

RECOMMENDATIONS ON IMPROVED MAN TESTS
FOR SCBA

R. L. Stein, Ph.D.
U.S. Divers Company
Santa Ana, California

INTRODUCTION

The Mining Enforcement and Safety Administration (MESA) and the National Institute for Occupational Safety and Health (NIOSH) jointly grant certificates of approval for self-contained breathing apparatus (SCBA). The certificates are granted when requirements of Title 30, Part 11 Code of Federal Regulations (30 CFR 11) are met.

Approval requirements for SCBA include a series of man tests during which selected subjects are required to use the breathing apparatus while performing a set of work tasks. The series of man tests are called Test 1 through Test 4. Test 1 familiarizes the man with the apparatus; Tests 2 and 3 are intended to provide difficult work tasks while also evaluating the comfort and fit of apparatus; Test 4 provides the most severe physiological test. The set of work tasks in each test is dependent of the service time of the apparatus.

The physiological requirements needed to meet Test 1 through 4 were not known. Therefore, a series of experiments were conducted to determine the steady state metabolic demands for each specified tasks.¹ However, this data was not useful for all the man tests. Users are able to incur a physiological deficit which may be an appreciable portion of the total cost for short (less than 30 minutes) duration man tests. This fact prompted another study to evaluate short duration man tests by continuous monitoring of the physiological responses instead of sampling only during rest periods. In addition to measuring the magnitude of the deficit, continuous monitoring was used to demonstrate how this technique could be used in actual man testing.²

This paper summarizes the steady state respiratory responses for the individual work tasks used in man testing of SCBA. It also summarizes information on the short duration tests. Based on these results, a new set of man test tables have been developed.

EXPERIMENTAL METHODS

Details are provided in References 1 and 2. However, a synopsis of techniques are in order. Note that all volumes are STPD conditions.

Short Duration Tests

Ten coal miners were used in the present study. The man tests required crawling on hands and knees, walking, and running, all of which were performed on a level treadmill. A pulley device similar to that used by MESA/NIOSH was constructed. The pulley allowed for the repetitive lifting of a 45 lb. weight to a height of five feet. The laddermill (vertical treadmill) was the same model as used by MESA/NIOSH.

An overcast in underground mines is a device which allows one air current to cross over another without interruption. During federal man tests a man is required to carry a 50 lb. sack over a simulated overcast. An overcast was not installed in the test laboratory. Substitution was made by walking on the treadmill without change in the physiological cost.

Four man tests were selected for study: (1) Test 3, 10 minute device (T3-10); (2) Test 3, 15 minute device (T3-15); (3) Test 4, 10 minute device (T4-10); and (4) Test 4, 15 minute device (T4-15). The schedule of activities for the four man tests studied is shown in Figure 1. The physiological responses measured were pulmonary ventilation rate (V_E), oxygen rate (VO_2), and carbon dioxide elimination rate (VCO_2). The responses were measured on laboratory instruments, then computed and recorded at 0.2 minute intervals. The data were averaged and plotted as mean response. The 95 percentile response was calculated as the mean plus 1.65 times the standard deviation.

Steady State Tests

A total of 32 subjects participated in this phase. Pulley and overcast tasks were performed alternately within one session. Random assignments of rate and type of pacing were made within each task. In other sessions, subjects were randomly assigned to walking, running, carrying, and ladder climbing. Recovery time between tasks was variable, but it was long enough to allow heart rate to return to within 5 beats per minute of the pretest resting value.

Expired air, O_2 , and CO_2 concentrations for the overcast and pulley tasks were measured for the total of the prescribed performance period plus a recovery period. The recovery period, defined as the time in which O_2 demand for the task was calculated as the total O_2 uptake less the resting value associated with recovery. For all the other tasks, performances lasted 5 minutes to ensure steady state responses, and the respiratory measurements were made during the last minute.

NIOSH personnel do not specify how a test shall be conducted. Therefore, both the overcast and the pulley were administered as paced or self-paced tasks. In a paced task, the subject was advised to perform the task at a steady rate. The paced subject could watch a clock to time himself and/or the investigator instructed him. In a self-paced task, the subject performed at his own pace. Self-pacing always used less than the time allowed, so the subject was required to remain still from the time he finished the task until the end of the prescribed time so that direct comparison of metabolic requirements between paced and self-paced tasks could be obtained.

RESULTS AND DISCUSSION

Steady State Tests

WALKING: The data showed that the following equation predicted the O_2 cost during walking:

$$VO_2 = 7.06 + 0.011S^2 + 0.012 \cdot GS \quad (1)$$

where VO_2 is in ml per kg body weight per minute, S is walking speed in meters per minute, and G is the uphill grade in percent.

