Wildland Firefighter
Health & Safety Report

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"That a man must be physically sound for his work we know, but a standard of soundness has never been defined...it is urgent that a simple but effective method be used by all employing officers to ensure the rejection of the clearly unfit."

Coert Dubois, 1914
Forest Service,
Pacific Southwest Region

Background

This report, the fourth in a series, reviews activities related to the U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center (MTDC) project on wildland firefighter health and safety. The project focuses on three main areas:

Work/rest issues: Development of an objective approach for determining work/rest standards and for recommending assignment lengths for crews and overhead teams.

Energy and nutrition: Improvement of the energy intake, nutrition, and immune function of wildland firefighters.

Fitness and work capacity: Implementation of work capacity and medical standards and improvement of the health, safety, and productivity of firefighters.

Work Capacity Tests

The Wildland Firefighter Safety Awareness Study (Tri Data 1998) called for a new fitness test to replace the step test, which had been used since 1975. The step test, a 5-minute, submaximal procedure to estimate aerobic fitness, uses the postexercise heart rate to predict the fitness score. While the test accurately predicts aerobic fitness, variations in the heart rate response to exercise led to errors of over and underprediction. In addition, the test did not measure muscular fitness, an important component of work capacity. Some respondents in the study thought the test was too easy. Others were concerned about the potential for cheating with breathing maneuvers or drugs.

The study recommended several work capacity tests that were valid, job-related, and gender neutral to meet National Wildfire Coordinating Group standards (NWCG 310-1). After extensive field trials, the following tests were adopted to determine a worker's capacity: the pack test (for arduous work), the field test (for moderate work), and the walk test (for light work). While the tests have met widespread approval among firefighters, test-related fatalities have led to a reexamination of the tests and the procedures for test administration. This report reviews the test development process, and issues of safety, medical screening, and test administration.

The Pack Test

This paper reviews the development and validation of a job-related work capacity test for wildland firefighting.

History

In 1965 MTDC and the University of Montana Human Performance Laboratory began work on a test to determine a candidate's fitness to perform arduous wildland firefighting tasks. Field measurements of the metabolic, cardiovascular, and thermal demands of firefighting were made on firefighters working on controlled (prescribed) burns. The results indicated that wildland firefighting tasks fell into the category of hard work, with average energy expenditures of 7.5 kilocalories per minute. These measurements and a review of the literature indicated that for the firefighters who were evaluated, aerobic fitness (maximal oxygen intake or VO_2 max) was the primary limiting factor in their ability to sustain hard work throughout long shifts.

The Astrand-Rhyming Step Test was modified, validated, field tested, approved by the Civil Service Commission (now the Office of Personnel Management), and adopted in 1975 as the test to determine firefighter fitness for duty. Because workers cannot sustain day-long workloads above 50 percent of their maximum capacity, the average cost of firefighting duties (7.5 kilocalories per minute or 22.5 milliliters per kilogram minute) was doubled to determine the minimum score (45 milliliters per kilogram minute) for wildland firefighters. Soon after the test procedure was implemented, concerns arose that some workers lacked the muscular strength to do the job. These concerns coincided with the integration of women into the wildland firefighting workforce. Field studies of muscular fitness and work capacity (Sharkey, Jukkala, Putnam, and Tietz 1980) confirmed the relationship of strength and lean body weight to performance in firefighting. The average female has 50 to 60 percent of the upper body strength of the average male. Recommendations to add muscular fitness measures to the selection process were not adopted. The step test (and alternative 1.5-mile run) remained the fitness measures used in the selection of firefighters.

> During the great fires of 1910 an old ranger phoned Elers Koch in Missoula to request some firefighters. When Koch asked how many, the ranger replied:
>
> ***"Send me 10 men if they wear hats, and if they wear caps, I'll need 30."***
>
> The distinction was that the respectable lumberjack always wore a felt hat...whereas the pool hall boys and general stew bums... usually wore caps and shoved their hands deep in their pockets.
>
> From *Year of the Fires* by Stephen Pyne, 2001.

In 1994 MTDC was assigned to review test procedures and revise training materials to ensure compliance with new laws and regulations, and with recent research. Research, new laws, and comments from employees called for replacement of the step test. It violated the Americans with Disabilities Act (by using biomedical data such as the heart rate, according to a ruling by the Equal Employment Opportunity Commission—EEOC No. 915.002, May 1994). The test was not directly job related, and there was evidence of cheating (breathing maneuvers and the use of drugs to lower the heart rate). A safety awareness study (Tri Data 1998) showed that workers were dissatisfied with the step test and eager for a change. MTDC revised the wildland firefighter job task analysis and conducted a series of laboratory and field studies to develop and validate a job-related work capacity test.

Job Task Analysis

The job task analysis was revised with input from subject matter experts associated with Federal and State land management agencies. Respondents rated the importance, as well as the intensity, duration, and frequency of tasks. New categories in the revised analysis included:

Performing under adverse conditions (including long work shifts; rough, steep terrain; heat, cold, altitude, smoke; insufficient food, fluids, sleep), and **Emergency responses** (fast pullout to safety zone, rescue, or evacuation assistance to others).

