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OCCUPATIONAL MEDICAL SURVEILLANCE RECOMMENDATIONS

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This report is written to assist base-level aerospace medicine services personnel establish an occupational medical surveillance program. A literature search was done of the most current information regarding occupational medical surveillance. A table was created of the most frequently used chemicals that includes target organs, routes of exposure, symptoms, and medical surveillance recommendations. The concepts behind an occupational medical surveillance program are discussed and the actual process is outlined. The appendixes of this report have dated material and will be updated as needed.

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OCCUPATIONAL MEDICAL SURVEILLANCE RECOMMENDATIONS

INTRODUCTION

Purpose

The purpose of this technical report is to provide guidance for establishing medical surveillance examinations as part of the Air Force Occupational Health Program. This document is intended for use primarily by the medical surveillance personnel responsible for initiating and maintaining this program.

Problem

There is currently no standardized system for establishing the physical examination requirements for the Air Force Occupational Health Program.

Scope

This report will cover the basic elements necessary to establish effective medical surveillance for the Air Force Clinical Occupational Health Program. An efficient information system (reference materials, databases for the specific types of hazards pertaining to each base, etc.) should be developed. The responsibility for establishing and maintaining this program is shared by the flight surgeon or occupational medicine consultant, the bioenvironmental engineer (BEE), and the environmental health officer (EHO).

Definitions and examples will be given to develop the concepts which should be used at each base for individual situations. The system presented here provides a uniform method for base level implementation. The key is uniformity in approach to surveillance activities. This provides for a definitive yet flexible process to satisfy particular exposure scenarios unique to each base program.

DISCUSSION

This report will present guidelines for establishing an occupational medical surveillance program. Examples will be given of various categories of chemicals that may be in use at most Air Force bases. Areas of importance are the routes of exposure, target organs and health effects, occupational health surveillance (preplacement/periodic, and termination examinations), and biological monitoring.

Definitions

Environmental monitoring identifies the existence of chemical, biological, physical, or ergonomic agents and characterizes each agent present in terms of duration, level, toxicity, etc. External dose measures the airborne concentration, water concentration, etc. at the time of measurement only and is not statistically valid as a measure of exposure by itself. It is not a measure of effect and does not measure the internal dose. It is one component

to be considered in the process and should not be used as the ultimate determining factor to initiate medical surveillance.

Biological monitoring measures the level of hazardous agents or their metabolites in biological specimens (blood, tissues, body fluids, expired air, etc.) and provides quantitative evidence of absorption and retention in the body. This procedure **may be used as** a means to measure the effectiveness of personal protective equipment and procedures. It provides a way to measure the internal dose of a toxic substance to the individual sampled. Internal dose is a measure of the amount of toxicant in fluid or tissue and can be used as one measure of health risk. As with environmental monitoring, it is not a measure of effect and does not predict the human response to the substance in question.

Occupational health surveillance defines the physical examination and historical elements required to assist in the monitoring of employees with various exposures. It is based on the systematic collection, analysis, and evaluation of the data necessary to define the presence of disease patterns. The surveillance program is sometimes confused with biological monitoring. Biological monitoring may be part of an overall surveillance program, but it is insufficient by itself to evaluate the effectiveness of disease prevention activities. Data collection by periodic interviews with employees, review of medical records and various medical logs is required for an effective program.

AL - action level, a concentration designated in 29 CFR 1910 for a specific substance, calculated as an 8-hour time-weighted average (TWA), which requires medical surveillance, such as exposure monitoring; complete exams are **required** when an individual is exposed to a hazard above the AL or the Short Term Exposure Limit (STEL).

CFR - Code of Federal Regulations. 29 CFR 1910--General Industry Standards.

Chemical hazard - a chemical for which there is significant evidence that acute or chronic health effects may occur in exposed personnel.

PEL* - permissible exposure limits regulated by the Occupational Safety and Health Administration (OSHA), specified in 29 CFR 1910.1000 Tables Z-1, Z-2, Z-3 and OSHA standards for specific substances in 1910.1001-1910.1101; the employer should assure that employees' exposures do not exceed the PEL's.

TLV* - threshold limit value. These are standards of exposure, based on current professional opinion and subject to change, for chemical, physical and biological agents. They are established by the American Conference of Governmental Industrial Hygienists (ACGIH), and are believed to define conditions to which nearly all workers may be exposed on a daily basis for a working lifetime without adverse effects.

* NOTE - AFOSH Std. 161-8, Permissible Exposure Limits for Chemical Substances, states that Air Force must comply with the most recent ACGIH, Threshold Limit Values for Chemical Substances booklet unless the PEL is more stringent. The key is that compliance should be with the most stringent value.

References

References are needed at base level to make recommendations for the health surveillance program. Use information obtained from the supplier of the chemical, such as material safety data sheets (MSDS's) or product safety bulletins. This information should be considered incomplete. Other sources must be used. The following references are recommended in addition to those found in Attachment 5, AFOSH Standard 161-17, Standardized Occupational Health Program. Be sure to use the latest editions:

1. OSHA guides, Code of Federal Regulations (CFR).

2. Patty, F. A. Industrial Hygiene and Toxicology.

3. Threshold Limit Values and Biological Exposure Indices for 1990-91, American Conference of Governmental Industrial Hygienists (ACGIH).

4. Doull, Klaassen, and Amdur, Casarett and Doull's Toxicology; The Basic Science of Poisons, Macmillan Publishing Co., Inc., New York, NY, 1986.

5. Proctor, N. H., J. P. Hughes. Chemical Hazards of the Workplace, J.P. Lipincott Company, 6 Winchester Terrace, New York, NY 10022, 1989.

6. Handbook of Chemistry and Physics, Chemical Rubber Company, Cranwood Parkway, Cleveland, OH 44128.

7. Last, J. M. Editor, Maxcy-Rosenau Public Health and Preventive Medicine, Appleton-Century-Crofts/Norwalk, Connecticut, 1986.

8. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment and Biological Exposure Indices with Intended Changes, ACGIH, 6500 Glenway Avenue, Bldg. D-5, Cincinnati, OH, 45211.

9. Zenz, C. Occupational Medicine Principles and Practical Applications, Year Book Medical Publishers, Inc., Chicago, London, Boca Raton.

10. The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals. Editor, Susan Budavari. 11th edition, 1989.

NOTE: The following documents may be acquired through the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

11. NIOSH Pocket Guide To Chemical Hazards, NIOSH Pub. No. 90-117

12. Occupational Health Guidelines, NIOSH/OSHA (NIOSH Pub. No. 81-123).

13. Registry of Toxic Effects of Chemical Substances, NIOSH Pub. No. 80-102. Also available as a quarterly microfiche or on CD-ROM through commercial sources.

14. Miscellaneous Documents published by the National Institute for Occupational Safety and Health (NIOSH):

Criteria Documents
Occupational Hazard Assessments
Special Hazard Reviews
Current Intelligence Bulletins

15. NTP Annual Report on Carcinogens and Summary of the Annual Report on Carcinogens, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; (703) 487-4650.

There are numerous sources of computerized databases and most can be accessed with personal computers. The data sources are associated with health hazards and safety as applied to hazardous chemicals. This information may help establish an occupational surveillance program. TOMES Plus (Toxicology, Occupational Medicine and Environmental Series) Information System is a user-friendly, industrial chemical database which is updated constantly and republished every three months. TOMES Plus contains MEDITEXT^{tm}, HAZARDTEXT^{tm}, DOT Emergency Response Guides, HSDB (Hazardous Substances Data Bank), 1st Medical Response Protocols, OHM/TADS (Oil and Hazardous Materials/Technical Assistance), CHRIS (Chemical Hazard Response Information System), IRIS (Integrated Risk Information System), RTECS (Registry of Toxic Effects of Chemical Substances), and TERIS (Teratogenicity Information System), REPRORISK^{tm} (Reproductive Risk Information System).

The detailed listing of the data sources is at Appendix A. Additional copies of the listing are available at AL/OEMB, Environmental Biology Branch. Professionals with expertise in toxicology, occupational medicine, industrial hygiene, and hazardous waste management and disposal are also available to answer any occupational health question, DSN 240-2063/3214.

Concept of Occupational Health Surveillance

Screening for occupational disease is the search for new or previously unrecognized symptoms and diseases that may be caused or influenced by work factors. It is the systematic collection, analysis and dissemination of disease data on groups of workers. Screening methods include questionnaires, physical examinations, laboratory and other procedures. Screening is one in a range of technics applied to the prevention of occupational disease. Screening should attempt to prevent disease occurrence. To do this effectively, worker responses to the environment must be monitored. More often, screening will identify conditions already in existence. It is hoped these conditions will be at a point where progression can be slowed, halted, reversed or effective rehabilitation applied.

There are three types of prevention activities: primary, secondary and tertiary.

Primary prevention is the action taken to reduce risk factors in order to prevent disease entirely. Some examples are:

1. Substitution of less toxic chemicals.
2. Containing hazards with engineering process controls.
3. Personnel protective measures.
4. Eliminating hazardous processes from the workplace.
5. Environmental monitoring.
6. Biological monitoring.
7. Worker symptom monitoring.

Secondary prevention is intervention early in a disease process in order to halt or reverse disease development. Some methods used at this level of prevention are:

1. Screening to detect early disease.
2. Medical treatment.
3. Reducing or eliminating exposure by job change, administrative control.

Tertiary prevention decreases the effects of disease and disability by rehabilitation. Some examples are:

1. The use of splints to prevent contractures.
2. Exercise to strengthen injured members.
3. Preventive techniques for pressure points and bladder function in paraplegics.

THE SURVEILLANCE PROCESS

Industrial Hygiene

Evaluating the Industrial Environment

A **multi-disciplinary** approach is required to eliminate hazards in the workplace. This approach requires the **coordinated** action of bioenvironmental engineers, physicians, environmental health officers, safety officers, fire inspectors, chemists, toxicologists, workplace supervisors and individual workers.

The practice of industrial hygiene begins with a review of the chemical, physical and biological stresses that workers may encounter on the job. For each stress there exists a dose-response relationship between the magnitude of exposure to the agent and the potential (risk) for injury. It is assumed that each agent can be dealt with at some acceptable level of contact without impairing workers' health. ("The dose makes the poison.") However, the level of contact which is assumed to be acceptable is based on current knowledge and professional opinion and subject to change. With this caveat in mind, the application of the TLV and PEL are two of many possible measures of this risk. The principles of concern in evaluating the industrial environment are: anticipation and recognition of potential hazards; data collection for hazard evaluation; data interpretation; and recommendations for controlling hazards.