The Man Test includes carrying the breathing apparatus, which adds to body weight. However, experiments on young adults walking with and without external loading on the back have shown that the energy cost of carrying up to about 30 kg is equivalent to carrying additional body weight. Hence, the above equation could be used to standardize the $\dot{V}O_2$ to the combined weight of the body and apparatus.

RUNNING: The $\dot{O}_2$ cost of running was:

$$\dot{V}O_2 = 4.5 + 0.25 + 0.012 \cdot GS \quad (2)$$

($\dot{V}O_2$, S and G units same as for walking.)

CARRYING 20 kg: The respiratory responses obtained for carrying 20 Kg at 3 mph are summarized in Table 1. This mode of carrying on the hands in front of the trunk is less efficient than carrying a backpack. For each Kg carried on the arms, the cost is 15% more than the cost for each kg carried on the back.

PULLING: Table 2 summarizes the $\dot{V}_E$, $\dot{V}O_2$ and RQ for paced and self-paced pulling. Although in most of the pulling regimens $\dot{V}_E$ and $\dot{V}O_2$ were higher for the self-paced groups than for the paced groups, analysis of covariance of the $\dot{V}O_2$ and $\dot{V}_E$ each on the number of pulls indicated that the differences were not significant.

As can be seen in Table 2 for a given pulling rate, PR (pulls per minute) $\dot{V}O_2$ in l/min. could be predicted:

$$\dot{V}O_2 = 0.143 PR \quad (3)$$

The ventilation during the self-paced performance, normalized in terms of $\dot{V}_p$ per pull, was 3.66 l/pull (± 0.67).

OVERCAST: The data on the self-paced performance were averaged, yielding the following means and s.d. for $\dot{V}O_2$:

$2,200 \pm 420$	ml/round
24.5 ± 3.8	ml/kg·round

These values for the total $\dot{O}_2$ cost are for an average body weight of 87 kg. The expected total $\dot{O}_2$ cost for the population could be expressed in ml per minute:

$$\dot{V}O_2 \text{ ml/min} = 2,200 R \quad (4a)$$

where R is the total round divided by the time (in minutes) allowed for the particular test.

Such use of total cost LS applicable to tests with small breathing apparatus (less than about 15 pounds) where the added weight is not expected to significantly change the total $\dot{V}O_2$. However, when heavier breathing apparatus are used in man testing, the use of VC)2 in ml/kg • round is suggested. The average values that were obtained from the pooled data can be incorporated as follows:

$$\dot{V}O_2 \text{ ml/kg} \cdot \text{min} = 24.5 \cdot R \quad (4b)$$

where R represents the number of rounds divided by the time allowed for the particular test. This value of $\dot{V}O_2$ per kg weight per minute can be multiplied by the sum of the body and apparatus weights, in order to get a better representative for the total O_2 cost during the overcast performance.

The ventilation during self-paced performance normalized in terms of $\dot{V}_E$ per round was 46.7 l/round (± 6.9).

Laddermill: The data yielded the following:

$$\dot{V}O_2 = 6.5 + 2.0 \cdot VS \quad (5)$$

where $\dot{V}O_2$ is in ml per kg body weight and VS is the vertical climbing speed in meters per minute.

The multiple regression of $\dot{V}O_2$ against mass (body weight plus backpack) and work load (kg•m) was calculated from the pooled data and yielded the equation:

$$\dot{V}O_2 \text{ ml/min} = 1.7 (\text{kg} \cdot \text{m/min}) + 19.5 \cdot \text{kg} - 800 \quad (6)$$

Thus, the increase in VC)2 due to the backpack could be predicted.

Since this work is close to maximum for many subjects, the $\dot{V}_E/\dot{V}O_2$ ratio was found to be similar to the $\dot{V}_E/\dot{V}O_2$ ratio for running. In both cases, this ratio was 28. Thus, the $\dot{V}_E$ for climbing was about 100 l/min.

Rest: During the periods requiring no external work (sampling and readings, and lying on side or back), but not at basal state, it is reasonable to use:

$$\dot{V}_E = 10 \text{ l/min and } \dot{V}O_2 = 0.35 \text{ l/min.}$$

Summary of Steady State Data: Table 3 summarizes the previous data in a form useful for estimating O_2 and $\dot{V}_E$ for all man tests of 30 minutes or longer.

