Winter/Spring 1992

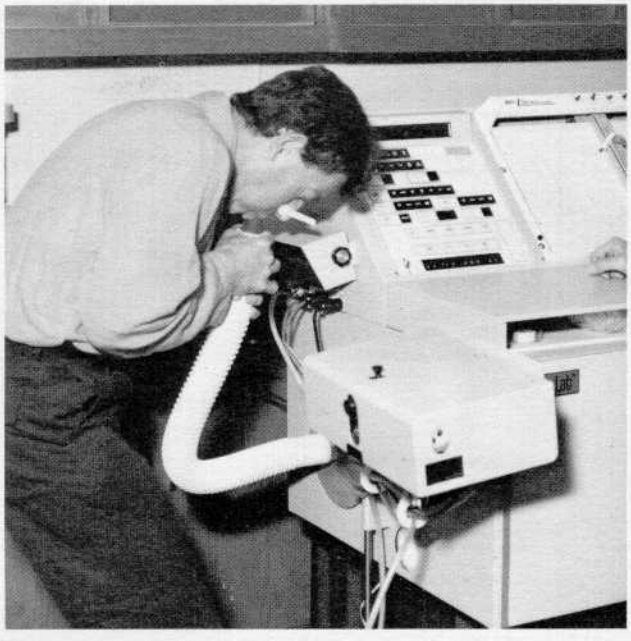
Health Hazards of Smoke

USDA Forest Service — Missoula Technology & Development Center

The National Wildfire Coordinating Group (NWCG) coordinates wildland firefighting efforts among federal and state agencies. NWCG assigned the Missoula Technology and Development Center (MTDC) to coordinate the national effort and serve as the focal point for on-going and future studies on the effect of forest fire smoke on firefighters. This status report, the fourth in a series, provides an update on project activities.

Proposed NFPA Standard: How To Be Heard

Pending approval of the draft by the National Fire Protective Association (NFPA) Technical Committee, a proposed standard on respiratory protection for wildland firefighters will be available for public review and comment in August, 1992. Individuals and organizations will be invited to review the technical committee report of the proposed NFPA standard No. 1977 on *Wildland Fire Service Protective Clothing and Equipment*. Public comment on the proposed standard, which includes a proposal for respiratory protection, will be invited from NFPA members and others prior to the end of the comment period (August - October 1992). Forms for public comment are available in the technical committee report, which will be available from the NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101. Each comment received on or before the closing date of the comment period will be considered and acted upon by the technical committee. Results of committee action will be published in the *Committee Documentation*, which will be available to all who request a copy. Commentors will receive the *Committee Documentation* automatically (see related item on page 6). If the proposed standard stays on schedule with the NFPA document cycle, the effective date of Standard No. 1977 will be August, 1993.



Firefighter performing a lung function test in the University of Montana Human Performance Laboratory. (See related item on page 3).

Firefighter Exposure

Industrial hygiene measurements of exposures to smoke during three consecutive fire seasons in northern California (1986-1989) were conducted by researchers associated with the California Department of Health Services. Results reported in the American Industrial Hygiene Association Journal indicate that wildland firefighters may at times be exposed to concentrations of carbon monoxide and respirable particulates at levels near or higher than recommended occupational exposure limits, although group means were generally well below the limits. Measurements were taken at both wildland fires and prescribed burns, in conjunction with health effects studies. Recommendations were made for exposure reduction, medical surveillance, training, and additional research (see related item on page 3).

NWCG Technical Panel

At the request of NWCG, a panel was named to help guide project activities. The panel includes Dave Blakeley of IFSL, Dana Headapohl, M.D., Bob Harrison, M.D., John Kelly of NIOSH, Paul Broyles of

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NPS, Kim Muller of CDFEA, Dick Mangan and Brian Sharkey of MTDC. The panel convened in Missoula in December to review existing research and make recommendations concerning research needs and priorities. Guests included Dan Sullivan of NPS, Bill Weaver of CDF, and Tim Reinhardt for PNW and the Radian Corporation. Part of the discussion centered on the NFPA document cycle and the need to provide as much information as possible to ensure that the proposed standard for respiratory protection is appropriate to the needs of the wildland firefighter. The panel recognized the urgent need to provide additional exposure data in time for the public comment period for the proposed document (August - October 1992). Priority was also given to the determination of chronic exposure effects on pulmonary function for firefighters who have been measured over several seasons.

The need to conduct a long-term prospective (forward looking) study of health effects was recognized but given a lower priority. It would take years to yield useful information, and there is an immediate need for data that will help identify the most appropriate risk management procedures. The panel recommended that the data needed for the prospective study be built into existing data bases. Similarly, the need for a retrospective morbidity and mortality study was recognized. This too was given a lower priority because of the projected cost and questions regarding its feasibility, due to a limited population for study, confounding factors (cigarette smoking, wood burning, pollution), and inadequate exposure data. Also, the panel recognized that implementation of risk reduction strategies will markedly change future exposure of firefighters to contaminants. The panel recommended that MTDC consider less expensive ways to determine the effects of previous long-term exposure, and to explore the availability of other sources of funding for a major retrospective cohort mortality study.

Other priorities listed by the panel include risk assessment, risk management, and respirator studies. The panel recognized that while additional research is still needed, the project must begin to focus on development of risk management and respiratory protection programs. This will include development of the programs, including training materials, monitoring guidelines, medical surveillance, and other methods of risk management (Fig. 1). If a proposed NFPA respirator standard is approved in August 1993, agencies may decide to implement programs for the 1994 fire season.