Anticipating and Recognizing Potential Hazards:

Use findings of previous or similar surveys.
Use findings/summary of previous occupational physicals.
   Epidemiological summary by Environmental Health Services (EHS).
Learn the shop processes/activities.
   Pre-survey conference and interviews.
   Perform the activity yourself.
Review building and utility systems plans.
Inventory the physical, chemical and biological agents present.
   Routes of entry.
   Medical effects of high exposures.
       Short and long term.
       Target organs.

Collecting Data:

Select proper equipment and analytical methods.
Calibrate equipment.
Sample/measure worker exposures.
   Frequency and length of process/operation.
   When, how long, how many samples?
   General area vs. breathing zone.
   Typical vs. maximum risk exposures.

Interpreting Data:

Compare to standards (TLVs, PELs) .
Compare to previous data.
Compare to personal observation of operations.
   Results make sense?
   Sample results "None Detected" (ND) while workers showing symptoms?
   "Worst case" exposures unrealistic?

Controlling Hazards:

Study existing control measures.
Change the operation.
   Material substitution.
   Reduce exposure time.
   Reduce intensity by increasing distance.
Engineering controls.
   Isolate worker from source with shield, barriers, ventilation.
Personal protective equipment (PPE).
   Selected for the hazard.
   Hazard does not overwhelm PPE capacity.
   Doesn't create secondary hazard.
Periodically review job activities and controls.

The Bioenvironmental Engineering Services (BES) approach to workplace evaluations can lead to a checklist approach whereby the surveyor performs an inventory of hazards, measures the hazards and compares them directly to PELs. However, reliance on PELs alone ("management by the numbers") leads to a false sense of security, and exposure measurements below the PELs can be totally ignored. BES surveyors can ignore conflicting workplace observations, medical providers can ignore medical effects reported by patients, and commanders can fail to accept Risk Assessment Codes (RACs) or recommended changes. All health standards require action for exposures above PELs or Action Levels. However, it is assumed exposure below PELs require controls such as personal protective equipment (PPE) and Occupational Physicals to be withdrawn. BES must remember that industrial hygiene measurements are an estimate (simulation) of the workers' exposures with many potential sources of error and variability. Interpreting survey results still requires professional judgment.

Determination of Screening Examinations

Determining medical screening (tests and frequency) is a responsibility of the flight surgeon/occupational physician, the EHO and BEE at the occupational medicine working group meetings. They should review the AF Form 2755, Master Workplace Exposure Data Summary, and discuss the findings of the BEE survey. They should consider the job demands, exposures to the workers, medical effects of the exposures, and any regulatory requirements. Determination of medical surveillance requires more than reviewing the raw data from environmental monitoring. This information should be compared with epidemiologic assessment of the entire workplace to include worker interviews and trend analysis of medical records. The EHO and flight surgeon should perform shop visits to accomplish these tasks prior to determining the medical examinations for the shop.

Subsequently, each local Aerospace Medicine Council (AMC) determines the type and frequency of occupational health examinations and documents these on AF Form 2766, Clinical Occupational Health Examination Requirements. Factors to consider in this process are outlined below.

Generally, medical surveillance is recommended **when exposures exceed the action level**, which is half the TLV or PEL for materials in the CFR Z Tables. Note that for chemicals with CFR standards, the AL is not necessarily half the PEL or AL, for example lead. According to the Handbook of Occupational Medicine (9):

> "Exposure to potentially hazardous substances does not necessarily indicate the need for special tests. Decisions should be based not only on the relative toxicity of the substance but also on the extent of control measures, sampling results, work practices, and usefulness of the tests themselves.... In fact, "unnecessary" tests may lead to difficulties in assessing "false-positive" results and may also cause alarm among the well population and needlessly increase health care costs. Furthermore, once a program is instituted, it is often perceived as a "benefit" and thus may be difficult

to discontinue (from a public relations perspective) even if ineffective. In turn, limited resources are diverted from activities that may prove even more beneficial to promoting the health of the working population."

Factors to Consider Prior to Selecting Screening Exams (7,9)

Occupational screening programs can serve to facilitate the primary means of worker protection: monitoring and control of the work environment.

1. The screening test must be selective and geared to the population at risk of developing specific diseases, given its exposure, demographic features and other factors. "A shot-gun approach which involves a battery of tests (such as a chemistry profile) applied indiscriminately without regard to the diseases for which the population is at risk, is generally not effective." (8) The natural history of the exposure-disease relationship must be considered.

2. The disease should be identified in its latent stage, not when the worker notes symptoms. Symptoms may be present before the patient recognizes them as indications of something wrong. Worker interviews conducted by professionals can be done periodically as a proactive approach in obtaining information. Passive collection of data through questionnaires and medical histories completed by the worker are not as effective. Once identified, measures must be taken to prevent additional cases.

3. The screening test should be both valid and reliable. Reliability indicates the reproducibility of the test. Validity indicates the ability of the test to correctly identify individuals with and without the disease. Validity involves specificity and sensitivity. Specificity--proportion of those **without** the disease that the test identifies correctly; sensitivity--proportion of those **with** the disease that the test identifies correctly.

4. Benefits outweigh the costs. Costs include both economic and human costs; the expense of doing the screening tests plus further confirmatory tests and the risks, inconvenience, and anxiety of the workups for the false positives.

5. Adequate follow-up is necessary. Lack of follow-up is common in occupational screening programs. Workers who have screening done should receive interpretation of their test results; this is an OSHA requirement and should be satisfied by correctly disseminating the AF Form 2770. Follow-up also includes action to reduce or eliminate the hazard. This is one of the major reasons for having a screening program--allowing an opportunity to control exposure before others are similarly exposed.

Health History and Physical Examination

A complete health history and physical examination are important considerations in the evaluation process. The provider takes a targeted medical history based on complaints and risk factors, does a review of systems to include physical examination and laboratory tests targeted to the organ

system. The effectiveness of the physical exam increases if directed primarily toward the target organ. In most cases a standard examination is established for the shop personnel. "The purpose of a 'standard exam' is to assist the practitioners, not replace them....If local medical personnel identify a group of workers who need occupational examinations, **qualified practitioners should see the patients.** For an occupational medical examination program to be effective the clinicians performing the exams and reviewing the results must clearly understand the reason(s) for the exam and what to do with the results."(5)

Performing the Examination (HQ USAF/SGPA Policy Ltr 7 Dec 90, Developing Occupational Examination Protocols, (5))

Occupational medicine is a diagnostic specialty. Many of the tools and techniques are the same as in other areas of medical practice. The practitioner takes a targeted medical history based on complaints and risk factors, does a review of systems and then performs selected physical examinations and laboratory tests to characterize the status of specific organ systems. In some cases a standard examination protocol (historical questionnaire and lab tests) can be administered to a group of workers with similar specific health risks.

The purpose of a "standard exam" is to assist the practitioners, not replace them. Patients receiving occupational examinations may have a variety of health conditions which can affect their job performance or indicate a problem. Determining a particular patient's fitness and risk for a particular job and identifying work related medical conditions requires medical judgment by a practitioner knowledgeable of the patient's working conditions and job demands.

If local medical personnel identify a group of workers who need occupational examinations, qualified practitioners should see the patients. For an occupational medical examination program to be effective the clinicians performing the exams and reviewing the results must clearly understand the reason(s) for the exam and what to do with the results.

The supervising physician is ultimately responsible for the proper evaluation and treatment of all patients.

Types of Physical Examinations

Preplacement and Periodic Exams

Preplacement exams are carried out before employment of a worker in the workplace with potential health hazards. The information obtained is used as baseline data for follow-up of the worker in subsequent years. It also enables management to place workers in jobs suited to their capacities and limitations.

Periodic exams should be carried out at regular intervals, usually annually. These exams should be tailored to the workplace and potential exposures. The focus should be on body organs and systems that are most likely to be affected by the agents in the workplace.

Termination Exams

Reference HQ USAF/SGPA Letter 9 Mar 1990, Termination Occupational Examinations (4):

There are two types of termination exams--termination of employment and termination of exposure. Most of the exams established by the AMC are termination of exposure. These exams are indicated when the organ system effect is likely to be present shortly after exposure, and will persist long enough to be detected. Generally, few exposures meet these criteria, therefore, few exposures except those required by law or regulation will require the AMC to establish termination exams.

Termination examinations required by law or regulation include:

Asbestos--29 CFR 1910.1001

Hazardous waste--29 CFR 1910.120

Hydrazine--AFOSH Standard 161-13

Laser Radiation--AFOSH Standard 161-10

Ionizing Radiation--AFR 160-132

Noise--DODI 6055.12

Interpretation of Screening Results

A plan for interpreting the screening results should be the highlight of the screening program. Interpretation of results must go beyond the clinical implication for the individual. A test result may be significant if present in every member of the exposed population. Consequently, this type of data interpretation must be done differently from routine interpretation of clinical results from an individual. "Interpretation of surveillance data is accomplished from two different perspectives--the first oriented to benefit the worker and the second designed to benefit the group of workers."(9)

Benefit to the Individual

Baseline for future reference: comparing future tests with an initial baseline exam. Raw data, not just interpretations, should be maintained. Also the technique used to obtain the results is needed so that future testing can be done with similar methods.

Risk factor identification: in occupational screening programs, people with 'positive' results do not necessarily have a disease but may be at greater risk of developing disease without appropriate intervention. For example, minor elevations in liver function tests (LFT) may be normal variants or due to nonoccupational factors. "If relatively minor abnormalities are detected, an occupational cause must be considered, rather than ascribing the abnormalities

to 'drinking'." (8) A careful history with details on occupational and nonoccupational factors is essential. Reviewing the industrial environment is necessary and includes reviewing medical information on other workers on the same job.

Biological monitoring: this data is used to assess potential exposures and not to make a medical diagnosis. Timing of specimen collection is imperative.

Benefit to the Group

Analysis of aggregate data may provide useful information. This is the premise behind doing trend analysis on shops annually. The information can be used to detect new hazards through the review of rates of abnormalities in groups of similarly exposed workers. Small changes in a test result may be important if all workers show that change, whereas the same result may be of no importance in an individual case.

Evaluating lost work day patterns may also be helpful in identifying occupational hazards. Ergonomic hazards can be detected in this manner.

JOB SPECIFIC OCCUPATIONAL EXAMINATION PROTOCOLS
(HQ USAF/SGPA Policy Ltr 7 Dec 1990,
Developing Occupational Examination Protocols (5))

Fire Fighters

Background

Fire fighters are potentially exposed to a wide variety of significant health hazards. They are subject to prolonged periods of inactivity punctuated by times of extreme physical exertion in a hostile environment. They must be capable of performing strenuous exercise, performing heavy lifting, wearing self-contained breathing apparatus, and working in temperature extremes.

Specific Job Tasks/Requirements

The primary method used to group these workers is job title. This is a diverse employee group containing workers who perform jobs as divergent as engine repair, medical rescue response, and hazardous waste spill response. Quantifying workplace and individual exposures with industrial hygiene methods is very difficult in this employee group.

