Medical Evaluation of Hazardous Materials Response Teams in The Semiconductor Industry

By

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Abstract

TITLE: Medical Evaluation of Hazardous Materials Response Teams in the Semiconductor Industry

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The goal of this descriptive study was to identify medical exam protocols used to evaluate the medical qualifications and fitness of semiconductor industry workers to participate on a hazardous materials response team (HazMat). These exams are required by law, however, the regulations do not include standards for conducting them. Data was obtained by mailing a questionnaire to safety managers or occupational nurses from 67 semiconductor companies. The sample was randomly selected from a list of 108 companies, representing 34 semiconductor parent organizations. The questionnaire included items about the characteristics of HazMat teams, exam frequency and content. The response rate was 34% (22/64) and 21 of the 22 surveys were acceptable for inclusion in the study. Results indicated a minimum standard for exam content as reported by 76% of the companies for pre-placement exams and 81% for annual exams. The majority of exams do not meet exam content criteria published by the National Institute for

Occupational Safety and Health (NIOSH). Respondents reported that medical decisions were made on a case by case basis. There were no uniform methods for analyzing physical exam data or determining medical qualifications for HazMat team participation. No tests were included on the standard exam that evaluated the cardiorespiratory fitness of workers to wear HazMat gear. (Failure to identify problems during the medical evaluation presents a risk that one or more team members may be incapacitated during an incident due to inadequate aerobic capacity and/or a medical event.) Without research based exam standards, disability discrimination lawsuits are a serious consideration. Greater communication between nursing and medical and safety professionals is needed to improve medical exam standards for the protection of HazMat team members, employees and the public.

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CHAPTER 1

Any facility that produces, stores or uses extremely hazardous substances in excess of threshold planning quantities is subject to the provisions of the Superfund Amendments and Reauthorization Act of 1986, also known as SARA. The intent is to protect the public from harmful effects that may occur as a result of an accidental release of hazardous substances (Federal Emergency Management Agency, 1987).

Industries subject to SARA regulations must develop comprehensive emergency response plans. Procedures must be established for handling and controlling hazardous substance leaks or spills and for protecting workers and the surrounding community. The plan must also provide for evacuation and rescue of individuals who may be potential or actual victims of a hazardous materials incident. Many companies meet SARA requirements by establishing hazardous materials response teams (HazMat teams).

In the event of a hazardous materials accident, the primary responsibility of these teams is to prevent harm to people and the environment by isolating the area, evacuating individuals in the

hazard zone and containing the hazardous materials release. Depending on team member training, they may also clean up solid or liquid hazardous materials spills, stop and repair hazardous gas leaks and return the situation to a normal operating mode.

The physical labor demands of hazardous materials response primarily involve evacuation and rescue response, spill clean up and site restoration. In addition, the physiologic demand on HazMat team members is further increased by the need to wear respirators and chemical protective clothing.

To protect the safety of these responders, medical surveillance exams are required by law (Code of Federal Regulations, 29 CFR 1910.120 and 134). The CFR regulations reference exam guidelines that are published by the National Institute for Occupational Safety and Health (NIOSH, 1985) and American National Standards Institute (ANSI, Z88.6-69, revised, 1984). Because these referenced standards are not incorporated into the Code of Federal Regulations, they are suggested but not mandated by OSHA. Determination of the ability to perform work or cardiopulmonary fitness while wearing protective equipment is one exam component, but with the exception of the ANSI respiratory standards, there are no set evaluation standards or criteria to do this. Consequently, the physician "...is called upon to do a job

for which the proper tools still have not been specified" (Gochfeld, 1990, p. 2).

Physical exams of team members are conducted by physicians or medical providers selected by the company. Choosing these medical providers, providing physical job descriptions, evaluating physical exam criteria used and the clinical findings of the exams is often the responsibility of the company occupational nurse or safety manager.

Because the legal requirement for the exam and suggested exam content does not specify precise criteria, occupational nurses, medical providers and/or safety managers have no standard criteria to help evaluate the effectiveness of the HazMat team medical exams. There are also no HazMat specific guidelines for evaluating a team member's cardiovascular fitness or the ability to withstand the physiological stressors of the respirators, chemical splash or vapor barrier suits and heat stress frequently required in HazMat response. The lack of standard criteria poses a problem for health professionals who need to provide adequate exams to protect the health and safety of HazMat team members and, by extension, the others who depend on HazMat teams in the event of an accident or incident.

Definitions

American National Standards Institute (ANSI)

ANSI is a voluntary consensus standards setting group. ANSI sets safety and health standards for use by professionals in these fields. OSHA incorporates some ANSI standards by reference in federal regulations.

Hazardous Materials

Hazardous materials are "any substance[s] or mixture[s] that, if improperly handled, may be damaging to our health and well-being or to the environment" (Meyer, 1989, p.6).

Hazardous Materials Response Team (HazMat team)

A HazMat team is "an organized group of employees designated by the employer who are expected to perform work to handle and control actual or potential leaks or spills of hazardous substances requiring close approach to the substance...for the purpose of control or stabilization of the incident" (OSHA, cited in 29 CFR 1910.120, 1992, p. 389). A HazMat team may also be called an Emergency Response Team (ERT).

Level A

Level A is the highest level of personal protective clothing worn during a response. The equipment worn consists of a self contained respirator and fully encapsulated vapor-proof suit, gloves, boots and optional hard hat.

Level B

Level B is the third level of personal protective clothing with the same level of respiratory protection as level A. The suit is a one or two piece hooded chemical-resistant splash suit but it is not vapor proof. Splash suits are not for use with gases or vapors that are harmful to the skin or capable of being absorbed through intact skin. Gloves, boots and a hard hat are also worn.

Level C

Level C is the second level of personal protective response clothing. The skin protection is the same as Level B, but an air purifying respirator is worn.

Level D

Level D is the lowest level of personal protective response clothing, consisting of different combinations of chemically resistant clothing depending on the anticipated exposure and including coveralls or aprons, safety glasses and/or goggles, gloves, boots, hard hats.

Metabolic Equivalent (MET)

MET is a measurement of oxygen consumption during energy expenditure. One MET is equivalent to 3.5 ml/kg/min of oxygen consumption representing the oxygen consumption rate of a seated individual at rest.

Respirators

Respirators are personal protective devices designed to prevent toxic chemical inhalation exposure. Respirators consist of a facepiece connected to either an air source or an air-purifying device.

Respirator, Air Purifying

An air purifying respirator consists of a facepiece and an air purifying device for the removal of toxic chemicals. The air purifying devices are chemical and gas specific. Contaminant identification and concentration must be known if an air purifying respirator is used.

Respirator, Air Supplied (SAR)

A supplied air respirator, also known as an air line respirator, supplies air from a stationary compressed air source via a long hose to the mask of the wearer. The air source may be either compressors or compressed air cylinders.

Respirator, Self Contained Breathing Apparatus (SCBA)

An SCBA is a respirator consisting of a facepiece connected by a hose and regulator to an air source. For HazMat teams, the air source is usually compressed air contained in an air cylinder which is supported by a harness and worn on the user's back although air for SCBAs may also be supplied by an oxygen-generating chemical system.

Training, Awareness

Awareness is a first level response. Individuals are trained to initiate an emergency response by notifying proper authorities if they witness a hazardous substance release.

Training, Operations

Operations is a second level HazMat response. Individuals are trained to initiate a response by recognizing a release, notifying proper authorities and protecting people and the environment by preventing entry to the area. They do not try to stop the release.

Training, Technician

Technician is the third level HazMat response. Technicians are trained to respond to a hazardous materials incident for the purpose of containment and clean up.

Training, Specialist

Specialists respond at the highest HazMat level. Specialists have more specific chemical knowledge and training to respond to incidents wearing the highest level of protective gear (Level A) and also are trained in incident command.

CHAPTER 2

Review of the Literature

Physical Demands on HazMat Team Members

In reviewing the literature, studies were found that addressed the function of the hazardous waste worker, however, none of these discussed semiconductor or industrial HazMat teams. Favata, Buckler and Gochfeld (1990) noted that "marked physiologic demands are placed on the cardiovascular system by hazardous waste work" (p. 85). Recommendations for physiologic response (pulse and temperature) were made, but the authors suggested that guidelines for interpreting electrocardiogram (EKG) exercise tests needed to be developed. Due to the nature of the work, sudden incapacitation of a worker could endanger coworkers and the public.

A case study by Mitchell (1994) documented the heavy physical demand caused by wearing HazMat personal protective equipment (PPE). Mitchell found atmospheric temperatures above 85 degrees F created serious concerns for workers wearing fully encapsulated suits. Crew members had body temperatures exceeding 100 degrees F and heart rates above 140 beats per minute when working in these conditions. Mitchell stated "because PPE often restricts dexterity, visibility and mobility, employees are at a high risk for injury" (p. 21).

Physiologic Demands of Respirators

While no studies were found that evaluated the physiologic work of industrial HazMat teams, related studies have attempted to determine the cardiovascular and respiratory demands of respirator use. Raven, Dodson & Davis (1979) found that wearing self contained breathing apparatus (SCBA) increased metabolic work by 34% and heart rate by 27%. Louhevaara et.al. (1985) conducted a field study to evaluate cardiorespiratory strain due to respirator wear. Oxygen consumption was found to have "..increased almost exponentially at progressive submaximal exercise levels" (p. 203). Heart rates increased 20 beats per minute while performing heavy work with an SCBA. The authors concluded that the SCBA is suitable "only for cardiovascularly healthy individuals in good physical condition" and the "VO2 max should be at very least 3.0 l/min" (p. 203). This finding is supported by NIOSH investigators who noted that, "Use of respirators in conjunction with protective clothing can greatly affect the human response and endurance", (1987, p. 122).

According to NIOSH, "examining physicians should realize that the main stress of heavy exercise while using a respirator is usually on the cardiovascular system and that heavy respirators [SCBA]...can substantially increase this stress" (1987, p. 32). The present study is based on the assumption that the physician

discretion permitted by NIOSH does not provide objective guidance for the physician, who must determine fitness of the worker to withstand heavy workloads.