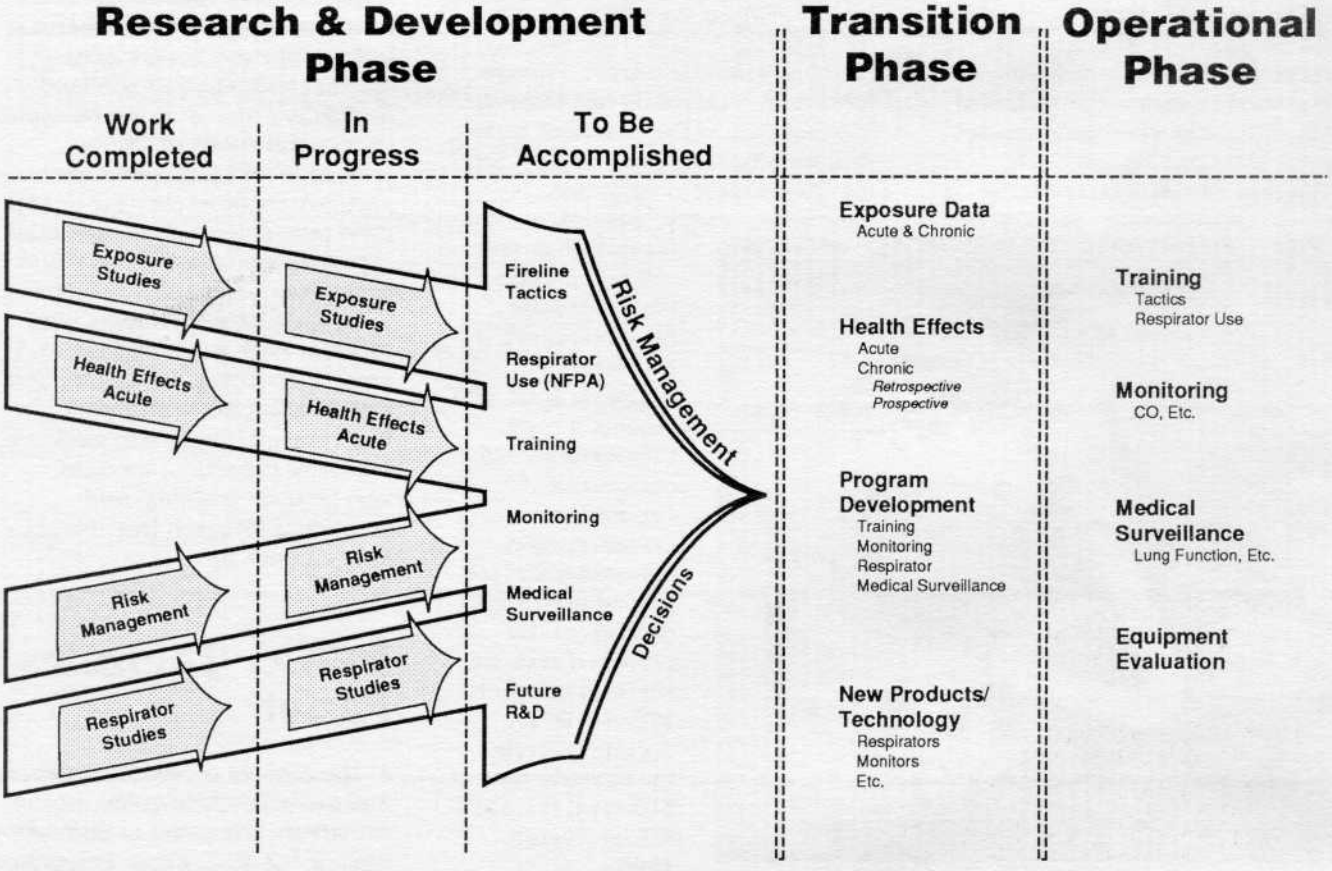

Figure 1.—Graphic summary of past, current, and future research and development activities associated with the Health Hazards of Smoke project.

Lung Function Tests

The American Thoracic Society recommends that individuals at risk for lung disease have at least one spirometry (lung or pulmonary function) test performed annually. This includes smokers, individuals with asthma, bronchitis, and other lung problems, those exposed to environmental air pollution, and workers with occupational exposure to inhaled particles and gases. Lung function tests have been used to evaluate the effects of acute and chronic exposure to smoke from wildland fires and prescribed burns. Materna *et al.* (1992) recommend the use of lung function tests as part of an occupational health surveillance program for firefighters. Lung function tests may aid in the selection of workers who are able to perform firefighting duties while wearing a respiratory protective device.

The test is conducted with a calibrated spirometer that measures gas volumes and flow rates in a maximum effort test. The subject takes a maximal inspiration and then exhales as quickly and forcefully as possible through a tube connected to the spirometer. The subject continues to exhale until all the air is expelled from the lungs. In some cases the subject also may be asked to quickly and forcefully inhale until the lungs are full, which provides information about inspiratory as well as expiratory capacity. The computerized device then calculates important volumes and flow rates and provides a graphic display. After a brief rest, the test is repeated. (see figure page 1)

Important measures include (Fig. 2):

FVC or forced vital capacity -shows lung capacity
FEV1 or forced expiratory volume in 1 second
FEV1/FC% or FEV1 as % of FVC - shows ability to move air quickly
FEF 25-75% or mid-expiratory flow - shows small airway flow
PEFR or peak expiratory flow rate
PIFR or peak inspiratory flow rate

These measures are used to evaluate pulmonary function and to provide a baseline for comparison following occupational exposures. Along with a related test, the maximal voluntary ventilation (MVV), these lung function measurements can be useful in the selection of workers capable of performing prolonged arduous work while wearing a respiratory protective device.

