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Technology & Development Program

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Health Hazards of Smoke

Brian Sharkey

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

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Fire Season Review

As of September 15, the 1994 fire season has consumed 3.5 million acres, with suppression costs expected to exceed 500 million dollars. The season is the worst since 1988 and has been compared to the disastrous fires of 1910.

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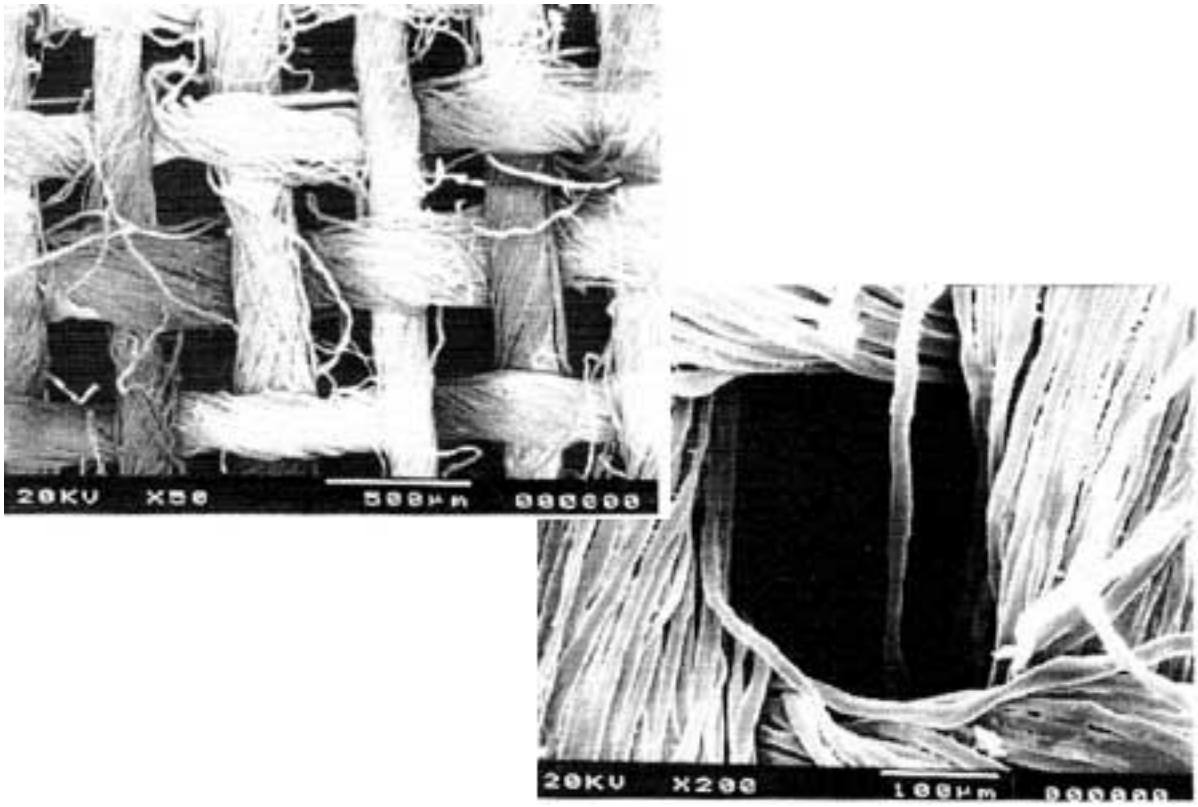
Project Review

The Health Hazards of Smoke technical panel met in Salt Lake City in May in conjunction with the NWCG Safety and Health Working Team. Panel members in attendance included Claudia Finney and Dan Sullivan of the National Park Service (NPS), Bill Weaver and Dan Francis of the California Division of Forestry (CDF), John Kelly of the National Institute for Occupational Safety and Health (NIOSH), Tim Reinhardt of Radian Corp., and Wei Min Hao (IFSL), Dick Mangan, and Brian Sharkey (MTDC) of the Forest Service. Safety and Health Working Team members included John Watt of California Division of Forestry, Joe Frank of Bureau of Indian Affairs, Stan Palmer of Bureau of Land Management, Paul Broyles and Karia Rocha of the National Park Service, and Pam Ensley and Dave Aldrich of the Forest Service. Project activities and studies on emissions characterization and employee exposure were reviewed.