Job demands, specific stresses and the intensity of exposures vary widely by duties and location and even change over time. Because of this, no scientific study has defined the level of cardiovascular, pulmonary, musculoskeletal, or neurologic fitness required to perform the minimum duties of a fire fighter.

Workplace Risk Factors (Exposures)

Fire fighters are potentially exposed to a multitude of hazards.

Physical: (heat, cold, noise, explosion, electricity, etc.).

Chemical: (smoke, toxic gases, hazardous chemicals, fire extinguishing agents, etc.).

Biological: Blood and body fluids.

Personal Risk Factors (Medical Status)

Because of the potential risk to personal health, fire fighters should be at low risk of sudden or subtle incapacitation. Medical evaluation programs should be designed to detect potentially incapacitating conditions. In general, fire fighters should be in relatively good cardiovascular, pulmonary, musculoskeletal and neurologic condition. The severity of a medical condition which might place an individual at risk will vary depending on specific requirements and the frequency, intensity and nature of specific exposures.

Probably the most sensitive and specific "test" available for detecting potentially incapacitating conditions is a medical history taken by a practitioner familiar with the workers' job demands.

Target Organ Systems and Potential Adverse Health Outcomes

Acute musculoskeletal injury (strains, sprains, contusions, cuts, etc.) and hearing loss are the most common work-related health events.

Some studies suggest an increased risk of ischemic heart disease, pulmonary disease and some cancers in fire fighters. However, we do not yet have a clear understanding of the exposure-health effect relationships which might increase these health risks nor do we really know the chronic health problems fire fighters are most likely to experience.

Performing numerous lab tests and extensive physical exams looking for chronic diseases is probably unnecessary unless the intensity of operations increases the likelihood of specific exposure-related health problems and exposure modification or medical interventions will arrest progression or limit impairment.

Potential Public Health and Safety Impact

Fire rescue duties are a public service. Fire fighters at risk of incapacitation while performing these duties may not only suffer significant personal harm but may endanger others.

Legal and Regulatory Requirements

AFR 92-1, Chapter 2, section 2-3.e, lists specific job demands and performance criteria for fire fighters.

Military fire fighters must meet the standards in AFR 160-43 for entrance and retention on active duty. AFR 39-1 requires fire protection personnel to have no record of pyrophobia, acrophobia, or claustrophobia, possess the ability to speak clearly, an uncorrected visual acuity of no more than 20/200 in either eye and a corrected acuity of at least 20/20 in one eye and 20/30 in the other eye.

Office of Personnel Management (OPM) Qualification Standards, GS-081, Fire Protection and Fire Prevention Series, defines the physical requirements for civilian fire fighters.

5 CFR 339, Federal Personnel Manual, describes management and medical responsibilities in performing occupational examinations and making medical recommendations.

Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response, specifies an examination requirement for fire response personnel on HAZMAT teams.

Employee Health Benefits and Personnel Programs

There are currently no DOD requirements or entitlements for civilian fire fighters to receive other clinical preventive services as part of their employment. Military fire fighters may require additional screening tests depending on age, and branch of service.

Recommended Fire Fighter Examination Protocols

This protocol is intended to be instructional and specifies a minimum examination for Air Force fire fighters. This protocol can guide development of local exam protocols but should not prevent consideration of other factors. Local medical personnel should not simply adopt this exam as a requirement. Local working conditions, job demands, specific exposures, other guidance, and current professional recommendations for occupational medical practice must be considered.

Baseline/Preemployment Exam:

All workers - History and review of systems with particular attention to musculoskeletal, auditory, cardiovascular, respiratory systems, and ability to wear required protective equipment. Physical exam should include a visual acuity, ECG, pulmonary function test, and blood pressure check and assessment of suitability for respirator wear.

Military - required by 39-1. History addressing pyrophobia, acrophobia, or claustrophobia, assessment of the ability to speak clearly.

Civilian - required by GS-081. Color vision, urinalysis, immunization review, height and weight.

Other baseline exams and tests may be indicated if specific exposures exist (e.g., hazardous noise). Other screening tests (CBCs, lipids, LFT, treadmill tests, etc.) should be ordered by the examining physician only if an indication exists.

Periodic Exam:

Exam frequency

HAZMAT personnel, at least biannual (29 CFR 1910.120)

Civilian - this is a local option but biannual exams are recommended. More or less frequent examination schedules may be adopted at the determination of the local AMC.

Military - this is a local option but biannual exams are recommended. More or less frequent examination schedules may be adopted at the determination of the local AMC.

Exam content. All workers (Military and Civilian). History and review of systems with particular attention to musculoskeletal, auditory, cardiovascular, and respiratory systems. Pulmonary function test and blood pressure check. Other exams and tests may be needed for specific exposures and additional physical exams, lab tests and other screening tests (CBCs, lipids, LFT, treadmill tests, etc.) should be ordered by the examining physician only if an indication exists.

Termination of Exposure:

Military - same as periodic above or separation exam if individual is leaving the service.

Civilian - Local option except for HAZMAT members.

These same principles can be used to develop examination procedures and guide the clinical evaluation of almost all employee groups. The effective application of these principles requires a large degree of flexibility. This works best when applied on a local level.

Hazardous Waste and Emergency Response Operations

Background

On 6 Mar 90, the Occupational Safety and Health Administration's (OSHA) final rule on hazardous waste operations and emergency response (29 CFR 1910.120) became effective. This rule requires employers to protect workers involved in specific operations from the adverse health effects which might result from exposure to hazardous substances. In the preamble to 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response; Final Rule, OSHA states the purpose of this rule is to:

> "... regulate the safety and health of employees involved in cleanup operations at uncontrolled hazardous waste sites being cleaned-up under government mandate, in certain hazardous waste treatment, storage, and disposal (TSD) operations conducted under the Resource, Conservation and Recovery Act of 1976 as amended (RCRA) (42 U.S.C. 6901, et seq), and in any emergency response to incidents involving hazardous waste substances."

Part of the OSHA requirement is a medical surveillance program. The intent of medical surveillance is to protect the health of workers by ensuring they receive baseline and periodic exams to detect abnormalities early enough to prevent progression or limit the extent of disease. Designing medical examination protocols to reliably and efficiently do this is very difficult.

Some hazardous waste workers have the potential for significant harmful exposure whereas others have little chance of exposure. However, regulations require surveillance of all workers involved in regulated operations. Present evidence suggests these workers are not routinely exposed to significant levels of harmful agents and do not experience specific pathologic conditions unique to hazardous waste work. In short, there is no "hazardous waste worker syndrome."

Specific Job Tasks/Requirements

Hazardous waste workers are identified by the operations they perform. Workers performing these operations work in diverse conditions and may be required to perform arduous labor while wearing chemical protective equipment.

OSHA directs medical surveillance programs be developed for workers performing specific cleanup and emergency response operations involving hazardous wastes. Specifically, three populations of workers are targeted for medical surveillance. These are:

1. workers engaged in the cleanup of hazardous waste sites,

2. workers in hazardous waste treatment, storage and disposal (TSD) facilities regulated under 40 CFR Parts 264 and 265 and,

3. personnel involved in emergency response operations for releases or substantial threat of releases of hazardous substances.

Air Force workers affected by this regulation will most likely fall into the last two categories and may include fire rescue personnel who respond as HAZMAT team members and Defense Reutilization and Marketing Organization (DRMO) workers that collect and store hazardous wastes for more than 90 days.

Workplace Risk Factors (Exposures)

Chemical and Biological Agents:

Characterizing the risk from exposures to chemical and biological agents in hazardous waste is difficult. Workers performing regulated tasks may be potentially exposed to hundreds of substances, in mixtures of unknown composition and usually at low levels. There are not good epidemiologic studies describing the expected health problems in hazardous waste workers and no specific protocols or criteria to use in assessing the potential work-relatedness of health problems.

Likewise, quantifying and controlling exposure is difficult. Hazardous waste sites and storage facilities are not generally amendable to standard industrial hygiene measurement methods and engineering controls like

ventilation, substitution, or process changes are frequently not possible to implement. Consequently, there is a high reliance on personal protective equipment. In addition, these workers are frequently highly educated and well trained and there is typically high turnover in the work force.

Physical Agents:

Many of the operations performed by hazardous waste workers occur outside in protective clothing and require a degree of musculoskeletal fitness. Heat stress from performing heavy manual labor in protective clothing and musculoskeletal injury are potential problems.

Personal Risk Factors (Medical Status)

Because of the high reliance on personal protective equipment and the need to perform manual labor, workers with medical conditions which preclude heavy exertion or prevent effective respirator wear may significantly increase the risk of personal health harm.

Assessing this risk requires clinical judgment by a physician familiar with the worker's health status, job demands, and working conditions.

Target Organs Systems and Potential Adverse Health Outcomes

Virtually any organ system may be affected due to the wide range of potential exposures a hazardous waste worker may receive. There is a particular concern over the potential for "cancer." However, epidemiologic studies have not yet demonstrated specific constellations of pathologic conditions in this occupational group.

Current practices among those performing occupational examinations on hazardous waste workers are widely variable. The most prudent approach being suggested is the site (or operation) specific exam protocol.

Legal and Regulatory Requirements

OSHA requires employers to establish a medical surveillance program for workers involved in these regulated operations if they:

"... are, or may be, exposed to hazardous substances or health hazards at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators for 30 days or more a year."

"... wear a respirator for 30 days or more a year as required in 29 CFR 1910.134."

"... are injured due to overexposure from an emergency incident involving hazardous substances or health hazards."

"... are members of a HAZMAT team."

Employee Health Benefits and Personnel Programs

Local collective bargaining agreements and support agreements may authorize some worker to specific health promotion/disease prevention programs.

Recommended Examinations

Preplacement: Required prior to assignment.

Exam Content -

All workers. Medical history, review of systems, and a work history with special emphasis on symptoms related to the handling of hazardous substances. An assessment of musculoskeletal, auditory, cardiovascular, respiratory systems, and ability to wear required protective equipment. The physical exam should include a pulmonary function test, blood pressure measurement, and assessment of the workers suitability for respirator wear (see Respiratory Protection Exam for details).

Other baseline exams and tests may be indicated if specific exposures at or above the PEL are known to exist. Other screening tests (CBCs, lipids, LFT, treadmill tests, etc.) should be incorporated into the protocol when site or operation specific exposure conditions warrant. Otherwise, these additional tests may be ordered by the examining physician when an indication from the history or physical exists.

Periodic Exam:

Exam Frequency - at least biannual (29 CFR 1910.120); more frequently if indicated by exposure conditions.