Previous editions of this report have indicated the effects of exposure on pulmonary function. Individuals with a history of shortness of breath upon exertion, wheezing or tightness in the chest, frequent colds or allergic rhinitis, or other lung problems may need to be tested. Some units include spirometry as part of the wellness program, and lung function tests may become part of an occupational health surveillance program.

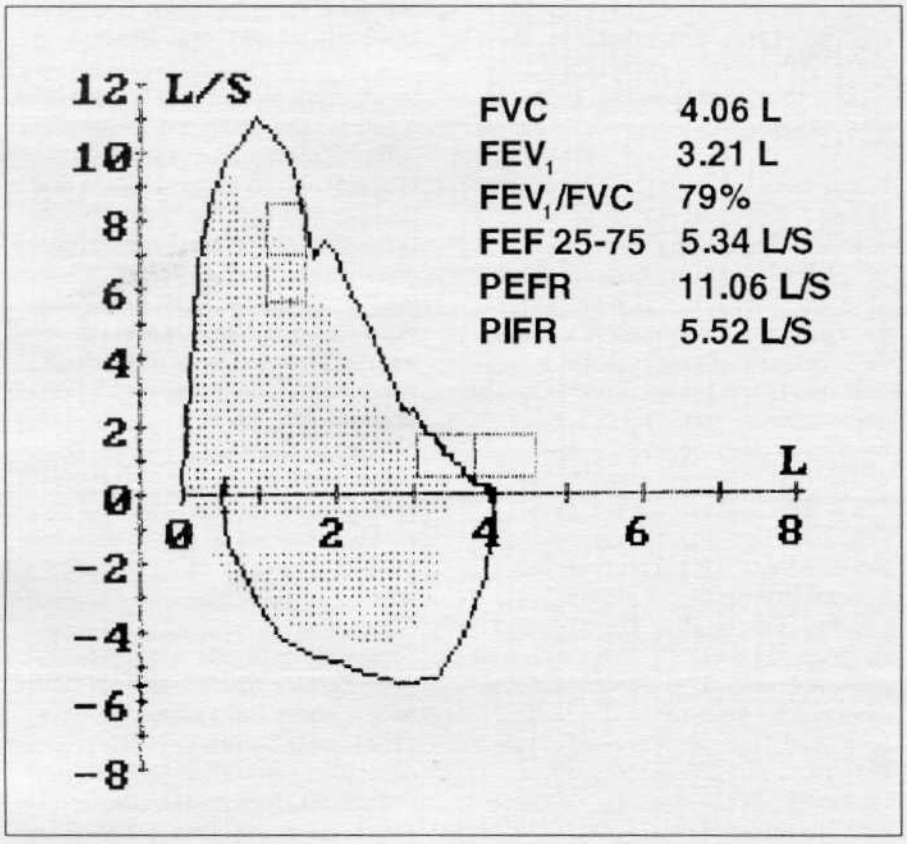

Figure 2.–Lung function test report including test results and graphic representation of test volumes (L) and flow rates (L/S).

Research

This section includes research abstracts and notes related to the health hazards of forest fire smoke.

Occupational Exposures in California Wildland Fire Fighting. B. Materna *et al.*, *American Industrial Hygiene Assoc. Journal*, 53:69, 1992.

Industrial hygiene measurement of exposure to wildland firefighters was conducted in northern California during three consecutive fire seasons (1986-1989) in conjunction with three separate health effects studies. Chemicals that were monitored included carbon monoxide, total and

respirable particulates, polyaromatic hydrocarbons (PAHs), crystalline silica, aldehydes, and benzene. Measurements were taken at both wildland fires and prescribed (planned) burns. A variety of collection methods were employed — colorimetric detector tubes and a CO monitor were used for direct-reading area measurements; colorimetric diffusion tubes, filter cassettes, sorbent tubes, and passive vapor monitors were used for determining personal time-weighted average exposures. A new screening method (NIOSH Method 2539) was used to identify the presence of specific aldehydes. Results show that wildland firefighters may at times be exposed to concentrations of carbon monoxide, total or respirable particulates, or silica at levels near or higher than recommended occupational exposure limits, although group means were generally well below the limits.

Time-weighted average formaldehyde levels, measured in a few instances above 0.37 mg/m3 (0.3 ppm), indicate a potential for formaldehyde-induced eye or respiratory irritation under these conditions. Certain characteristics of the work such as high altitude, temperature, and breathing rate; extended work shifts; and additional off-shift exposures suggest that adjustment of 8-hour exposure limits may be necessary to provide adequate protection. In part, because of the rigors of performing industrial hygiene measurements under firefighting conditions, data are limited and could not be considered representative of the full range of exposures firefighters may encounter. Further exposure monitoring is needed, particularly to identify job tasks and fire conditions that contribute to higher exposures. Short-term measurements should be done for acute hazards such as carbon monoxide and aldehydes. Recommendations are made for exposure reduction, medical surveillance, training, and additional research.

The Use Of Respiratory Protective Devices By Wildland Firefighters. J. Driessen, B. Sharkey, and D. Buskirk, Missoula Technology and Development Center, 1992.