Completion of these studies sets the stage to begin development of comprehensive risk assessment and risk management programs. Emissions and exposure studies will continue to insure representation of geographically diverse fuel types, burning conditions, and work tasks, and to confirm the ratios of toxic compounds to carbon monoxide.



Scanning Electron Microscope (SEM) Photographs of new, unwashed bandanna at x50 and x200 magnification.
See NIOSH report in Research.

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Environmental vs. Occupational Air Standards

Those working on environmental air quality issues and those interested in occupational exposures are often surprised to see how the regulations differ. The Environmental Protection Agency (EPA) establishes air quality levels for the general population, while the National Institute for Occupational Safety and Health (NIOSH) recommends, and the Occupational Safety and Health Administration (OSHA) establishes permissible exposure limits and monitors compliance with workplace health and safety standards.

EPA has set a carbon monoxide (CO) exposure limit of 9 parts per million (ppm), while the OSHA time-weighted average permissible exposure level is 35 ppm. EPA currently has a respirable particulate (PM10) limit of 150 **micro**grams per cubic meter (ug/m^3), while the OSHA level is 5 **milli**grams per cubic meter (mg/m^3), well above the EPA standard. There are 1,000 milligrams (mg) in one gram (g), and 1,000 micrograms (ug) in a mg:

1 mg = 0.001 g

1 ug = 0.001 mg = 0.000,001 g

The EPA has the responsibility to protect the health of the entire population, including children, the elderly and those with chronic diseases and disabilities. OSHA standards represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.

Because of a wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at a concentration at or below the permissible exposure limits; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. Smoking of tobacco is harmful for several reasons: it may reduce defense mechanisms, and it may enhance the effects of chemicals encountered in the workplace. Individuals may also be hyper susceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, drugs), medication, or previous exposures. Such workers may not be adequately protected from adverse health effects from certain chemicals

at concentrations at or below the OSHA exposure limits. (Note: EPA total particulate ratings for wood stoves are reported in grams per hour, e.g., 4 g/hr).

Figure 1—Firefighter wears smoke sampling pack during mop-up.

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Research

Smoke Exposure at Prescribed Burns Reinhardt, T., Hanneman, A., & Ottmar, R., USDA Forest Service, Pacific Northwest Research Station, Seattle, WA, 1994 (final report).

A study of smoke exposure at prescribed fires was done by the USDA Forest Service, Pacific Northwest Research Station and Radian Corporation between 1991 and 1994. The study was done to assess exposure to smoke among firefighters at prescribed fires in the Pacific Northwest. The study compared the relative smoke exposure potential of each job task at a prescribed fire and identified environmental conditions associated with high smoke exposures. The study examined the correlations among pollutants in smoke to determine whether exposure to many pollutants might be estimated from measurements of a single surrogate pollutant. The study also evaluated simple dosimeter technology for routine monitoring of carbon monoxide exposure.

The study found that 1 to 10 percent of firefighters may have exposures to respiratory irritants and carbon monoxide which are above limits recommended by advisory organizations (NIOSH, ACGIH). Less than 5 percent of these smoke exposures may exceed permissible exposure limits set by the Occupational Safety and Health Administration (OSHA), which are less stringent than the recommended limits but legally applicable to federal agencies. Average exposures are higher during the burns, but are brought within workshift exposure limits by unexposed time spent in travel and setting up the burn. The workshift exceedences are mostly due to intense smoke exposures during line-holding, line supervision, and direct attack activities. These peak exposures can exceed recommended limits for short-term exposures.

Excessive exposure during these work tasks is significantly correlated with burning under higher windspeed conditions.

A health risk assessment is recommended to determine the significance of the measured smoke exposures. The assessment should evaluate the likelihood of both acute and chronic health effects based on the exposure data, dose-response relationships, and pollutant metabolism. The health risk

assessment results could be used to establish peak and shift-duration exposure limits that are appropriate for firefighters at prescribed fires.

A smoke exposure management program is recommended to reduce the overexposure to smoke at prescribed fires. The program should include:

- Smoke exposure hazard awareness training;
- Routine, simplified evaluation of smoke exposure at prescribed burns;
- Development of management strategies to maintain all exposures below acceptable limits;
- A health surveillance program to identify individuals at risk of adverse health effects from smoke exposure, and to track the health of workers who are chronically exposed to smoke.