Exam Content - history and review of systems with particular attention to musculoskeletal, auditory, cardiovascular, and respiratory systems. An interval history should determine any changes in the worker's health since the last exam and all reported health problems assessed for potential work-relatedness. Pulmonary function test and blood pressure check. Other exams and tests may be needed for specific exposures and additional physical exams, lab tests and other screening tests (CBCs, lipids, LFT, treadmill tests, etc.) should be ordered by the examining physician only when an indication exists.

Termination of Exposure:

Required when the worker ceases to perform regulated operations, either because they leave employment or are reassigned.

Exam Content. Same as periodic. A military separation exam will suffice if the individual is leaving the service.

Respirator Users

Background

Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.134 states:

> "Persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually)."

This requirement was established as a prudent measure to ensure workers were not inappropriately placed at risk. The requirement was not based on evidence showing that workers were actually being harmed by respirator use. Since no specific health problems have been associated with inappropriate respirator wear no standardized questionnaires or examinations have been developed and tested for reliability and validity.

For these reasons, it is not possible to develop an all inclusive standardized examination protocol for respirator users. An individual's fitness and risk for respirator wear is fundamentally a subjective medical opinion. Therefore, physicians performing these evaluations must be familiar with the workplace, the specific exposures, the specific respirator being used, and the workers medical condition.

A minimum examination is presented (see Personal Risk Factors (Medical Status)). This must be supplemented with additional historical questions and physical evaluations specific for the job, operation, or exposure.

Specific Job Tasks/Requirements

Respirator users may be exposed to a wide variety of inhalant hazards under drastically differing conditions. The level and duration of exposure (continual, intermittent, or potential), the exposure conditions (confined space, open air, explosive atmosphere, etc.), the nature of the hazard (pulmonary irritant, systemic toxin, oxygen deficiency) must all be considered in assessing a worker's risk and determining the level of fitness required to safely and capably perform the job.

Workplace Risk Factors (Exposures)

The specific hazard necessitating respirator wear, the exposure level, exposure conditions, and duration of exposure must be available at the time of the exam. Also, specific exposures may require specific examination items. For example, asbestos workers must be given an OSHA mandated questionnaire and chest X-ray and lead exposed workers may need a blood lead level.

Personal Risk Factors (Medical Status)

For each worker the examining physician should, as a minimum, answer the following questions:

Does this worker have a medical condition which would pose a significant risk if the protective device fails and even a transient exposure occurs? An example might be a worker with mild coronary artery disease who occasionally takes nitroglycerin. If this worker is placed in a confined space oxygen-deficient atmosphere and the respirator fails or it must be removed to take a nitroglycerin pill the worker could die.

Does the worker have a medical condition which requires a level of protection not possible with a respirator? An example of this might be a worker with an allergic sensitivity to the hazard (animal dander, isocyanate). For these workers respirators frequently do not reduce exposure enough to prevent development of symptoms.

Does the worker have a condition which would keep them from oeing able to tolerate respirator wear or achieve an adequate fit. Examples might be a facial deformity, facial hair, or skin conditions which prevent shaving (pseudofolliculitis Barbae, severe cystic acne) claustrophobia, need for glasses with a half-face piece respirator, restrictive or obstructive lung disease sufficient to make increased dead space a problem, obesity, heart disease etc. Generally speaking, FEV1/FVC less than 70% should prompt a careful history. If 50% or less, it is probably warranted to test the individual at the task or an equivalent workload while wearing the respirator.

Target Organ Systems and Potential Adverse Health Outcomes

Pulmonary function tests are frequently performed as part of respirator certification exams. However, they are not reliable in predicting who can and cannot wear a respirator. Nevertheless, pulmonary function testing is appropriate as noted previously and when the worker will be exposed to a lung hazard. In these cases a baseline should be performed at preplacement and periodic tests should be compared with the baseline to identify early changes. All pulmonary function tests must be performed, assessed for acceptability, and interpreted in accordance with accepted standards.

Unless required by regulation or indicated to evaluate a specific medical finding chest X-rays are not recommended.

Potential Public Health and Safety Impact

For respirator wearers, the specific risks posed to the public must be assessed in relation to specific tasks and the likelihood of harm if the individuals become suddenly or subtly incapacitated.

Legal and Regulatory Requirements

The background discussion gives the OSHA requirement. AFOSH Standard 161-1, Respiratory Protection Program, reiterates the OSHA requirement. However, no specific examination protocols are given.

Employee Health Benefits and Personnel Programs

For respirator wearers as a group, no specific employee health benefits of personnel programs are applicable.

CHEMICAL EXPOSURES BY GROUP

This section will be devoted to brief descriptions of chemical exposures in the workplace by group. Many chemicals in the same groups have similar effects on target organs so it may be helpful to review several groups. The group categories are: organic compounds, polychlorinated dibenzo-p-dioxins (PCDD's), polychlorinated biphenyls (PCB's), polybrominated biphenyls (PBB's), pesticides, and toxic and irritant gases. (6)

See Appendix A for listing of specific chemicals.

Organic Compounds (Solvents)

This is a large group of compounds with the ability to dissolve and disperse fats, oils, paints, rubber, etc. Exposure to this group of chemicals affects people in industrial as well as household settings.

Examples

Alcohols (methyl alcohol)
Ketones
Ethers
Esters (ethyl chloroacetate, etc.)
Glycols (ethylene glycol)
Aldehydes (formaldehyde)
Aliphatic hydrocarbons (jet fuels, acetylene, gasoline, etc.)
Aromatic hydrocarbons (benzene, toluene, benzo(a)pyrene, etc.)
Halogenated hydrocarbons (chloroform, tetrachloroethane, etc.)
Carbon disulfide

Some examples of hydrocarbon mixtures are: gasoline, petroleum ether, rubber solvent, petroleum naphtha, mineral spirits, Stoddard solvent, kerosene, and jet fuels. The composition varies, but all contain aliphatic saturated and nonsaturated hydrocarbons; alicyclic saturated and nonsaturated hydrocarbons; and some aromatic hydrocarbons such as benzene, toluene, xylene; and polycyclic hydrocarbons.

Target Organs

This category of compounds will effect the following organs:

Liver
Kidney
Bone marrow
Central nervous system (CNS)
Skin

The higher the proportion of volatile hydrocarbons in the mixture, the greater the hazard of acute CNS depression with possible loss of consciousness, coma, and death resulting from acute overexposure. The irritant effects on the respiratory and conjunctival mucosae are moderate. Bone marrow depression with

resulting low red blood cell counts and leukopenia with neutropenia and/or low platelet counts can develop. Skin irritation caused by the degreasing properties of these solvents is common when repeated contact occurs.

Medical Surveillance

Annual medical surveillance should include blood counts for the early detection of bone marrow depression. Emphasis in early detection should be on toxic peripheral neuropathy, chronic CNS dysfunction, hematologic effects, and dermatitis. Chronic CNS effects have been documented by clinical, electrophysiological, neurobehavioral and brain imaging techniques.

In the case of accidental ingestion, the following may be seen:

Severe chemical pneumonitis
Pulmonary edema
Hemorrhage
Necrosis

When there is skin irritation from chronic exposure, there may be increased susceptibility to infections and chronic dermatitis. The purpose of surveillance is early detection of peripheral neuropathy, chronic CNS dysfunction, dermatitis, and hematologic effects. Education of employees (including use of respirators) is vital to ensure awareness of the potential health hazards.

In the case of methyl alcohol, medical surveillance concentrates on visual, neurologic, hepatic, and renal functions. Formic acid in urine and methyl alcohol in blood can be used to determine excessive exposure.

Polychlorinated dibenzo-p-dioxins (PCDD's)

These compounds are the result of the substitution of hydrogen atoms by chlorine on the basic structure of the PCDD nucleus. They are not produced commercially but are a by-product of the manufacturing of chlorinated organic compounds, especially chlorophenols and their derivatives, and herbicides (2,4,5-T and 2,4-D).

Examples

2,3,7,8-tetrachlorodibenzo-p-dioxin, commonly known as "dioxin"
Tetra-CDD
Penta-CDD (wood industry)
Hexa-CDD

Target Organs

Skin
CNS
Liver

Chloracne, a severe follicular hyperkeratosis, is the most consistently reported problem. The lesions are characterized by comedones, cysts and secondary infection in severe cases. The distribution is on the face, the ears

and behind the ears. The nose is usually not involved and in rare cases the involvement can include the back, arms and legs. The lesions appear from several days to a few weeks after exposure and can remain for several years with subsequent scarring.

Other toxic effects are seen in the central and peripheral nervous systems. Effects include fatigue, drowsiness, depression, memory deficits, headaches, irritability, sensory and motor peripheral neuropathy (confirmed by electromyographical changes), and sensory impairment of smell, taste, and hearing. Liver damage can be mild to severe. Centrolobular hepatocellular necrosis and fatty infiltration are the pathological changes seen with the most severe toxic hepatitis.

Medical Surveillance

The medical surveillance for this group of chemicals should include close observation of the workplace and monitoring personal protective equipment use. Preplacement and periodic exams should consider the history of skin/respiratory problems. Annual exams should include:

- Examination of the skin
- Liver function tests
- Serum lipids
- Evaluation of the endocrine system

Polychlorinated Biphenyls (PCB's)

PCB's are very stable compounds and usually contain 12 to 68 percent chlorine. They are of low flammability and very persistent in the environment. Note that burning PCB's and chlorinated benzenes (common constituents in transformer fluid) can produce the extremely toxic polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs).

Uses

- Insulating materials (in transformers)
- Plasticizers in waxes
- Paper manufacturing
- Additives to paints and surface coatings
- In hydraulic systems
- Constituents in carbonless copying paper

Target Organs

- Skin
- Liver
- Reproductive systems

Medical Surveillance

The medical surveillance for this chemical group is very similar to the PCDDs. Skin lesions (chloracne) are seen in about 60 percent of the cases. In known occupationally exposed people, the following tests are recommended:

Examination of the skin
Liver function tests
Serum lipids
Serum levels of PCBs
Evaluation of the endocrine system

Polybrominated Biphenyls (PBB's)

These chemicals have a similar structure to PCB's and are mixtures of brominated biphenyls.

Uses

Fire retardants in thermoplastic resins, lacquers, polyurethane foam
Dielectric in capacitors and transformers
Investment casting processes
Heat exchange fluid
Hydraulic fluid

Target Organs

Eyes
Skin
Liver

PBB's are irritants to the eyes and mucous membranes. Mild to moderate skin irritation and chloracne have been reported to workers exposed to 0.1 mg/m^3 for several months. The skin areas most sensitive are around the eyes and behind the ears.

Medical Surveillance

Physical exams should concentrate on skin problems and liver functions. CBC's with differentials and UA's with microscopic examinations are recommended.

Pesticides

This group of chemicals covers a wide range of uses in pest control. They are among the few toxic agents added to the environment on purpose (4 billion pounds used worldwide in 1975 according to some experts).