Short Duration Tests

Figures 2 and 3 present the mean (50 percentile) and 95 percentile responses to tests T4-10 and T4-15, respectively. The physiological responses shown are pulmonary ventilation ($\dot{V}_E$), oxygen uptake ($\dot{V}O_2$), and carbon dioxide elimination ($\dot{V}CO_2$). The steady state method of analysis would show the responses changing in a stepwise fashion from one level of activity to another. In reality, the responses do not change stepwise to immediately reflect the changed demand; the responses were more gradual or transitory.

Physiological Costs: Measured values for the total amount of air used for pulmonary ventilation (V_E) and the total volume of oxygen consumed (VO_2) are recorded in Table 4. In general, the volumes of gases measured (V_E , VO_2) were smaller for the transient experiments than the values calculated using the steady state analysis. This difference is the physiological deficit,

Table 4 indicates an oxygen deficit of less than three liters can be expected from the man test. While this may be significant for very short term apparatus, it accounts for less than 15% of the total cost in the ten and fifteen minute tests.

There are some discrepancies in total pulmonary ventilation (V_E) between the values measured in the short term work and the values calculated from the steady state data. Part of the difference can be explained by the differences in oxygen uptake. The remainder of the difference is accounted for by a greater extraction of oxygen from the pulmonary ventilation during the transitory phases studied here, as opposed to the steady state.

Sample and Reading Periods; For this study, the physiological requirements were continuously monitored. During normal federal approval testing, however, the test is stopped at stipulated times for a two-minute sample and read period. During these two minutes of inactivity, all of the measured responses are decreasing. The result is that what is being read at the designated sample time is not what is occurring during high levels of activity. It is very difficult to predict the effect on the temperature and gas concentrations in the apparatus during these periods of transition. However, since the measured pressure is approximately a squared function of the flow rate, the resistance to breathing can change quickly with the pulmonary ventilation rate. Table 5 shows the magnitude and percentage change of the ventilation rate decrease over the first thirty second interval during the other sampling periods of T3-10, T3-15, T4-10, and T4-15.

Pulmonary ventilation practically drops off as a first order exponential function of time with a rate constant of 0.93 min^{-1} or with a half time of about 45 seconds when there was a sudden drop in work rate from one level to another. Therefore, the time of measurement is very important and the measurement must be made as close to the end as possible in order to measure as high a value as is truly incurred by the man. The data from all the measured sample and reading periods indicate that changes of 30% can easily be expected 30 seconds after termination of work.

NEW MAN TESTS

The Man Tests 1-4, used for determining service life of breathing apparatus, need to be re-examined for the following reasons;

1. The tests require that measurements be taken at specified intervals only, and as a result, the resistance, temperature, and CO₂ values are unknown during the non-sampling periods. Since these non-sampling periods take place during exercise, the most likely hazardous conditions can occur while the apparatus is not monitored. Continuous measurement also provides a clear indication of how apparatus react during use. Such information is extremely valuable for understanding how the apparatus interacts with the user.

A study of the implications of sampling times in man testing was discussed in the previous section. The Federal test schedule requires two minutes for sampling. During these two minutes of inactivity, all of the measured responses are decreasing. For example, since the measured pressure is approximately a squared function of the flow rate, breathing resistance can change quickly with the ventilation rate. Data show that within 30 seconds of completion of exercise, ventilation drops by 30%, with an attendant drop in breathing resistance of about 50%. Therefore, measuring the resistance in an apparatus is dependent on when it is measured and a single measurement at specified sampling times is not the most valid method of testing. With the decreasing flow rate, the effect of CO₂ breakthrough from the scrubber is minimized.

Continuous measurement of breathing apparatus should be conducted for at least the most difficult man test. This can be done by arranging the testing laboratory in a manner so as to place measuring equipment in the center of all exercise equipment. Such a system has already been used by several laboratories when developing breathing apparatus.

Another suggestion is to develop a test using the treadmill alone, where equipment can be centralized.

2. There is no differentiation made between testing of entry apparatus and escape apparatus. Yet, users of escape apparatus have different metabolic requirements because of the way these apparatus will be used. The man test schedule should include a test which ensures that the apparatus will not fail catastrophically (fire, explosion, becomes blocked, etc.) when used in a special "panic demand" test.
3. Analysis of the metabolic requirements of the man-tests indicate that test 2 and 4 are of the same difficulty for tests up to two hours (see Table 3). Thus, man-test 2 is redundant and therefore an unnecessary test. Since Part 11.85-15 (2) states that tests are in order of gradual increase in activity, the Bureau suggests NIOSH combine man-test 2 and 3 so that the combined tests are of less difficulty than man-test 4.