The analysis indicated that the most important firefighting tasks included:

- Building fireline with handtools
- Performing under adverse conditions
- Hiking with light loads
- Lifting and carrying light loads

Tasks receiving lower ratings, primarily because they occurred less frequently, included:

- Packing heavy loads
- Emergency responses
- Chain sawing

Wildland firefighting clearly deserves the definition of **arduous work**:

> "Duties involve field work requiring physical performance calling for above-average endurance and superior conditioning. These duties may include an occasional demand for extraordinarily strenuous activities in emergencies under adverse environmental conditions and over extended periods of time. Requirements include running, walking, climbing, jumping, twisting, bending, and lifting more than 50 pounds; the pace of work typically is set by the emergency condition." (NWCG 310.1)

Energy Cost of Firefighting Tasks

Task	Energy cost (kilocalories/minute)
Digging line with a handtool	7.5
Chain sawing	6.2
Shoveling	6–8
Chopping	8–10
Lifting and carrying a light load	6–8
Hiking with a light load	
Flat (hill)	6 (12)
Hiking with a heavy load	
Flat (hill)	7 (15)

Source: University of Montana Human Performance Laboratory

Job-Related Work Capacity Tests

The test development and validation process followed the **Uniform Guidelines for Employee Selection** published by the U.S. Department of Labor (1979). The job task analysis and data from past field studies were used to identify potential tests. Based on the relationships to other firefighting tasks, a fireline construction (pulaski) test for upper body performance and a load carry (pack test) for lower body performance were selected for further laboratory and field evaluation. The fireline construction test used a small treadmill to simulate line building with a pulaski.

Laboratory Studies—The fireline test and pack test had energy costs similar to those required on the job (7.5 kilocalories per minute). Both tests were significantly correlated to laboratory measures of aerobic and muscular fitness, and to performance on firefighting tasks. The tests were judged to be valid, reliable, objective, and job-related measures of work capacity. However, because of its reliance on upper body strength, the fireline test was found to have an adverse impact on females (based on the EEOC 80-percent rule; the female pass rate was less than 80 percent of the male pass rate). The fireline test also had a higher administrative cost (for equipment and time). The pack test used available equipment and did not show evidence of adverse impact to any group of candidates. The flat version of the test was highly related to performance on a hilly course ($r = 0.87$), but the hilly course had an adverse impact on female candidates. A score of 45 minutes on the pack test was equivalent to a score of 45 on the step test (the established standard for wildland firefighters). Based on these studies (Sharkey, Rothwell, and DeLorenzo-Green 1994; DeLorenzo-Green and Sharkey 1995), the pack test was scheduled for field trials.

Field Trials

During the 1995 fire season, field trials were conducted on 320 firefighters from three Federal agencies, three regions of the Forest Service, and one State. The sample represented the gender and ethnic distribution of the firefighter population (Sharkey, Rothwell, and Jukkala 1996).

Ethnicity did not appear to be a factor in test performance. For a passing score of 45 minutes, 84.4 percent of males passed compared to 71.9 percent of females. Females passed at 85.2

percent of the male pass rate, which does not constitute adverse impact as defined by the EEOC (table 1). The field trial was not a condition of hire, so some individuals did not give their best effort. Also, field experience has shown that subjects improve substantially when retested, so those within 1 minute of the passing score would be likely to pass on a retest (89.5 percent of the males and 79.7 percent of the females had scores under 46 minutes, yielding a potential female pass rate of 89 percent of the male pass rate, table 2). The scores were also analyzed for the effects of age, height, and weight.

Age—The age of test participants ranged from 18 to 63, including 30 individuals who were over 40. Those over 40 averaged 41.4 minutes on the pack test, which was better than the overall average (41.8 minutes). Of the 30 individuals over 40, 5 scored over 45 minutes and 25 scored under 45 minutes, for a pass rate of 83.3 percent. This pass rate was slightly better than the pass rate for all individuals (81.9 percent).

Height—The height of test participants ranged from 61 to 79 inches with an average of 69.7 inches for all test participants (70.6 inches for males, and 66.3 inches for females). While the data for all individuals suggested a low negative relationship between height and pack test performance (r = -0.294), analysis of scores above 45 minutes revealed no significant relationship (r = -0.022, r^2 = 0.0005). The coefficient of determination (r^2) indicates the proportion of the variance in performance accounted for by a relationship. Far less than 1 percent (0.05 percent) of the variation in performance among test scores over 45 minutes can be attributed to height.

Weight—Weights ranged from 104 to 270 pounds, averaging 170.9 pounds for all test participants (178.7 pounds for males and 140.9 pounds for females). There was no relationship between weight and performance on the pack test for all individuals, for males, for females, or for those who scored over 45 minutes.