Examples

Insecticides (Malathion, Parathion)
Ascaricides (Diazinon)
Fungicides (Maneb, Zineb)
Herbicides (Picloram, Diquat)
Algicides (methylene bisthiocyanate, sodium pentachlorophenate)
Fumigants (Chlorpicrin, Ethylene dibromide)
Rodenticides (Pyriminil, Alpha-naphthylthiourea - ANTU)

Target Organs

Respiratory system
Liver
CNS
Gastrointestinal tract
Cardiovascular system
Kidneys

Medical Surveillance

Most exposures to pesticides are in the areas of manufacturing, application and harvesting. Some workers with increased risk of pesticide exposure are Civil Engineering pest management personnel, truckers, and fire fighters. There are many other jobs that have the potential of pesticide exposure. The important steps in the medical surveillance process are a complete preplacement exam, a work history, and accurate determination of the best personal protective gear. The chemical used and the work conditions under which it is used must be considered (e.g., confined spaces vs. open air). Baseline erythrocyte cholinesterase activity should be taken since the organophosphates are acetylcholinesterase inhibitors. Semiannual tests should be conducted on pest management personnel during the heavy usage season.

Toxic and Irritant Gases

Examples

Carbon dioxide
Carbon monoxide
Hydrogen sulfide
Hydrogen fluoride
Sulfur dioxide
Ammonia
Chlorine
Phosgene
Bromine
Ozone
Oxides of nitrogen

Target Organs

Eyes
Skin
Respiratory system
CNS
Cardiovascular system

Medical Surveillance

A good preplacement physical and history with emphasis on the respiratory, skin and cardiovascular systems is critical. Periodic exams are recommended and the importance of personal protective equipment should be stressed in the occupational surveillance program.

MEDICAL SURVEILLANCE TABLE

The medical surveillance table at Appendix A, will highlight the most important areas to consider. This program centers around types of hazards, target organs and the routes of entry of toxic materials into the body.

The chemicals discussed in this report will be listed in alphabetical order. Any references found in 29 CFR will be noted. Also, if the agent is considered carcinogenic, it will be noted with (carc) in the "symptoms" column. **It is not the authors' intention that this table be used without additional current information or consultation.** The table is only an example of the surveillance process methodology that could be used in an Occupational Medicine Program at base level.

See Appendix B for abbreviations used in Appendix A.

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APPENDIX A

Medical Surveillance Table

APPENDIX A

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC TERMINATION
Acetic acid	inh	lac,conj,irrit throat,eyes,skin; bron; skin sens, dental eros; hyperkeratosis	Resp sys, skin, eyes, teeth	**PRE:** work history, PFT **ANNUAL:** same as **PRE**
Acetone	inh, skin, eyes	irrit eyes,nose, throat;head, dizz, derm	Resp sys, skin	**PRE:** quest w/ emphasis on history of chron resp or skin disease **ANNUAL:** same as **PRE**
2-Acetylamino-fluorene (CFR 29 1910.1014)	inh, ing, skin	reduced liv fun kid, bladder pancreas (carc)	Liv, bladder, kid, pancreas, skin,lungs	**PRE:** his w/ genetic backgrd, &reduced immunologic cometance, preg, smoking **ANNUAL:** same as **PRE**
Acrylonitrile (CFR 29 1910.1045)	inh,abs, ing,con	asphy, irrit eyes, head, sneezing, nau, vomit, weakness scaling dermatitis li-head, skin vesic (carc)	CVS, liver,kidneys, CNS,skin,brain, lung and bowel	**PRE:** phys exam w/ emphasis GI sys, resp sys,PNS & CNS skin,thyroid, fecal occult blood (over 40 years of age & as appropriate) **ANNUAL:** Same as **PRE**
Ammonia	inh, skin	eye,nose,throat irrit,dysp, bron spas, chest pain, pulm edema,skin burns URI, pneu; eye injury, blindness, severe skin burns, chest pain, pneumonia	resp sys, eyes	**PRE:** PFT **ANNUAL:** same as **PRE**

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Antimony	inh	irrt eye, throat, skin,head,dys, vom,diarr,nau	resp sys, CVS skin, eyes	**PRE:** PFT, ECG **ANNUAL:** same as **PRE**	
Asbestos (29 CFR 1910.1001) (29 CFR 1926.58—Construction)	inh, skin	dysp, restricted pulm func	lungs	**PRE:** medical and work history, PE w/ emphasis on resp sys, CVS, GI tract, PFT, CXR (see table) **ANNUAL:** same (see table)	Same as **PRE** (see table)
Benzene (29 CFR 1910.1028)	inh,skin ing	Acute:irri eye, nose,skin,resp sys gidd,head,nau,stagg gait,anor,lass, Chronic: derm, bone marrow depres; (carc)	blood,CNS,resp sys skin, bone mar,eyes	**PRE:** CBC w/diff platelet; PFT if repirators at least 30 days/yr **ANNUAL:** same as PRE; repeat abn CBC 2 wks; If overexposure UA for phenol	
Benzidine (29 CFR 1910.1010)	inh,ing, skin	acute cystitis,acute liver disorders, derm, hematuria, painful & irreg urination (carc)	bladder,kidneys, liver,skin,blood	**PRE:** Hx of reduced immunologic competance, pregnancy; UA w/micro CBC w/diff & platelet **ANNUAL:** Same as **PRE**	

yrs since 1st exposed	years of age 15–35	35+ to 45	45+
0–10	——every 5 yrs ——		
10+	every: 5 yrs	2 yrs	1 yr

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Beryllium	inh	resp symptoms, wt loss; (carc)	lungs,skin,eyes, mucous memb	**PRE:** CBC w/ diff UA w/ micro, PFT **ANNUAL:** Same as **PRE**	
2-Butanone	see Methyl ethyl Ketone				
Butyl Cellosolve	inh,skin	Acute: irrit eyes, nose, throat Chronic: URI, allergies hemolytic anemia	Blood,liver,kidneys	**PRE:** CBC w/diff, LFT, UA **ANNUAL:** Same as **PRE**	
Cadmium	inh,ing	pulm edema,dysp, cough,head,chills, nau, vomit,diarr, mild anemia	resp sys, kidneys, blood	**PRE:** CBC w/ diff, UA w/micro, PFT **ANNUAL:** Same as **PRE**	
Carbaryl	inh,ing, abs,con	blurred vision,nasal disch, sal,sweat,abdom cramps, nau,vomit,diarr,tremor, cyan,convuls,skin irrit	Resp sys, CNS, CVS, skin	**PRE:** physical exams with determination of preexposure red blood cell cholin-esterase activity **ANNUAL:** same	
Carbon tetra-chloride	inh,abs, ing,con	CNS depres,nau,vomit, skin irrit	CNS, eyes,lungs, liver, kidneys, skin	**PRE:** physical exams w/ emphasis on liver, kidneys, skin **ANNUAL:** same as **PRE**	

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Chlordane	inh, abs ing, con	blurred vision; conf; ataxia, delirium; cough; abdom pain, nau, vomit, diarr; irrity, tremor, convuls; anuria; in animals- lung, liver, kidney damage	CNS, eyes, lungs, liver, kidneys, skin	**PRE:** physical exams w/ emphasis on exam of ner system, eyes, lungs, liver, kidneys; CBC w/ diff, UA **ANNUAL:** same as **PRE**	
Chlorine	inh, con	burning eyes,nose, skin mouth,lac,rhin,cough, choking,subs pain,nau, vomit,head,dizz,syncope, pulm edema,pneu,hypox,derm,	resp sys	**PRE:** physical exams w/ emphasis on eyes resp tract, teeth, and skin, PFT **ANNUAL:** same as **PRE**	
Chloroform	inh, ing, con	dizz,mental dullness,nau, head,fatg,anes,hepatomeg-aly,eye/skin irrit	liver, kidney,heart, eyes, skin	**PRE:** physical exams w\ emphasis on liver, kidneys, heart, skin. LFT, UA (Alcoholics may be at increased risk from exposure) **ANNUAL:** same as **PRE**	
Ethyl acetate	inh,ing, con	irrit eyes,nose, throat; narco; derm	eyes,skin,resp sys	**PRE:** LFT, PFT, skin exam **ANNUAL:** same as **PRE**	
Ethyleneimine (29 CFR 1910.1012)	inh, ing, abs, con	nau, vomit; head; dizz; pulm edema; liver, kidney damage; eye burns; skin sens; irrit nose, throat (carc)	eyes, lungs, skin, liver, kidneys	**PRE:** physical exam w/ emphasis on eyes, resp tract, kidneys, blood; CXR, PFT **ANNUAL:** same as **PRE** except CXR	

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE	
				PREPLACEMENT/PERIODIC	TERMINATION
Ethylene glycol	inh,ing abs,con	throb head; dizz, nau,vomit,abdom pain; hypotension, flush; palp; methemoglobinemia; delirium,depres CNS; angina; skin irrit	CVS, blood, skin	**PRE:** physical exam w/ emphasis on CVS, blood, liver, kidneys; CBC w/ diff, ECG **ANNUAL:** same as PRE	
Ethylene oxide (29 CFR 1910.1047)	inh,ing, con	irrit eyes,nose,throat; peculiar taste; head, nau, vomit, diarr; dysp, cyan, pulm edema; drow, weak; EKG abnor; burns eyes,skin; frostbite; (carc)	eyes,blood,resp sys liver,CNS,kidneys	**PRE:** physical exam w/ emphasis on eyes, blood, resp,neuro, reprod, skin, CBC w/ diff **ANNUAL:** same as **PRE**	Same as **PRE**
Formaldehyde (29 CFR 1910.1048)	inh,ing con	irrit eyes,nose,throat; lac, burns nose, cough; bron spasm, pulm irrit; derm (carc)	resp sys, eyes, skin	**PRE:** hx & physical exam w/ emphasis on resp tract and skin;PFT **ANNUAL:** same as **PRE**	
Fuels- JP-4 JP-8	inh,ing con	derm, eye irrit, CNS depres, chemical pneuitis	skin, bone marrow	**PRE:** phys exam w/empasis on skin,UA w/micrp, PFT,BUN & Cr, CBC w/diff Ur phenol for over expose **ANNUAL:** same as **PRE**	
Hexane	inh,ing con	li-head, nau, head; numb extremities, musc weak; irrit eyes, nose; derm; chemical pneu; gidd	skin, eyes, resp sys	**PRE:** physical exam w/ emphasis on CNS and the skin **ANNUAL:** same as **PRE**	
Hydrazine	inh,ing, abs,con	irrit eyes, nose, throat; temporary blindness; dizz, nau; derm; burns skin, eyes; (carc)	CNS, resp sys, skin, eyes	**PRE:** physical exam w/ emphasis on nervous & resp sys, liver, kidneys, skin; PFT, CXR **ANNUAL:** same as **PRE** except no CXR	Same as **PRE**

