. This development work involves international collaboration in PPE standards as well as with partners from government and industry.

Goal: To develop and validate performance-based specifications and standards for PPE.

Goal: To establish voluntary standards or 42 CFR certification programs for PPE.

One priority under this goal includes:

■ ***NIOSH issues recommendations for respirator use. Industrial type approvals are in accordance to the NIOSH federal respiratory regulations 42 CFR Part 84.***

Pillar 3. Product Development and Evaluation

Using PPE, such as seat belts on tractors, and other equipment such as safety gloves, coveralls, boots, hats, aprons, goggles, face shields could significantly reduce farming injuries. PPE such as respirators and protective clothing can be used to isolate workers from the hazard. PPE must not only be effective, but also practical for use. Microsensing devices assess workers' exposure to environmental contaminants, notify workers before chemicals break through protective clothing, and identify failures in containment systems for hazardous materials. New materials in clothing would improve the protection of workers from burns, explosions, and hazardous chemicals. In addition to field surveys of chemical protective clothing (CPC) performance, studies need to examine ways to detect when chemicals have gotten inside CPC, and how to effectively remove chemicals from protective clothing after it has been contaminated. PPE research includes literature searches and data gathering, laboratory and field studies, and materials, filter/cartridge, shelf-life and design evaluations.

Goal: To incorporate advanced protective technologies into fully-integrated, intelligent, and reliable ensembles.

Goal: To collaborate with partners in the development of PPE to protect workers from high risk, frequency, and/or severity hazards.

Priorities under this goal include:

■ ***Continue ongoing research, e.g., hearing protectors, respirators, protective clothing, eye protection, and ergonomics.***

■ ***Pursue new research into survival gear relative to extreme exposures and restraint technology for off-road vehicle survival in the event of an equipment overturn or collision.***

Pillar 4. Education, Training, and Feedback

The purpose of training and training-related research is to understand and act on the multiple factors influencing occupational education and training effectiveness. NIOSH evaluates the impact of training programs and their components by investigating theoretical models gleaned

from health promotion, psychology, learning and educational perspectives, the role of attitudes, beliefs, behavioral intentions, and other characteristics of the individual that affect learning and transfer of learning into action, barriers affecting adoption of health and safety behaviors promoted by training, and environmental influences on occupational safety and health training.

Goal: To improve and implement PPE training programs, guidelines, and products for optimum use and acceptance by workers.

A priority under this goal includes:

■ ***Demonstrate approaches for protecting self-employed workers, child labor, and non-English speaking employees.***

Appendix 1: Agriculture, Forestry, and Fishing Subsector Descriptions

111 Crop Production

Industries in the Crop Production subsector grow crops mainly for food and fiber. This subsector comprises establishments, such as farms, orchards, groves, greenhouses, and nurseries, primarily engaged in growing crops, plants, vines, or trees and their seeds. The production process is typically completed when the raw product or commodity grown reaches the "farm gate" for market, that is, at the point of first sale or price determination. Within the subsector, establishments are classified to a specific industry when a product or industry family of products (i.e., oilseed and grain farming, vegetable and melon farming, fruit and tree nut farming) account for one-half or more of the establishment's agricultural production.

112 Animal Production

Industries in the Animal Production subsector raise or fatten animals for the sale of animals or animal products. The subsector comprises establishments, such as ranches, farms, and feedlots primarily engaged in keeping, grazing, breeding, or feeding animals. These animals are kept for the products they produce or for eventual sale. The animals are generally raised in various environments, from total confinement or captivity to feeding on an open range pasture. Establishments are classified to the Animal Production subsector when animal production (i.e., value of animals for market) accounts for one-half or more of the establishment's total agricultural production.