Based on field interviews, a questionnaire was constructed to assess field use of respiratory protective devices by wildland firefighters during wildfire suppression or prescribed burning. Questionnaires were sent to field units of federal and state agencies for distribution and, therefore, represent a non-probability sample. Of the 300 respondents to the questionnaire, 53.8 percent were Forest Service employees and 46.2 percent were employees of other federal or state agencies. A wide range of job titles was represented—47 forestry techs, 30 hotshots, and 17 fire management officers were the most common. Ages ranged form 18 to 56 years with a mean of 33.6 years; 94.6 percent of the respondents were male. Firefighting experience range from 1 to 36 years, with a mean of 11.1 years.

When asked, "Do you feel the health hazards of smoke in wildland firefighting and/or prescribed burning warrant the use of respiratory protective devices"?, 82.2 percent responded yes. Of the 50.6 percent of respondents who had used respiratory protection, the overwhelming majority (92.9%) responded yes, protection was warranted. Seventy-two percent of those who had not used a device felt protection was warranted. Respondents felt protection was needed during direct attack (70.4%), line holding (79.8%), and mop-up (64.8%). Of those who had used a device, 37.5 percent used a disposable, 43.8 percent a half-face, and 18.8 percent a full-face respirator (18.8% marked other, and wrote in bandanna). Of those who had used a device, 76.1 percent said the device provided relief, but 75 percent reported that the device adversely affected productivity. In addition, 84.6 percent reported satisfaction with the fit of the device; only 7.1 percent reported problems with a beard, 12.6 percent with glasses, and 5.5 percent with hard hat and goggles. Also, 69.1 percent said the device interfered with communication (talking, radio), while 48.6 percent said a device that provides protection from some but not all hazards could provide a false sense of security. Most added that training would minimize that problem. The results indicate that firefighters believe that the health hazards of smoke warrant the use of respiratory protection, that the perceived need for protection increases with respirator use, and that fit and other problems are minor and manageable with proper training. (See summary of responses on page 8).

Acrolein Effects Reviewed—*in Toxicological Profile for Acrolein*, by U.S. Dept. of Health and Human Services, from National Technical Information Services, 1990.

In addition to throat irritation and a reflex suppression of respiratory rate, acrolein can cause destruction of the respiratory epithelium and its inherent defense mechanisms. Subjects experienced eye irritation after exposure to 0.6 ppm acrolein for 7.5 min, or to 0.17 ppm for 1 hour. Lacrimation (tears) occurred within 20 seconds in individual exposed to 0.81 ppm, and within 5 seconds at 1.22 ppm. A summary of human data shows that concentrations between 0.5 and 5 ppm caused lacrimation and various degrees of eye irritation in exposure periods of 10 minutes or less.

Exposure limits for acrolein are 0.1 ppm (OSHA, NIOSH, and ACGIH), with a short-term exposure limit (STEL) of 0.3 ppm (ACGIH or American Council of Government Industrial Hygienists). [**Note**: Exposure limits for acrolein have been exceeded in a small proportion of the exposure samples

taken on wildland firefighters. Due to the sensitivity of the eyes to acrolein, eye irritation may provide warning of excess exposure to forest fire smoke.]

Effects Of Inhaled Particulate Matter. O. Raabe and D. Wilson, University of California, Davis, 1990.

Controlled laboratory studies were conducted using two experimental animal models, one healthy and one impaired with emphysematous lung disease, to evaluate the nature and severity of responses to inhaled respirable aerosols that were typical of air pollution in California, alone and in combination with ozone. Studies were performed with a respirable aerosol (similar to London smog), alone and in combination with sulfur dioxide. Exposures were acute (3 days) or subchronic (30 days). Effects were evaluated with biochemical measures, lung clearance, clinical signs, and histological evidence.

Neither aerosol was effective by itself in causing significant responses in healthy rats, but some significant aerosol effects were observed in association with ozone exposure or lung impairment. In the 3-day studies there were some significant increases in total lung DNA and protein content in rats exposed to the California aerosol compared to controls. In addition, small airway inflammation was observed in animals exposed to ozone, and this effect was exacerbated by inhalation of aerosol or in impaired animals. In 30-day studies, analyses showed increases in lung collagen and potential lung fibrosis in rats exposed to the California smog, and to the London aerosol in impaired animals. Both aerosols decreased the clearance rate with test particles. Airway lesions and fibrosis were associated with ozone exposure and were exacerbated by exposure to the California smog.

The Normal Range Of Diurnal Changes In Peak Expiratory Flow Rates: Relationship To Symptoms And Respiratory Distress. J. Quackenboss, M. Lebowitz and M. Krzyzanowski. *American Review of Respiratory Disease*, 143:323, 1991.