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Herbicides: 2,4-D, 2,4,5-T	inh, abs ing, con	weak, stupor, hypo-reflexia, musc twitch; convuls; derm;	skin, CNS liver, kidneys	**PRE:** LFT, UA **ANNUAL:** same as **PRE**	
Hydrochloric acid	inh,ing con,abs	irrit resp tract, burns skin, eyes	resp sys, eyes, skin	**PRE:** phys exam w/ emphasis on the resp tract,teeth,skin; PFT **ANNUAL:** same as **PRE**	
Hydrogen cyanide	inh,ing abs,con	asphy & death at high levels; weak,head,conf, nau,vomit; incr rate & depth of resp or resp slow & gasping	CNS, CVS, liver, kidneys	**PRE:** physical exam w/ emphasis on CVS **ANNUAL:** same as **PRE**	
Isocyanates	inh,ing con	irrit nose, throat; choke, paroxysmal cough; chest pain, retro-sternal soreness; nau, vomit, abdom pain, bron spasm, pulm edema; dysp, asthma; conj, lac; derm, skin sens; (carc)	resp sys, skin	**PRE:** physical exam w/ emphasis on resp sys and skin; PFT **ANNUAL:** same as **PRE**	
Iron oxide (fume)	inh	benign pneumoconiosis with x-ray shadows indistinguishable from fibrotic pneumoconiosis	resp sys	**PRE:** physical exam w/ emphasis on resp tract, PFT **ANNUAL:** same as **PRE**	
Isoamyl acetate (amyl acetate)	inh,ing con	irrit eyes,nose,throat; narco; derm	eyes, skin, resp sys	**PRE:** none **ANNUAL:** none	
Isopropyl alcohol	inh,ing con	mild irrit eyes,nose, throat; drow, dizz, head, dry cracking skin	eyes, skin, resp sys	**PRE:** physical exam w/ emphasis on the skin, paranasal sinuses, and the resp sys **ANNUAL:** same as **PRE**	

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC TERMINATION
Lead (29 CFR 1910.1025)	inh,ing con	weak, lass, insom; facial pallor, pal eye, low-wtg, malnut,constip, abdom pain, colic, anemia; gingival lead line, tremor para wrist, ankles, enceph-alopathy, nephropathy, irrit eyes, hypotension	GI tract, CNS, kidneys, blood, gingival tissues	**PRE:** physical exam w/ emphasis on the CNS, GI tract, blood, kidneys; CBC w/ diff, UA w/micro, blood lead zinc protopor, BP, BUN & Cr
Magnesium oxide (fume)	inh,con	irrit eyes, nose; metal fume fever; cough, chest pain, flu-like fever	resp sys, eyes	**PRE:** screening questionnaire w/ emphasis on detecting a history of chronic resp dis **ANNUAL:** physical exam w/ emphasis on resp tract
Malathion	inh,ing, con,abs	miosis, aching eyes, blurred vision,lac; eye, skin irrit; salv; anor, nau, vomit, abdom cramps, diarr, gidd, conf, ataxia; rhin, head;tight chest, wheeze, lar spasm	resp sys, liver, blood chol, CNS, CVS, GI tract	**PRE:** physical exam w/ determination of pre-exp red blood cell cholinesterase activity. **SEMI-ANNUAL:** cholinesterase; if falls to or below 40% of the baseline level, remove from exposure until level returns to 80% of the baseline level.
Manganese	inh,ing	Parkinson's; asthenia, insom, mental conf; metal fume fever; dry throat, cough, tight chest, dysp, rales, flu-like fever; low back pain; vomit; mal,fatg	resp sys, CNS, blood, kidneys	**PRE:** physical exam w/ emphasis on the resp sys and CNS **ANNUAL:** same as **PRE**

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Mercury	inh,ing, abs,con	pares; ataxia, dysarthria; vision, hearing dist; spastic, jerky; dizz, salv; lac; nau, vomit,diarr,	CNS, kidneys, eyes, skin	**PRE:** physical exam w/ emphasis on the resp and nervous sys, kidneys and skin; UA **ANNUAL:** same as **PRE**	
Methyl alcohol	inh,ing abs,con	eye irrit,head, drow, li-head, nau, vomit, vis dist, blindness	eyes, skin, CNS, GI tract	**PRE:** physical exam w/ emphasis on eyes **ANNUAL:** same as **PRE**	
Methylene chloride	inh,ing con	fatg, weak, sleepiness, li-head; limbs numb, tingle; nau, irrit eyes, skin; (carc)	skin, CVS, eyes, CNS	**PRE:** physical exam w/ emphasis on nervous sys, resp sys, skin, eyes, liver, kidneys, CBC w/dif **ANNUAL:** same as **PRE**	
Methyl ethyl ketone (MEK) 2-Butanone	inh,ing, skin	irrit eyes,nose,head dizz,vomiting	CNS,lungs	**PRE:** CBC w/diff UA w/ micro, liver profile **ANNUAL:** same as **PRE**	
Naphtha (petroleum distillates) (29 CFR 1910.1002)	inh,ing, con	li-head, drow; irrit eyes, nose, skin; derm	resp sys, eyes, skin	**PRE:** questionnaire w/ emphasis on detecting history of chronic resp, kidney, liver, or skin disease **ANNUAL:** same as **PRE**	
Nitric acid	inh,ing, con	irrit eyes, muc memb, skin; del-ayed pulm edema, pneuitis, bron; dental erosion	eyes, resp sys, skin, teeth	**PRE:** physical exam w/ emphasis on the resp tract, teeth, and skin; PFT **ANNUAL:** same as **PRE**	

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Paraquat	inh, abs ing con	irrit eyes, nose, epis; derm; fingernail damage; irrit GI tract; heart, liver, kidney damage; acute pulm inflamm	eyes, resp sys, heart, liver, kidneys, GI tract	**PRE:** physical exam w/ emphasis on the resp sys & skin; PFT **ANNUAL:** same as **PRE**	
Perchlorethylene	inh,ing con	irrit eyes, nose, throat; nau, flush face, neck; verti, dizz, inco; head, som; skin eryt; liver damage (carc)	liver, kidneys, eyes, upper resp sys, CNS	**PRE:** physical exam w/ emphasis on the nervous sys, liver, and skin; LFT **ANNUAL:** same as **PRE**	
Polychlorinated biphenyl (PCB)	inh,eye, ing,con	reprod failures, GI disorders, skin lesions, tumors	eyes, skin, resp sys	**PRE:** CBC w/ diff **ANNUAL:** same as **PRE**	
Radiation Ionizing (AFR 161-132)		acute dose-effect seen first in cells that rapidly divide-bone marrow, GI tract hair follicles	bone marrow, GI tract	**PRE:** CBC w/diff Ionizing radiation exposure hx, hx of hx of family genetic defects **ANNUAL:** none	CBC w/diff
Radiation (broadband, non-laser) Infrared Ultraviolet Visible		eryt, pig, kera conj	skin, eyes	**PRE/ANNUAL:** No requirement	
Radiation (Laser) Ultraviolet (150-400 nm) and Far Infrared (1400-10,000 nm)		eryt, kera, corneal damage, opacification of lens	skin, eyes	**PRE:** Slit lamp corneal and lenticular examination. Medical hx to include hx of cataracts and lens surgery. **ANNUAL:** No requirement	

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC TERMINATION
Visable & Near Infrared (400-1400 nm)				**PRE:** Visual acuity, retinal exam **ANNUAL:** No requirement
Radiation Radio Frequency Microwave (APOSH Std 161-9)		feeling of warmth at exposed site, little is known about effects-long term	biolog effects depend on power density, freq, modulation etc.	**PRE:** No requirement **ANNUAL:** No requirement
Sulfuric acid	inh, ing con	eye, nose, throat irrit; pulm edema, brom; emphy; conj; stomatis; dental erosion; skin, eye burns	resp sys, eyes, skin, teeth	**PRE:** physical exam w/ emphasis on the resp tract, eyes, teeth & skin; PFT **ANNUAL:** same as **PRE**
Stoddard solvent PD-680	inh, ing, con	irrit eyes, nose, throat; dizz; derm	skin, eyes, resp sys, CNS	**PRE:** quest w/ emphasis on detecting a history of chronic resp or skin disease **ANNUAL:** same as **PRE**
Tetrachloroethane	inh, ing abs, con	nau,vomit, abdom pain; tremor fingers; jaun, enlarged tend liver; derm; kidney damage	liver, kidneys CNS	**PRE:** physical exam w/ emphasis on liver, kidneys, CNS; LFT, UA **ANNUAL:** same as **PRE**
Toluene	inh, ing, abs, con	fatg, weak; conf, euph, dizz, head; dilated pupils, lac; ner, musc fatg, insom; pares; derm	CNS, liver, kidneys, skin	**PRE:** physical exam w/ emphasis on CNS, liver, kidneys; UA **ANNUAL:** same as **PRE**

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC TERMINATION
Trichloroethane	inh, ing, abs, con	irrit nose, eyes; CNS depres; liver, kidney damage; (carc)	CNS, eyes, nose, liver, kidneys	**PRE:** questionnaire w/ emphasis on detecting history of chronic resp, liver, or kidney dis **ANNUAL:** same as **PRE**
Trichlorotri-fluoroethane	inh, ing con	irrit throat, drow, derm	skin, heart	**PRE:** questionnaire w/ emphasis on detecting a history of CNS disorders, Cardiovascular, skin and chronic resp disease **ANNUAL:** same as **PRE**
Triorthocresyl-phosphate (TCP, TOCP)	inh, abs, ing, con	GI dist; peri neur; cramps in calves, pares in feet or hands; weak feet, wrist drop, para	PNS,CNS	**PRE:** physical exam w/ emphasis on the PNS and CNS **ANNUAL:** same as **PRE**
Vinyl chloride (29 CFR 1910.1017)	inh	weak; abdom pain, GI bleeding; hepatomegaly; pallor or cyan of extrem-ities; (carc)	liver, CNS, blood, resp sys, lymphatic sys	**PRE:** physical exam w/ emphasis on liver, spleen, kidneys, skin, resp sys; LFT,Bili, alk phos, UA **ANNUAL:** same as
Wood dust	inh, con	resp irrit, skin irrit	skin, resp tract	**PRE:** CXR, PFT, skin exam **ANNUAL:** same as **PRE** except no CXR
Xylene	inh, ing abs, con	dizz, excitement, drow, staggering gait; irrit		**PRE:** physical exam w/ emphasis on CNS, eyes, GI tract, blood, liver, kidneys; CBC LFT, UA **ANNUAL:** same as **PRE**