A 1998 field evaluation of more than 5,000 firefighters verified the results of the 1996 field trial. The test was used to qualify firefighters; average scores (41.8 minutes) and pass rates (91.5 percent) were substantially higher than the earlier field trial. However, the trial identified a somewhat lower pass rate for 101

Table 2—Pass rate on the pack test.

	Pack test (< 45 min)	**F/M***	**Pack test**** (< 46 min)	**F/M**
Males	216/256 = 84.4%		229/256 = 89.5%	
Females	46/64 = 71.9%	85.2%	51/64 = 79.7%	89.1%

*Female pass rate relative to the male pass rate.
**The passing score is 45 minutes. Those who have scores of 46 minutes or less can usually pass on a retest.

Table 1—Summary of field test data for the pack test. Standard deviation is abbreviated by SD.

	Average age (years)	**Average height** (inches)	**Average weight** (pounds)	**Average pack test (SD) score**
Males (256)	28.4	70.6	178.7	41.4 (4.23)
Females (64)	26.7	66.3	140.9	43.5 (3.58)
Caucasian (232)	28.8	69.5	166.5	41.8 (4.45)
American Indian (45)	26.0	70.3	188.6	42.5 (3.58)
Hispanic (27)	28.2	69.5	173.7	42.1 (3.21)
Other (10)*	25.4	71.0	169.6	42.8 (2.80)

*Black, Asian, and unknown

individuals shorter than 5 feet 3 inches tall. Subsequent analysis of 33 individuals who did not pass indicated that 18 did not finish, 10 were overweight, several were underweight, and 27 trained less than 12 hours for the test, including 9 who did no training at all. The results suggested that those factors and the low lean body weight associated with short stature contributed to the somewhat lower pass rate for persons shorter than 5 feet 3 inches. In the 1998 trial, those who did not pass were allowed to take the step test or 1.5-mile run to qualify for employment.

Pack Test Summary and Recommendations

The pack test is a valid, job-related test of work capacity. The test uses a common firefighting tool (pack) and requires an energy cost similar to that required on the job. Pack test scores were correlated to laboratory measures of fitness (aerobic and muscular fitness, lactate threshold), and to performance of the firefighting tasks identified in the job task analysis. The duration of the test ensures the capacity to perform **prolonged arduous work**, **under adverse conditions**, **with a reserve to carry out emergency responses**. Pack test scores are not adversely influenced by gender, ethnicity, age, height, or weight. MTDC recommended:

- Introduce the pack test in a national interagency implementation program.
- Develop and implement tests for other fire-related positions (table 3).
- Require work capacity tests for a red card (a card used to certify firefighters).
- Develop materials to support implementation of tests.

Health Screening

Both the American Heart Association and the American College of Sports Medicine have recommended a health screening questionnaire designed to identify the small number of individuals who should seek medical advice before becoming involved in moderately strenuous physical activity. Use of the questionnaire by apparently healthy adults substantially reduces the risk of taking exercise tests or beginning training. Candidates for fitness training, firefighting, or field work should complete the questionnaire before beginning strenuous training or taking a work capacity test. The American Heart Association and the American College of Sports Medicine have raised the recommended age for medical evaluation from 40 to 45. A medical exam may be recommended for individuals older than 45, individuals with one or more heart disease risk factors (for example smoking, high blood pressure, or elevated cholesterol), those who have been inactive, or those for whom the test, training, or work represent a significant increase in intensity. For many others, the questionnaire provides assurance of the readiness to engage in training, work, or a job-related work capacity test.

Medical Examinations—The need for more extensive health screening, physician examinations, and medical tests for wildland firefighters is being studied. Federal agencies are considering the need for comprehensive medical standards, medical history, medical tests, and a physician's examination for entry-level firefighters. The medical history would be updated annually, and the physician's examination and some medical tests would be repeated every 5 years until age 45, then every 3 years thereafter (under the current proposal). Costs include several hundred dollars per candidate for medical tests

Table 3—Work capacity tests.

	Work category	**Fitness level** (mL/kg-min)	**Distance** (mi)	**Pack** (lb)	**Time** (min)	**Energy cost** (kcal/min)
Pack test	Arduous	45	3	45	45	7.5
Field test	Moderate	40	2	25	30	7.0
Walk test	Light	35	1	None	16	6.2

and examinations. Benefits could include early detection of health problems, some reduction in worker's compensation costs, and assignment of candidates to more appropriate positions, when possible. Problems include the waste of scarce resources on a young, generally healthy population, false positive results (indication of problems that may not exist), and the costs of additional testing needed to clear candidates for arduous work. Alternatives to comprehensive examinations include risk stratification by low-cost screening (such as a health screening questionnaire) or a more comprehensive medical history, with tests and examinations for those at higher risk (such as those older than 45).

Training for the Pack Test— Before training, candidates should complete the health screening questionnaire or an equivalent questionnaire and consult a physician, if indicated. They should begin training at least 4 to 6 weeks before they report for duty. If previously inactive, candidates should exercise at moderate intensity for the first few weeks. They can train by hiking, wearing the ankle-height footwear they will use during the test.

