TECHNICAL BULLETIN

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OCCUPATIONAL AND ENVIRONMENTAL HEALTH

SPIROMETRY IN OCCUPATIONAL HEALTH SURVEILLANCE

HEADQUARTERS, DEPARTMENT OF THE ARMY
DECEMBER 1986

TECHNICAL BULLETIN
NO. MED 509

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *24 December 1986*

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CHAPTER 1
INTRODUCTION

1–1. Purpose

a. This bulletin—

(1) Outlines the role of spirometry in occupational health surveillance and respiratory surveillance.

(2) Describes the proper methods for—

(a) Calibrating the spirometer.

(b) Performing spirometry.

(c) Calculating spirometric parameters.

(d) Maintaining calibration results.

(e) Incorporating spirometric data into the medical record.

(3) Establishes training and quality assurance requirements for spirometry technicians.

(4) Defines the minimum acceptable spirometer specifications.

(5) Discusses the use of spirometry in determining the medical suitability of personnel for wearing respirators.

b. This document applies to all Active Army, U.S. Army National Guard and U.S. Army Reserve medical treatment facilities (MTFs) which provide occupational health surveillance to specific military and civilian populations. The MTFs providing spirometric surveillance for personnel exposed to airborne concentrations of pulmonary hazardous materials in excess of the action levels (as defined in existing Federal, DOD, and Army Occupational Safety and Health Standards) are included in the scope of this bulletin.

1–2. References

A list of required and related publications is provided in appendix A. A selected bibliography is presented in appendix B.

1–3. Explanation of abbreviations and terms

Abbreviations and special terms used in this bulletin are defined in the glossary.

1–4. Responsibilities

a. Commanders, U.S. Army Medical Department activity/medical center (MEDDAC/MEDCEN) will—

(1) Ensure that all MTFs providing occupational health surveillance have spirometry technicians who have attended a National Institute of Occupational Safety and Health (NIOSH)-approved course in spirometry, and who have been certified to perform spirometry as detailed in chapter 6.

(2) Ensure that physicians interpreting spirograms generated as part of occupational health surveillance have, as a minimum, expertise in assessing decrements in pulmonary function equivalent to that provided in chapter 4.

(3) Ensure that all MTFs providing occupational health surveillance are supplied with calibration syringes and spirometers meeting the minimum specifications outlined in chapters 3 and 7 respectively.

b. Physicians interpreting spirograms will—

(1) Ensure that the spirometry examination is complete and of acceptable quality prior to rendering an assessment of pulmonary function as described in chapter 4.

(2) Ensure that spirometric data are incorporated into the medical record as described in chapter 5.

(3) Ensure that the spirometry technician's proficiency is maintained by implementing procedures described in chapter 6.

(4) Conduct "use" tests with the worker wearing a respirator when abnormal spirometry results are obtained as part of the medical evaluation of a respirator user as outlined in chapter 8.

(5) Ensure that the written scope of practice for nonphysician health care providers who perform spirometry includes this additional duty (AR 40–48).

c. Spirometry technicians will carry out the techniques, calibrations, calculations and interpretations, equipment checks, and recordkeeping procedures described in this bulletin when performing spirometry.

d. Physician or nurse supervisors knowledgeable in the performance and interpretation of spirometry testing will ensure that the quality assurance procedures for technician proficiency are accomplished (para 6–3).

1–5. Introduction to spirometry in occupational health surveillance

a. The routine assessment of ventilatory function with a spirometer has become part of the accepted standard of practice of occupational medicine. Spirometry is now regarded as an essential component of respiratory surveil-

lance programs for workers exposed to hazardous pulmonary substances. Combined with the respiratory and occupational health histories, physical examination, and chest radiograph, spirometry can identify the job applicant with preexisting pulmonary disease and facilitate proper job placement. Routine followup studies in workers exposed to hazardous airborne substances can detect respiratory impairment in its earliest stages when corrective measures are more likely to be beneficial.

b. The Occupational Safety and Health Administration (OSHA) requires spirometry as part of the medical surveillance for employees exposed to asbestos, coke oven emissions, and cotton dust. In addition, DOD Manual 6055.5–M recommends spirometry examinations for workers exposed above the action level to 48 different chemical substances (see app C). Furthermore, workers wearing respirators designed to prevent exposure to toxic substances must be evaluated to determine if they are physiologically able to withstand the added work of breathing associated with certain types of respiratory protection (see TB MED 502). Thus, spirometry has become a key part of occupational health surveillance at installations where personnel are exposed to hazardous pulmonary substances.

c. Serious obstacles hinder the widespread effective use of spirometry in occupational health surveillance. Many spirometry technicians, nurses, and physicians are not adequately educated to perform, calculate, or interpret tests correctly. Certain spirometers are technically unsatisfactory, and test methodology and procedure have lacked standardization; this makes it difficult to compare results obtained at different facilities. Preplacement or periodic respiratory data obtained under these circumstances is worse than no information at all. The physician must obtain an accurate representation of the patient's pulmonary function to make an informed occupational health assessment or disposition.

d. This bulletin is intended to provide an introduction to the use of spirometry in occupational health surveillance. It was written with physicians, nurses, and spirometry technicians in mind. This document does not replace the education requirements for spirometry technicians outlined in chapter 6. See appendix A for further information.

CHAPTER 2
SPIROMETRY AND RESPIRATORY SURVEILLANCE

2–1. The role of the respiratory surveillance program within occupational health surveillance

a. The four objectives of occupational health surveillance are—

(1) Identify the job applicant with preexisting functional impairment and facilitate proper placement.