AGENT	ROUTES OF EXPOSURE	SYMPTOMS	TARGET ORGANS	MEDICAL SURVEILLANCE PREPLACEMENT/PERIODIC	TERMINATION
Zinc chloride (fume)	inh, con	conj; irrit nose, throat; cough, copious sputum; dysp, chest pain, pulm fib, cor pulmonale; fever; cyan; tachypnea; burn skin; irrit skin	resp sys, skin, eyes	**PRE:** physical exam w/ emphasis on resp tract & skin; PFT **ANNUAL:** same as PRE	
Zinc oxide (fume)	inh	sweet, metallic taste; dry throat, cough; chills, fever; tight chest, dysp, rales, reduced pulm function; head; blurred vision; musc cramps, low back pain; nau, vomit; fatg, lass, mal	resp sys	**PRE:** screening questionnaire w/ emphasis on detecting history of resp disease; CBC w/ diff, PFT **ANNUAL:** same as PRE	

APPENDIX B

Medical Abbreviations for Use with Appendix A

APPENDIX B
LIST OF MEDICAL ABBREVIATIONS USED IN APPENDIX A

abdom	Abdominal
abs	Skin absorption
anes	Anesthesia
anor	Anorexia
arrhy	Arrhythmias
asphy	Asphyxia
BP	Blood pressure
breath	Breathing
bron	Bronchitis
broncopneu	Bronchopneumonia
BUN	Blood urea nitrogen
(carc)	Carcinogen
card	Cardiac
CBC	Complete Blood Count
CXR	Chest X-ray
chol	Cholinesterase
cirr	Cirrhosis
CNS	Central nervous system
musc	Muscle
con	Skin/eye contact
conf	Confusion
conj	Conjunctivitis
constip	Constipation
convuls	Convulsions
CVS	Cardiovascular system
cyan	Cyanosis
depres	Depressant/depression
derm	Dermatitis
diarr	Diarrhea
dizz	Dizziness
drow	Drowsiness
dysp	Dyspnea
emphy	Emphysema
epis	Epistaxis
eryt	Erythema
fail	Failure
fatg	Fatigue
FEV	Forced expiratory volume
fib	Fibrosis
fibrl	Fibrillation
func	Function
GI	Gastrointestinal
halu	Hallucinations
head	Headache
hemog	Hemoglobinuria
hemorr	Hemorrhage
hypox	Hypoxemia
incr	Increase(d)
ict	Icterus
inflamm	Inflammation
ing	Ingestion
inh	Inhalation
inj	Injury
irreg	Irregular
irrit	Irritation
irrity	Irritability
jaun	Jaundice
kera	Keratitis
lac	Lachrymal
lar	Laryngeal
LFT	Liver fuction tests
li-head	Lightheadedness
mal	Malaise
muc memb	Mucous membrane
narco	Narcosis
nau	Nausea
nec	Necrosis
neph	Nephritis
ner	Nervousness
numb	Numbness
palp	Palpitations
para	Paralysis
pares	Paresthesia
perf	Perforation
peri neur	Peripheral neuropathy
phar	Pharyngeal
photo	Photophobia
pig	Pigmentation
pneu	Pneumonia
pneuitis	Pneumonitis
PNS	Peripheral nervous-system
prot	Proteinuria
pulm	Pulmonary
PFT	Pulm Function Tests
RBC	Red blood cells
resp	Respiratory
rhin	Rhinorrhea
salv	Salivation
sens	Sensitization
sez	Seizure
subs	Substernal
swell	Swelling

sys	System
tacar	Tachycardia
tend	Tenderness
trachbronc	Tracheobronchitis
URI	Upper respiratory infection
venfib	Ventricular fibrillation
verti	Vertigo
vesic	Vesiculation
vis dist	Visual disturbance
vomit	Vomiting
weak	Weakness
wheez	Wheezing

APPENDIX C

Occupational Carcinogens and Potential Occupational Carcinogens

OCCUPATIONAL CARCINOGENS AND POTENTIAL OCCUPATIONAL CARCINOGENS

This appendix contains five **mutually exclusive** listings of carcinogenic substances:

LIST 1: Carcinogens currently regulated by OSHA for which a special rule exists in 29 CFR 1910.1001 - 1910.1101.

LIST 2: Carcinogenic substances for which OSHA has initiated rule-making.

LIST 3: Substances currently regulated by OSHA 29 CFR 1910.1000, that NIOSH identified as meeting OSHA's criteria for potential occupational carcinogens in testimony to OSHA regarding its 1988 PEL revisions.

LIST 4: Additional substances for which bioassays indicate potential human carcinogenicity by virtue of being positive or showing clear evidence of carcinogenicity in: (1) both sexes of either mice and/or rats; or (2) in male rats and male mice, or in female rats and female mice.

LIST 5: Additional substances listed in the Fifth Annual Report on Carcinogens 1989.

List 1

Carcinogens Currently Regulated as such by OSHA

CAS Number	Carcinogen
000050-00-0	Formaldehyde
000053-96-3	2-Acetylaminofluorene
000057-57-8	beta-Propiolactone
000060-11-7	4-Dimethylaminobenzene
000062-75-9	n-Nitrosodimethylamine
000071-43-2	Benzene
000075-01-4	Vinyl Chloride
000091-59-8	beta-Naphthylamine
000091-94-1	3,3-Dichlorobenzidine
000092-67-1	4-Aminodiphenyl
000092-87-5	Benzidene
000092-93-3	4-Nitrophenyl
000096-12-8	1,2-Dibromo-3-Chloropropane
000107-13-1	Acrylonitrile
000107-30-2	Methyl Chloromethyl Ether
000134-32-7	alpha-Naphthylamine
000151-56-4	Ethyleneimine
000542-88-1	bis-Chloromethyl Ether
Several	Asbestos
Several	Inorganic Arsenic
None	Coke Oven Emissions

List 2

Carcinogenic Substances for which OSHA has Initiated Rulemaking

CAS Number	Carcinogen
000075-09-2	Dichloromethane (Methylene Chloride)
000106-93-4	Ethylene Dibromide
000106-99-0	1,3-Butadiene
007440-43-9	Cadmium Dust and Fume
013552-44-8	4,4'-Methylenedaniline Dihydrochloride

List 3

Substances in 29 CFR 1910.1000 Table Z-1-A that NIOSH Considers to Meet the OSHA Criteria (29 CFR 1990) for Potential Occupational Carcinogens

CAS Number	Substance
000000-00-0	Wood dust, Hardwood
000000-00-0	Rasin Core Solder Pyrolysis Products
000000-00-0	Welding Fumes
000000-00-0	Wood Dust - Soft Wood
000000-00-0	Chromite Ore Processing & Chromate Pigment mfr.
000050-29-3	DDT
000050-32-8	Benzo[a]pyrene
000056-23-5	Carbon Tetrachloride
000057-14-7	1,1-Dimethylhydrazine
000057-74-9	Chlordane (Analytical Grade)
000060-34-4	Methyl Hydrazine
000061-82-5	Amitrole
000062-53-3	Aniline
000067-66-3	Chloroform
000067-72-1	Hexachloroethane
000074-83-9	Methyl Bromide
000074-87-3	Chloroform
000075-00-3	Ethyl Chloride
000075-07-0	Acetaldehyde
000075-35-4	Vinylidine Chloride
000075-55-8	Propyleneimine
000075-56-9	1,2-Propylene Oxide
000076-44-8	Heptachlor
000077-78-1	Dimethyl Sulfate
000077-88-4	Methyl Iodide
000078-87-5	Propylene Dichloride
000079-00-5	1,1,2-Trichloroethane
000079-01-6	Trichloroethylene
000079-06-1	Acrylamide
000079-34-5	1,1,2-2-Tetrachloroethane
000079-44-7	Dimethyl Carbamoyl Chloride
000079-46-9	2-Nitropropane
000087-68-3	Hexachlorobutadiene
000095-53-4	o-Toluidine
000096-18-4	1,2,3-Trichloropropane
000100-00-5	p-Nitrochlorobenzene
000100-63-0	Phenylhydrazine
000101-14-4	MBOCA
000106-46-7	1,4-Dichlorobenzene
000106-49-0	p-Toluidine
000106-87-6	4-Vinyl-1-Cyclohexene Diepoxide
000106-89-8	Eipchlorohydrin
000107-06-2	1,2-Dichloroethane

List 3 (Continued)

CAS Number	Substance
000111-44-4	Dichloroethyl Ether
000117-81-7	Di(2-Ethylhexyl)Phthalate
000119-93-7	o-Tolidine
000121-14-2	2,4-Dinitrotoluene
000122-60-1	Phenylglycidyl Ether
000123-91-1	1,4-Dioxane
000127-18-4	Tetrachloroethylene
000133-06-2	Captan
000135-88-6	N-Phenyl-Beta-Naphthylamine
000140-88-5	Ethyl Acrylate
000218-01-9	Chrysene
000302-01-2	Hydrazine
000309-00-2	Aldrin
000542-75-6	Dichloropropene
000584-84-9	Toluene-2,4-Diioscyanate
000593-60-2	Vinyl Bromide
000680-31-9	Hexamethyl Phosphoramide
001103-86-9	Zinc Chromates
001120-71-4	Propane Sultone
001189-85-1	tert-Butyl Chromate
001317-95-9	Silica, Crystaline-Tripoli (Respirable)
001333-86-4	Carbon Black
002238-07-5	Diglycidyl Ether
002425-06-1	Captofol
007440-02-0	Nickel (Soluble Compounds)
007440-41-7	Beryllium & Compounds
007440-61-1	Uranium
007572-29-4	Dichloracetylene
007738-94-5	Chromic Acid, Chromates
007758-97-6	Lead Chromate
007784-42-1	Arsine
008001-35-2	Toxaphene
008006-61-9	Gasoline
008052-42-4	Asphalt Fumes
011097-69-1	Chlorodiphenyl 54%
013463-39-3	Nickel Carbonyl
013530-65-9	Zinc Chromates
014464-46-1	Cristobalite
014808-60-7	Silica, Crystaline Quartz (Respirable)
014977-61-8	Chromyl Chloride
015468-32-3	Tridymite
026471-62-5	2,4- & 2,6-Toluene Diisocyanate
029191-52-4	Anisidine (o-,p-Isomers)
037300-23-5	Zinc Chromates
053469-21-9	Chlorodiphenyl 42%
060676-86-0	Silica, Amorphous-Fused (Respirable)
065996-93-2	Coal Tar Pitch Volatiles

List 4

Additional NTP Tested Compounds that Meet OSHA Criteria for Category I or Category II Carcinogens