Measuring peak expiratory flow rates (PEFR) several times a day can provide an objective assessment of functional changes relative to environmental or occupational exposures. This report describes the pattern of diurnal changes in PEFR in a reference population, and defines ranges of normal between and within-day variability. An index of diurnal changes was defined as the ratio between maximal and minimal values where the maximal value was restricted to PEFR measured at noon or in the evening (N,E) and the minimal value was restricted to the morning or at bedtime (M,B). A ratio greater than normal represented an exaggeration of the normal diurnal pattern in PEFR. Normal limits, based on the ninety-fifth percentile in the reference population, were larger for children (130%) than for adults 15 to 35 years of age (117%) and those older than 35 years of age (118%). The meaningfulness of excessive diurnal changes in PEFR was examined by relating this ratio (max/min) to chronic respiratory symptoms and diseases in 939 adults and children who recorded PEFR values 2 to 4 times per day for as long as 14 days. There was a strong relationship of diurnal changes in PEFR that exceed normal limits with physician-confirmed asthma (relative risk of 2.99 with max/min) with exertional dyspnea (Grade 2+), and with more frequent reporting of acute symptoms of wheeze, attacks of wheezing dyspnea, cough and chest colds. In addition, those exceeding the normal limits had about 2.9 times greater risk of having FEV1 below 80 percent of predicted, and nearly 7 times greater risk of being below 70 percent. These associations support the interpretation of excessive diurnal changes in PEFR as an indicator of bronchial responsiveness. [**Note**: The PEFR were at least as sensitive as provocative methacholine challenge tests in determining bronchial responsiveness. Along with other pulmonary function tests, the PEFR measures could help identify those likely to experience respiratory problems when exposed to forest fire smoke.]

Respiratory Symptoms And Risk Factors In An Arizona Population Sample Of Anglo And Mexican-American Whites. C. Di Pede, *et al.*, *Chest*, 99:916, 1991.

Prevalence rates of respiratory symptoms and diseases in a large group of Anglos and Mexican-Americans were analyzed. Each subject completed a questionnaire. Among current smokers, chronic productive cough and dyspnea were significantly higher in both ethnic groups; wheezy symptoms were higher in Anglos. There were no significant differences in the symptom prevalence rates between the two groups, after stratifying by current cigarette consumption and childhood respiratory trouble (CRT). The spirometric values were not significantly different. In both ethnic groups, the prevalence rates of wheeze, shortness of breath with wheeze (SOBWHZ) and asthma were significantly higher in those who had CRT. Among Anglos, less educated smokers had significantly higher prevalence rates of SOBWHZ, and dyspnea; nonsmokers with less education had higher prevalence rates of cough, chronic cough, and dyspnea. Our results confirm the importance of CRT and lower educational level as risk factors for respiratory symptoms. Ethnicity is not associated with symptomology or lung function impairment. [**Note**: Dyspnea is shortness of breath, difficult or labored respiration.]

Risk Management

Proposed NFPA Respirator Standard

The proposed NFPA standard for respiratory protection for wildland firefighters will be available for public comment in August. The proposed standard is intended to provide relief from some of the contaminants found in the firefighting environment. The standard will not provide protection from all sources of airborne contaminants in forest fire smoke, which include carbon monoxide, respirable particulate, and organic gases. Approved air purifying respirators do not provide relief from carbon monoxide. The universal or type "N" canister provides protection from all three hazards, but that device is not approved by the National Institute for Occupational Safety and Health (NIOSH) for firefighting activities. Therefore, the respirator user must be thoroughly trained in the use and limitations of the device. They must not develop a false sense of security while wearing the respirator. Crews will have to monitor carbon monoxide levels to avoid overexposure.

The proposed NFPA standard should be viewed as the basic standard of protection for wildland firefighters, to be worn at the discretion of the worker. Agencies may develop regulations that mandate use when minimum exposures are exceeded. Lightweight inexpensive devices that meet the proposed standard are available. Higher levels of protection can be achieved with more expensive devices (full-face, powered air-purifying respirators or PAPR), and protection from organic gases can be added by using sorbents along with the proposed level of protection. Thus, the standard will meet the basic needs of wildland firefighters, while allowing additional protection for those who regularly encounter higher levels of exposure (e.g., during prescribed burns). For additional information concerning the proposed standard see the related item on page 1.

Mouthpiece Respirator

The small, lightweight mouthpiece respirator is approved for escape use only from specific hazardous atmospheres (chlorine, sulfur dioxide, etc.). Some firefighters have asked about the use of these devices during wildland firefighting. With the proper filter and/or sorbent, it would appear to be a possible alternative for firefighters (Fig. 3). However, mouthpiece respirators have been restricted to escape use only by NIOSH. One reason is that the nose clip provided with the device interferes with the sense of smell and masks the warning properties of gases. Another reason for restriction could be a concern for the fit and function of the devices. The following abstract addresses those issues.

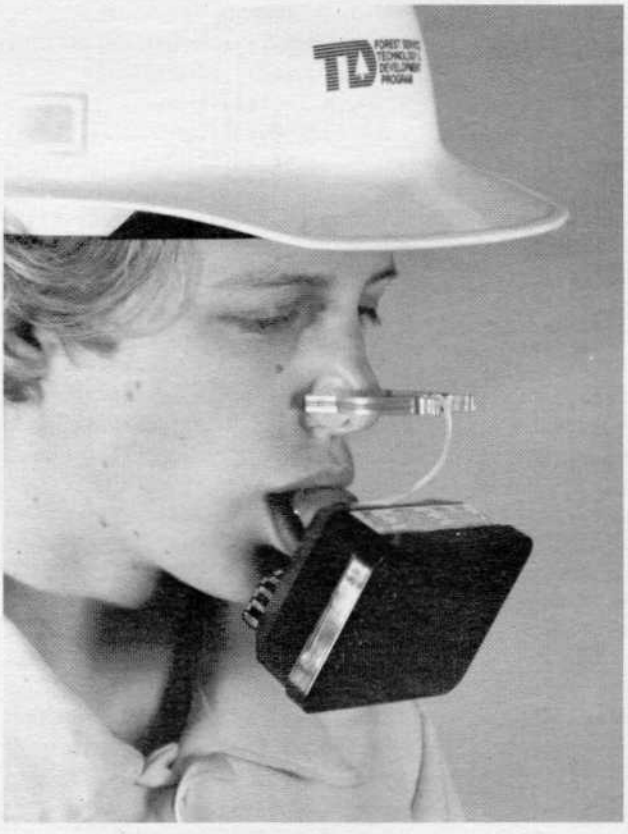

Figure 3.– Mouthpiece respirator.