(2) Detect both occupational and nonoccupational diseases at an early stage when corrective measures are most likely to be beneficial.

(3) Identify hazardous working conditions and underscore the need for improvements in industrial hygiene.

(4) Reduce the human and economic toll of occupational disease.

b. The identification of preexisting functional impairment on preplacement evaluation is an important *first step* in any ongoing surveillance effort. It should not be the primary intent of the physician to reject an applicant for employment based on medical considerations. Rather, the physician should provide the personnel office with sufficient information to ensure proper placement of the individual in the workplace. This includes any duty limitations or restrictions on the use of personal protective equipment. The physician determines whether the worker is capable of performing a particular job without substantial risk of danger to himself and/or herself or to others. The respiratory surveillance program is used to screen individuals for preexisting pulmonary disease which may place personnel at increased risk of illness or injury due to potential job-related exposures or from having to wear a respirator.

c. The *second objective* of occupational health surveillance is to detect disease in its earliest stages, thereby enhancing the likelihood of successful therapeutic intervention. For some of the chronic occupational pulmonary diseases, early detection of disease and removal from exposure may be of limited value. Many of the pneumoconiosis tend to progress despite the elimination of further dust exposure. On the other hand, eliminating cotton dust exposure in patients with acute, reversible decrements in airflow rates may prevent the development of severe, permanent airway obstruction.

d. One of the most difficult dilemmas facing the physician involves worker removal from exposure (i.e., whether to recommend that the patient be allowed to continue work in the same occupation which caused the pulmonary disease). Serious gaps in medical knowledge and possible legal ramifications complicate patient disposition. In addition to pulmonary impairment, the physician must consider the age of the employee, number of work years the employee has remaining, the total duration of previous exposure, present environmental conditions, the availability of alternate employment, and the personnel office/union policy regarding job transfer. The unknown or minimal medical benefits of removal from further exposure must be balanced against the known and potentially damaging economic consequences of forced early retirement or involuntary job transfer. Many physicians may recommend job transfer without sufficient consideration given to other issues involved. Job transfer may be recommended on the basis of a single set of laboratory abnormalities of uncertain significance. Such action may be unwarranted and reflects uncertainty about the natural history of certain occupational pulmonary diseases or medical liability/workers' compensation concerns. In the absence of medically-validated guidelines, decisions regarding job transfers will continue to require an extraordinary exercise of clinical and sociological judgment with due consideration for individual circumstances. Although respiratory surveillance may be used successfully to detect pulmonary disease, appropriate disposition of the patient requires decisionmaking which may transcend the simple application of arbitrary clinical criteria.

e. The *third objective* of occupational health surveillance is to identify work conditions requiring improvements in industrial hygiene or other control techniques. Although this retrospective approach is less than ideal, it is the means by which many occupational diseases have been identified in the past. Furthermore, even firm adherence to exposure limits or threshold limit values (®TLVs) may not protect everyone in the workplace. Because of variations in individual susceptibility, a small percentage of workers may experience discomfort

®TLV—Threshold limit values established by the American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

or develop disease at exposure concentrations well below the TLV. For example, workers who have become sensitized to toluene diisocyanate may develop symptoms with exposures to 0.001 parts per million (ppm), well below the present TLV of 0.005 ppm. Respiratory surveillance will help identify those personnel who require additional safeguards in the workplace.

f. Finally, the overall goal of occupational health surveillance is to reduce the human and economic toll of occupational disease. The economic consequences of past neglect are becoming increasingly apparent. Direct expenses including medical bills, workers' compensation insurance premiums, and payments for disability have all increased dramatically. Indirect expenses, such as clerical and administrative costs and product liability claims, may exceed direct expenses. Properly managed respiratory surveillance programs can play an important role in reducing the costs of occupational disease.

2–2. Elements of a respiratory surveillance program

a. The five respiratory surveillance program elements are—

(1) A respiratory history with emphasis on past pulmonary disease, present respiratory symptoms, and detailed smoking habits.

(2) A comprehensive occupational health history detailing prior exposure to hazardous pulmonary substances or jobs requiring respirator use. Additional information should be obtained on any hobbies, part-time jobs, or recreational activities which may result in hazardous pulmonary exposures. Any adverse health effects related to these exposures should be documented in the medical record.

(3) A careful examination of the chest to include inspection, auscultation, and percussion.

(4) Where appropriate, a 14- by 17-inch posterior-anterior chest radiograph.

(5) Spirometry testing to include forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC).

b. The periodic health evaluation of workers engaged in potentially hazardous occupations has become increasingly comprehensive in recent years. Along with the respiratory and occupational health history, physical examination of the lungs, and chest radiograph, spirometry has become an essential component of the respiratory surveillance program. The important point to emphasize is that *spirometry testing is only one element of this program.* The interpretation of spirometry data may be limited without additional pieces of information obtained from a respiratory history, list of occupational exposures, careful auscultation of the chest, or chest radiograph. The other four program elements may be used to focus spirometry screening on populations which are at increased risk of pulmonary impairment.