Additional recommendations from this report are summarized in the Risk Management section, page 6. *(Note: The next two reports were produced in conjunction with this PNW study of exposure at prescribed burns).*

Cross-shift Study of Pulmonary Function and Respiratory Symptoms in Forest Firefighters Betchley, C., Koenig, J., van Belle, G. & Checkoway, H., University of Washington, 1994 (preliminary summary).

This study was conducted to evaluate pulmonary responses to smoke exposure in the personal air space of wildland firefighters at prescribed burns. Spirometric measurements and respiratory symptoms were collected during typical work shifts on 76 individuals from Oregon and Washington across the 1992 and 1993 burning seasons. There were significant mean individual declines in FVC, FEV1, and FEF25-75. The pre-shift to mid-shift decreases were 0.089 L, 0.190 L, and 0.437 L/sec respectively, with pre-shift to post-shift declines of 0.065 L, 0.150 L, and 0.496 L/sec. These decreases remained significant even when covariates (colds, smoking, lung conditions, and allergies) were considered. Cold environmental temperatures did not significantly change the lung function results. Diurnal effects on spirometric testing may have underestimated mid-shift changes and overestimated cross shift declines. No seasonal differences were noted between spring and fall burns, although the high p-value (.0.99) for FEF25-75 could indicate a difference not detected in this study. All respiratory symptoms (phlegm, sore throat, chest tightness, chest pain and wheezing) except for coughs increased from pre-shift to mid-shift. This same trend is seen in pre-shift to post-shift symptoms including coughs, although some resolution of symptoms was noted across the shifts. Sore throats increased

significantly from pre-shift to mid-shift and chest tightness increased significantly across the entire work shift.

Chemical exposures of the individuals tested for pulmonary function were obtained from the USDA Forest Service PNW Research Station. Modeling was used to determine if smoke exposure could be linked directly to the decrements seen in lung function. Four of the five chemicals measured (respirable particulate (PM10), acrolein, formaldehyde, and carbon monoxide) displayed a cubic relationship to FVC, FEV1, and FEF25-75 with p-values <0.05. Due to the high correlations among these chemicals, any one may be used as a predictor of lung function decrement. As expected, benzene did not show an association with lung function. Adverse responses to benzene are centered in blood forming organs with no direct effect on the lung.

A subgroup of this study (N = 6) was examined to determine if individuals returned to their normal lung function from one day's exposure to the next. The decreases seen were resolved by the beginning of the next day's work shift. Respiratory symptoms of cough, phlegm, and sore throat did develop from one day to the next but were not significant. It would be helpful to follow a group over an entire season to determine if resolution continues throughout the season.

This study indicates acute decrements in lung function and increases in respiratory symptoms do occur during fire suppression activities at prescribed burns, and that these results are linked to occupational exposure to vegetative smoke.

Cross-season Study of Pulmonary Function and Respiratory Symptoms in Forest Fire Fighters Betchley, C., Koenig, J., van Belle, G., & Checkoway, H., University of Washington (preliminary summary), 1994.

Spirometric measurements and a self-administered respiratory questionnaire (ATS) were collected on 53 wildland firefighters before and after the 1992 fire season. Pre-and post-season lung function measurements were taken at the same time of day to remove the possibility of a diurnal effect. Mean individual declines for FVC, FEV1, and FEF25-75 were 0.033 L, 0.104 L, and 0.275 L/sec respectively. The decreases noted were significant for FEV1 and FEF25-75 (p,0.05). The results agreed with three previously reported cross-seasonal studies. Covariates (smoke exposure prior to pre-season testing, smoking, colds, medications, and allergies) had little or no effect on the declines or significant outcomes. Post-season testing was performed after a considerable period since the last

firefighting activity (average 77.7 days, range 1- 211 days). To continue to see significant declines after two and one-half months is a concern. Factors that may play a role in the continued declines, including 50 to 60 percent residential wood burning, were explored. Respiratory symptoms did not increase or decrease significantly across the 1992 season, although symptoms may have resolved during the time between final exposure and testing.

A subgroup of this study (N = 12) was retested prior to the 1993 burning season to determine if individuals returned to normal lung function. Lung function tests were performed an average of 257.1 days (range = 171 - 380 days) after the last firefighting activity. All variables improved across the winter months. In all cases but one, lung function returned to the 1992 level after an extended period essentially free from occupational exposure. These findings indicate that firefighting and wood burning for home heating do not interfere with recovery to the extent that individuals are able to return to normal values if given sufficient time. Longitudinal studies are needed to determine if the acute decrements in lung function seen in this study and the cross-shift study are causing long-term chronic effects similar to those found in urban firefighters. (For information contact Christine Betchley, Department of Environmental Health, University of Washington (206) 685-1596).