Cardiorespiratory Fitness Requirements

Bruce and Fisher (1989) identified cardiac disorders as the primary cause of sudden incapacitation of men in public safety; the majority of events occurred in persons without prior symptoms. In this study, seven and a half percent of the events causing incapacitation of men in public safety were found to be potentially hazardous to others. The authors stated the greatest predictor of sudden incapacitation is a cardiovascular risk assessment with exercise treadmill. Low risk of sudden cardiac incapacitation was defined "as the ability simultaneously to complete stage III, or 9 min of exercise by the Bruce protocol, to attain at least 85% of age-predicted maximal heart rate and to manifest less than 1 mm of ischemic ST depression" (p. 127).

A study of Belfast ambulance workers measured the physical demands of emergency response and the questioned the fitness of the workers to meet those demands. According to the authors, 54% of those over 40 and 24% under 40 found a moderate work load of 6km/hr (3.75 mi/hr) taxing. They stated, "Lactate concentrations measured during a staged emergency incident also suggested that personnel may work at intensities exceeding their anaerobic

threshold" (Gamble, Stevens, McBrien, Black, Cran & Borchan, 1991, p. 592).

Physiologic Demands on Firefighters

Comparison Between Firefighter and HazMat Team Physiologic Demand

A number of studies have been done quantifying the physiologic demands of firefighter work. There are similarities between the physiologic work of firefighting and the work of HazMat team response. Respirators and personal protective gear are worn by both groups. Both are subject to hazards of heat stress, HazMat teams as a consequence of the vapor barrier suits and firefighters as a result of both the turnout gear and the firefighting task. In addition, both groups respond to emergency situations.

There are differences between firefighters and HazMat teams that must be considered as well. The heat stress is greater for firefighters than HazMat responders. Firefighter turnout gear weighs up to 85 pounds (including the SCBA) as compared to the 40 to 45 pounds for HazMat gear with SCBA. Firefighter tasks demand a higher level of muscular work than is usually required for an average hazardous materials response. One major difference is that firefighters wear their gear more frequently for responses and for practice than HazMat team members, whose primary job responsibilities are in other areas. Nonetheless, enough

similarities exist to make review of the studies of physiologic work of firefighting worthwhile.

Measures of Firefighter Physiologic Work Load

Davis, Dodson and Santa Maria (1982) utilized multilead exercise treadmill testing and Holter EKG monitoring of actual task performance to conclude that a minimum fitness criteria of 12 METS with a recommended 14 METS is necessary to perform the firefighter job. Consequently they suggested an EKG monitored treadmill or bicycle ergometric test be included in medical exams.

Bernard and Duncan measured EKG and heart rate during firefighting tasks and noted heart rates up to 188 beats/minute (1975). Lemon and Hermiston (1977) reported a firefighting energy cost of 60% to 80% of maximum oxygen uptake (VO2) max. O'Connell, Thomas, Cada and Karwasky (1986) measured the energy cost of stair climbing with full firefighter protective clothing, SCBA and hose pack. They found the task required a minimum of 11 METS for satisfactory performance supporting the 12 to 14 MET criteria established by Davis, Biersner, Barnard and Schamadan (1982). A 1990 performance test validation study by Schonfeld, Doerr and Convertino for Kennedy Space Center firefighters concluded that treadmill time predicted performance on field tests with reasonable accuracy. Their data also supports the O'Connell stair climb data and the METS criteria suggested by Davis.

Fitness of HazMat Team Members

Because no data is available that is specific to the hazardous materials responder, one option for occupational medicine providers is to use the Davis firefighter performance criteria of 12 METS (1982). However, because of the differences between the HazMat protective clothing and workload and the firefighter gear and job demands noted earlier, the Davis firefighter performance criteria may not be a valid measure for hazardous materials responders.

HazMat team response is often not the primary job description for industry team members who may be technicians, electricians or fill any one of a number of different roles. Consequently, while no research exists to document fitness levels of these groups, it is reasonable to assume that their level of fitness approximates that of the general working population. If so, serious health risks exist in the occupational setting. Recent research in the New England Journal of Medicine by Willich and colleagues documented "an increased risk of acute myocardial infarction during strenuous physical activity or within the one hour period after it....a particularly high risk was associated with physical exertion by patients who usually exercised only infrequently" (1993, p.1687). The study design, a case crossover technique, used each individual as his or her own control. The

methodology assessed the study group's "...usual frequency of heavy physical exertion over the past year, and their actual level of exertion in the comparable one to two hour control period at the same time on the day before onset of myocardial infarction" (p. 1678). The study also included matched neighborhood controls.

Qualifications of Occupational Medicine Providers

Finding a qualified medical provider to perform HazMat exams may present a challenge for the occupational health nurse. According to a study by Udasin, Buckler and Gochfeld (1991), of 17 facilities throughout the United States, there is an increased economic incentive for medical facilities to participate in occupational medicine. However, while the number of programs are increasing, serious quality problems were found in the 328 medical surveillance exams studied. Deficiencies were frequently attributed to a lack of occupational medicine physician and technical staff education, training and experience. The authors also noted that the regulatory guidelines for conducting the exams are loose. Udasin concluded that "the level of medical surveillance varies dramatically among providers and that employers who bear legal responsibility for examinations should undertake closer scrutiny of services.." (p. 1173).

Disability Discrimination

Avoiding claims of discrimination under the Americans with Disabilities Act (29 CFR Part 1630) imposes an added concern for companies who, for safety reasons, must use selection criteria requiring evaluation of physical ability to perform the job. Standards that are too strict may eliminate otherwise qualified candidates; in contrast, insufficient standards may pose a risk not only for the responder but for co-workers and the general public if the responder is incapacitated or unable to perform in an emergency (Favata, Buckler and Gochfeld, 1990).

Summary

The presence of risk to personal health and safety due to participation on a HazMat team is suggested by regulations requiring medical examinations for team members. Regulations do not list required exam contents nor do they state how the exam data collected should be used to determine who is medically qualified to be a HazMat team member. How these decisions are being made is a question that has not been adequately addressed by research and is the subject of the present study.

Research Purpose

The purpose of this research is to identify the prevailing medical exam protocols in use by the Semiconductor industry, with emphasis on the tests and evaluation criteria used for

determination of cardiorespiratory fitness for duty. The proposed research is intended to address the lack of available information delineating fitness requirements for duty of hazardous materials response teams.

Conceptual Framework

Conceptual framework for the proposed study

The conceptual framework developed for this study identifies a number of risk factors that increase the HazMat team members' physiological workload including; (1) protective clothing, (2) respirator gear and (3) response tasks. The increased physiologic workload leads to an increased risk of HazMat responder injury and incapacitation. Individual characteristics of individual team members such as age, body fat percentage, fitness, smoking and co-morbid conditions also contribute to the increased risk for injury and incapacitation. Increased HazMat incapacitation risk leads to an undetermined risk to workers and the population at large. The ability of the HazMat team member to adapt to these stressors and perform the job safely can be evaluated by medical surveillance exams. The underlying premise for the research is based on the assumption that a lack of standards precludes an adequate assessment of the health risk to HazMat team members.

Exams without adequate standards performed by trained and experienced occupational medicine providers also are not expected

to reduce the potential for injury. The conceptual framework model suggests that potential for an incapacitation event decreases when exams are performed by experienced providers using research based criteria and reasonable standards. The first step in defining worker risk is the identification of current standards of practice for medical exams.

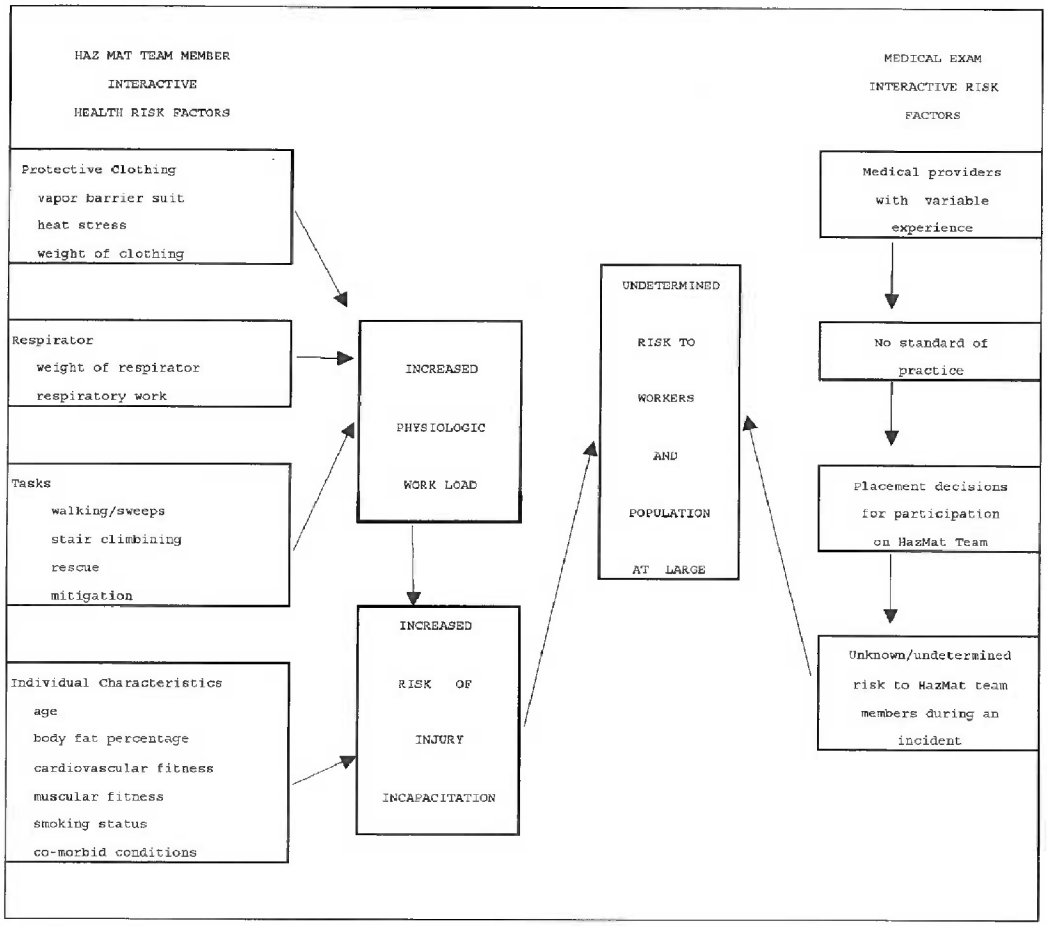

Figure 1. Conceptual model for HazMat team medical standards evaluation.