2–3. The role of spirometry in respiratory surveillance

a. Spirometry is used as a screening tool within respiratory surveillance programs. A screening examination is not necessarily equivalent to a diagnostic one. The key distinction is that a *diagnostic test* is performed on a patient because of a specific medical complaint or finding; a *screening test* is conducted on a worker at risk from a specific occupational exposure. An effective screening test must be simple, convenient, safe, inexpensive, reproducible, and reasonably sensitive and specific. Spirometry exhibits most of these desirable characteristics.

b. Spirometry has variable degrees of sensitivity in identifying individuals with decreased lung function. For example, spirometry is relatively insensitive in detecting some of the pneumoconioses (such as uncomplicated silicosis and simple coal-workers' pneumoconiosis) in which radiographic changes are frequently present without abnormal spirometry. It is somewhat more sensitive in detecting early asbestosis (although not usually before some parenchymal change is evident on chest radiograph). Spirometry has greatest sensitivity for detecting those lung diseases, such as byssinosis and asthma, which primarily affect the airways. However, it is difficult to distinguish fixed airway obstruction caused by occupational exposure from the same type of ventilatory abnormality produced by cigarette smoking or other causes. Thus spirometry alone has little or no specificity for occupational lung disorders.

c. These strengths and weaknesses of spirometry must be kept in mind when interpreting the results of screening examinations. Careful review of the respiratory history, smoking habits, past occupational and avocational exposures, physical examination, and (if appropriate) chest radiograph should be undertaken before a definitive clinical assessment is made. When used intelligently with the other elements of the respiratory surveillance program, spirometry remains a useful tool in the early detection and further prevention of occupational pulmonary disease.

CHAPTER 3
TECHNIQUE AND CALIBRATION

3–1. Introduction

There are three essential prerequisites for valid spirometry—

a. Standard methodology for performance and calculation of tests.

b. Technician competence.

c. Minimum acceptable instrument specifications.

Of these elements, the training and skill of the technician performing spirometry will often make the difference between a successful and unsuccessful screening program. The spirometry technician must devote meticulous effort to subject preparation, testing technique, and the generation of acceptable tracings. This chapter summarizes the methods to be used for checking spirometer calibration, preparing the patient, and administering the tests.

3–2. Calibration

The evaluation of spirometer calibration is an equipment check which is essential prior to performing spirometry tests. Instrument inaccuracy is a source of error which is unacceptable, and it is easily detected and corrected. The potential for introducing spirometer error must be precluded by instituting the following series of equipment checks and procedures:

a. Test the spirometer for accuracy daily by injecting 3.0 liters of room air from a calibrated syringe into the spirometer. To be accurate, the volume displayed on the spirometry tracing must equal the stated syringe volume ±3 percent of the syringe volume (i.e., the recorded volume must fall in the range of 2.91 to 3.09 liters for a 3-liter calibrated volume). If a microprocessor is used with the spirometer, the same daily calibration requirements apply. Calibration of both the spirometer and microprocessor requires the use of 3.0-liter calibration syringes which are commercially available. (Note: The body temperature, ambient pressure, saturated with water vapor (BTPS) correction factors described in chapter 4 are not used when checking equipment calibration.)

b. Check the spirometer and hoses weekly for leaks. This is done by injecting air into the spirometer and leaving the syringe attached to the spirometer hose. The chart recorder is activated and allowed to record for a 10- to 15-second interval. A leak is detected by the presence of a descending line on the chart paper. When a leak is discovered, establish whether the leak is in the hose or in the spirometer. This may be done by removing the hose, injecting air directly into the spirometer, and observing the chart recorder. If no further leakage is detected, the previous leak is presumed to be in the hose which should then be discarded.

c. Check the spirometer chart recorder or pen speed with a stopwatch weekly. This is done by measuring the time it takes for a 15-second segment of chart paper to pass under the recording pen when the paper speed is set at 20 mm/second. For the chart speed to be accurate, the stopwatch reading must be within ±1 percent of 15 seconds (i.e., 14.85 to 15.15 seconds). The microprocessor timing must also be checked using procedures outlined in the system's operator manual.

d. Record the results of each equipment check in a log as described in chapter 5.

e. Ensure that any inaccuracies identified during equipment checks are corrected prior to further use of the spirometer in patient testing.

3–3. Patient preparation

Prior to beginning the spirometry examination, the spirometry technician must explain the purpose of the test, identify potential indications for postponing spirometry, and properly position the patient for the forced expiratory maneuver.

a. The procedure should be explained to the patient in simple terms. The brief statement "I want to test how hard and fast you can breathe" may not be physiologically precise, but is usually the only explanation necessary.

b. Because the proper performance of spirometry is an effort-dependent phenomenon, it is prudent to postpone testing if the individual is acutely ill from any cause. This is particularly true for severe upper respiratory tract infections, pneumonia and acute bronchitis where inflammation of the airways or pulmonary parenchyma may lower spirometric results. A 3-week recovery period is recommended in such circumstances before testing is undertaken. Improvements in the FVC of up to 1 liter may occur in individuals 3 weeks after recovering from an episode of nonspecific bronchitis. Postponing spirometry is usually not necessary in uncom-

plicated upper respiratory tract infections (colds) unaccompanied by profound systemic complaints. Cigarettes or aerosolized bronchodilators may transiently alter airway resistance, particularly in the smaller bronchi or bronchioles. It is advisable to postpone spirometry if the patient has used either of these in the past 2 to 3 hours. A recent heavy meal is also regarded as reason to postpone spirometry for approximately 1 hour. *Any deviations from this accepted standard of patient preparation should be indicated on the spirometry tracing.*

c. The patient should then be instructed to loosen tight clothing and to remove any dentures. The dentures may be left in place if, in the opinion of the spirometry technician, their presence will help the patient maintain a better seal around the mouthpiece. The individual may sit or stand, whichever is more comfortable and convenient. Most test subjects are comfortable sitting and, under normal circumstances, there is little difference in pulmonary function values obtained in either position. (The sole exception is in the case of a grossly obese individual where seated test results may be lower.) The chin should be elevated and the neck slightly extended. While the use of a noseclip is not explicitly required, it is highly recommended.