Quantification of Major Components Emitted from Smoldering Combustion of Wood McKenzie, L., Hao, W.M., Richards, G. & Ward, D., University of Montana and Intermountain Fire Sciences Laboratory, Missoula, MT, 1994) (accepted for publication in Atmospheric Environment).

The major condensable products (-45 C) from smoldering combustion of ponderosa pine sapwood have been identified and quantified. Methylene chloride extracts of the condensate, as well as nonextracted condensate were analyzed by gas chromatography/mass spectrometry (GC/MS). Noncondensed gases were analyzed by gas chromatography/flame ionization detector (GC/FID). About 83 to 93 percent of the carbon consumed in the fires has been accounted for. Variability in yields of compounds between individual fires ranged from 3 to 39 percent for most compounds, which indicates the fires and the analytical procedures are reproducible. The major products in the condensate (as percentage by weight of wood consumed) are acetic acid(0.44%), methanol (0.43%), vinyl acetate (0.3%), pyruvic aldehyde (0.12%), and acetol (0.12%). Vinyl acetate does not appear to have been reported as a major component of wood smoke. The other major products are known components of wood smoke. The molar ratios of emitted condensable products to carbon monoxide have been calculated and may form a future basis for assessing

the exposure of humans to these products in large-scale biomass fires.

Health Hazard Evaluation Report, Yosemite National Park (HETA 90-0365-2415) Reh, C., Letts, D., & Deitchman, S., National Institute for Occupational Safety and Health, Cincinnati, OH, 1994 (final report).

NIOSH received a request from the National Park Service to characterize exposures and evaluate possible respiratory effects among forest firefighters at the Arch Rock Fire in Yosemite National Park. On August 15-16, 1990, NIOSH conducted industrial hygiene (IH) and medical surveys on firefighters belonging to three firefighting crews (two Type I and one Type II). The IH survey measured firefighter's exposures to carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), respirable particulate matter (RPM), polynuclear aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), aldehydes, and acid gases. Also, samples of new and old bandannas were submitted for scanning electron microscope analysis to measure the pore size of the fabric. The medical survey evaluated cross-shift changes in lung function, CO levels in exhaled breath (to estimate carboxyhemoglobin [COHb] level), and irritant, respiratory or central nervous system (CNS) symptoms during one workshift.

The average CO and SO2 exposure concentrations measured in the breathing zone of the Pike Hot Shots were 18.3 ppm and 1.4 ppm respectively. All of the CO exposure concentrations were below the NIOSH recommended exposure limit (REL), the OSHA permissible exposure limit (PEL), and the ACGIH threshold limit value (TLV); however, one of six air samples for SO2 was above the NIOSH REL of 2.0 ppm. The CO breathing zone exposure concentrations in the Plumas Hot Shots averaged 3.9 ppm, and the average breathing exposure level for SO2 was 1.4 ppm, with one of five samples above the NIOSH REL of 2.0 ppm. Nitrogen dioxide was not detected in the ten time-weighted average (TWA) air samples collected in the breathing zone of firefighters. The authors used the Coburn, Foster, Kane (CFK) equation to adjust the CO exposure limit for length of workshift, level of work activity, and altitude. The CFK equation predicts that a 5 percent COHb level would be reached at an exposure concentration of 21 ppm. Ten (30%) of the Pike Crew and none of the Plumas had exposures in excess of 21 ppm.

Low airborne concentrations of particulate-bound acenaphthene, anthracene, and naphthalene; and gaseous acenaphthene, anthracene, fluorathene, and benzo(b)fluorathene, were measured in the breathing zones of firefighters. In addition, low airborne concentrations of the following aldehydes and other VOCs were measured in the firefighters' breathing zone: acetaldehyde, formaldehyde, acrolein, furfural, benzene,

toluene, xylene, and total hydrocarbon compounds. The concentrations of hydrochloric acid, sulfuric acid, and hydrofluoric acid measured in the air samples for acid gases were also considered to be low. The exposure levels for RPM were below OSHA PEL for respirable particulates not otherwise regulated (RPNOR) of 5 milligrams per cubic meter. The OSHA PEL for RPNOR may not be applicable when evaluating exposures to this particulate matter, since the dust contains particulate-bound PAHs. Scanning electron microscope pictures of the new and old bandanna samples demonstrate that the rectangular pore size of the fabric exceeds 100 microns (um) in both length and width. The pore size will allow both respirable and inhalable particles to freely pass through the fabric, and to enter the workers respiratory tract (see figure 2).