113 Forestry and Logging

Industries in the Forestry and Logging subsector grow and harvest timber on a long production cycle (i.e., of 10 years or more). Long production cycles use different production processes than short production cycles, which require more horticultural interventions prior to harvest, resulting in processes more similar to those found in the Crop Production subsector. Reforestation requires production of seedlings in specialized nurseries. Timber production requires natural forest or suitable areas of land that are available for a long duration. The maturation time for timber depends upon the species of tree, the climatic conditions of the region, and the intended purpose of the timber. The harvesting of timber (except when done on an extremely small scale) requires specialized machinery unique to the industry. Establishments gathering forest products, such as gums, barks, balsam needles, rhizomes, fibers, Spanish moss, and ginseng and truffles, are also included in this subsector.

114 Fishing, Hunting and Trapping

Industries in the Fishing, Hunting, and Trapping subsector harvest fish and other wild animals from their natural habitats and are dependent upon a continued supply of the natural resource. The harvesting of fish is the predominant economic activity of this subsector, and it usually

requires specialized vessels that, by the nature of their size, configuration and equipment, are not suitable for any other type of production, such as transportation. Hunting and trapping activities utilize a wide variety of production processes and are classified in the same subsector as fishing because the availability of resources and the constraints imposed, such as conservation requirements and proper habitat maintenance, are similar.

115 Support Activities for Agriculture and Forestry

Industries in the Support Activities for Agriculture and Forestry subsector provide support services that are an essential part of agricultural and forestry production. These support activities may be performed by the agriculture or forestry producing establishment or conducted independently as an alternative source of inputs required for the production process for a given crop, animal, or forestry industry. Establishments that primarily perform these activities independent of the agriculture or forestry producing establishment are in this subsector.

Appendix 2: Applicable Standards and Standards Setting Organizations

U.S. Department of Human Services
NIOSH
42 CFR Part 84, Approval of respiratory protective devices
Outer Continental Shelf Lands Act, Section 208(e) "conduct studies of underwater diving techniques and equipment"
U.S. Department of Labor (DOL)
Occupational Safety & Health Administration (OSHA)
29 CFR 1910 – Occupational Safety and Health Standards
1910.95 – Hearing Protection
Subpart I – Personal Protective Equipment
1910.132 – General requirements
1910.133 – Eye and face protection
1910.134 – Respiratory protection
1910.135 – Head protection
1910.136 – Foot protection
1910.138 – Hand protection
1910.137, 335 – Electrical workers' clothing and equipment
1910.266(d) (1) – Logging operations, personal protective equipment
1910.266(d) (3) – Logging operations, seatbelts
29 CFR 1928 – Occupational Safety and Health Standards for Agriculture
1928.51(b) – Seatbelts
U.S. Environmental Protection Agency
40 CFR 211 hearing protector label requirements
40 CFR 170.240 worker protection standards for agricultural pesticides
U.S. Coast Guard
46 CFR Shipping
Part 28 – Requirements for Commercial Fishing Industry Vessels
28.110 Life preservers or other personal flotation devices.
28.115 Ring life buoys
28.120 Survival craft
28.130 Survival craft equipment
28.140 Operational readiness, maintenance, and inspection of lifesaving equipment
28.150 Emergency Position Indicating Radio Beacons (EPIRBs).
28.155 Excess fire detection and protection equipment
28.205 Fireman's outfits and self-contained breathing apparatus
28.810 Deck rails, lifelines, storm rails and hand grabs
International Maritime Organization
International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995
American National Standards Institute
ANSI Z88.7-2001, Color Coding of Air-Purifying Respirator Canisters, Cartridges, and Filters
ANSI Z88.10-2001, Respirator Fit Testing Methods
ANSI Z 88.2-1969, Standard Practice for Respirator Protection
ANSI Z41.1-1991, Protective Footwear

ANSI S12.6-1997, Methods for Measuring the Real-Ear Attenuation of Hearing Protectors
ANSI Z87.1-2003, Standard for Occupational and Educational Eye and Face Protection Devices
ANSI Z359.1-1992, Safety Requirements for Personal Fall Arrest Systems, Sub-Systems and Components
ANSI Z89.1, Safety Requirements for Industrial Head Protection
ANSI Z89.2, Safety Requirements for Industrial Protective Helmets for Electrical Workers
ANSI J6.6-1971, Rubber Insulating Gloves
ANSI/ASSE Z359.1 Safety Requirements for Personal Fall Arrest Systems