Quantitative Fit Testing Of Personnel Utilizing A Mouthpiece Respirator. L. Packard, H. Brady, and O. Schumm (C. O'Leary *et al.*, ed.) *in Respiratory Protection*, Akron: American Industrial Hygiene Association, 1985.

Fifty volunteers participated in a comparison of a mouthpiece respirator and half-face respirators. Fit tests were conducted before and after a 30-day test period. When used in a chlorine plant work situation, the half-face respirator offered less protection than the mouthpiece respirator. The half-face respirator was inferior in an emergency exposure. It interfered with vision and communication and required removal of the hard hat to put on. It was judged less handy, more awkward to use, and generally less effective in keeping out contaminated atmospheres. The user had to remain clean-shaven to assure an acceptable fit. A small portion of the population could not be fit with a half-face respirator because of their facial configuration. While a few individuals with dentures had difficulty with the mouthpiece respirator, the authors strongly recommended that the mouthpiece respirator be allowed equal status with the half-face respirator for use in the chlorine plant work situations.

For Wildland Firefighters? With the proper filter and/or sorbent for intermittent use in atmospheres that are not considered immediately dangerous to life and health, the

mouthpiece respirator would seem to be a useful option for wildland firefighters who are difficult to fit, have facial hair, or wear glasses. Existing devices would need a larger airway to accommodate the ventilation associated with the vigorous work of firefighting. However, such a device is not currently approved for extended wear by NIOSH.

Effect Of Facial Hair On Respirator Performance. E. Hyatt *et al., in Respiratory Protection*, Akron, OH: American Industrial Hygience Association, 1985.

The effect of facial hair on the performance of half-mask and full-face respirators was measured with a quantitative aerosol test system. Different test subjects having varying degrees of facial stubble, sideburns, and beards were used in the study. Test results showed that the effect of facial hair on the performance of a respirator depends upon the degree to which the hair interferes with the sealing surface of the respirator, the physical characteristics of the facial hair, the type of respirator worn in relation to the subject's facial characteristics, and other factors. It is concluded that persons with excessive facial hair such as facial stubble, sideburns, and beards, which interfere with the respirator seal, cannot expect to obtain as high a degree of respirator performance as persons who are clean shaven. [Note: The major drop in respirator performance occurs in the first 3 days of beard growth, with variable but continued degradation in performance thereafter.]

Carbon Monoxide Exposure

Carbon monoxide (CO) is a colorless, odorless product of incomplete combustion. When inhaled, it competes with oxygen for space on the hemoglobin molecule, thereby reducing oxygen transport. Prolonged exposure leads to elevated levels of carboxyhemoglobin (COHb) in the blood. The following table summarizes some of the effects of exposure.

COHb%	Effect
1.0	*No apparent effect*
1 to 2	*Some effect on behavioral performance*
2 to 5	*Central nervous system effects: Impairment of ime interval discrimination, Visual discrimination (sharpness/brightness), Psychomotor function (coordination)*
5.0	*Cardiac and pulmonary function changes*
10 to 20	*Headaches, fatigue, drowsiness, nausea, dizziness*
50 to 60	*Intermittent convulsions*
70 to 80	*Coma, cardiovascular failure, and death*

Note: Symptoms may be present at levels below or above those indicated. Non-smokers may experience headaches and nausea at levels well below 10 percent COHb.

The maximal safe exposure for firefighting personnel is considered to be 5 percent COHb, a level achieved after 8 hours of exposure at 50 ppm. With the strenuous effort of firefighting, increased respiration shortens the time to equilibrium. Therefore, the 8-hour time-weighted average of 35 ppm recommended by NIOSH for CO exposure seems more appropriate for wildland firefighters. The short-term exposure limit is 200 ppm, which would lead to 5 percent COHb in a short period of exposure. Since no currently approved air purifying respirator provides protection from carbon monoxide, firefighters must be well acquainted with the symptoms of exposure and crews should monitor CO levels to avoid overexposure.

Maximal work capacity is diminished at levels above 4 percent COHb, but there is little immediate effect on submaximal work at levels below 15 percent COHb. Of course, CO exposure accentuates symptoms in those with heart and respiratory disease. Carbon monoxide is additive with the effects of altitude and CO lowers the body's resistance to work in the heat. COHb levels are slow to decline when the worker leaves the contaminated atmosphere. As a general rule, levels decline 50 percent every 3 hours. Removal can be accelerated by breathing oxygen. Some symptoms (e.g., visual) can persist after COHb levels have been reduced. For more information on carbon monoxide, refer to previous editions of this report.

Lower Carbon Monoxide Standard for Firefighters? NIOSH investigators believe that the 35 ppm standard for exposure to carbon monoxide (CO) may not be protective for wildland firefighters. The 35 ppm standard is designed to keep COHb levels below 5 percent in most workers. However, since that standard is based on an 8-hour work shift, low energy expenditure and air intake, and low elevations, the standard may not be appropriate for firefighters engaged in arduous work for long shifts, sometimes at higher elevations. Using values appropriate for wildland firefighters in Yellowstone Park, NIOSH researchers calculate that the 5 percent COHb level could be reached at an exposure concentration of 17 ppm (time weighted average for 12-hour shift). For more information, consult Health Hazard Evaluation Report, HETA 88-329-2176, USDI National Park Service, Yellowstone National Park. C. Reh and S. Deichtman, NIOSH.