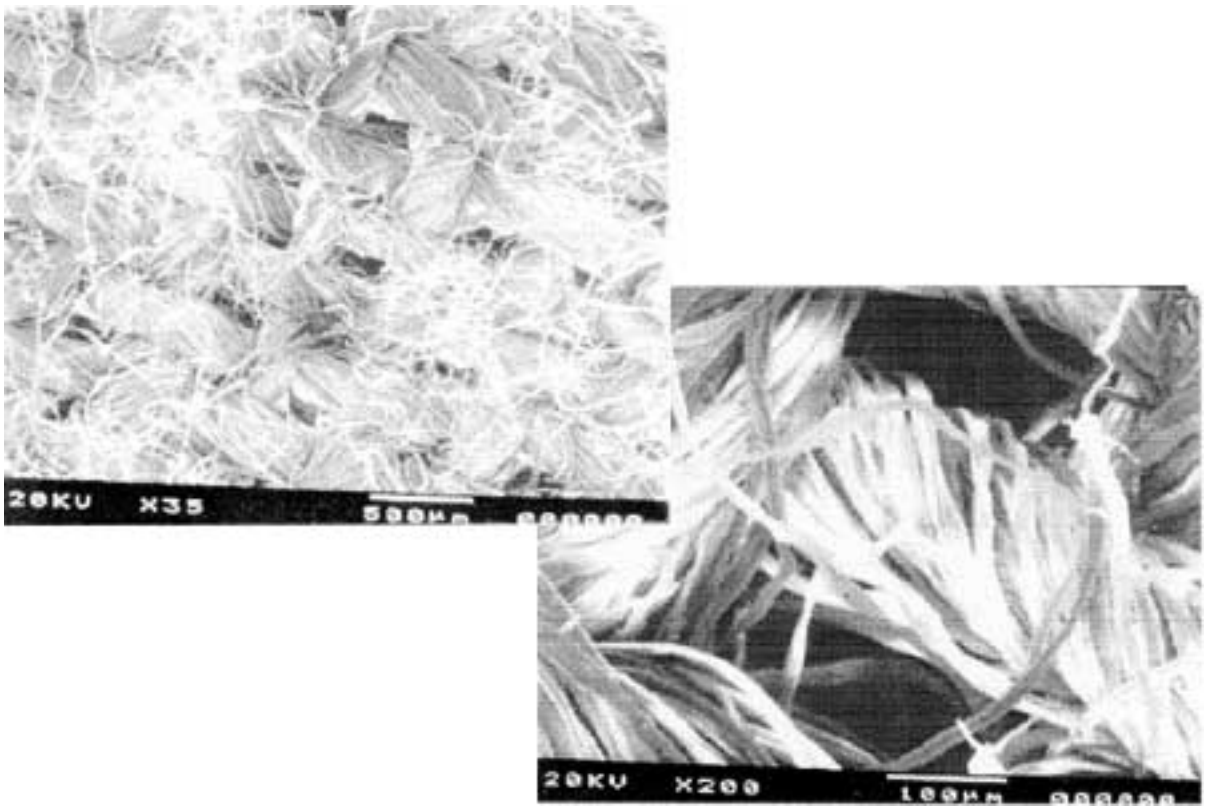

Figure 2—SEM Photographs of old, washed bandanna at x50 and x200 magnification.

Overall the mean cross-shift changes in lung function for the 21 participants were -0.7 percent in forced vital capacity (FVC), -1.2 percent in forced expiratory volume in 1 second (FEV1), -0.4 percent in the mean forced expiatory flow during the middle half of the FVC (FEF25-75), and -1.4 percent in the ratio of FEV1 to FVC (FEV1/FVC). The Type I crew had larger declines than the Type II crew in all spirometric values, and those for FVC, FEV1, and FEV1/FVC were significant at the level of $p = 0.05$ although each changed by 3 percent or less. The Type II crew had small cross-shift declines in pulmonary function, none of which were significant. The magnitude of cross-shift declines in lung function did not appear to increase with self-reported increase in exposure. Nor did the cross-shift increase in

COHb (1.4%) increase with self-reported exposure to smoke. Cross-shift symptom data were available on 10 participants from the Type II crew. The most frequent respiratory symptom developing during the shift was nose irritation; headache was the most frequent CNS symptom. The occurrence of respiratory or CNS symptoms was not associated with self-reported degree of exposure.