Four new man-tests (see Tables A - D) could better serve the purpose of ensuring safe apparatus than the present man-tests 1 - 4:

- A. Table A is substituted for Table 1 of Part 11. This test familiarizes the user with the apparatus, and allows for continuous measurement of CO₂, O₂, temperature and resistance.

- B. Table B is substituted for Tables 2 and 3 of Part 11. Table B combines Tables 2 and 3 so as to provide information on how the apparatus performs during a variety of tasks. The task scheduling has been arranged so that the work rate is greater than Table A, but less than in Table C.
- C. Table C is substituted for Table 4 of Part 11. Table C provides oxygen consumption levels about equal to Table 4. The tasks are all performed on the treadmill to facilitate continuous monitoring of CO_2 , O_2 , temperature, and resistance.
- D. Table D is a new test designed specifically for escape apparatus. The purpose of Table D is to evaluate the safety of an escape apparatus under unusually high demands. It would not be used to specify service time.

The proposed man-test schedule provides the following:

- a. The work rate increases from Table A to Table D.
- b. Within each table, the work rate decreases as the service is increased. For example, in Table C a 5 minute test to determine service life requires an average VO_2 of 2.5 lpm while a 60 minute test requires an average $\text{VO}_2 = 1.4$ lpm.
- c. Table B provides a variety of tasks to determine the usefulness of apparatus under varying conditions.
- d. The service life test (Table C) allows continuous monitoring because it is performed on a treadmill.
- e. The test of extreme demand (Table D) is also a treadmill test for complete monitoring.
- f. A laddermill test run in the straight up position to simulate fire activities, rescue and escape in mines, ships, chemical plants, and missile silos has been added.
- g. A task in confined spaces has been added to simulate work of firemen and mines rescue men in areas of similar height.
- h. The overcast has been removed. The information obtained using the overcast is available in the other tasks. This also allows the man-tests to be done in a smaller laboratory for convenience. it will also allow a more centralized testing area which will facilitate close supervision and observation of the wearer, and thus provide a safer test procedure.

THE FUTURE

The current Man Tests are inadequate. The recommended tests are one suggested method for improvement. However, before they can be implemented, a research study must be accomplished to determine the applicability of these suggested tests. This is under way at the Los Alamos Scientific Laboratories.

Hand-in-glove with new tests are new test criteria for rating apparatus. New tests with new test methods render using old CO₂, and temperature measurements unapplicable. In addition, resistance levels are not a specified part of this man test evaluation and should be added.

REFERENCES

1. Kamon, E, Bernard, T.E., and R.L. Stein, Steady State Responses to Tasks Used in Federal Testing of Self-Contained Breathing Apparatus, Am. Ind. Hyg. Assoc., V36, 1975, p. 886.
2. Bernard, T.E., Stein R.L., and E. Kamon, Evaluation of Federal Man Tests for Self-Contained Breathing Apparatus, Am. Ind. Hyg. Assoc., V38, 1977, 689.
3. Goldman, R.F. and P.F. Farnpierto, Energy Cost of Load Carriage, J. Appl. Phys., 1962, p. 675.

TABLE 1

Ventilation (V_E), O_2 Uptake and CO_2 Elimination for Carrying 20 kg at 3 mph (level).

	V_E l/min	O_2 Uptake l/min
Average	42.6	1.75
STND Deviation	9.0	0.28

TABLE 2
Ventilation (V_E), O_2 Uptake (VO_2) and RQ for the Pulling Tasks*

PULLS MIN	MODE	V_E	V_{O_2} (ml)		RQ
		LITERS	TOTAL	PER PULL	
15 1	paced	50.4	2037	136	—
		13.8	403	27	—
		5	7	7	—
	self-paced	57.9	2524	168	1.07
		9.6	320	21	.07
		8	3	8	3
30 2	paced	95.0	3574	119	—
		27.7	364	12	—
		5	7	7	—
	self-paced	99.8	3690	123	1.05
		19.0	613	21	0.09
		9	8	8	3
36 3	paced	125.6	4631	129	—
		24.7	613	17	—
		7	8	8	—
	self-paced	137.5	5163	144	1.04
		14.5	1055	29	0.18
		10	9	9	5
60 5	paced	230.8	8350	139	—
		22.9	1342	22	—
		5	6	6	—
	self-paced	218.6	8356	139	0.98
		54.0	1607	27	0.11
		9	9	9	4
60 6	paced	2100	9180	153	—
		24.6	1090	18	—
		8	8	8	—