CAS Number	Compound Name	IARC #*	AP**
000050-33-9	Phenylbutazone	3	-
000050-55-5	Resperine	3	2
000052-24-4	Tris(Aziridinyl)-Phosphine Sulfide	2A	2
000063-92-3	Phenoxybenzamine Hydrochloride	2B	2
000072-55-9	p,p'-Dichlorodiphenoldichloroethylene	NE	-
000075-27-4	Bromodichloromethane	NE	-
000082-28-0	1-Amino-2-Methylanthraquinone	3	2
000086-30-6	N-Nitrosodiphenylamine	3	-
000087-29-6	Cinnamyl Anthranilate	3	-
000087-62-7	2,6-Xylidine	NE	-
000087-86-5	Pentachlorophenol, Dowicide EC-7	3	-
000088-06-2	2,4,6-Trichlorophenol	NE	2
000090-94-8	Michler's Ketone	NE	2
000091-93-0	3,3'-Dimethoxybenzidine-4,4'-Diisocyanate	3	-
000094-52-0	6-Nitrobenzimidazole	NE	-
000095-06-7	Sulfallate	2B	2
000095-79-4	5-Chloro-o-Toluidine	NE	-
000095-80-7	2,4-Diaminotoluene	2B	2
000095-83-0	4-Chloro-o-Phenylenediamine	2B	2
000096-45-7	Ethylene Thiourea (ETU)	2B	2
000099-55-8	5-Nitro-o-Toluidine	NE	-
000099-59-2	5-Nitro-o-Anisidine	3	2
000101-61-1	4,4'-Methylenebis(N,N-Dimethyl)Benzenamine	3	2
000101-80-4	4,4'-Oxydianiline	2B	2
000101-90-6	Diglycidyl Resorcinol Ether (DGRE)	2B	2
000102-50-1	M-Cresidine	3	-
000103-23-1	Di(2-Ethylhexyl)Adipate	3	-
000103-33-3	Azobenzene	3	-
000105-55-5	N,N'-Diethylthiourea	NE	-
000115-28-6	Chlorendic Acid	NE	2
000117-79-3	2-Aminoanthraquinone	3	2
000120-71-8	p-Cresidine	2B	2
000122-66-7	Hydrazobenzene	NE	2
000126-72-7	Tris(2,3-Dibromopropyl) Phosphate	2A	2
000129-15-7	2-Methyl-1-Nitroanthraquinone	2B	-
000134-29-2	o-Anisidine Hydrochloride	NE	2
000135-20-6	Cupferron	NE	2

List 4 (Continued)

CAS Number	Compound Name	IARC #*	AP**
000136-40-3	Phenazopyridine Hydrochloride	2B	2
000137-17-7	2,4,5-Trimethylaniline	3	-
000139-13-9	Nitrilotriacetic Acid (NTA)	NE	2
000139-65-1	4,4'-Thiodianiline	2B	-
000142-04-1	Aniline Hydrochloride	NE	-
000143-50-0	Chlordecone (Kepone)	2B	2
000271-89-6	Benzofuran	NE	-
000303-34-4	Lasiocarpine	2B	-
000303-47-9	Ochratoxin A	3	-
000366-70-1	Procarbazine Hydrochloride	2A	2
000389-08-2	Nalidixic Acid	NE	-
000509-14-8	Tetranitromethane	NE	-
000510-15-6	Chlorobenzilate	3	-
000513-37-1	Dimethylvinyl Chloride	NE	-
000556-52-5	Glycidon	NE	-
000563-47-3	3-Chloro-2-Methylpropene	NE	2
000569-61-9	C.I. Basic Red 9 Monohydrochloride	3	2
000598-55-0	Methyl Carbamate	3	-
000602-87-9	5-Nitroacenaphthene	2B	-
000609-20-1	2,6-Dichloro-P-Phenylenediamine	3	-
000636-21-5	o-Toluidine Hydrochloride	NE	2
000842-07-9	C.I. Solvent Yellow 14	3	-
000924-42-5	N-Methylolacrylamide	NE	-
000961-11-5	Tetrachlorvinphos	NE	-
001746-01-6	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	2B	2
001836-75-5	Nitrofen	2B	2
001897-45-6	Chlorothalonil	3	-
001937-37-7	C.I. Direct Black 38	NE	2
001955-45-9	Pivalolactone	NE	-
002243-62-1	1,5-Naphthalenediamine	3	-
002385-85-5	Mirex	2B	2
002475-45-8	C.I. Disperse Blue 1	NE	-
002602-46-2	C.I. Direct Blue 6	NE	2
002784-94-3	HC Blue 1	NE	-
003165-93-3	4-Chloro-O-Toluidine Hydrochloride	NE	-
003546-10-9	Phenesterin	NE	-
003778-73-2	Isophosphamide	3	-
005131-60-2	4-Chloro-m-Phenylenediamine	3	-
006109-97-3	3-Amino-9-Ethylcarbazole HCL	NE	-
006959-48-4	3-Chloromethylpyridine Hydrochloride	NE	-
007008-42-6	Acronycine	NE	-
007446-34-6	Selenium Sulfide	NE	2
017924-92-4	Zearalenone	3	-
018662-53-8	Nitrolotriacetic Acid Trisodium Monohydrate	NE	-

List 4 (Continued)

CAS Number	Compound Name	IARC #*	AP**
020325-40-0	3,3'-Dimethoxybenzidine Dihydrochloride	NE	-
021416-87-5	ICRF-159	NE	-
021739-91-3	Cytembena	NE	-
022966-79-6	Estradiol Mustard	3	-
024382-04-5	Malonaldehyde, Solium Salt	NE	-
039156-41-7	2,4-Diaminoanisole Sulfate	NE	2
057653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	NE	-
067774-32-7	Polybrominated Biphenyl Mixture	2B	-
108171-26-2	Chlorinated Paraffins: C12, 60% Chlorine	NE	2

*International Agency for Research on cancer overall evaluation score:

1	Carcinogenic to humans
2A	Probably carcinogenic to humans
2B	Possibly carcinogenic to humans
3	Not classifiable as to human carcinogenicity
NE	Not considered by IARC or no overall evaluation made

**Fifth Annual Report on Carcinogens:

-	not listed
2	in list 2 of report

List 5
Additional Substances Listed in the Fifth Annual Report on Carcinogens 1989

CAS Number	Substance
000050-18-0	Cyclophosphamide
000050-28-2	Estradiol-17 β
000051-52-5	Propylthiouracil
000051-79-6	Urethane
000053-16-7	Estrone
000053-70-3	Dibenz(a,h)anthracene
000055-18-5	N-Nitrosodiethylamine
000055-86-7	Nitrogen Mustard Hydrochloride
000055-98-1	1,4-Butanediol Dimethylsultonate (Myleran)
000056-53-1	Diethylstilbestrol
000056-55-3	Benz(a)anthracene
000057-41-0	Phenytoin
000057-63-6	Ethinylestradiol
000057-83-0	Progesterone
000058-89-9	γ-Hexachlorocyclohexane
000059-89-2	N-Nitrosomorpholine
000062-44-2	Phenacetin
000062-55-5	Thioacetamide
000062-56-6	Thiourea
000064-67-5	Diethyl Sulfate
000068-22-4	Norethisterone
000072-33-3	Mestranol
000081-07-2	Saccharin
000095-06-7	Sulfallate
000098-07-7	Benzotrichloride
000100-75-4	N-Nitrosopiperidine
000118-74-1	Hexachlorobenzene
000119-90-4	3,3'-Dimethoxybenzidine
000148-82-3	Melphalan
000154-93-8	Bischloroethyl Nitrosourea
000156-10-5	p-Nitrosodiphenylamine
000189-55-9	Dibenzo(a,i)pyrene
000189-64-0	Dibenzo(a,h)pyrene
000191-30-0	Dibenzo(a,l)pyrene
000192-65-4	Dibenzo(a,e)pyrene
000193-39-5	Indeno(1,2,3-cd)pyrene
000194-59-2	7H-Dibenzo(c,g)carbazole
000205-82-3	Benzo(j)fluoranthene
000205-99-2	Benzo(b)fluoranthene
000207-08-9	Benzo(k)fluoranthene
000224-42-0	Dibenz(a,j)acridine
000226-36-8	Dibenz(a,h)acridine
000301-04-2	Lead Acetate
000305-03-3	Chlorambucil
000319-84-6	α-Hexachlorocyclohexane
000319-85-7	β-Hexachlorocyclohexane

List 5 (Continued)

CAS Number	Substance
000394-59-7	Safrole
000434-07-1	Oxymetholone
000438-67-5	Sodium Estrone Sulfate
000443-48-1	Metronidazole
000446-86-6	Azathioprine
000505-60-2	Mustard Gas
000513-78-0	Cadmium Carbonate
000608-73-1	Hexachlorocyclohexane
000612-83-9	3,3'-Dichlorobenzidine Dihydrochloride
000621-64-7	N-Nitrosodi-n-Propylamine
000684-93-5	N-Nitroso-N-Methylurea
000759-73-9	N-Nitroso-N-Ethylurea
000924-16-3	N-Nitrosodi-n-Butylamine
000930-55-2	N-Nitrosopyrrolidine
001066-30-4	Chromium Acetate
000116-54-7	N-Nitrosodiethanolamine
001271-28-9	Nickelocene
001306-19-0	Cadmium Oxide
001306-23-6	Cadmium Sulfide
001308-38-9	Chromic Oxide
001313-99-1	Nickel Oxide
001314-20-1	Thorium Dioxide
001333-82-0	Chromium Trioxide
001402-68-2	Aflatoxins
001464-53-5	Diepoxybutane
001937-37-7	Direct Black 38
003697-24-3	5-Methylchrysene
003817-11-6	N-Nitroso-n-Butyl-N-(4-Hydroxybutyl)Amine
004342-03-4	Dacarbazine
004549-40-0	N-Nitrosomethylvinylamine
007280-37-7	Piperazine Estrone Sulfate
007446-27-7	Lead Phosphate
008001-58-9	Creosote
008007-45-2	Coal Tar
008021-39-4	Creosote
009004-66-4	Iron Dextran Complex
010034-93-2	Hydrazine Sulfate
010108-64-2	Cadmium Chloride
010124-36-4	Cadmium Sulfate
010325-94-7	Cadmium Nitrate
011114-92-4	Cobalt Chromium Alloy
012035-72-2	Nickel Subsulfide
012054-48-7	Nickel Hydroxide
013010-47-4	1-(2-Chloroethyl)-3-Cyclohexyl-1-Nitrosourea
013256-22-9	N-Nitrososarcosine
014486-19-2	Cadmium Fluoborate
016543-55-8	N-Nitrosonornicotine
016680-47-0	Sodium Equilin Sulfate

List 5 (Continued)

CAS Number	Substance
018883-66-4	Streptozotocin
023214-92-8	Adriamycin
029689-14-3	Chromium Carbonate
038252-74-3	N-Nitroso-n-Butyl-N-(3-Carboxypropyl)Amine

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