Operational Definitions

Standards of Practice

Standards of practice are consistent and generally recognized methods and protocols for physical exams. The protocol has three components, (1) standard of practice for exam content, (2) standard of practice for setting pass/fail criteria and (3) standard of practice for decision making related to a worker's fitness to participate on the team.

Cardiorespiratory Fitness

Cardiorespiratory fitness is defined in this study as the capacity of the respiratory and circulatory systems to adequately provide and sustain sufficient oxygen to the body in response to an exercise or stress induced increased demand.

Disqualifying and/or Limiting Conditions

These are conditions that have been evaluated in terms of essential functions of HazMat response, and, based on research or medically appropriate decision making, have been determined to limit or prohibit a worker from safely participating on the team.

Medical Surveillance Exams

Medical surveillance exams are defined by the Chemical Manufacturers Association (CMA) as "the ongoing and systematic collection, analysis and interpretation of data related to health"

(OSHA, 1993). This definition is the one selected for the present study.

Pass/Fail Criteria

Pass/fail criteria are objective measures which must be met or exceeded for a team member to be medically qualified to participate as a HazMat team member. These should be based on a clearly defined rationale for use. As an example: established spirometry measures such as a minimum forced vital capacity (FVC) of 80%.

Physiologic Work Load

Physiologic work load refers to the total body function including, but not limited to, cardiovascular, respiratory and muscular systems.

Fitness for Duty

Fitness for duty is a term used to classify workers in regard to individual medical conditions, disabilities, limitations or diseases which could interfere with the safe performance of the essential functions of the HazMat responsibilities. It also indicates that an individual has been able to meet any minimum standards for performance on objective tests or measurements conducted as part of the evaluation.

Assumptions

A number of basic assumptions underlie the conceptual framework, research design and research questions proposed for this study:

1. Any company which manufactures, stores or otherwise uses hazardous materials in sufficient quantity to require an onsite hazardous materials team also has an inherent risk of an incident involving the accidental release of these materials.

2. As a result of this accidental release, there is a potential safety and health risk for responders and others in the workforce in these locations.

3. The hazardous materials responders have a degree of responsibility for not only their own safety, but for the safety of other team members and the rest of the workforce.

4. Most industry hazardous materials team members are selected for their skills and abilities in the primary jobs for which they are hired. In most instances, responder qualifications are either not a factor or are of minimal consideration during the interview process.

5. Hazardous materials team members are assumed to be no more or less fit than the general population.

6. The safety of the responders and those in the workforce could be at risk if a responder either is not fit enough to carry

out his or her duties or becomes incapacitated while performing these duties.

Research Questions

As the literature review indicates, some recommendations for exam content exist, but no evidence was found linking these recommendations to physical exams provided for HazMat teams. There is even less information available for analyzing collected exam data and determining the medical fitness for duty of HazMat team members. The following research questions are addressed in the present study:

1. What are the characteristics of HazMat teams and team members?
2. What are the components of the medical exams?
3. What are the pass/fail criteria for the medical exams?
4. How are the criteria used to make decisions regarding team placement or continuation?

CHAPTER 3

Methods

Design

The literature review provided evidence that there is limited information about current standard practices for providing and evaluating HazMat team medical exams. A descriptive research design was chosen to collect and describe this data.

The present study employs a written questionnaire to describe the characteristics of HazMat teams and the content and frequency of medical exams. The survey also asks questions about who provides exams, how content and criteria are determined, how the exam data is evaluated and what medical exam problems exist.

Population of Interest

Health and safety professionals are the primary population for the present study. Industry hazardous materials response team members are the secondary population. The study was limited to the semiconductor industry to reduce the measurement variables. Names of semiconductor industry health and safety professions were obtained from a list of companies belonging to the Semiconductor Safety Association. Most companies in this association manufacture integrated circuits (chips). Because a clean environment is essential, facilities are of similar architectural

design in terms of physical layout and delivery of gases, chemicals and utilities. Chips are manufactured in a limited access temperature, humidity and particle controlled clean room because contamination is the primary reason for chip failure.

There is relative uniformity in the use of hazardous materials, in terms of identity, relative quantities, use and distribution among semiconductor manufacturing facilities. Integrated circuits are built on silicon wafers through a series of processes so the chip will conduct electric current. Building the circuits on the chip requires the use of many hazardous chemicals and gases. The choice of the chemicals and gases used is determined by the end use of the product. A few common examples include hydrofluoric, hydrochloric, sulfuric, phosphoric and nitric acids, ammonia, flammable gases such as silane and hydrogen, toxic and corrosive gases including arsine, phosphine, diborane, chlorine and boron trifluoride. Because the hazardous materials are similar, protective gear worn by responders is also similar. Results of the study are intended to be generalized to the semiconductor industry, but can not be generalized to other industries.

Sample Selection

The sample was drawn from a list of semiconductor companies who are members of the Semiconductor Safety Association (SSA) and

one other semiconductor industry association. Two association rosters were employed to maximize the chances that the selected survey group would be manufacturing facilities with hazardous materials teams and would not include sales and service vendors without emergency response teams.

Thirty-four parent organizations were identified, however, most parent organizations such as Intel or Hewlett Packard have two or more companies located in different cities and states. Because of the small number of parent organizations and because safety practices and HazMat team management may vary between sites, the decision was made to include all parent organization company locations. In addition, the physician providers would in most cases be different since few companies have corporate physicians on staff.

Sixty-seven of the 108 companies on the list were selected using random assignment and invited to participate in the survey. Questionnaires were sent to each company and were directed to the health service or safety manager whose name was published in the SSA directory (if these names were available). If no health services or safety managers were listed, questionnaires were sent to the individual who would most likely be responsible for emergency team management (emergency managers, safety engineers, industrial hygienists etc.).

Development of Questionnaire

The measurement tool was a written questionnaire developed by the author. In addition to demographic questions, a number of questions were asked to quantify the activity of response team members for purposes of evaluating physiological workload similarity. The medical reference questions were derived from the guidelines in the NIOSH publication (1985) and the study by Udasin, Buckler and Gochfeld (1991). These included items covering exam content. An attempt was made to determine exam evaluation criteria, although with the exception of pulmonary function values for respirator use, there is limited information to guide the structure of these questions. Additional content included items related to physical exam administration and the satisfaction of the respondent with exam protocols.

A number of variables could affect physiological response (i.e. blood pressure, heart rate, temperature, endurance). These were incorporated into the questionnaire so differences and similarities could be considered in evaluating demands that may be placed on individual team members.

Significant differences were anticipated in the qualifications, training and experience of physicians and medical professionals providing the exams (Udasin, Buckler and Gochfeld, 1991). The variety of experience by those conducting the exams

was addressed by soliciting information about the provider background and experience.

Procedures

While the study focused on the level of fitness in HazMat team members, questionnaire data was obtained from safety and health individuals responsible for management of these teams. A package was sent to all selected participants including a cover letter (Appendix A), a consent form (Appendix B), the questionnaire (Appendix C) and a pre-addressed, postage-paid return envelope. The cover letter described the purpose of the study and requested participation. Respondents were given the option of completing the written survey and returning it in the envelope provided, or calling the principal investigator for a verbal interview. A fax number for the principal investigator was also available.

Protection of Human Subjects

Confidentiality was maintained by limiting the identity of the companies and respondents to the researcher. No attempt was or will be made to learn the identity of individual HazMat team members. The study proposal was reviewed and determined exempt by the Oregon Health Sciences Committee on Human Research (Appendix D).

CHAPTER 4

Results

Because the purpose of this research is to characterize current practice, descriptive statistics were used to analyze the data. Results are reported in terms of frequencies and percentages. Some comments received are also reported.

Sample Response

A total of 67 questionnaires were mailed. Three questionnaires were returned by mail and never reached their destination. Responses were received from twenty-two companies; 17 mail responses, three telephone interview responses and two fax responses. The resulting response rate (22/64) was 34 percent. Of those completing the survey, eight (36%) were occupational nurses or nurse managers, eight (36%) were safety and health managers, two (9%) were emergency services managers, and four (18%) were safety and health engineers and technicians.

Since the sample was drawn from a list of 108 companies representing 34 parent organizations, there was some concern that the responses would not be randomly distributed among the different parent organizations. However, the data provided some evidence that the sample was generally representative of the population in regard to geographic location and industry names. Respondents represented 17 of the possible 34 parent

organizations. Five parent organizations were represented twice in the sample and one of those was a corporate office without a HazMat team so results were not tabulated as part of the HazMat team data analysis.

Semiconductor facilities in the United States are clustered in certain cities and states such as Arizona, California and Colorado. Consequently, some potential for uneven clustering of responses according to city and state existed, but did not occur. Responses were received from 18 different cities and 10 states. Only two cities were represented twice. An acceptable distribution across states also occurred. Of the total 21 responses, one response per state was received from Arizona, Illinois, Rhode Island and Utah. Two responses were received from Colorado, Maine and Oregon. Three responses were received from Pennsylvania and Texas and five came from California.

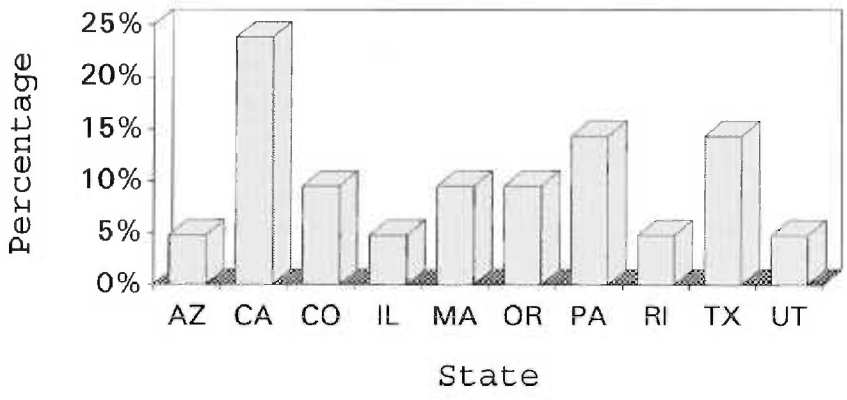

Figure 2. Survey responses by percentage from each state.