They can begin by hiking a 3-mile flat course without a pack; when they can cover the course in less than 45 minutes they should add a pack with 25 pounds. They should increase the pack weight until they can hike 3 miles in 45 minutes with a 45-pound pack. In addition, they can hike hills (with a pack) to build leg strength and endurance, jog the flat course (without a pack) to build aerobic fitness, and cross train (for example mountain bike or lift weights) to build stamina and strength.

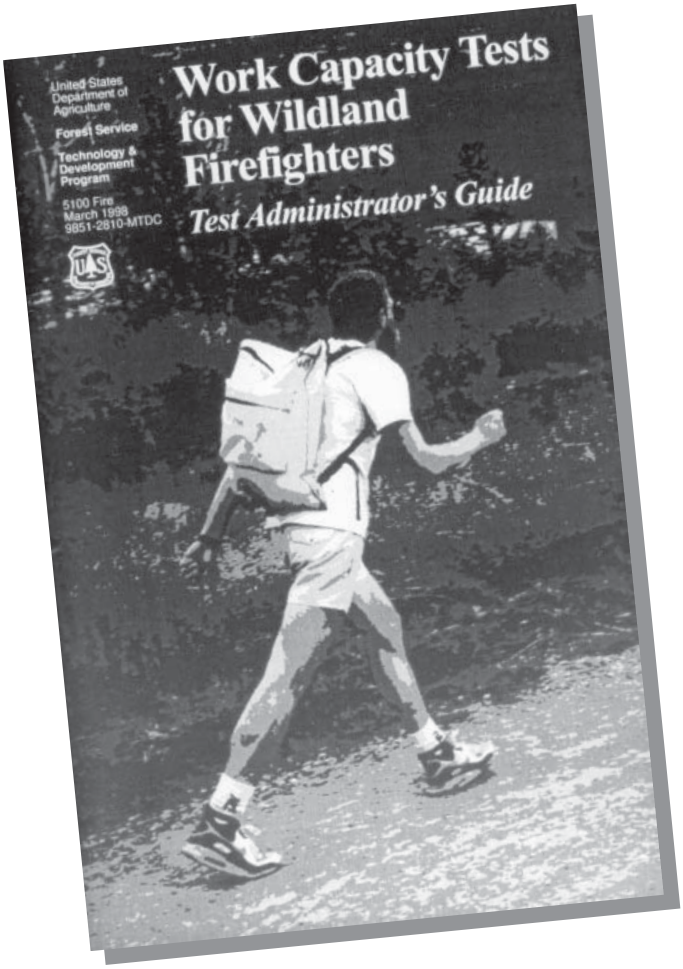
Adoption of the Work Capacity Tests

After extensive field tests MTDC recommended:

- Retiring the step test
- Adopting the work capacity tests
- Developing administrative materials (a test booklet and an information brochure)

The pack test has been adopted by five Federal land management agencies, by some States, by the Province of British Columbia, and by Australia, where it has been endorsed as the minimum national standard.

Note: Brian Sharkey, Ph.D., is professor emeritus of the University of Montana Human Performance Lab and a project leader at MTDC. Versions of this paper were presented at meetings of the American College of Sports Medicine (1996), the International Association of Wildland Fire (1999), and the Canadian Society of Exercise Physiology (2000).



Research

Test Development

Since 1975, Federal land management agencies have used a 5-minute step test to qualify wildland firefighters. New laws (such as the Americans with Disabilities Act), field experience, and research concerning long-term work capacity have led to a reexamination of the selection procedure. This 1994 study was the initial step in the search for a new test. Eighteen volunteers (nine male, nine female, all from 20 to 36 years old) performed leg tests of maximal oxygen intake, arm tests of peak VO_2 and sustained (30-minute) performance, a battery of muscular fitness tests, and a field (pack) test, which consisted of a 4.83-kilometer (3-mile) hike over level terrain while wearing a 20.5-kilogram (45-pound) pack. Blood lactate measures were recorded after each test. The analysis was intended to determine the relationship of the candidate (pack) test to the existing step test and to identify factors correlated with the pack test. Results showed significant differences in muscular fitness measures between males and females, but neither leg VO_2 max nor pack test differences were significant. The pack test was significantly related to the leg VO_2 max (r = -0.579) and to muscular fitness measures, including leg press (r = -0.553) and pullups (r = -0.501). The pack test correlated to arm peak VO_2 (r = -0.52), the arm VT (r = -0.592), and the sustained arm endurance test (r = -0.707). Multiple regression (R) analysis of pack test performance compared to tests of aerobic (arm and leg VO_2 max, arm endurance, pack test lactate) and muscular (leg press, pullups) performance yielded R = 0.846 (R^2 = 0.72). The results indicate that performance on the pack test involves components of aerobic and muscular fitness, and that a time of 45 minutes for the 3-mile test predicts the current fitness requirement of 45 milliliters per kilogram-minute.

Development of a job-related work capacity test for wildland fire-fighters, Sharkey, B., Rothwell, T., and DeLorenzo-Green, T., Medicine and Science in Sports and Exercise. 26: S88, 1994.