3–4. Test administration

a. Having been properly prepared to take the test, the patient is now instructed on how to perform the forced expiratory maneuver. The spirometry technician asks the patient to take the deepest possible inspiration during a normal breathing pattern, close the mouth firmly around the outside of the mouthpiece, and without further hesitation, blow into the spirometer as hard, fast, and completely as possible. Before asking the individual to blow, the spirometry technician activates the recording pen and makes sure that it is tracing a smooth path across the baseline of the chart paper. This should be done at least 1 second before the subject blows into the mouthpiece. While the patient is blowing, the technician must actively coach the subject until a smooth plateau occurs in the tracing. The forced expiratory maneuver may then be terminated.

b. This particular method of eliciting the forced expiratory maneuver is referred to as the *open circuit technique.* Most patients master this technique with minimal explanation and practice, consistently performing reproducible forced expiratory efforts. An occasional individual may have difficulties. Examples are failure to maintain an airtight seal around the mouthpiece, pursing of the lips as with a musical instrument, or obstruction of the mouthpiece with the tongue. These problems may be avoided by routinely demonstrating proper mouthpiece positioning to each patient. Make sure that the patient's chin remains elevated and neck slightly extended during the forced expiratory maneuver.

c. A valid spirometry examination must consist of three acceptable tracings in which the largest two vital capacities do not differ by more than 5 percent or 100 mL, whichever is greater. An acceptable tracing is one that is free of coughing, hesitant or false starts, inconsistent or variable effort, early termination of expiration, excessive variability, and baseline artifact. Tracings marred by coughing, hesitant starts, and inconsistent effort are illustrated in figures 3–1 through 3–3. Exceptionally hesitant starts may prevent accurate determination of the zero time point. Early termination of expiration occurs when the tracing fails to become horizontal or plateau as depicted in figure 3–4. Mathematically, the plateau or end-of-test is reached when there is less than 25 mL volume change over 0.5 seconds. The criteria for a valid spirometry examination are summarized in table 3–1 with an example of such an examination in figure 3–5. Almost all subjects, when properly instructed and actively coached, can produce three acceptable tracings within five expiratory efforts. The spirometry technician should not elicit more than five expiratory maneuvers during one examination, since the patient's performance will not likely improve beyond this point.

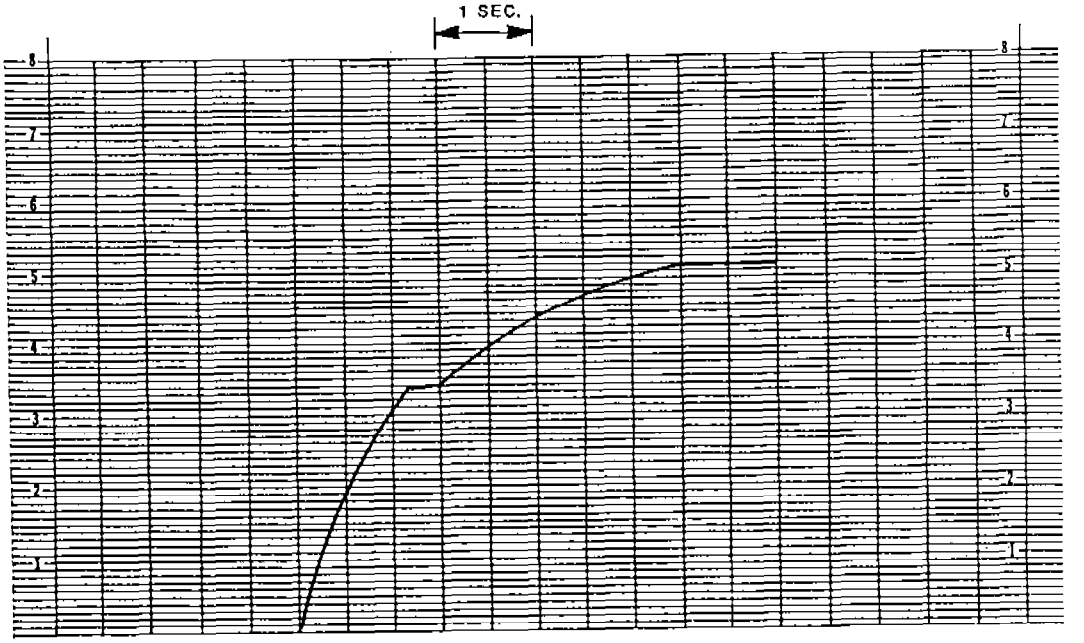


Figure 3–1. Unacceptable tracing—cough.
Source: Manual of Spirometry in Occupational Medicine, E.P. Horvath (editor), NIOSH, Nov 81.