The survey was limited to semiconductor companies to control for extraneous variables. Seventeen of the 21 companies (81%) are semiconductor/integrated circuit manufacturing facilities and three (14%) are closely related electronic manufacturing or semiconductor specialty gas facilities.

Demographics

Responses to demographic questions indicate the operational characteristics of the companies are similar. Twenty of the 21 companies (95%) operate 24 hours a day and one (5%) operates 16 hours a day. Seventeen (81%) operate 7 days a week, two (10%) 6 days a week and one (5%) 5 days a week. Sixteen companies (76%) have an on site nurse and three (14%) have an on site physician.

Of the twenty-two respondents, 21 have HazMat teams. The one that did not was excluded from analysis for the survey.

The majority of the companies are large in regard to the number of workers. Thirteen companies (62%) employ over 1000 people, six (29%)have more than 500, two (10%) employ between 251 and 500 and none have less than 250 employees.

Characteristics of HazMat Teams and HazMat Team Members

Similarities and Differences Between HazMat Teams

Company size and number of members on team. There is little relationship between company size and the number of members on a HazMat team. There is a wide variability in the total number of

HazMat members for companies with more than 1000 employees who report team sizes ranging from less than 25 up to more than 550 members per team. The maximum number of members for the two smaller companies is 49.

Table 1

Number of HazMat Team Members by Size of Company

	Total Number of Employees					
Number of Employees on HazMat Team	251 to 500		501 to 1000		> 1000	
	f	f (%)	f	f (%)	f	f (%)
6 to 24	1	50%			2	15%
25 to 49	1	50%	1	20%	3	23%
50 to 74			4	80%	2	15%
75 to 99					2	15%
100 to 200					3	23%
> 200					1	8%
Totals	2	100%	5	100%	13	100%

Age of members on HazMat teams. There are no age limits imposed on team members by any of the responding industries. Fourteen of the 21 respondents (67%) provided an age breakdown on their teams; of this group, 43% of HazMat team members were between the ages of 18 and 30, 42% between 31 and 40 and 13% between 41 and 50 years. Two percent of the members were over 50 years old.

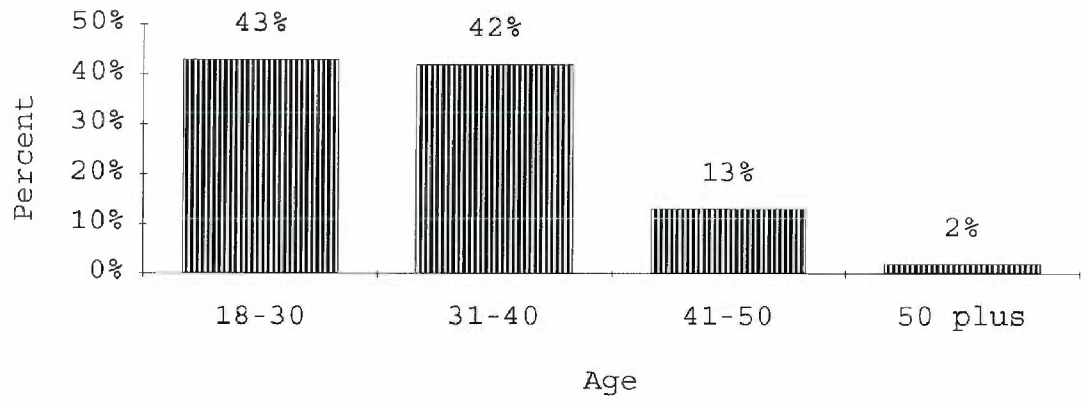

Figure 3. Age distribution by percent of members in age bracket.

Gender Distribution. Twenty companies provided data addressing the gender distribution of their teams. Twelve (60%) of the teams are comprised of male memberships of 90 to 100% and sixteen (80%) are 80 to 100% male. Females make up less than 22% of hazardous response teams. Fourteen teams (70%) are less than 15% female and twelve teams (60%) are 10% or less.

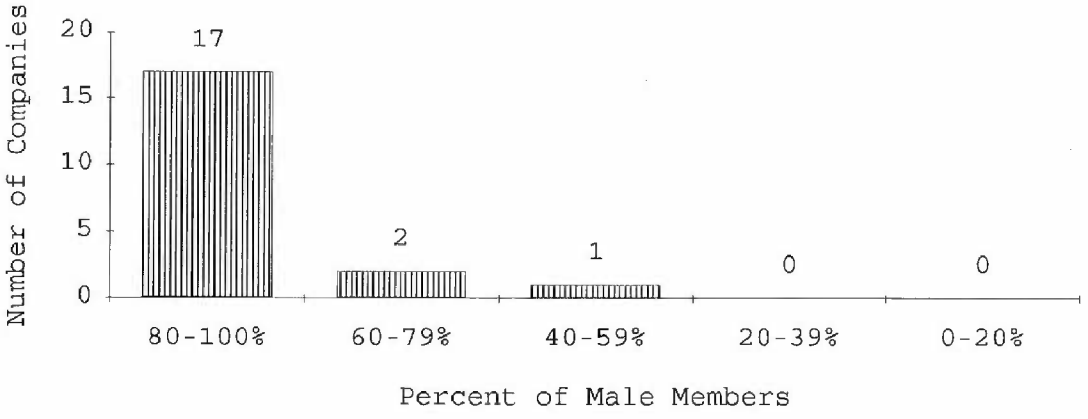

Figure 4. Percent of male HazMat team members by company.

Staffing of HazMat teams. Teams are staffed by volunteers at 13 of 21 companies (62%), three companies (14%) require membership as part of a job description and five (24%) use a combination of some volunteers and some required positions.

There are no consequences for workers who choose not participate on HazMat teams at five of 21 companies (24%). Non-participants are removed from their jobs at two companies (10%) and one company restricts promotional opportunities. Three companies (14%) have other sanctions for non-participation including loss of monetary compensation. There was no response to this question by 10 companies (48%) in most cases because they had indicated that membership on the team is voluntary.

Comparison of HazMat Physical Demands

Response requirements. Questionnaire items addressing the frequency, duration, response level, distance, stair workload and task requirements were included to examine the physical demands required of the HazMat team members and to make comparisons between companies.

Response levels are associated with increased physiologic demand due to the personal protective equipment required. Technician and specialist are the highest response levels. Higher levels of response require SCBA respirators which can weigh up to

35 to 40 pounds. SCBA cylinders are rated by minutes of use based on the amount of air contained in the cylinder. Cylinders with more time are heavier. Heat stress increases as the clothing protective level increases (A is the highest level). Higher levels of protective clothing also decrease mobility, hearing and visual acuity.

Response levels are similar with 11 of 21 teams (52%) responding at the technician level and 10 teams (48%) at the specialist level. Medical emergencies are part of response duties for 12 teams (57%), 16 teams (76%) respond to fire emergencies and 18 teams (86%) are responsible for victim rescue if necessary.

Respirators worn most often by members of 18 of 21 teams (86%) are self contained respirators (SCBA), members of two teams (9%) wear air purifying respirators and no team used supplied air as the most frequently worn respirator. The cylinder size for 18 teams (86%)is 30 minutes or less. One team uses 45 minute tanks, one team 60 minute and one did not know cylinder size. HazMat gear worn most frequently by 12 teams (57%) is Level B. Level D is worn most often by six teams (29%) and Level C by three teams (14%).

Table 2

Level of HazMat Protective Clothing Most Frequently Worn by Company Teams

Protection Level	f	f (%)
Level A	0	0%
Level B	12	57%
Level C	3	14%
Level D	6	29%
Total	21	100%

The greatest variation in response characteristics between teams is in stair climb workload and frequency of response. Stair flight workload for 14 of 21 teams (67%) is one to two flights. Two teams (10%) have no stairs to climb and four teams (20%) may climb 3 or more flights. The least variation is in response distance at 1/4 mile or less for 17 teams (81%), 1/2 mile or less for 2 teams (10%) and up to 3/4 of a mile for 1 team (5%).

Response frequency of less than once a month was reported for 8 teams (38%), with the next highest frequency rate of 1 to 3 times a week for 7 teams (33%). Four teams respond daily (19%).

Table 3

Frequency of HazMat Team Response by Company

Response Frequency	f	f(%)
daily	2	10%
1-3 /wk	7	33%
1-3 /mo	4	19%
< 1/mo	8	38%
Total	21	100%

Average response incident duration is 15 to 30 minutes for 10 teams (48%), 0 to 14 minutes for 5 teams (24%) and 30 to 60 minutes for another 5 teams (24%). Only one team reported average responses lasting 60 minutes or longer.

Table 4

HazMat Incident Duration in Minutes by Company

Time in Minutes	f	f(%)
0-14	5	24%
15-30	10	48%
30-60	5	24%
> 60	1	5%
Total	21	101%

Note: Percentage total is greater than 100% due to rounding.

What Are the Components of the Exams?

Selection of Exam Standards

A question on the survey asked respondents to identify references used to guide selection of exam components. According to study responses, the most common reference source for determining exam content is independent physician judgment, the source reported by 12 of 21 companies (57%). Published reference sources used for setting standards include NIOSH criteria cited by eight companies (35%) and fire fighter standards used by two companies (10%).

Whatever the reference source, physicians and nurses are primarily responsible for deciding what to include on the exam. Physicians make these decisions for 19 companies (90%). Nurses participate in the exam content decision making process at nine companies (43%).

Physicians conduct exams for 11 of the 21 companies (52%). Doctor and nurse teams give the exams at six companies (29%), the company nurse is the exam provider at one company (5%) and one company uses a physician's assistant (5%).