*Each set of numbers in vertical order are: mean, standard deviation, and number of participants (n)
(Reprinted from Reference 1, with permission)

TABLE 3
Minimal Values in Liters for Pulmonary Ventilation (V_E) and Oxygen Consumption (VO_2)*
for 95 percentile and 50 percentile Expected Values for Man Tests One, Two, Three,
and Four** (Reprinted from Ref. 1, with permission)

DURATION (MIN)	95 PERCENTILE						50 PERCENTILE					
	30	45	60	120	180	240	30	45	60	120	180	240
Test One												
V_E	1020	1360	2310	4610	6920	9220	720	1160	1590	3190	4780	6370
VO_2	40	65	91	181	272	363	31	51	70	140	210	230
Test Two												
V_E	1200	1630	2510	4600	4690	4690	918	1434	1832	3457	3457	3457
VO_2	49	76	102	194	194	194	38	59	79	150	150	150
Test Three												
V_E	1170	1550	2100	4400	4400	4400	891	1170	1570	3160	3160	3160
VO_2	45	59	81	172	172	172	36	47	64	134	134	134
Test Four												
V_E	1370	2020	2530	4570	7150	9450	1050	1550	1830	3370	5110	6700
VO_2	55	ft?	106	184	236	377	43	64	81	142	221	291

*Note: $V_{CO_2} = VO_2$
**30 CFR, Part 11

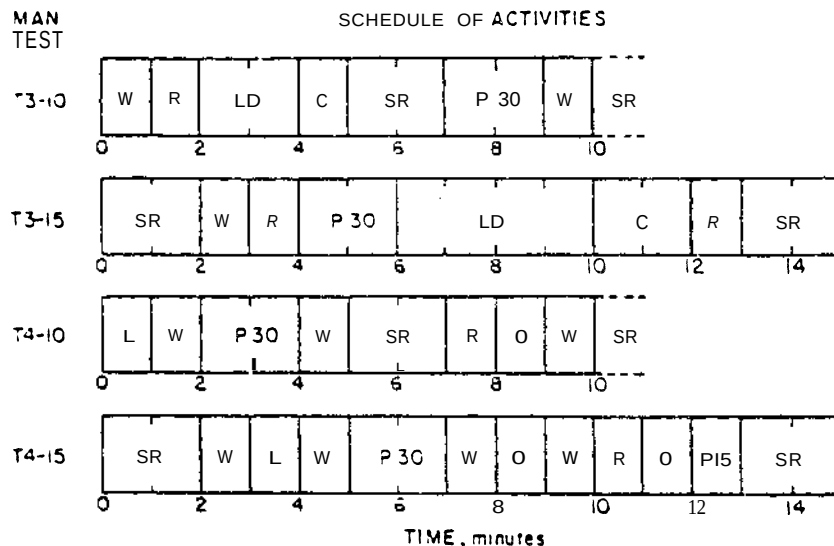


Figure 1— Schedule of activities for test 3, 10 min (T3-10); test 3, 15 min (T3-15); test 4, 10 min (T4-10); and test 4, 15 min (T4-15). Activities are denoted as:

C: Crawl at 1.5 mph
 L: Ladder mill
 O: Overcast (treadmill at 47 mph substituted, see Ref. 2).
 R: Run at 6.0 mph
 W: Walk at 3.0 mph
 LD: Lie down
 SR: Sample and reading (sitting)
 P15: Pull weight 15 times
 P30: Pull weight 30 times

(Reprinted from Ref. 2 ; with permission)

TABLE 4
 Total Gas Volumes (Pulmonary Ventilation and Oxygen Uptake) as Measured (M) and as Calculated (C) for the Mean and 95 Percentile Data of Tests

T4-10 and T4-15 (Reprinted from Ref. 2 , with permission)

Man Test	Procedure*	Mean		95 Percentile	
		VE (liters)	VO ₂ (liters)	VE (liters)	VO ₂ (liters)
T4-10	M	351	15.3	441	19.7
	C	446	17.6	574	22.4
T4-15	M	521	21.9	700	28.6
	C	597	23.9	766	28.5

*M: measured (transient)
 C: calculated (steady state)

TABLE 5
 Magnitude and Percentage Drop in Pulmonary Ventilation During the First Thirty (30) Seconds of Sampling and Reading Periods for Mean and 95 Percentile Responses in the Four Man Tests (Reprinted from Ref. 2 , with permission)

Man Test	Time Period (min)	Mean		95 Percentile	
		Magnitude Change (l/min)	Percent Change	Magnitude Change (l/min)	Percent Change
T3-10	5-7	8	26	5	13
T3-10	10-12	10	29	14	32
T3-15	13-15	15	35	13	26
T4-10	5-7	14	38	14	32
T4-10	10-12	9	31	14	36
T4-15	13-15	7	18	9	18

* The first sample periods T3-15 and T4-15 are not included (see text).