Test Validation

This 1995 study investigated alternative work capacity tests based on a comprehensive job analysis that identified tasks requiring strength and endurance of the legs and upper body. Eight male and seven female volunteers performed:

- Direct (treadmill) and indirect (step test) tests of maximal oxygen intake
- Muscular fitness tests (bench press, pulldowns, pushups)
- A field pack test consisting of a 4.83-kilometer (3-mile) hike over level terrain while wearing a 20.5-kilogram (45-pound) pack (performed with and without a respirator)
- A 5-minute simulated fireline construction test

Subjects also carried a pack and simulated line-building on a treadmill to determine the energy cost of those activities. Results indicated that the energy cost of the pack test at 4 miles per hour was 22.2 milliliters/kilogram-minute, which is similar to the documented cost of firefighting duties, including line construction (22 milliliters/kilogram-minute). There was no significant difference between males and females on the pack test, but there were differences between males and females on the fireline test (161 feet for males, compared to 109 feet for females; $p < 0.013$) and the muscular fitness tests ($p < 0.0001$). There was no significant difference in pack test performance with or without a respirator, and the trials were highly related (r = 0.92), indicating test reliability. The pack test performance was correlated to the fireline test (r = -0.79) and pulldown (r = -0.72). The fireline test was correlated to the pulldown test (r = -0.73), the pushup test (r = -0.70), and VO_2 max (r = -0.56). Multiple regression analysis of the pack test and pushups yielded R = 0.862 (R^2 = 0.743). Results indicate that both the pack test and the fireline test are valid and job related, but the pack test has lower administrative costs and less potential for adverse impact to women.

Development and validation of a work capacity test for wildland firefighters, DeLorenzo-Green, T. and Sharkey, B., Medicine and Science in Sports and Exercise. 27: S166, 1995.

Field Evaluation

This 1996 study was the final phase in developing a job-related work capacity test for wildland firefighters. This 1996 study related the candidate pack test to field performance and measures of aerobic and muscular fitness, and evaluated the potential for adverse impact to women. Ten male and ten female volunteers (ages 21 to 40) performed strength and VO_2 max tests, 4.83-kilometer (3-mile) hikes with a 20.5-kilogram (45-pound) pack on both a level and a hilly course (including a 0.23-mile stretch with a 17.5-percent grade), and a 15-minute simulated fireline construction test.

Males and females did not differ significantly on the pack test (average score of 39.2 minutes for males compared to 42.4 minutes for females). Times for the flat and hilly versions of the pack test for males and combined (male and female) subjects were not significantly different, but were for females (2.56-minute difference, $p < 0.01$). The flat and hilly versions of the test were significantly related ($r = 0.87$). They were correlated to strength measures, and to the fireline test (table 4). The results confirm the relationship of the pack test to field performance, and to measures of aerobic and muscular fitness. Regression analysis indicated that a score of 45 minutes for the 3-mile pack test predicts a VO_2 max of 45 milliliters/kilogram-minute, the current standard for wildland firefighters. A field evaluation of 320 firefighters (including 69 females) did not reveal evidence of adverse impact to women.

Table 4—Relationships of the flat and the hilly versions of pack test with measures of strength and the fireline test.

	Flat version	Hilly version
Pullups	-0.61	-0.67
Pushups	-0.68	-0.67
VO_2 max	-0.77	-0.65
Fireline test	-0.50	-0.60

Validation and field evaluation of a work capacity test for wildland firefighters. Sharkey, B., Rothwell, T. and Jukkala, A., Medicine and Science in Sports and Exercise. 28: S79, 1996.

Research Briefs

Aerobic Fitness

This study of 67 men and women confirmed the correlation between the pack test and aerobic fitness (max VO_2). A score of 45 minutes on the pack test is equivalent to a VO_2 of 45 milliliters/kilogram-minute.

Analysis of predictive tests of aerobic fitness for wildland firefighters. Strickland, M., and Petersen, S., Canadian Society for Exercise Physiology. 1999 (reported in Wildland Firefighters Health and Safety, No. 2, 0051-2855-MTDC).

Escape

This study showed that a higher level of fitness is associated with faster travel to a safety zone; that dropping the pack reduced transit time 21.5 to 26 percent; and that the energy demands of evacuation can equal or exceed the minimal aerobic fitness level required of wildland firefighters (45 milliliters/kilogram-minute).

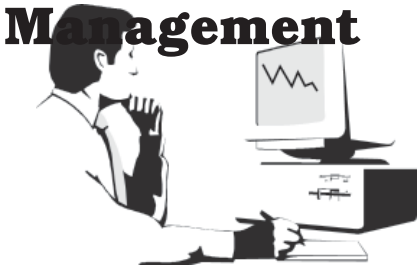
Wildland firefighter load carriage: effects on transit time and physiological responses during simulated escape route evacuation. Ruby, B., et al., International Association of Wildland Fire. 2000 (reported in Wildland Firefighter Health and Safety: No. 2, 0051-2855-MTDC).