Table 5

Exam Component Decision Makers and Exam Providers by Company

	Who Determines Exam Components		Who Conducts Exams	
Medical Provider	f	f (%)	f	f (%)
Occ Med Dr. or Clinic	5	24%	9	43%
Private Practice Dr.	0	0%	0	0%
Company Dr.	5	24%	2	10%
Co. nurse & any Dr.	9	43%	6	29%
Nurse	0	0%	1	5%
Physician Assistant	0	0%	1	5%
No answer	2	10%	2	10%
Total	21	100%	21	100%

Exam Contents and Frequency

Medical exams are required by 20 of the 21 companies (95%). NIOSH is cited as the source for exams by 35% of respondents, however, the NIOSH exam content is much more comprehensive than the standard exam evidenced in this study. The NIOSH suggested exam includes a history, physical, spirometry, blood chemistry, complete blood count, chest x-ray, audiometry and vision test. Recommended, although at physician discretion, is a standard

electrocardiogram and consideration of a stress or other graded exercise test (NIOSH, 1985).

Pre-placement exams. The minimum standard for pre-placement exam content reported by 16 of 21 companies (76%) includes a history and physical, height, weight, blood pressure and heart rate. Fifteen companies (71%) add urinalysis and spirometry (FVC, FEV1, Ratio) and 13 (62%) also include blood chemistry and blood counts.

Less frequently added tests include audiometry given by eight companies (38%), chest x-rays by seven companies (33%) and electrocardiograms (EKGs) standard at five companies (24%). Four companies add standard EKGs only after age 40 or 50. EKG treadmills are part of the protocol for one company (5%) and after age 40 or 50 for three companies (14%).

Annual exams. Annual exams are given by 17 companies (81%). Exam content includes a history and physical, height, weight, blood pressure and heart rate. The FVC spirometry test is added by 15 companies (71%), 14 (67%) also include FEV1 and ratio on the annual exam. Urinalysis, complete blood counts and blood chemistries are added by 12 companies (57%). Audiometry is added by 5 companies (24%), EKGs by 2 (10%) and EKGs for those over 40 or 50 by 5 (24%). One company (5%) provides treadmill EKGs (5%) three companies (14%) add this only for those over 40 or 50 years.

Table 6

Number and Percent of Companies Requiring Exam Component at Pre-placement, Annual, Biannual and 3 Year Exams

Required Exam Components	Pre-Placement		Annual Exam		Biannual Exam		Every 3 Years	
	f	f (%)	f	f (%)	f	f (%)	f	f (%)
Physical	16	76%	17	81%	3	14%	1	5%
BP/HR	16	76%	17	81%	3	14%	1	5%
Height/Weight	16	76%	17	81%	4	19%	1	5%
Spirometry FVC	15	71%	15	71%	4	19%	1	5%
Spirometry FEV1	15	71%	14	67%	4	19%	1	5%
Spirometry Ratio	15	71%	14	67%	4	19%	1	5%
Urinalysis	15	71%	12	57%	1	5%	1	5%
Complete Blood Count	13	62%	12	57%	1	5%	1	5%
Blood Chemistry	13	62%	12	57%	1	5%	0	0%
Cholesterol	12	57%	9	43%	1	5%	1	5%
Audiometry	8	38%	5	24%	1	5%	1	5%
Chest X-ray	7	33%	1	5%	2	10%	3	14%
EKG, all members	5	24%	2	10%	1	5%	2	10%
EKG by age	4	19%	5	24%	0	0%	0	0%
EKG Treadmill by age	3	14%	3	14%	0	0%	0	0%
Biological tests	3	14%	2	10%	0	0%	1	5%
EKG Treadmill	1	5%	1	5%	0	0%	0	0%
Other	1	5%	1	5%	0	0%	0	0%
Back x-ray	1	5%	0	0%	0	0%	0	0%
Step Test	0	0%	1	5%	0	0%	0	0%
Other fitness tests	0	0%	0	0%	0	0%	0	0%
Muscle Strength	0	0%	0	0%	0	0%	0	0%

Note: Calculated percentages based on 21 survey responses. Of the 21 companies, only one indicated they do not provide any exams. The other 20 provide some type of exam. This is a

multiple response question, percentages equal more than 100%. Nine companies of the 21 (43%) provide exposure exams.

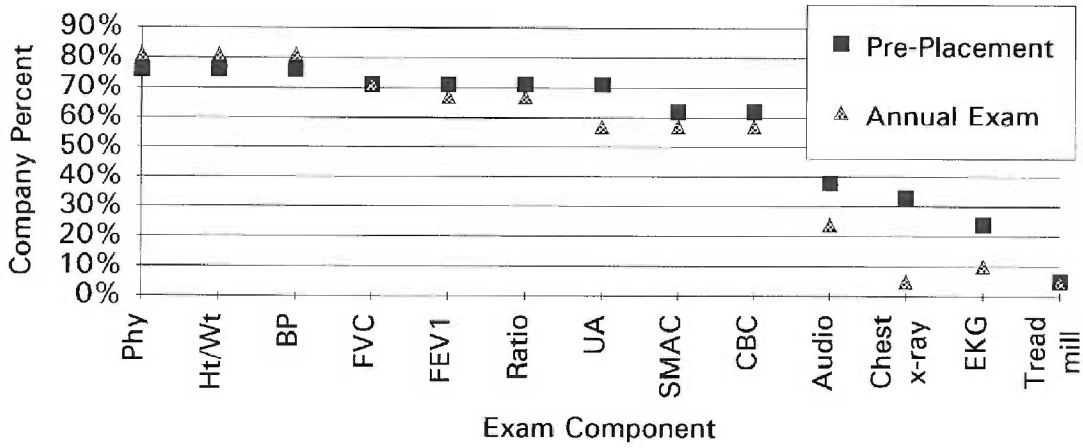

Figure 5. Components of annual and pre-placement exams

What Are the Criteria for Pass/Fail for the Exams?

Selection of Criteria

The criteria for determining who is medically qualified to participate on the HazMat team is established by physicians and nurses. Selection of criteria is solely the responsibility of the physician at 14 of the 21 companies (67%). A doctor and nurse team make these judgments at three companies (14%) and the company nurse at two companies (10%).

Table 7

Exam Criteria Decision Makers by Company

Medical Provider	f	Who Sets Criteria f (%)
Occ Med Dr. or Clinic	8	38%
Private Practice Dr.	0	0%
Company Dr.	6	29%
Co. nurse & any Dr.	3	14%
Nurse	2	10%
Physician Assistant	0	0%
No answer	2	10%
Total	21	100%

Exam Pass/Fail Criteria

Responses to questions quantifying what the pass/fail standards are were few and sketchy, although 15 of the 21 companies (71%) stated they use a pass/fail criteria for exams. Two companies (10%) do not use pass/fail criteria and two companies (10%) responded to this question by stating they make decisions on a case by case basis. Most respondents were unable to identify written, established criteria for data analysis and the determination of who is medically qualified for team

membership. The objective pass/fail measurements reported by study respondents are listed in Appendix E.

Spirometry standards. OSHA spirometry standards reference ANSI standards which require an FVC of 80% and an FEV1 of 70% for respirator use. Spirometry pass/fail standards were reported by 10 of 21 companies (48%), however, few respondents use either all or part of the ANSI standard. Seven of 21 respondents (33%) use the ANSI 70% FEV1 standard, two (10%) use the ANSI 80% FVC standard and six companies (29%) use a 70% measure for FVC.

Cardiovascular criteria. There is a lack of both testing procedures and data analysis criteria for evaluation of cardiorespiratory fitness to wear a respirator and HazMat suit. A blood pressure standard was reported by five companies (24%). A normal EKG is listed as a standard by two companies (10%) and one company (5%) requires participants to pass an EKG treadmill. Two respondents (10%) indicated they use firefighter standards, however, the firefighter 12 MET minimum fitness standard was not listed as a measurement criteria.

Audiometry and vision. One respondent of 21 (5%) stated a pass fail standard is used for audiometry but no numbers were given. Three respondents (14%) listed objective measures for vision standards.

Medical conditions. Disqualifying medical conditions were reported by 16 companies (76% of 21 total respondents), three (14%) do not have disqualifying conditions and one (5%) makes this decision on a case by case basis. Thirteen respondents listed specific disqualifying or limiting conditions.

Table 8

Disqualifying and Limiting Medical Conditions by Percentage of Companies Responding to Question

	Disqualifying Conditions		Limiting Conditions	
Medical Condition	f	f (%)	f	f (%)
Respiratory Conditions	13	100%	1	8%
Cardiac Conditions	4	31%	2	15%
Orthopedic (back, etc.)	4	31%	0	0%
Hypertension	2	15%	2	15%
Seizures, uncontrolled	2	15%	0	0%
Treadmill, failure	1	8%	0	0%
Abnormal blood tests	1	8%	0	0%
Other chronic disease	6	46%	1	8%
Aids, Hepatitis B	0	0%	1	8%
Diabetes	0	0%	1	8%

Note. Percentages calculated on 13 companies who responded to

the question. This is a multiple response question. Total percentages are greater than 100% (i.e. of the 13 companies 100% disqualify for respiratory conditions).

How Criteria Are Used to Make Decisions

The data regarding pass/fail criteria was minimal. Consequently, data describing how the criteria are used to make decisions about the worker's ability to participate on the HazMat team was also limited.

Cardiorespiratory decision making. Three of the five companies that listed a blood pressure pass/fail criteria listed uncontrolled hypertension or cardiac problems as conditions that would either disqualify or limit participation on the HazMat team. Five of the ten companies that listed at least one spirometry pass/fail criteria also listed disqualifying or limiting medical conditions that would be directly related to this standard, including asthma and other respiratory conditions. Decisions about HazMat team participation are made on a case by case basis by five of the 11 companies that indicated they use blood pressure and/or spirometry pass/fail criteria.

HazMat team exclusions for medical reasons. Members have been excluded from participation on HazMat teams for medical reasons in 12 of the 21 companies (57%). Eight companies (38%) have not excluded anyone for medical reasons.