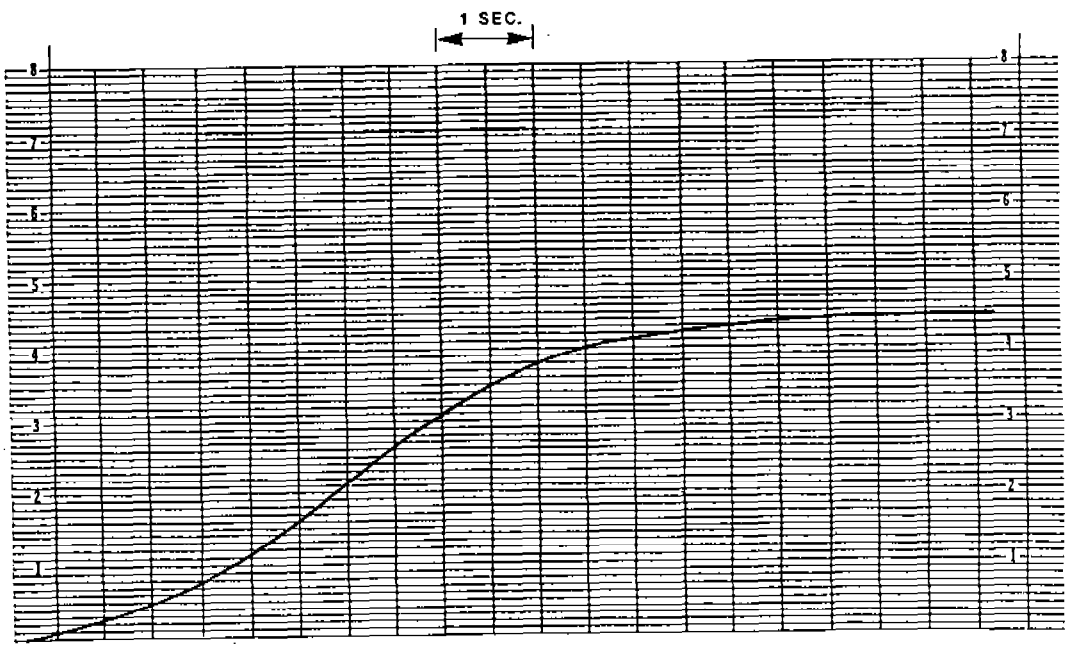


Figure 3–2. Unacceptable tracing—hesitant start.

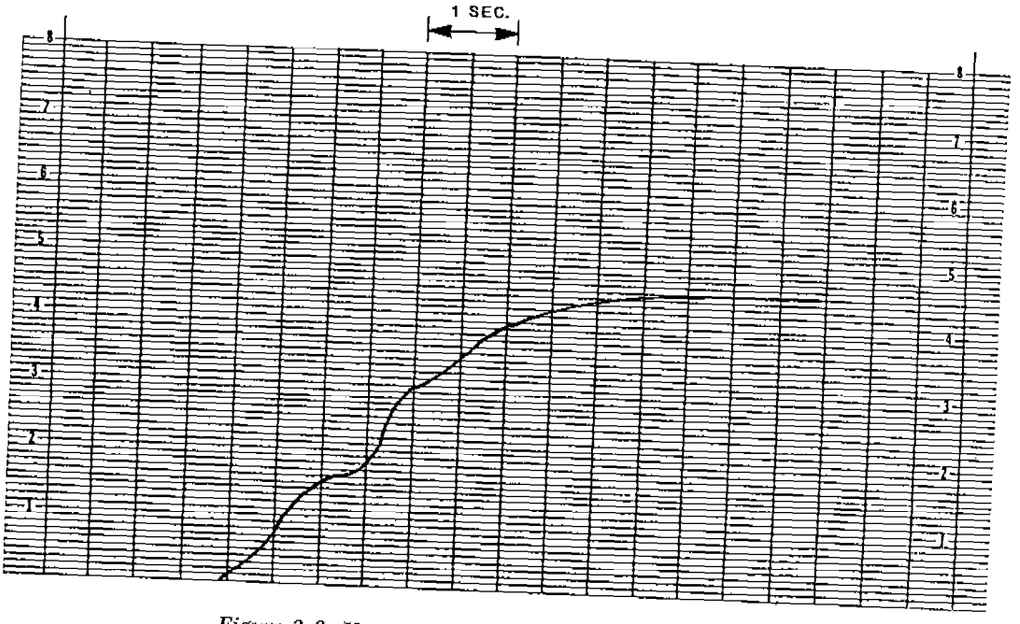


Figure 3–3. Unacceptable tracing—inconsistent effort.

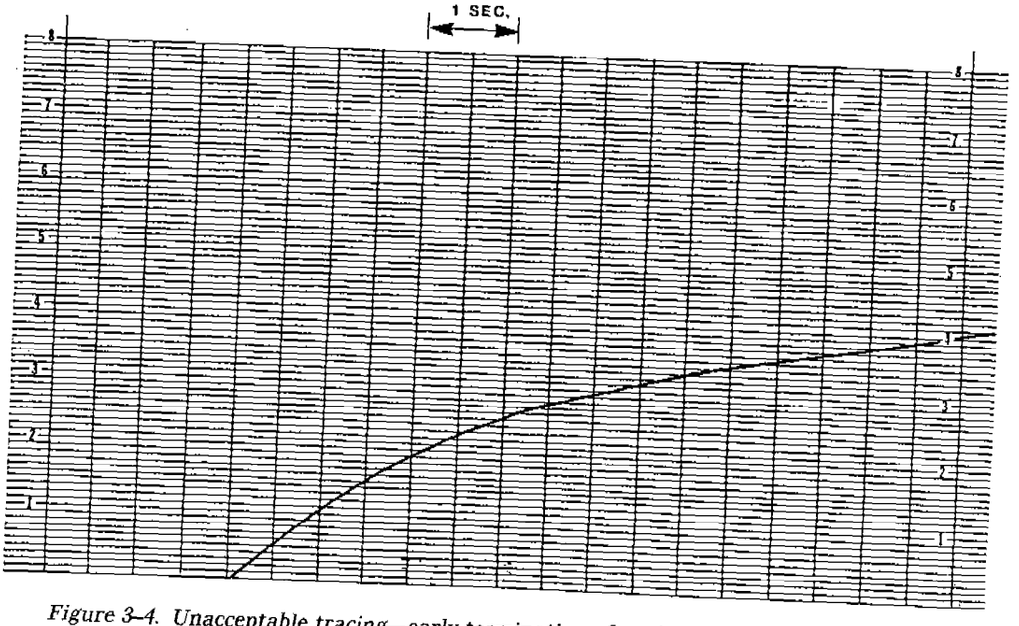


Figure 3–4. Unacceptable tracing—early termination of expiration—failure to "plateau."