The NIOSH investigators conclude that a potential health hazard existed from exposure to CO and SO2 at the Arch Rock Fire in Yosemite National Park. This is based on the three CO exposure concentrations above their adjusted guideline of 21 ppm and the two of eleven exposure concentrations for SO2 above the NIOSH REL of 2.0 ppm. There is limited evidence of acute changes in lung function associated with activities of Type I crew members. Recommendations are made for respiratory protection, and a respiratory surveillance program to further examine the effects of forest firefighting on lung function. (Note: See discussion regarding lung function changes).

The Effects on Blood Pressure and Heart Rate from Respirator Wear During Moderate Steady-state Work Bardsley, S., unpublished M.S. Thesis, Montana College of Mineral Science and Technology, Butte, MT, 1994.

The purpose of this study was to observe the effects on blood pressure and heart rate when moderate steady-state work was performed while wearing three types of respirators. Thirty apparently healthy volunteer participants (15 men and 15 women) 21 to 58 years old performed a four-treatment bicycle ergometer assessment. The treatments were N (no respirator), H (half-face respirator), F (full-face respirator), and P (powered air-purifying respirator). The duration of each treatment was 3 to 4 minutes. All respirators were 3M models fitted with HEPA filters. The workload of 420 kilogram meters per minute at a pedaling rate of 70 rpm was in the moderate range (200-350 kcal/hr). Heart rate was monitored continuously with a pulse oximeter, and blood pressure was measured at the end of each treatment. A two-way interactive analysis of variance and simple regression were used to analyze the data. The results showed no significant effect on heart rate or blood pressure during exercise due to the respirator treatments. The differences in heart rate and blood pressure levels between genders were significant. The relationship between the percentage of functional capacity at which the subject was working and heart rate, systolic and diastolic blood pressure, and mean arterial pressure were statistically significant.

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Risk Management

Smoke Exposure Management

The study "Smoke Exposure at Prescribed Burns" summarized in the Research section contained recommendations for a smoke exposure management program including: smoke hazard awareness training; smoke monitoring; management strategies to maintain exposures below acceptable limits; and a health surveillance program to identify individuals at risk of adverse health effects, and to track the health of chronically-exposed workers. The authors note that some of these elements (smoke exposure hazard awareness training) are already in place. Exposure monitoring might be relatively inexpensive if consensus can be reached regarding the use of CO as an index of exposure. CO is highly related to the concentrations of other pollutants in smoke. Since it is easy to measure, while particulate, formaldehyde and other pollutants are not, it could be the ideal way to monitor exposure. The proposed monitoring plan, including a reduced time-weighted average (TWA) for CO (e.g., 25 ppm) to insure protection from other pollutants, will require approval by OSHA.

Several modifications to prescribed fire planning could reduce smoke exposure and may be initiated now with little cost. These include:

- Reducing the need for holding and direct attack operations on smoky sections of fireline by adequate line preparation and prewetting with sprinklers or foams;
- Burning under spring-like conditions to reduce the need for line-holding and mop-up. Avoiding burning at extremes of fuel-moisture range.
- Burning in light winds when downwind resources require protection, and avoiding the temptation to ignite burns when winds are forecast to increase.

The report makes additional recommendations concerning health surveillance and monitoring, but makes no recommendations for respiratory protection equipment. For more information contact Roger Ottmar at the PNW Research Station (206-553-7815).

Lung Function and Firefighting

Previous issues of this report have described the respiratory system, discussed the purpose and procedures for testing lung function (pulmonary function), and presented data on the cross-shift and cross-seasonal effects of firefighting and smoke exposure on lung function. The smoke from forest fires contains respirable particulate that has the potential to temporarily reduce pulmonary function. With adequate recovery time the healthy respiratory system is able to cleanse itself. However, sensitized or highly reactive individuals may be affected at lower concentrations, or they may experience greater reductions in pulmonary function at higher concentrations. Prolonged exposure to the constituents of smoke reduces the effectiveness of some defense mechanism (e.g., mucociliary escalator).