* For ten minute tests, the last sample and reading period is after the service time.

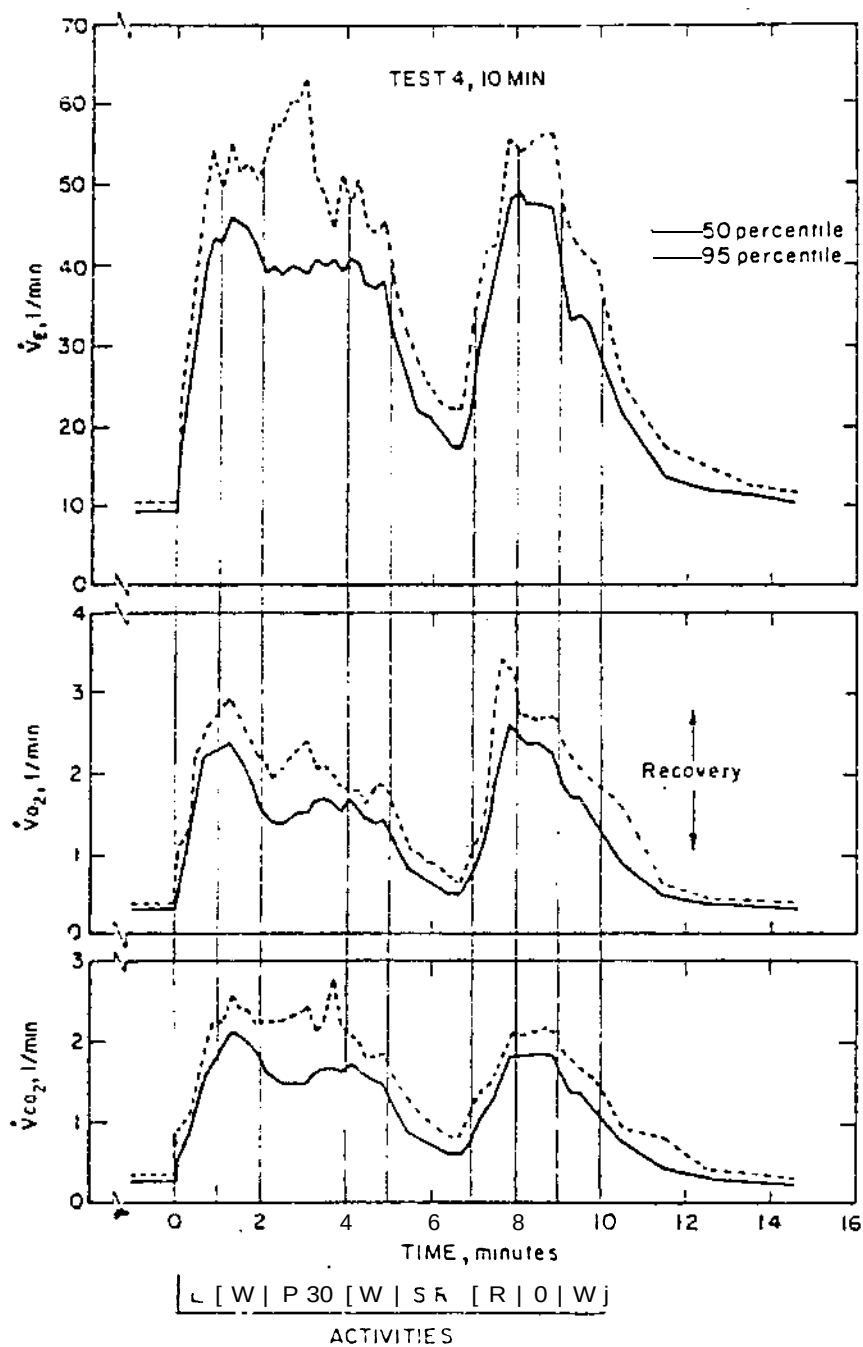


Figure 2—Physiological responses to test T4-10 for nine coal miners as a mean and 95 percentile curve (see figure 1, for work tasks) (Reprinted from Ref. 2, with permission)