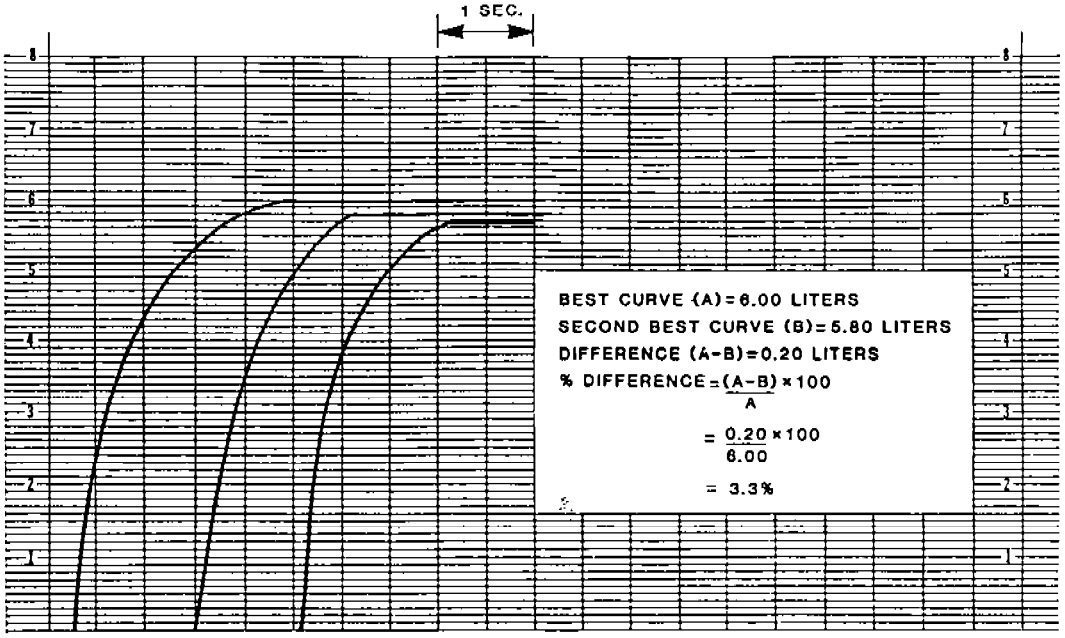


Figure 3–5. Valid spirometry examination—two best curves within 5 percent.

Table 3–1
Criteria for a valid spirometry examination

Three acceptable forced expiratory maneuvers free from—	Comment
Coughing	.....
Hesitant or false starts.	.....
Inconsistent or variable effort.	Active coaching is essential throughout the duration of the patient's effort.
Early termination of expiration.	End-of-test occurs when a plateau is noted in the tracing, with less than 25 mL volume change in 0.5 seconds.
Excessive variability.	The two best FVC readings should not vary by more than 5 percent or 100 mL, whichever is greater.
Baseline artifact.	The recording pen must begin tracing the subject's effort at the zero volume line.

CHAPTER 4
CALCULATION AND INTERPRETATION

4–1. Introduction

Several spirometric indices can be calculated from the time-volume tracing. These include the FVC, FEV_1, and (FEV_1/FVC)%. This chapter focuses on the calculation of FVC, FEV_1, and (FEV_1/FVC)% since these are the parameters most commonly used for interpreting the spirogram.

4–2. Forced vital capacity

The FVC is the volume of air which can be exhaled forcefully after full inspiration. The determination of the FVC is illustrated in figure 4–1. In most individuals, the values obtained for the vital capacity (VC) and FVC are nearly identical. In patients with severe obstructive pulmonary disease, however, the FVC is often smaller than the VC because of expiratory slowing, air trapping, and hyperinflation. In the absence of airway obstruction, reduction of the FVC is usually described as a restrictive ventilatory defect. This term encompasses conditions in which there is an actual reduction in the volume of air which can be inspired. Extrapulmonary factors such as neuromuscular disorders (Guillain-Barre) or chest wall abnormalilties (kyphoscoliosis) can interfere with full expansion of the chest. Replacement or removal of functional lung tissue by tumor, fluid, or surgery directly diminishes lung volume. Interstitial fibrosis stiffens the lungs, lowering pulmonary compliance. These conditions interfere with the ability to achieve full inspiration and thereby decrease the FVC.

4–3. Forced expiratory volume in 1 second

a. Determination of FEV_1 is influenced by the point selected as the start of the test, the zero time point. A uniform method of selecting this point is required to maintain consistency of results. In a published statement on the standardization of spirometry, the American Thoracic Society (ATS) identified the back extrapolation method as the most consistent and accepted technique for determining the zero time point. The ATS recommended the use of back extapolation until other methods are demonstrated to give equivalent results. The determination of the zero time point and FEV_1 by the back extrapolation method are illustrated in figure 4–2. Exceptionally hesitant expiratory starts may prevent accurate back extrapolation and determination of the zero time point. Any tracing with an extrapolated volume in excess of 10 percent of the total FVC or 100 mL, whichever is greater, should be repeated. In actual practice, such tracings are a rare occurrence. The determination of exptrapolated volume is illustrated in figure 4–3.