American Society for Testing Materials

ASTM F23 Protective Clothing

International Organization for Standardization

ISO 12402-1:2005 – Personal flotation devices
ISO 15027-1-3:2002 – Immersion suits
ISO 13.340.01 Protective equipment in general
ISO 13.340.10 Protective clothing, including flameproof clothing
ISO 13.340.20 Head protective equipment, including helmets, eye-protectors, hearing protectors, ear muffs, teeth protectors and hoods.
ISO 13.340.30 Respiratory protective devices
ISO 13.340.40 Hand and arm protection, Including protective gloves, sleeves and mits
ISO 13.340.50 Leg and foot protection, Including safety boots and shoes
ISO 13.340.60 Protection against falling and slipping, including safety ropes, harnesses and fall arrestors
ISO 13.340.70 Lifejackets, buoyancy aids and flotation devices
ISO 13.340.99 Other protective equipment
ISO 3873:1977 Industrial safety helmets
ISO 4007:1977 Personal eye-protectors, Vocabulary
ISO 4849:1981 Personal eye-protectors, Specifications
ISO 4869-1:1990 Acoustics, Hearing protectors, Part 1: Subjective method for the measurement of sound attenuation
ISO 4869-2:1994 Acoustics, Hearing protectors, Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn
ISO/TR 4869-3:1989 Acoustics, Hearing protectors, Part 3: Simplified method for the measurement of insertion loss of ear-muff type protectors for quality inspection purposes
ISO/TR 4869-4:1998 Acoustics, Hearing protectors, Part 4: Measurement of effective sound pressure levels for level-dependent sound-restoration ear-muffs
ISO 6161:1981Personal eye-protectors, Filters and eye-protectors against laser radiation
ISO 8194:1987Radiation protection, Clothing for protection against radioactive contamination, Design, selection, testing and use
ISO/CD 2801 Clothing for protection against heat and flame -- General recommendations for selection, care and use of protective clothing
ISO/FDIS 11612 Protective clothing -- Clothing to protect against heat and flame
ISO/DIS 13506.3 Protective clothing against heat and flame -- Test method for complete garments -- Prediction of burn injury using an instrumented manikin
ISO/FDIS 14116 Protective clothing -- Protection against heat and flame -- Limited flame spread materials, material assemblies and clothing

ISO/DIS 16602.3 Protective clothing for protection against chemicals -- Classification, labeling and performance requirements

ISO/CD 17491-1 Protective clothing -- Test methods for clothing providing protection against chemicals -- Part 1: Determination of resistance to outward leakage of gases (internal pressure test)

ISO/CD 17491-2 Protective clothing -- Test methods for clothing providing protection against chemicals -- Part 2: Determination of resistance to inward leakage of aerosols and gases (inward leakage test)

ISO/AWI TR 26061 Guidelines on the selection, use, care and maintenance of protective clothing

American Conference of Governmental Industrial Hygienists

Guidelines for Selection of Chemical Protective Clothing, 1987

American Welding Society

ANZI Z49.1-1967, Safety in Welding and Cutting

American Society for Testing Materials

ASTM F23 Protective Clothing

National Fire Protection Association

NFPA 1977 Standard on Protective Clothing and Equipment for Wildland Fire Fighting, 2005 Edition *(covers protective garments, helmets, gloves, footwear, goggles, chain saw protectors and load carrying equipment)*

Snell Memorial Foundation

B-90A 1998 Augmentation to the 1990 Standard for Protective Headgear

M200 2000 Standard For Protective Headgear for Use with Motorcycles and Other Motorized Vehicles

M2005 2005 Standard for Protective Headgear for Use with Motorcycles and Other Motorized Vehicles

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