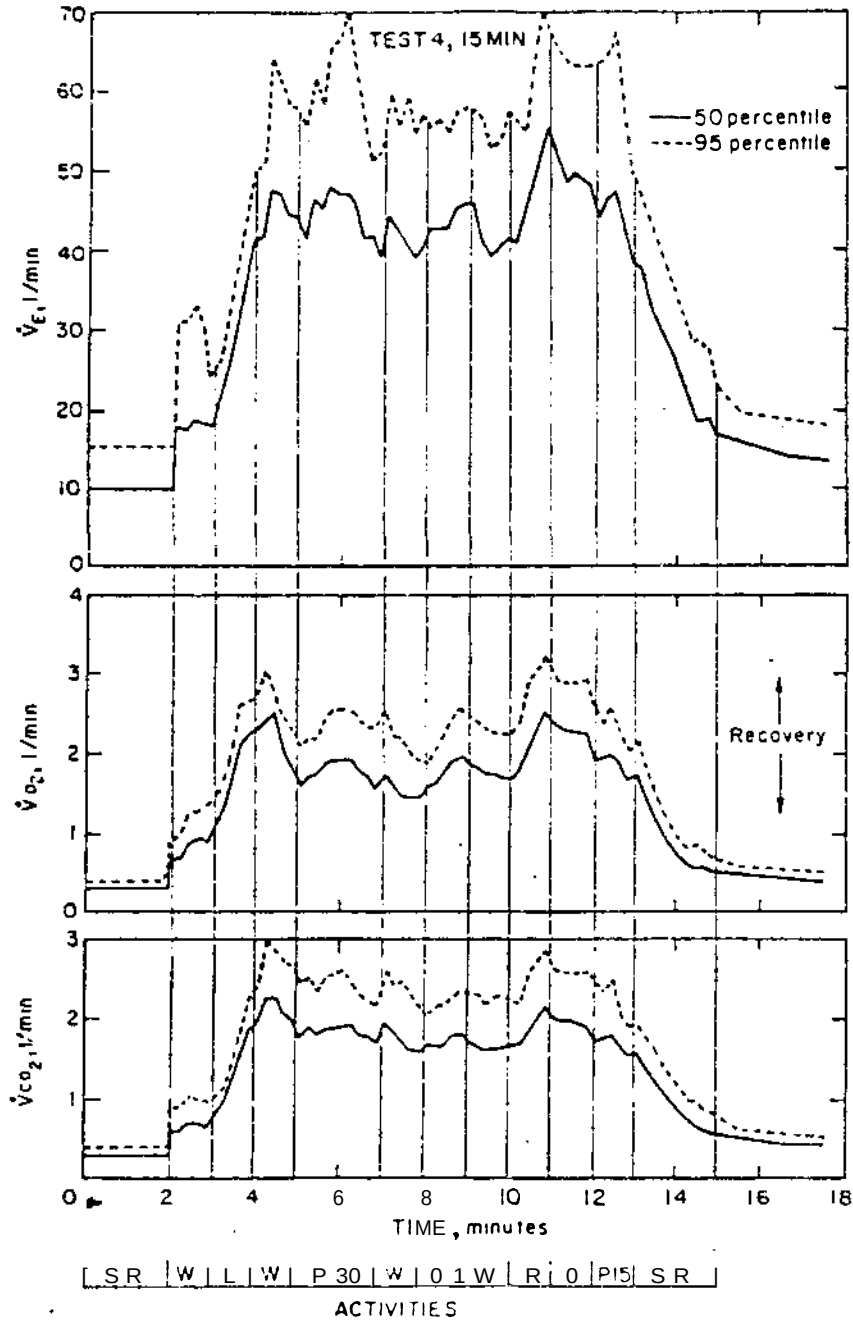


Figure 3- Physiological responses to test T4-15 for pine coal miners as J mean and a 95 percentile curve (see Figure 1 for work tasks). (Reprinted from Ref. 2, with permission)

TABLE A. - DURATION AND SEQUENCE OF SPECIFIC ACTIVITIES FOR TEST A, IN MINUTES

(30 CFR Part 11, Subpart H, § 11.85, et seq.)

Activity	Service time--									
	3 min.	5 min.	10 min.	15 min.	30 min.	45 min.	60 min.	120 min.	180 min.	260 min.
Walk (level) 4.8 km/hr (3 mph)	3	5	10	15	15	15	15	Use 60 min. test 2 times	Use 60 min. test 3 times	Use 60 min. test 4 times
Sit					5	5	5			
Walk (5% grade) 4.8 km/hr (3 mph)					10	15	15			
Sit						5	5			
Walk (level) 4.8 km/hr (3 mph)						5	15			
Sit							5			
$\dot{V}_{O_2}$ 1pm	1.3	1.3	1.3	1.3	1.23	1.18	1.0	1.0	1.0	1.0

(for 87 kg person)

TABLE B. - DURATION AND SEQUENCE OF SPECIFIC ACTIVITIES FOR TEST B, IN MINUTES

(30 CFR Part 11, Subpart II, § 11.85, et seq.)