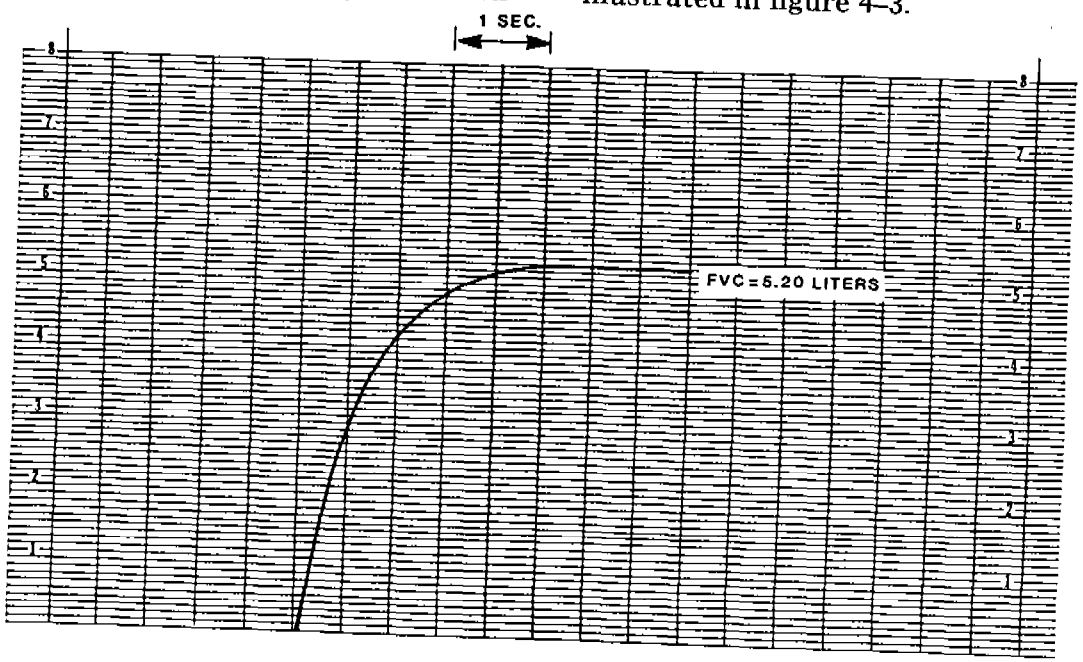
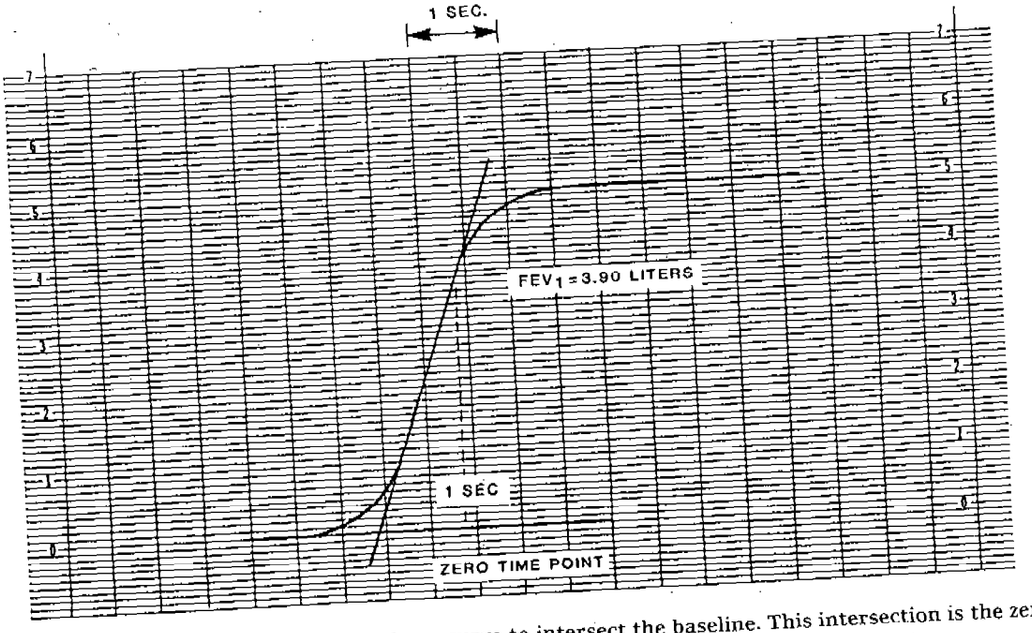