"From what I have seen working with firefighters, they would rather die as a group than leave one behind."

J. D. Zaitz

From a letter in the June 2001 issue of *Wildland Firefighter* in which Zaitz, a physical therapist and athletic trainer, argues for maintaining or raising fitness standards for wildland firefighters and continuation of the pack test.

Risk Management



Arduous Work

The pack test is based on the demands of wildland firefighting. It was developed to test the ability to perform prolonged arduous work under difficult environmental conditions, with a reserve to carry out emergency responses. The test includes elements of aerobic and muscular fitness that are related to the performance of firefighting tasks. While the pack test was developed to screen firefighters, the arduous category has been extended to cover 20 additional positions (NWCG 310-1). Several test-related fatalities raise questions regarding application of the test to these positions. Positions that do not fit the arduous category and are not required to perform the tasks of wildland firefighting may be better served by the moderate or light categories.

The Safety and Health Working Team (SHWT) has requested a review of the work capacity requirements for all line positions. MTDC has begun a review and will report recommendations for further study. Recommendations will be considered by the National Wildfire Coordinating Group. In the meantime, test administrators should conduct health screening for all work capacity tests. Candidates should engage in training appropriate for the test and the job.

Firefighter Fatalities

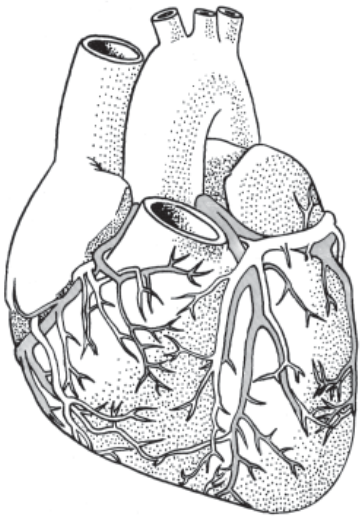
According to the National Institute for Occupational Safety and Health (NIOSH) Fire Fatality Investigation and Prevention Program, 49 percent of deaths among municipal (structural) firefighters are from heart disease. The largest firefighter mortality study ever conducted confirms that municipal firefighters die from heart disease at a rate similar to the population at large (Baris et al. 2000). Data for wildland firefighting indicate 42 percent of volunteer firefighter deaths were due to heart disease, compared to 15 percent for firefighters associated with Federal agencies and 11 percent for those associated with State agencies (Mangan 1999). The vast majority of deaths occur in firefighters who are more than 45 years old. Demographics (the number of firefighters older than 45) and annual work capacity requirements explain some of the differences between municipal, volunteer, and wildland firefighter fatality rates.

On wildland fires, heart attacks constituted 21 percent of all fatalities from 1990 to 1998, while entrapments were associated with 29 percent, aircraft 23 percent, and vehicles 19 percent of all fatalities. Studies show that active and fit individuals have less than half the heart disease risk of the sedentary population. During strenuous exercise, the risk of heart attack for habitually active individuals rises to a level slightly above the risk of sedentary living, but only during the period of exertion. The risk for sedentary individuals rises dramatically during strenuous effort.

Heart disease is the major cause of death for men and women. It begins early in life and develops at a rate that depends on the influences of heredity and lifestyle (diet, physical activity, smoking, body weight). While exertion may trigger a heart attack in a susceptible individual (a person with preexisting disease), it does not cause the disease. Regular activity has been proven to **substantially reduce the risk of heart disease and cardiac death**. The reduction in risk ranges from 30 percent for moderately active individuals to 70 percent for those habitually engaged in vigorous activity. The American Heart Association considers physical inactivity a major risk factor for heart disease.

Heart Attacks

About 10 percent of all heart attacks occur during exertion. Physically inactive individuals are 56 times more likely to experience a problem during exertion.



Risks of Exertion

Unstable Plaque— As people age, their coronary arteries are gradually narrowed by the deposition of plaque, a scale consisting of cholesterol and other debris. Some plaque is soft and easily dislodged, capable of causing a clot that interrupts the flow of blood to the heart. Heavy physical exertion, along with increased heart rate, blood pressure, and hormones (such as epinephrine), may disrupt vulnerable plaque and trigger an acute myocardial infarction (heart attack). At present, no readily available test can identify persons with vulnerable plaque.

Blood Pressure—Individuals with elevated blood pressure (hypertension) may exhibit an exaggerated blood pressure response to exertion, increasing the risk of a heart problem. The exaggerated increase in blood pressure, along with the elevated heart rate associated with a low level of fitness, increase the work and oxygen needs of the heart muscle. If the coronary arteries are narrowed, the muscle may experience the pain of ischemia or lack of oxygen. The Centers for Disease Control report that 61 percent of the population is overweight or obese. Excess weight is associated with elevated blood pressure and low fitness.