HazMat Medical Exam Problems

Incapacitation during a response. One company (5%) has had a member become incapacitated while participating in a hazardous materials response. The incapacitation was due to an asthma attack. No other information was available.

Standards and decision making. Responders were asked to list problems they encountered regarding the HazMat team assessment and physicals. The lack of useful guidelines was the most difficult medical problem for eight of twenty-one respondents (38%). Eleven respondents (52%) stated they have no problems. The "other" category was reported by two respondents (10%) who listed concerns that exams were superficial and required excessive time. HazMat member weight gain was also mentioned as a problem. Eleven of twenty-one companies (52%) are comfortable with the exam standards they use; but seven (33%) are either uncomfortable or are not sure.

Table 9

HazMat Medical Exam Problems by Company Percentage

Problem	f	f (%)
None	11	52%
Lack of useful guidelines	8	38%
Other Weight gain by members Amount of time for exam	2	10%
Total	21	100%

Table 10

Exam Standard Comfort Level by Company Percentage

Comfort Level	f	f (%)
Comfortable with standard used	11	52%
Not comfortable or not sure	7	33%
No response	3	14%
Total	21	100%

CHAPTER 5

Discussion

Characteristics of HazMat teams and team members

Physiological demand required for industry hazardous materials response could vary significantly depending on the type of industry, the hazardous materials present and the physical layout of the facility. For this reason, similarities and differences that might affect physical demand and medical qualifications must be considered. The present study was limited to the semiconductor industry to minimize these differences. The anticipated similarity in HazMat team response characteristics and physical demand was supported by study data.

The most frequently reported team size is 25 to 75 members. However, a variation was seen in the number of HazMat team members in large organizations of over 1000 employees. In some cases this is due to different organizational structures. A few of the larger companies have separate fire, medical and HazMat teams so the total response group would be much larger than indicated by considering only HazMat teams membership.

HazMat Team Membership Characteristics

A number of HazMat team management practices may decrease medical exam problems and medical risks for members on a day to

day response basis. However, some of these same practices may actually increase risk in the event of a major catastrophe.

Self selection and membership. Membership is most frequently voluntary as reported by 13 of 21 companies (62%). Voluntary membership contributes to a self selection process possibly biased toward those who are healthier and younger. Self selection for membership and/or full response could be expected to reduce the number of unfit members. Those who know they are unfit would most likely either not join the team or would choose roles that did not require full response, SCBA respirators and protective clothing. There are some consequences for failure to participate on the team but this is not a major issue in most cases (72%) further increasing the likelihood of self selection.

Age. The age distribution of teams seems to indicate voluntary membership and self selection does contribute to a younger HazMat team membership. Eighty-five percent (659/771) of HazMat team members are below the age of 40. Less than 2% (15/771) are over 50 years of age. While not all companies reported age distributions of team members, the 67% response percentage (14 companies of 21) is significant enough to suggest these conclusions can be supported.

Gender. Gender differences in strength and stamina are minimal since team members in the study are primarily men. Eighty

percent of teams have memberships that are 80% to 100% male. Women members are in the minority representing only 22% (356/1684) of the whole sample. Over 60% of the individual team memberships are less than 5% female. The response rate for this question was 100% for the 21 companies.

Physiological Demand and Responsibility for Others

Physiological demand increases as response level increases. Higher level responders wear more restrictive gear imposing greater physiological burdens. Task response is greater and there is the added psychological stress of responsibility for the safety of others.

Routine response physiologic demand. Study data demonstrated the physiologic demand on team members for day to day response is significant because all groups (100% of 21 companies) respond at a technician or specialist level. The respirator alone, without additional protective clothing places an added physiological burden on a responder of 20% to 30%. The most significant demand is on the respiratory and cardiovascular systems (Raven, Dodson, Davis, 1979, Louhavaara et al. 1985, NIOSH, 1987). However, members may be at the upper level of their cardiovascular response capability without being aware of it because response frequency and duration is generally limited and victim rescue tasks are uncommon.

HazMat team member fitness. Infrequency of responses and short response distances may cause companies and team members themselves to become complacent about the need for maintaining physical fitness and regular exercise programs. Unfit members may not have the physical reserve to function during incidents more demanding than routine responses. Incidents requiring response are limited to 12 times or less each month for 90% of the teams (19/21) and three times or less per month for 57% (12/21). Response distances are 1/4 mile or less for 86% of the teams (18 of 21) and stair climb work load is two flights or less for 75% of HazMat teams (16/21).

Team member fitness and responsibility for life safety. Tasks are not limited to spill response and clean up. A majority of the teams have many of the same responsibilities for life safety as professional emergency responders. Victim rescue is a requirement for 86% of the 21 HazMat teams and fire response for 76%. These duties increase physiologic and psychologic stress. Additional burdens include heat stress and muscular exertion for lifting and transporting victims. This adds a greater degree of liability and responsibility for team members to be able to respond safely without placing themselves or others at risk. Safe response should be a key consideration when evaluating the medical condition and physical fitness of team members.

Exam Components

Cardiorespiratory Fitness

Since the most frequently provided standard exam does not measure cardiovascular fitness, there is no reason to believe that HazMat responders have incentive or are required to be more fit than the general population. As the studies cited in the review indicated, this may pose a problem. A majority of cardiac disorders occur without prior warning and are the primary cause of incapacitation of men in public safety (Bruce & Fisher, 1989). The study cited in the New England Journal of Medicine warns that individuals who do not exercise regularly are at greater risk for cardiac events during sudden and demanding exercise (Mittleman et al and Willich et al, 1993). Previous work does suggest that standardized fitness tests can predict sudden incapacitation and that they do predict performance on firefighter field tests with reasonable accuracy(Bruce & Fisher, 1989 and Schonfeld, Doerr & Convertino, 1990).

Nonetheless, this appears to be lost in medical evaluation considerations based on analysis of the standard exam identified in the study. Due to the infrequency of the response, members are not full time responders but are hired for other jobs. HazMat team membership is only one component of the job description and

as the data indicates, is most often voluntary. Exam cost factors may contribute to this as well.

Exam Pass/Fail Criteria

A significant percentage of the 21 respondents (71%) report they use pass/fail criteria. However, most respondents are either unsure what specific pass/fail criteria are used or failed to identify those criteria. Seventy six percent also indicated they use disqualifying criteria for participation or limit participation based on medical conditions.

Medical provider qualifications and responsibility for establishing criteria. In addition, results of the present study indicate that, for the majority of the 21 companies, physicians are totally or partially responsible for choosing what is included on the exam, (90%), conducting the exams (82%) and setting exam criteria (81%). Nurses are involved less frequently at 43%, 34% and 24% respectively. Yet there is little help from regulatory guidelines or published research to help physicians and nurses set standards, particularly for evaluating results of cardiovascular fitness components of exams. This is a problem because previous research found a dramatic variation in the level of medical surveillance examinations among providers due to differences in experience and training (Udasin, Buckler and Gochfeld, 1991). The

more the experience and training vary, the more critical research based standard practice objective guidelines become.

How Criteria Are Used to Make Decisions

Evaluating Fitness for HazMat Team Participation

Decisions seem to be made on a case by case basis in most instances. Thirteen companies listed a number of medical conditions that either disqualify or limit HazMat team participation, more than the number of respondents listing objective measurement criteria such as spirometry measures or blood pressure standards. Fifty seven percent report they have excluded individuals from participating for medical reasons. Linking the reported disqualifying or limiting medical conditions to clearly defined rationales or pass/fail criteria was not possible based on the data from this study.

Legal Concerns

The recent American's with Disabilities Act (1990) requires employers to quantify the reasons for any restriction based on medical disability and to provide "reasonable accommodation" to the disabled. This would seem to make the current approach of relying on individual physician determination without research backed rationales to document response requirements difficult to defend in many instances. This is important in those situations where team members respond on an infrequent basis.

Medical Exam Problems

Not many of the occupational nurses and safety professionals responding to this study appear to have questioned whether the exams fulfill regulatory requirements or are sufficient to evaluate the fitness of HazMat responders and to prevent a member from becoming incapacitated during a response. A majority (52%) of the twenty-one respondents indicated they were satisfied with the exam criteria they were using. Similarly, 52% noted no exam problems. The comfort level may be due to reliance on physicians judgment, the looseness of regulatory guidelines and the lack of objective measurements available. It is also possible that survey respondents are not familiar with the physiologic demand imposed by the respirators and HazMat gear (NIOSH, 1987) and the resultant risk of an incapacitation event during an incident.

Thirty-three percent of the 21 survey respondents did indicate they were not comfortable with exam standards and criteria or were unsure. Lack of useful guidelines was cited by survey responders from eight companies (38%) as their most serious medical exam problem. A sense of discomfort may lead to questioning and closer scrutiny of current practices, and as a result, begin to open up communication with other health and safety professionals to address the issues this study raises.

Risk Evaluation

Based on the findings of this study, an incapacitation during a hazardous response event is a somewhat rare event. It could be argued that because incapacitation was reported by only one of the 21 companies (5%) it is, therefore, not an issue.

However, the study also demonstrated that responders are a young and likely self selected group. As the general population and the population in semiconductor facilities' ages, the risk to responders and those whose lives they are protecting may increase.

It is also possible that no serious problems have been reported because no major disasters with multiple medical casualties have occurred. Responses may have been limited and routine, allowing teams to rely on a few self selected healthy responders with others performing backup.

In addition, 65% of teams allow individuals with medical conditions to participate, but limit their participation to non SCBA response and/or non victim rescue response. Because teams allow workers to participate who are not medically qualified for full response there are questions that must be considered. How would the team handle a major disaster if one were to occur? Would teams have too few qualified responders to handle an event of larger magnitude? In a major disaster would there be time to sort out the medically qualified from the unqualified? Would

medically limited responders be called upon to respond, risking their own safety or the safety of others?

Limitations

The population base for this study was limited to members of professional semiconductor associations. This may not be representative of the whole semiconductor manufacturing industry.

A limited number of parent organizations were identified (34). Multiple companies of these parent organizations were included in the sample which also might bias the results since company culture and practice might be similar from site to site, although, the review of the results did not seem to indicate this was the case.