The human respiratory system is oversized for its work. The short-term maximum breathing capacity (measured with a maximal ventilatory volume test [MVV]) indicates that a healthy subject has the capacity to ventilate approximately 50 percent more air than is used in a maximal oxygen intake (VO_2 max) test; (e.g., MVV = 180 L/min vs 120 L/min for VO_2 max). Ventilation requirements for the work of firefighting fall in the 40 to 60 L/min range, and studies show that workers are able to sustain 50 percent of their MVV during prolonged work.

Studies have documented small but statistically significant reductions in pulmonary function across shifts and seasons (Betchley et al.; Letts and Deitchman; Reh, Letts and Deitchman; Rothman et al.; and Harrison et al.). Decrements in FVC, FEV1 and FEF25-75 have typically averaged 1 to 5 percent. Some studies show a return to baseline by the start of the next shift while others have not. One study showed a cross-season rise in airway reactivity (as measured with a methocholine challenge test) while another study by the same authors did not. Betchley et al. found that lung function returned to the previous year's level prior to the start of the next fire season.

Asthma is a condition characterized by an increased responsiveness of the trachea and bronchi to a variety of stimuli, resulting in airway obstruction that is reversible either spontaneously or as a result of treatment. Exercise-induced asthma (EIA) affects almost all those with asthma as well as many who do not have the condition. Potential triggering mechanisms for asthma (or EIA) include cold, dry air, exertion, emotions, viral infections, allergens, and environmental irritants. For some individuals, exertion is the only trigger. Severity of EIA is determined by the decrease observed in FEV1:

Decrease of	
15 - 20%	*mild EIA*
20 - 40	*moderate EIA*
over 40	*severe EIA*

The small but statistically significant decreases in pulmonary function measured on wildland firefighters (1-5%) are imperceptible and, given the capacity of the pulmonary system, unlikely to compromise the work capacity of most firefighters. Those with clinically-established asthma should consult their physician to determine an appropriate course of treatment. The health consequences of temporary or long-term exposures have yet to be determined.

Medical Evaluation for Respirator Wear

In order to use respiratory protection devices to mitigate the health hazards of smoke, managers must implement the 11 step respirator program mandated by OSHA (CFR 1910.134b). One part of that program requires medical evaluation: “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 must determine what health and physical conditions are pertinent. OSHA does not indicate what tests should be conducted, what limits should be set, or what the physician should know about the work environment and respirator use.

The Americans with Disabilities Act (ADA) specifically prohibits pre-employment medical examinations that seek information on disabilities. The employer is strictly prohibited from conducting a medical examination of job applicants **prior to** an offer of employment. After employment the ADA does not preempt legitimate medical standards or requirements established by federal, state, or local law or by employers of applicants for safety positions if the medical standards are consistent with the ADA. It is unclear how these restrictions will impact the OSHA requirement, especially for job applicants. Those who pose a direct threat or harm to the health and safety of themselves or others in the workplace may be excluded from employment on the basis of medical judgment that relies on most current medical knowledge, and/or the best available objective evidence.

Job-related work capacity tests are not medical examinations and so may be given at any point in the application or appointment process The tests must

be given to all applicants, regardless of disability. If such tests tend to screen out individuals with disabilities, the employer would have to demonstrate that the test is job-related and consistent with business necessity, and that performance cannot be achieved with reasonable accommodation.

MTDC Studies – To determine a valid, reliable and objective evaluation procedure for wildland firefighters, MTDC has studied the relationships of pulmonary function and work capacity measures to work performance with a respirator. Standard pulmonary function tests (FVC, FEV1, FEF25-75, PEFR, PIFR) and the maximal voluntary ventilation test (MVV) were evaluated along with job-related work capacity tests to determine their ability to predict work performance with a respirator. Results indicate that pulmonary function and work capacity tests (e.g., step test) are significantly related to work performance while wearing a respirator. Since work capacity and pulmonary function are both correlated to the maximal oxygen intake (VO_2 max), it is not surprising that the pulmonary function and work capacity tests are also highly related. Results indicate that workers with a VO_2 max of 45 ml/kg-min (the standard for wildland firefighters) have sufficient pulmonary function to perform the work and wear a respirator.