Activity	Service time--									
	3 min.	5 min.	10 min.	15 min.	30 min.	45 min.	60 min.	120 min.	180 min.	240 min.
Ladder								TA-60 min.	TA-60 min.	TA-60 min.
10 ra/min (33 ft/min)...	3	3	3	3	3	3	3	TB-60 min.	TB-60 min.	TA-60 min.
								TA-60 min.	TB-60 min.	TA-60 min.
Pulley 10/min										
20 kg/1.5m (44 lb/5 ft).....	2	3	5	5	5	5				
Crawl thru tunnel										
2/min.....	2	2	3	3	5					
Run (level)										
7 km/hr.....	2	2	3	3	3					
Carry 20 kg (44 lb)										
4.8 km/hr (3 mph).....	3	5	5	5						
Stooped walking: 127 cm (50")										
4.1 km/hr (2.5 mph).....	5	5	5							
Walk (level)										
4.8 km/hr (3 mph).....	5	5	5							
Sit.....	5	5								
Crawl (level)										
1.6 km/hr (1 mph).....	3	3								
Lie on back, side, front.....	3	3								
Walk (level)										
4.8 km/hr (3 mph).....	5	15								
Sit.....	2									
V_u 1pm.....	2.0	1.76	1.72	1.69	1.45	1.29	1.21	1.1	1.07	1.05

TABLE C. - DURATION AND SEQUENCE OF SPECIFIC ACTIVITIES FOR TEST C, IN MINUTES

(30 CFR Part 11, Subpart H, § 11.85, et seq.)

Activity	Service time--												
	3	rain.	5 min.	10 min.	15 min.	30 min.	45 min.	60 min.	120	rain.	180 min.	240 min.	
											TA-30 min.	TA-60 min.	
Walk (level)											TA-30 min.	TA-60 min.	
4.8 km/hr (3 mph)				2	2	5	5	17			TC-60 min.	TC-60 min.	
Run (level)											TC-60 min.	TC-60 min.	
7 km/hr	3		5	8	10	5	5	3			TA-30 min.	TA-30 min.	
Walk (level)											TA-60 min.	TA-60 min.	
5.6 km/hr (3.5 mph)					3	5	10	10			TA-60 min.	TA-60 min.	
Walk (5% grade)													
6.4 km/hr (4 mph)						10	5	5					
Sit						5	5	5					
Walk (5% grade)													
5.6 km/hr (3.5 mph)							10	10					
Walk (5% grade)													
6.4 km/hr (4 mph)							5	5					
Sit								5					
Ave. $\dot{V}_{O_2}$	2.5		2.5	2.24	2.16	1.63	1.63	1.40		1.32	1.21	1.20	

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TABLE D. - DURATION AND SEQUENCE OF SPECIFIC ACTIVITIES FOR TEST D IN MINUTES*

(30 CFR Part 11, Subpart H. § 11.85, et seq.)

Activity**	Service time--									
	3 min.	5 min.	10 min.	15 min.	30 min.	A5 min.	60 min.	120 min.	180 min.	240 min.
Walk			1	2	2	2	2			TD-60 min.
Run	3	5	5	5	5	5	5			TA-60 min.
Walk			2	3	3	3	3			TA-60 min.
Run			2	2	3	3	3			TA-60 min.
Walk				1	3	3	3			TA-60 min.
Run				2	2	2	2			TA-60 min.
Walk					4	4	4			TA-60 min.
Run					2	2	2			TA-60 min.
Walk					5	5	5			TA-60 min.
Run					1	1	1			TA-60 min.
Walk						10	10			TA-60 min.
Run						2	2			TA-60 min.
Walk						2	2			TA-60 min.
Run						1	1			TA-60 min.
Walk							10			TA-60 min.
Run							3			TA-60 min.
Ave. V_{O_2}	2.8	2.8	2.38	2.24	2.01	1.90	1.84	1.42	1.28	1.21

*Termination and alteration is discretionary during the course of test.

**Walk = 5.6 km/hr (3.5 mph) (level)

Run = 8.1 km/hr (5 mph) (level)