There was no practical way to identify nurses practicing at all of these facilities so the sample was sent to safety managers or those who would be most likely to be involved with this issue. Nurses presumably would have been more familiar with exam criteria and responses could be predicted to be more complete, especially in the area of exam evaluation. Thirty six percent of responses were from nurses, however, and while information was somewhat more complete, the problems noted were also evident in these responses.

Every effort was made to achieve a balance between items to answer the research questions and keeping the questionnaire short enough so recipients would participate. However, when results

were received, the failure to include standard electrocardiograms in the exam content portion of the questionnaire was recognized as a problem. Some survey respondents wrote it in. The information was obtained by telephone from the rest of the respondents.

One content area left off the exam was assessment of vision tests. No attempt was made to obtain this information. In retrospect, it would have been a good idea to obtain data addressing HazMat team member vision.

The survey was written as simply as possible to elicit a favorable response rate, however, without a verbal conversation with each respondent, there was no way to clarify issues. This was not part of the design.

In spite of the random selection of the sample, a possibility of selection bias still exists. Those who choose to participate may be more aware of or interested in HazMat medical surveillance exam problems and not representative of the whole population.

Finally, this study is missing a critical component which needs to be addressed before a judgment can be made about the current standard of practice for industry HazMat exams. That missing element is the physician. Since a majority of the companies are relying on physicians or physicians and company nurses for choosing and conducting exams and setting standards,

the study questions need to be revised and targeted to this group. It is possible there is a standard that is uniformly used by medical practitioners. The Udasin, Buckler, Gochfeld (1991) study suggests this is not the case, however, before a standard of practice statement can be made, this must be verified.

Summary

Companies that manufacture, store or otherwise use hazardous materials are required by law to have on site HazMat teams. Response characteristics for these teams in the semiconductor industry are similar, including level of response, personal protective equipment, required task performance, response frequency, duration and workload. Teams respond to chemical and gas releases and spills. A majority also respond to fire and medical emergencies and rescue victims.

HazMat members are the first line of defense in an emergency. They are accountable for the safety and even the lives of people who may be in harms way in the event of an accident involving hazardous materials.

HazMat response requires the use of chemical protective gear and respirators that significantly increase physiological workload and cardiorespiratory demand. This increased physiologic demand interacts with response stress and individual physical condition to create an increased potential for injury and incapacitation.

Incapacitation of a responder could endanger team members, other employees and the public. Medical examinations, required by federal law, are a critical element in assuring the safety of team members and those they protect. However, a review of the literature and regulations indicated that there are no standards for determining medical fitness for duty on industry HazMat teams. This descriptive survey study was initiated to identify the current standard of practice in the industry for HazMat team medical exams.

The exam content is suggested by NIOSH but the industry standard exam identified in this study does not meet NIOSH criteria. Only a few companies provide cardiovascular fitness testing in spite of the significant increased cardiorespiratory demand imposed by respirators and chemical suits.

No research was found that provides standards to evaluate medical fitness for participation on an industry HazMat team. As a result, providers develop their own standards, or more frequently, make decisions on a case by case basis.

ANSI standards are available for evaluating pulmonary fitness for respirator use. However, according to the study, these are not incorporated into evaluation criteria as a uniform industry standard of practice. Until research is available for measuring HazMat physiologic workload, oxygen consumption

measurements from firefighter studies could be used as a criteria for cardiovascular fitness but this is not current practice.

Clinical Significance

The information summarized in this research can be used to deduce the current standard of practice for industry HazMat medical surveillance exams and reveals a number of problems for further consideration.

According to the results of this study, current standard of practice exams in the industry do not meet published (NIOSH) criteria for content.

Providers have no uniform standards for evaluating individual medical fitness for participation on HazMat teams. Exam data is collected, but respondents seem to be unclear what to do with the data when they get it. A deficiency in measurement and evaluation of cardiorespiratory fitness to wear a respirator and chemical suit is of particular significance.

Individuals with medical conditions that are allowed to be on the teams but on a limited participation basis might be pressed into response in the event of a major emergency risking their own safety and the safety of others.

Without research based standards, disability lawsuits are a serious consideration when individuals with medical conditions are

not allowed to participate on the team or are allowed to participate but with restrictions.

There is a need for greater communication among nursing, medical and safety providers to improve medical exam standards for the protection of the HazMat team members, employees and the public.

Suggestions for Future Research

The study should be repeated and attempts should be made to elicit a larger response. The nurses and medical providers within the company should be the target survey population.

Physicians were not surveyed, but were identified by the study as key decision makers in terms of exam content, pass/fail criteria selection and using that criteria to make decisions about the workers' fitness to participate on the HazMat team. the questionnaire should be revised and the study repeated with this group to more clearly identify current practice both in terms of exam content and evaluation of fitness for duty.

When the current standard of practice is identified, future work to quantify physiological demands on responders as well as more studies on responder fitness and risk of incapacitation should begin. A published measure for physiologic work of HazMat response similar to the 12 METS accepted as the firefighter standard should be one ultimate goal.

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Appendix A

February 14, 1994

As the Health and Safety Manager for a semiconductor company, I have had difficulty finding published information to define medical exam standards for industry emergency response team members (ERT). Perhaps you have had this same problem and have either found solutions or are still looking. Either way, I am asking for your help.

I am conducting a study to identify what medical exam standards are used by other semiconductor/electronics companies for their emergency response teams. I am especially interested in how results are evaluated when the exam is complete and how cardiovascular fitness to wear a haz mat suit and SCBA is determined.

Your response to this survey is important in establishing the current standard of practice in the industry for ERT medical exams and laying the groundwork for future research in this area.

I would very much appreciate it if you would take a few minutes to complete the attached survey and return it by **February 25** in the enclosed postage paid envelope. **Everyone who participates will receive a copy of the study results.**

Because this study is being conducted through the University of Oregon Health Sciences University, a standard consent form required by the University for all research is also enclosed. Please sign that form and return it as well.

If you would prefer to answer the survey by talking with me directly, or if you have questions, my telephone number is 503-669-6091 and my Fax number is 503-669-6109.

Thank you for your help! I am looking forward to hearing from you!

Sincerely,

June Ann Cole, R.N., BSN
Section Head
Safety and Environmental Control

Appendix B

OREGON HEALTH SCIENCES UNIVERSITY
Consent Form

TITLE: Medical Evaluation of Hazardous Materials Response Teams in the Semiconductor Industry

PRINCIPAL INVESTIGATOR(S): June Ann Cole, RN, BSN
Phone number (503) 669-6091
Pat Butterfield, RN,PhD
Phone number (503) 494-2536

PURPOSE: The purpose of this research is to identify what medical exam standards are currently used by semiconductor industries to evaluate the medical fitness for duty of hazardous materials team members. You are being asked to complete a written survey that may take 30 to 45 minutes of your time to complete.

PROCEDURES: The survey asks questions about your company, your hazardous materials team and team medical surveillance exams. Information from your survey will be combined with information from other semiconductor companies to form a profile of exam standards in the industry.

RISKS AND DISCOMFORTS: It is possible that the time required to complete this survey may cause some inconvenience to you. June Ann Cole has offered to answer any questions you might have about this research study. Her phone number is (503) 669-6091.

BENEFITS: By participating in this study you will receive a summary copy of the results which can be used to help you evaluate your own protocols to those in use by other companies. You may also contribute new information which may be beneficial for future research.

CONFIDENTIALITY: Your survey will be assigned a study number and will be analyzed by this number. This study number will be used to combine your survey response with responses from other semiconductor companies. A master list that links your name and company to your study number will be kept in a locked file, with only Oregon Health Sciences University investigators having access to this list. Neither your n me nor your identity will be used for publicity purposes.

COST: There is no cost to you for participating in the study.

LIABILITY: The Oregon Health Sciences University, as an agency of the State, is covered by the State Liability Fund. If you suffer any injury from the research project, compensation would be available to you only if you established that the injury occurred through the fault of the University, its officers or employees. If you have further questions, please call Dr. Michael Baird at (503) 494-8014.

Your participation is voluntary. You may refuse to participate or you may withdraw from this study at any time without affecting your relationship with or treatment at Oregon Health Sciences University. If you have questions about your rights as a research subject, you may contact OHSU Institutional Research Board at (503) 494-7887. You will receive a copy of this consent form.

Your signature below indicates that you have read the foregoing and agree to participate in this study.

Subject:_____ Date_____

Witness:_____ Date_____

Please sign this copy and return it with the survey
We will store it separately from your survey.

Appendix C

INDUSTRIAL HAZARDOUS MATERIALS RESPONSE TEA
MEDICAL EXAMINATION STANDARDS SURVEY

Please complete the following survey and return in the enclosed postage paid envelope by _____
Thank you for your participation.

Company Name:

_____

City: _____ **State:** _____

Survey completed by: _____

Title: _____

1. **What are the main products produced at your company?**

   _____

2. **Does the company have an onsite**
   nurse? ☐ yes ☐ no
   physician? ☐ yes ☐ no

3. **How many hours a day does your company usually operate?**
   ☐ 8 hours
   ☐ 16 hours
   ☐ 24 hours
   ☐ other _____

4. **How many days a week does your company usually operate?**
   ☐ 5 days
   ☐ 6 days
   ☐ 7 days
   ☐ other

5. **Please check the category closest to the number of employees in your company**
   ☐ 0- 50
   ☐ 51- 100
   ☐ 101- 250
   ☐ 251- 500
   ☐ 501-1000
   ☐ more than 1000

6. **Does your company have a hazardous m**
   response (haz mat) team? (also may be c
   emergency response or spill response tea
   ☐ yes
   ☐ no

   IF THE ANSWER TO QUESTION 6 IS
   STOP HERE. . . . . Thank you for your re

7. **How many members does your haz mat t**
   have? _____

8. **What is your haz mat response level?**
   (Please check the one best response)
   ☐ Awareness - recognize an emergency, c
   appropriate response group
   ☐ Operations - recognize a haz mat emerg
   intiate response
   ☐ Technician - respond to the emergency
   chemical protective gear/respirator
   ☐ Specialist - respond to a spill requiring
   highest level of protective gear

9. **Do haz mat team members respond to**
   medical emergencies? ☐ yes ☐ no
   fires? ☐ yes ☐ no

10. **Is haz mat team membership**
    ☐ voluntary?
    ☐ required as part of the job?
    ☐ voluntary for some groups, required for
    ☐ other _____

11. **If membership is required, what are the consequences of not participating?**
    ☐ none
    ☐ disciplinary action
    ☐ no opportunity for promotion
    ☐ loss of position
    ☐ other _____

12. **How many haz mat team members are**
    male? _____
    female?