Tent Reduces Particulate

MTDC is evaluating a personal tent as a means of improving the sleeping environment for firefighters. The tent provides protection from cold, moisture, insects, smoke, and dust. Preliminary tests conducted by Dave Blakeley at the Intermountain Fire Sciences Laboratory indicate that particulate levels are 25 times

higher outside the tent when compared with samples collected inside the shelter, indicating a 96 percent reduction in exposure to particulate. The 35 square-foot semi-freestanding tent has received field evaluation and is currently undergoing modification. Tents should be available from GSA for the 1993 field season. For information, contact Ted Putnam or George Jackson at MTDC (406-329-3967).

Firefighters Respond

This section summarizes the responses of firefighters to open-ended questions in the questionnaire on the use of respiratory protective devices in wildfire suppression and prescribed burning (see related item on page 4).

Do you feel that the health hazards of smoke in wildfire fighting and/or prescribed burning warrant the use of a respiratory protective device? Of 225 written responses, 65.3 percent would agree with the statement: *The use of a respiratory protective device is warranted during work in dense or heavy smoke when extended exposure time is expected.*

What situations (other than direct attack, line holding, mop-up) warrant the use of a respirator? Fifty-nine written responses included : *In fire camps located in dense or heavy smoke; during air inversions and dead air periods, and any period when there are dense or heavy concentrations of dust, ash, CO or other harmful gasses.*

Did the device used provide relief from smoke? Of the 63 respondents who said no and provided an explanation, 73 percent of them said: *The device provided some relief from smoke but that it could have been much better.*

Did the device affect your productivity? Of the 100 who answered yes and described how, 55 percent would agree with the following statement: *The device limited my ability to breathe enough air when working hard or walking uphill; 20 percent said the devices are too heavy, bulky and difficult to work in to be effective.*

Did the device fit reasonably well? Of the 39 individuals who said no and described the problem, 64 percent said: *No the device did not fit well because of constant adjustment needed and smoke leaking in around the seals.* When asked to describe other things (other than beard, scar or glasses) that affected proper fit, three had difficulty wearing the device with a hard hat and two said the straps got tangled in their hair.

Did the device interfere with talking or radio use? Of 110 people who described the problem, 94.6 percent said: *The device muffled the voice so you had to take it off to talk effectively on the radio or to others.*

Describe what would be the ideal respiratory protective device for fighting wildland fires or prescribed burns? Of the 165 who described the ideal device, 76.4 percent said: *It should be small, lightweight, comfortable, easy to maintain, easy to carry, and effective at filtering heavy smoke, dust, ash, CO, and other harmful gasses; 15.2 percent said full-face masks; and 5.5 percent said bandannas.*

In your experience...what may be some of the problems associated with the use of respiratory protective devices? Of 170 respondents, 62.3 percent would agree with all or part of the following: *Devices are too heavy and bulky to carry and/or wear; they restrict breathing, vision, communication, and mobility, and are ineffective at properly filtering the smoke, dust, ash, CO, and other gasses that are encountered in wildland firefighting.*

In your opinion, would a device that protects against some but not all the hazards of smoke provide a false sense of security? Of the 200 who chose to explain their response, 50 percent said: *Yes, they could provide a false sense of security and cause people to stay in heavy smoke or hazardous areas too long.* However, they thought that with proper education on the hazards of smoke and proper training on the limitations and use of the devices, the situation could be corrected.

What guidelines would you recommend for when a respiratory protective device should be deployed and used? Of the 280 who responded, 78.2 percent would agree to the following: *Anytime the smoke, dust, ash, or CO levels are high and an extended exposure time is expected, the device should be used.*

Aside from respiratory protective devices, what other ways should be used to avoid or limit exposure to smoke? Of the 250 respondents who listed or described other ways to avoid smoke, 69.2 percent suggested: *Common sense, use more indirect attack, rotate crews out of heavy smoke areas often to limit exposure time and put fire camps outside of heavy smoke areas; 33.6 percent said use common sense and stay out of heavy smoke, realize that trees and animals aren't worth the lungs and lives of fire fighters; 11.6 percent said wear bandannas.*

Any final comments you may have about respirators, smoke, and wildland firefighting? Of 185 comments, 61.6 percent would agree with the following: *A good, lightweight, functional, effective protective device should be developed and available for use by wildland firefighters when the conditions warrant its use or the firefighter feels it is needed.*

OSHA Proposes Amendments To Formaldehyde Standard from *Federal Register*, U.S. Department of Labor, July 15, 1991.

The Occupational Safety and Health Administration (OSHA) is proposing amendments to its existing formaldehyde standards. The proposed amendments would lower the permissible exposure limit (PEL) to 0.75 from 1 ppm as an 8-hour time-weighted average (TWA). The amendment would add medical removal protection provision for those employees suffering adverse health effects from occupational exposure to formaldehyde. The proposed amendment would require that employee training be conducted on an annual basis for all employees exposed to formaldehyde concentrations greater than 0.1 ppm. [**Note**: Exposure limits for formaldehyde have been exceeded in a small portion of the limited number of breathing zone samples collected on wildland firefighters.]