In reference to the medical evaluation, the American Industrial Hygiene Association suggests “The respirator should be worn for at least 30 minutes, and during part of this time, workers should exert themselves to the level that would be required on the job.” MTDC has developed a field test that predicts work performance and allows evaluation of an individual’s ability to work with a respirator. The Pack Test involves a 3 mile hike over level terrain while wearing a 5 gallon suppression water bag (45 lbs). Lab and field studies indicate that a pace of 4 mph has the equivalent energy requirements of typical firefighting tasks (22-23 ml/kg-min), and that a time of 45 minutes approximates a fitness score (VO_2 max) of 45 ml/kg-min. When subjects completed the Pack Test with and without a respirator, the results were not significantly different. The high correlation between trials ($r = .92$) indicates that the test w/o the respirator is an accurate predictor of performance with the device, and that the test procedure is reliable. MTDC studies show that individuals who pass the job-related work capacity test have the pulmonary function capacity to perform the work and use a respirator. The Pack Test will receive further evaluation in laboratory and field trials.

Reproductive Risks of Firefighting

Wildland firefighters face many hazards in the conduct of their duties.

Among these hazards are potential reproductive risks, such as exposure to toxic chemicals, heat and other factors that can pose a threat to an individual's ability to conceive or bear a healthy child. These potential risks affect both men and women employed as firefighters. While exposure to cigarette smoke has been linked to low birth weights, there is little data concerning the risks of exposure to toxic chemicals at levels measured in the breathing zone of wildland firefighters. Carbon monoxide has the potential to affect the developing fetus but, aside from birth weight, that has not emerged in studies of smokers who are regularly exposed to much higher levels of CO than firefighters.

Researchers are more concerned about exposure to extreme heat, which has been linked to male infertility and possibly to birth defects in the offspring of exposed mothers. Maternal illness with prolonged high fever has been associated with birth defects, but sauna studies and case studies of pregnant runners have not revealed birth difficulties or defects. In fact, the opposite has been true for those who remain active during pregnancy. And while wildland firefighting has the potential for heat stress, studies of firefighters have not indicated severe heat problems, especially when firefighters are fit, acclimatized and hydrated. The low humidity and air movement of the burning season enhance evaporative and convective cooling, and lower the risk of heat stress.

Firefighters who are pregnant, breast feeding, or attempting to conceive should consult their physician if they are concerned about the reproductive risks of fire suppression. Pregnant firefighters who are physically capable of performing the duties of the position may, at their discretion, remain in active duty (US Supreme Court, UAW v Johnson Controls, 1991). While it is not the obligation of the employer to protect the fetus, the employer may be able to assign the firefighter to less hazardous duties upon receipt of a request. Pregnant firefighters who, on the advice of a physician, cannot continue working in any capacity, should be granted leave in accordance with existing pregnancy or other leave policies of the agency having jurisdiction. (Note: For more information contact: Women in the Fire Service, P.O. Box 5446, Madison, WI 53705 [608-233-4768]).

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Coming Up

Technical Committee

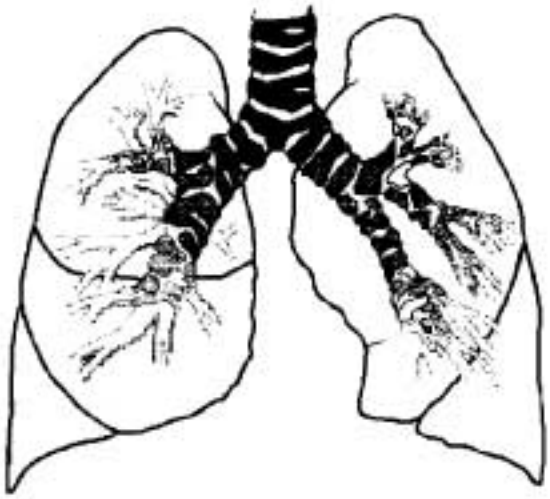
The Health Hazards of Smoke technical committee will meet in conjunction with the NWCG Safety and Health Working Team at their Spring meeting in May.

Northwest Fire Council

The council meeting in November will focus on “Fireline Personnel - Health and Safety”. The meeting, which will take place in Whistler, B.C., on November 16-17, will feature sessions on Smoke and Exposure, and Occupational Hazards and Risks.

Next Issue

The next issue of Health Hazards of Smoke will be available in the Spring of 1995. If you have questions, a contribution to the report, or want to be added to the mailing list, contact Brian Sharkey c/o USDA Forest Service MTDC, 5785 Hwy 10 W, Missoula, MT 59808 (406-329-3989).



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