13. Approximately how many members are in each age group?

18-30 _____
31-40 _____
41-50 _____
over 50
☐ don't know

14. Does your company have an age limit for haz mat team members?

☐ yes, what is the limit? _____
☐ no

15. How often, on the average, do members respond to emergencies?

☐ daily
☐ 1-3 times per week
☐ 1-3 times per month
☐ less that 1 time per month
☐ don't know

16. What is the average duration time of the response in minutes?

☐ less than 15 minutes
☐ 15-30 minutes
☐ 30 minutes to 1 hour
☐ over 1 hour

17. What level of protection is <u>most</u> often worn? (Please check the best response)

☐ Level A - highest level, self contained respirator and vapor proof protective suit
☐ Level B - same level of respiratory protection but with chemical resistant splash suit
☐ Level C - same level of skin protection as level B but with an air purifying respirator
☐ Level D - coveralls or apron, safety glasses, safety gloves, hard hat

18. What respirators are <u>most</u> often worn for response?

☐ air purifying
☐ SCBA - self contained breathing apparatus
☐ supplied air respirator
☐ don't know

19. What is the SCBA cylinder time rating?

☐ 30 minutes or less
☐ 45 minutes
☐ 60 minutes
☐ don't know

20. How many flights of stairs must respond in a <u>worst case</u> scenario?

☐ none
☐ one
☐ two
☐ three
☐ four or more

21. What is the distance responders <u>usually</u> travel during response?

☐ 1/4 mile or less (1380 feet)
☐ 1/4 to 1/2 mile
☐ 1/2 to 3/4 mile
☐ 3/4 to 1 mile or more
☐ don't know

22. Is victim rescue considered a haz mat te

☐ yes
☐ no

23. Has any member of your team become i citated (had a medical problem) during a response?

☐ yes
☐ no
☐ don't know

24. What is your most difficult medical exa problem? (Please check the one best res

☐ No useful guidelines for determining fi membership on the haz mat team
☐ Too many members are unable to pass
☐ The company and/or physician is uncle what to do if the exam reveals problem
☐ The company is unable to find a qualifi medical provider willing to conduct the
☐ none
☐ other _____

25. Are medical exams required for haz mat team members and at what frequency? (Check all that a

- ☐ a. prior to placement on the team
- ☐ b. if exposure occurs
- ☐ c. annual (every year)
- ☐ d. every two years (bi-annual)
- ☐ e. every three years or more
- ☐ f. none

IF YOUR ANSWER TO QUESTION NUMBER 25 WAS "NONE" PLEASE STOP HERE. .
Thank you for your response.

---

26. If an exam is used, please indicate which of the following exam components are included and at what frequency? (Check all that apply.)

	prior to placement on team	annual	every 2 years	3 or more years
(a) BASIC EXAM				
history/physical	☐	☐	☐	☐
height/weight	☐	☐	☐	☐
blood pressure/heart rate	☐	☐	☐	☐
chest x-ray	☐	☐	☐	☐
back x-ray	☐	☐	☐	☐
(b) LABORATORY TESTS				
blood chemistry (SMAC)	☐	☐	☐	☐
blood count (CBC)	☐	☐	☐	☐
urinalysis	☐	☐	☐	☐
cholesterol	☐	☐	☐	☐
other biological tests	☐	☐	☐	☐
(c) SPIROMETRY				
FVC	☐	☐	☐	☐
FEV1	☐	☐	☐	☐
Ratio	☐	☐	☐	☐
(d) AUDIOMETRY	☐	☐	☐	☐
(e) CARDIOVASCULAR FITNESS				
(Choose the test used most often)				
EKG treadmill test	☐	☐	☐	☐
protocol: if known				
☐ Bruce				
☐ Balke				
☐ other or don't know				
bicycle test	☐	☐	☐	☐
step test	☐	☐	☐	☐
12 minute walk/run	☐	☐	☐	☐
1.5 mile run	☐	☐	☐	☐
other	☐	☐	☐	☐
(f) MUSCLE STRENGTH				
strength (weight lifting)	☐	☐	☐	☐

27. Do you use a pass/fail criteria for any of the above exam components

- ☐ yes
- ☐ no
- ☐ don't know

IF THE ANSWER TO NUMBER 27 IS YES, COMPLETE QUESTION 28. IF THE ANSWER I PROCEED TO QUESTION 29.

---

28. Please indicate which tests are evaluated using pass/fail criteria and what the criteria is. For example: a passing criteria that states blood pressure cannot exceed 140/90 (140 is the systoli measure, 90 is the diastolic measure) Please leave anything you do not know blank.

	If there is a criteria for passing, what is it?				none	dc
(a) BLOOD PRESSURE	systolic_____		diastolic_____		☐	
(b) SPIROMETRY	FEV1_____%		FVC_____%	Ratio_____	☐	
(c) CARDIOVASCULAR						
	mets	minutes	normal EKG	other		
Electrocardiogram (EKG)			_____	_____	☐	
Treadmill with EKG	_____	_____	_____	_____	☐	
Treadmill without EKG	_____	_____		_____	☐	
Bicycle with EKG	_____	_____	_____	_____	☐	
Bicycle without EKG	_____	_____		_____	☐	
	distance	time	other			
12 minute walk/run	_____	_____	_____		☐	
1.5 mile run	_____	_____	_____		☐	
Step test		_____	_____		☐	
other	_____	_____	_____		☐	

(d) AUDIOMETRY

	1000Hz	2000Hz	3000Hz	4000Hz	6000Hz
Right					
Left					

☐

(e) CORRECTED VISION ☐

Acuity	Near	Far
Right	20/	20/
Left	20/	20/

Color	Red	Green	Blue/Violet	other
	_____	_____	_____	_____

(f) OTHER _____ ☐

29. Are there any existing medical conditions which disqualify individuals from participating on the

- ☐ yes
- ☐ no
- ☐ don't know

30. If the answer to question 29 is yes, please list up to 5 of these in order of importance (1 is most im 5 is least important)

1. _____
2. _____
3. _____
4. _____

31. Are you comfortable with the medical exam standards used by your company, expecially the cardiovascular fitness standards?

- ☐ yes
- ☐ no
- ☐ unsure

32. If pass/fail criteria are used, what are the consequences for failing medical or fitness tests?
Check all that apply

- ☐ no consequences
- ☐ referred to physician or medical provider for further testing and/or treatment
- ☐ put on probation until medical problem is corrected
- ☐ eliminated from team
- ☐ allowed to be on the team, but on some limited basis depending on the nature of the problem
- ☐ job related consequences (i.e. must change to a different job)
- ☐ don't know

33. Who is responsible for the following? (please check one response for each question)

	Occ Med Clinic or MD	Private Practice MD	Company MD	Company Nurse and MD
(a)Who determines what is included on the exam?	☐	☐	☐	☐
(b) Who conducts the exams?	☐	☐	☐	☐
(c) Who sets pass/fail criteria for exams?	☐	☐	☐	☐

34. What source does your company use for setting medical exam standards?

- ☐ fire fighter standards
- ☐ NIOSH guidelines (Guidance Manual for Hazardous Waste Site Activities)
- ☐ physician determination
- ☐ no specific guidelines
- ☐ other published guidelines (please list) _____

35. Have you had any workers who wanted to be on the haz mat team but were excluded for medical reasons?

- ☐ yes
- ☐ no
- ☐ don't know

36. Do you have any other comments or concerns?

_____

_____

WOULD YOU LIKE A COPY OF THE RESULTS OF THE SURVEY

- ☐ YES
- ☐ NO

IF YES, SEND TO? _____

THANK YOU FOR YOUR PARTICIPATION

Appendix D

OREGON
HEALTH SCIENCES UNIVERSITY
3181 S.W. Sam Jackson Park Road, Portland, OR 97201-3098
Mail Code L106, (503) 494-7887 Fax (503) 494-7787
Institutional Review Board/Committee on Human Research

DATE: January 19, 1994

TO: June Ann Cole, MSN SON-CH
Dr. Pat Butterfield, Advisor

FROM: Nancy White, Admin. Asst.
Committee on Human Research L-106

SUBJECT: Project entitled "Medical Evaluation of Hazardous Materials Response Teams in the Semiconductor Industry."

It is my understanding that this project involves survey procedures. This study would fit exemption category #2 of the federal regulations (45 CFR Part 46.101 (b)) and is considered to be exempt from review by the Committee on Human Research. If you wish, a cover letter explaining the study may be attached to the questionnaire (instead of having subjects sign a consent form).

This study has been put into our exempt files, and you will receive no further communication from the Committee concerning this study. However, if the involvement of human subjects in this study changes, you must contact the Committee on Human Research to find out whether or not these changes should be reviewed. If possible, please notify the Committee when this project has been completed.

If you have any questions regarding the status of this study, please call me at 494-7887.

Appendix E

Exam Pass/Fail Measurement Criteria by Number of Companies Reporting Criteria for Exam Component

Exam Component	Standard	f	f (%)
Blood Pressure	140/90	3	75%
	160/100	1	25%
Total		4	100%

Exam Component	Standard	f	f (%)	f	f (%)	f	f (%)
Spirometry		FVC		FEV1		Ratio	
	65%	0	0 %	0	0%	1	50%
	70%	6	60%	7	78%	1	50%
	80%	2	20%	1	11%		
	90%	2	20%	1	11%		
Total		10	100%	9	100%	2	100%

Exam Component	Standard	f	f (%)
Near Vision	20/40	1	100%
	20/100		0%
Total Near Vision		1	100%
Far Vision	20/40	2	67%
	20/100	1	33%
Total Far Vision		3	100%