Forest Uses SCBA

The San Bernadino National Forest has purchased self-contained breathing apparatuses (SCBA) to protect firefighters from hazardous emissions encountered while fighting vehicle fires. During a recent fire season, the Forest recorded 101 vehicle fires, of which 36 resulted in wildland ignitions with 205 acres burned. Since 36,000,000 vehicles pass Forest gates yearly, the potential for vehicle fires is great. Wildland firefighters are the first line of defense against these fires and SCBA will protect firefighters from the hazardous emissions.

Coming Up

PNW Continues Study

The USDA Forest Service Pacific Northwest Research Station (PNW) will continue its study, *Smoke Exposure Assessment at Prescribed Burns* during the 1992 fire season.The list of supporting groups has grown to include the California Department of Forestry, the Rocky Mountain and Pacific Northwest Regions of the Forest Service, the BLM, NWCG, and the Washington State Department of Natural Resources. In addition, several Regions of the Forest Service are planning to conduct dosimeter evaluations during the 1992 fire season. This project, which includes the Radian Corporation and the University of Washington Department of Environmental Health, in cooperation with PNW, is under the leadership of Roger Ottmar of PNW and Tim Reinhardt of the Radian Corporation (206-441-1106). [**Note**: See *Monitoring Firefighter Exposure to Air Toxins at Prescribed Burns of Forest and Range Biomass.* Tim Reinhardt, Research Paper PNW-RP-441, Portland, OR, USDA Forest Service, Pacific Northwest Research Station.]

Field Trials

The Missoula Technology and Development Center (MTDC) will be conducting field trials during the 1992 fire season. The trials will allow field units to sample a range of respiratory protection devices, to gain experience monitoring air quality during prescribed burning and wildfire exposures, and to see how exposure affects pulmonary function. A limited number of crews will be provided with respirators and monitoring equipment. They will be pre-tested for pulmonary function, fit, and trained in respirator use, and trained in the use of monitoring equipment. Users will be asked to keep records of air quality, respirator use, and exposure. Pulmonary function tests will be administered at the end of the season. In addition to the experience gained by the crews, the results will contribute to the development of a comprehensive risk management program for wildland firefighters. For information contact Brian Sharkey at MTDC (406-329-3989).

Lab Studies

MTDC will continue studies in the University of Montana Human Performance Laboratory. The current series will investigate the effect of the proposed NFPA respirator standard on prolonged work capacity and will continue the search for predictors of work capacity while wearing a respirator. Data from treadmill studies will be used to validate a field test that predicts prolonged work capacity and the effect of a respiratory protective device on work capacity.

Lawrence Livermore National Laboratory (LLNL) will continue laboratory studies to document the effectiveness of commercially available respirator cartridges for use by wildland firefighters. The studies involve the use of vegetative fuels to create a test atmosphere that will be used to measure the efficiency of cartridges in removing respirable particulate. The study will also determine the resistance to breathing imposed by the various cartridges. The results of these studies will help field personnel make informed purchasing decisions from the list of approved (NIOSH, NFPA) filter cartridges.

Meeting

The NWCG Technical Panel on the **Health Hazards of Smoke** will meet in the spring of 1992. Panel members will meet with cooperators to review 1992 projects and to recommend research and development priorities for 1993. The date and site for the meeting have not been established.

Next Issue

The next issue of this report will be available in the fall, 1992. For information on this project contact Brian Sharkey, Ph.D., at the Forest Service Technology and Development Center, Bldg. #1 Fort Missoula, Missoula, MT 59801 (409-329-3989).

Just Arrived . . .

From NIOSH: On July 18, 1991 NIOSH received a request for a health hazard evaluation (HHE) from the USDI Park Service. The purpose of the request was to collect information on the potential health effects from firefighters' exposure to smoke during fire suppression activities at wildland fires. Industrial hygiene data was collected during the Thompson Creek Fire on the Gallatin National Forest.

During the HHE, personal breathing zone (PBZ) air samples were collected for carbon monoxide (CO), sulfur dioxide (SO_2), aldehydes, respirable particulate matter (RPM), and respirable crystalline silica.

The CO exposure levels ranged from non-detected to 17 parts per million (ppm); these levels are below the evaluation criteria used by NIOSH, OSHA, and the American Congress of Government Industrial Hygienists (ACGIH). SO_2 concentrations ranged from 0.6 to 3.0 ppm. Three of the 26 PBZ samples were above the evaluation criteria of 2.0 ppm used by NIOSH, OSHA, and ACHIH for an 8-hour time-weighted average (TWA). Aldehyde concentrations were an order of magnitude or more below the evaluation criteria used by OSHA and ACGIH. NIOSH considers acetaldehyde and formaldehyde to be potential occupational carcinogens, and therefore recommends that exposures be reduced to the lowest feasible level. Of the 14 samples analyzed for respirable silica, one sample was above the OSHA and ACGIH evaluation criteria for quartz. NIOSH considers silica to be a potential occupational carcinogen and therefore recommends that exposures be reduced to the lowest feasible level. J. Kelly, NIOSH HETA 91-312-2185.

Suggestion Box

Do you have ideas for techniques, tactics, or equipment that may help firefighters avoid the health hazards of forest fire smoke? If so, send your suggestions to Health Hazards of Smoke, MTDC, Bldg. 1 Fort Missoula, Missoula, MT 59801. New and unusual ideas will be featured in future editions of this report.