Fire Storm 2000—During the 2000 fire season, the worst in 50 years, over 25,000 fire personnel were deployed. Fatality data for the year indicated one heart death related to firefighting and one heart death related to training for the pack test. The fatality incidence was consistent with historic trends that included three fatalities in 1994 and four fatalities in 1996. The small number of fatalities is remarkable considering the number of personnel deployed, the length and severity of the season, and the advanced age of returning retirees (the risk of heart-related deaths increases after age 45 for men and 55 for women).

Population Risks

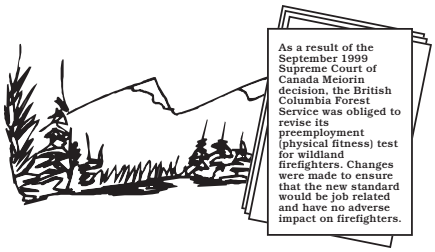
Population data reveal the life-threatening risks of clinical exercise tests (1.59/10,000 hours) and screening tests (1.06/10,000 hours). The pack test fatality in 2000 yields an estimated risk rate below 0.5/10,000 hours, so the risk of testing firefighters is less than half the population risk.

During exercise training the risk of death in apparently healthy individuals ranges from 0.01 to 0.2/10,000 hours of exercise (Foster and Porcari 2001). The two fatalities during the 2000 fire season yield an estimated risk rate of 0.00017/10,000 hours (based on 25,000 employees working 45 days of 10 hours per day). The risk of exertion associated with wildland firefighting is a small fraction of the risk associated with exercise training.

To Reduce Risk—

- Screen all candidates for wildland firefighting with a health screening questionnaire.
- Provide a medical examination for those individuals over 45 years of age and those identified by the health questionnaire.
- Train at a moderate intensity for several weeks before engaging in vigorous training or work, particularly if you have been inactive.
- Encourage a year-round fitness program for those required to pass at the arduous level (pack test).
- Provide an employee health (wellness) program to help reduce cardiovascular risk.
- Review the Incident Command System positions that require the pack test.

Field Notes



The Canadian Case

As a result of the September 1999 Supreme Court of Canada Meiorin decision, the British Columbia Forest Service was obliged to revise its preemployment (physical fitness) test for wildland firefighters. Changes were made to ensure that the new standard would be job related and have no adverse impact on firefighters based on gender or ethnicity (social group). Subsequently, the pack test and a pump-hose test were selected as the components of the new standard. These changes were implemented for the 2000 fire season for the following reasons: they are job specific; they have been extensively researched and validated as legitimate measures of a person's ability to fight fire; and they do not discriminate or create gender, ethnic, age, or weight barriers.

The British Columbia Forest Service employed about 700 firefighters during the 2000 fire season. Preemployment fitness test results were obtained from 575 of those firefighters. Fifteen percent (88 of 575) were new recruits (firefighters who were hired just before the 2000 fire season). About 7 percent of the firefighters were females. This percentage corresponds to the current gender distribution of wildland firefighters in the British Columbia Forest Service. The large sample also reflects the normal distribution of social groups (first nations, visible majority, visible minority) among British Columbia Forest Service wildland firefighters.

Pump-Hose Test

This validated work test has been used by the British Columbia Forest Service since 1994. The test requires an applicant to carry a 29.5-kilogram (65-pound) pump, nonstop, for 100 meters (with no time limit). A timed portion of the test requires an applicant to carry a 30.9-kilogram (68-pound) rolled hose 300 meters and then drag a water-filled hose 200 meters (50 meters "out and back" twice). This task must be completed in 4 minutes and 10 seconds.

Males had a 98.6 percent pass rate for the pack test and a 99.1 percent pass rate for the pump-hose test. All females passed both tests. The revised preemployment fitness standard for wildland firefighters reflects the minimum standard necessary for the safe and efficient performance of firefighting in British Columbia. The pack and pump-hose tests are job specific and they have been extensively researched and validated as legitimate measures of a person's ability to fight wildland forest fires. The results of these data collected during the 2000 fire season confirm previous findings that the revised preemployment fitness tests do not have a disproportionately negative impact on a gender or social group. Although age and weight have a small association with scores, they do not make a powerful contribution to the variability in mean test scores. (for more information, contact British Columbia Forestry at: *steve.bachop@gems5.gov.bc.ca*).

Gender and Size

This October 2000 presentation addressed the related issues of gender and physical size in the preparation for, and the performance of, emergency response duties.

"Evidence accepted by the arbitrator designated to hear the grievance demonstrated that, owing to physiological differences, most women have a lower aerobic capacity than most men and that, unlike most men, most women cannot increase their aerobic capacity enough with training to meet the aerobic standard." (Supreme Court of Canada on appeal from BC Court of Appeals re: BC Government & Service Employees Union v. Government of the Province of BC, 1999).

Two of the primary factors influencing the recent Supreme Court of Canada decision regarding the adverse effect discrimination of a female wildland firefighter involved arguments that:

- Women have a lower aerobic capacity than most men.
- Even with training, most women cannot increase their aerobic capacity enough to meet the aerobic standards.

The precedent-setting decision has far-reaching implications for bona fide occupational requirements (BFOR), particularly those that involve intense physical demands.

It is assumed that valid and reliable BFORs will provide a means of determining whether an individual can meet the demands of the job effectively and efficiently without undue risk of injury. Individuals interested in pursuing employment in emergency response occupations (such as urban or wildland firefighting, or police work) must recognize the physical demands involved in such positions. There is an obvious need to prepare before applying to work in such occupations as well as a need to maintain a level of physical ability while in such a physically demanding position.

The lower aerobic power, strength, and work capacities of women compared to men have been used to argue the discriminatory effect of BFORs. This presentation included a discussion of gender differences in physical capacities and the use of average values to represent the abilities of a specific population. A question that must be considered is whether women are truly at a disadvantage, or whether size (women on average are smaller than males) is the disadvantage. Lowering aerobic BFOR standards for some populations would be likely to force some individuals to work at a much higher percentage of their maximal aerobic power. This will lead to an increase in the rate of fatigue and risk of injury, as well as a reduction in productivity. It is recommended that in some circumstances standards may need to be set higher for smaller individuals.

The argument of poor training responsiveness has also been used in the determination of adverse effect discrimination. The ability of women to improve their physical abilities, specifically aerobic power, and muscular strength and power were discussed. Research from sport studies including competitive and well-trained female athletes provides evidence that with appropriate training most women can enhance their muscular strength, power, and cardiovascular efficiency.

Physically challenging occupations often require absolute capacities and performances. Absolute demands, such as being able to lift and handle heavy equipment place the smaller individual (often female) in a disadvantageous situation. In addition, the externally imposed absolute loads of the protective gear used in firefighting and the energy requirements of such encumbered work will impact job effectiveness. Accommodation for smaller individuals (both male and female) often cannot be made without risk to the employee, the general public, and even the employer. In order to perform effectively under these conditions, a smaller individual may be required to work at an intensity level higher than that of a larger person. The report discussed the impact these additional demands have on the development of fatigue, as well as the determination of valid employment standards.

The report concluded that physical size is probably more of an issue than gender when dealing with difficulties of developing and meeting BFORs. Accommodation related to size differences must include consideration for absolute demands of employment-related tasks. It is possible that physical requirements may need to be altered to take into account the size differences of employees. However, such alterations may lead to an increased level of difficulty in meeting the standards. It must not be presumed that altering standards to accommodate size differences will necessarily mean making them easier to meet. The inability of one individual to complete job requirements may place coworkers in a compromised, risky situation. Ultimately, it is the ability of an employee to meet the physical demands of the occupation in a safe, effective, and appropriate manner that must be considered.

Issues of gender and size in emergency response occupations. Gaul, Katherine, Ph.D., University of Victoria. Paper presented at the annual meeting of the Canadian Society of Exercise Physiology, Canmore, Alberta, October 25 to 28, 2000.

Is the Pack Test Too Difficult?

Energy Cost of Hiking			
	Pace (mph)	**Grade** (percent)	**Kilocalories/minute**
Pack test w/45 lb	4.0	level	7.5
Hike w/o pack	3.5	4	7.5
Hike	3.0	8	7.5
Hike	2.5	12	7.5

The pack test is used to determine a wildland firefighter's ability to carry out the arduous duties of the job. The test, which replicates a portion of the firefighter's job, requires the same energy expenditure as firefighting (7.5 kilocalories per minute). The pack test has been taken by thousands of individuals in Federal and State agencies in the United States, Canada, and Australia. Even though more than 90 percent of the candidates pass the pack test, the test has been criticized as too difficult, the pack (45 pounds) as too heavy, and the pace (4 miles per hour) as too fast. Smokejumpers carry 110 pounds for 3 miles to qualify for duty. Female U.S. Army recruits have trained to carry 75 pounds at 4.4 miles per hour. Marines routinely carry 75 pounds in awkward Alice packs (similar to rucksacks), even on snowshoes. A recent article in the journal Military Medicine recommends a backpack run test (a 2-mile run with a 66-pound pack) as "a model for a fair and occupationally relevant military fitness test" that eliminates body-size bias, and measures work and health-related components of fitness.

Wildland firefighters are told not to run while taking the pack test. The pack test is a pass or fail test. Running is not necessary to pass the test, and doing so increases the risk of injury. Candidates should be reminded of proper lifting techniques and the need to warm up and stretch before taking the test. They should follow all safety instructions, wear a comfortable pack, hike with an upright posture, and avoid extreme body positions (crouching or leaning). Finally, candidates are told they are free to stop at any time.

Publications

Wildland Firefighter Health and Safety Report, Nos. 1 (0051-2825-MTDC), 2 (0051-2855-MTDC), and 3 (0151-2817-MTDC) are available from MTDC.

Coming up. . .

The next Wildland Firefighter Health and Safety Report in spring 2002 will consider:

- Firefighter fatigue
- Work/rest issues
- 14-day assignments
- Energy requirements
- Fatigue countermeasures

If you have comments, questions, or suggestions about this report or project, send them to: bsharkey@fs.fed.us.

Additional single copies of this document may be ordered from:

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