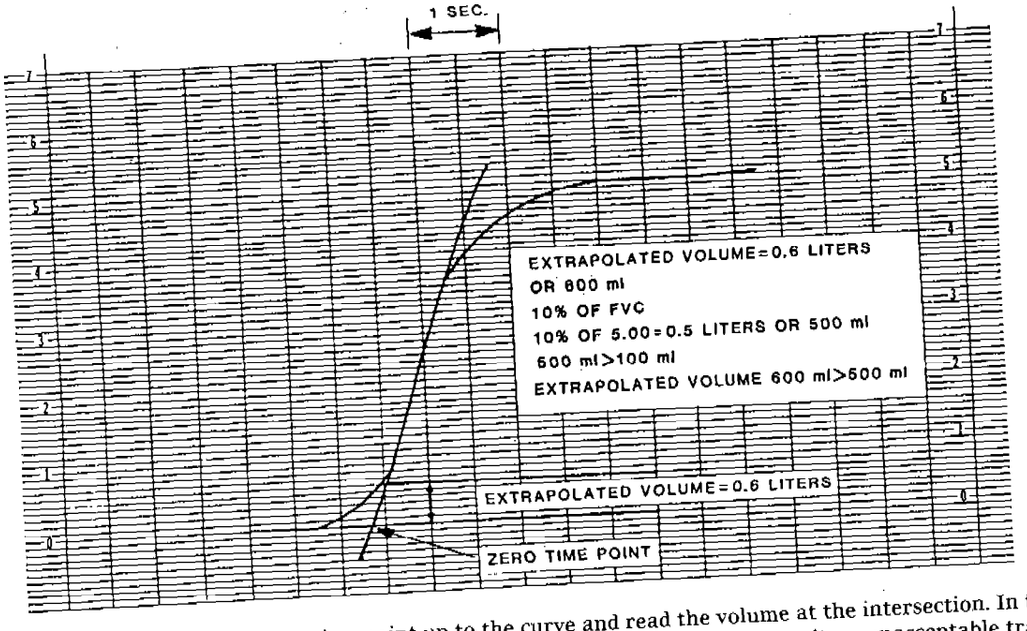
Figure 4–1. Forced vital capacity.

b. Decrements in FEV_1 usually occur in obstructive disease. Resistance to airflow in the bronchial tree can result from airway collapse secondary to loss of elastic tissue in the lung parenchyma seen with emphysema. Alternatively, the bronchial lumen may be narrowed by retained mucous or spasm of the bronchial smooth musculature in asthma or chronic bronchitis.



Draw a line along the steepest portion of the volume curve to intersect the baseline. This intersection is the zero time point for the purpose of timing the FEV_1.

Figure 4–2. Determination of zero time point and FEV_1 by the back extrapolation method.



Draw a perpendicular line from the zero time point up to the curve and read the volume at the intersection. In this example, the extrapolated volume at 600 mL is greater than 10% of the FVC (i.e., 500 mL) making it an unacceptable tracing. 10% of the FVC is the criterion used here because it is greater than 100 ml.

Figure 4–3. Determination of the extrapolated volume.

4–4. The FEV_1 as a percent of FVC

The patient's observed (obs) FEV_1 (which has been corrected to BTPS as described in para 4–5a) can be expressed as a percent of the total observed FVC—

$$\frac{\text{obs } FEV_1}{\text{obs FVC}} \times 100 = (FEV_1/FVC)\%$$

a. Calculation of $(FEV_1/FVC)\%$ is particularly useful in severe restrictive pulmonary disease where reduction in FEV_1 may falsely suggest airway obstruction. A normal individual should be able to expire 70 to 80 percent of the FVC in 1 second, depending on age and sex. An $(FEV_1/FVC)\%$ of 80 percent in a patient with low values for FVC and FEV_1 suggests restrictive disease. In contrast, $(FEV_1/FVC)\%$ of less than 70 percent in the presence of low FEV_1 suggests obstructive disease.

b. In determining FEV_1, FVC, and $(FEV_1/FVC)\%$, the largest FEV_1 and the largest FVC should be used regardless of the curve(s) on which they occur. For example, in the calculation of the $(FEV_1/FVC)\%$, the FEV_1 and FVC need not come from the same curve. This admittedly arbitrary decision has been adopted by the ATS as the recommended uniform methodology.

4–5. Correction of spirometric measurements for temperature and barometric pressure

a. Before the results of spirometric tests are incorporated in the patient's medical record, they must be corrected to BTPS. The BTPS correction is necessary for the following reasons. The volume of gas exhaled exits the respiratory tract at a body temperature 99°F (37°C). This volume, while it is collected in the spirometer, rapidly contracts as the air cools and approaches the lower ambient temperature. The volume recorded by the spirometer must be multiplied by the appropriate BTPS conversion factor (table 4–1) to correct for the volume contraction. Correction usually increases the volume recorded on the spirogram by approximately 8 percent (although corrected volumes may vary from 5 to 10 percent depending on ambient temperature). The BTPS correction is particularly important in areas where ambient temperatures vary considerably. Although the temperature of exhaled gas in the spirometer is slightly higher than that of the room, the room temperature is usually the best approximation to the spirometer air temperature and is used for purposes of BTPS correction. (Note: Some spirometry systems may contain an internal thermometer which measures spirometer air temperature. The latter is then used by the microprocessor to calculate the BTPS correction factor. In this case no further correction to BTPS is necessary.)

b. The calculation sequence for BTPS conversion is summarized in appendix D along with other calculation procedures. The BTPS correction factor is applied only to FEV_1 and FVC. The $(FEV_1/FVC)\%$ is never multiplied by the BTPS correction factor.

Table 4–1
Factors for converting gas volumes at ambient temperature to BTPS

Temperature		Conversion factor
°F	°C	
64	18	1.114
66	19	1.111
68	20	1.102
70	21	1.096
72	22	1.091
73	23	1.085
75	24	1.080
77	25	1.075
79	26	1.068
81	27	1.063
82	28	1.057
84	29	1.051
86	30	1.045
88	31	1.039
90	32	1.032
91	33	1.026
93	34	1.020
95	35	1.014
97	36	1.007
99	37	1.000

c. Some spirometers have recording paper that is lined to correct for a predetermined room temperature. This approach must be avoided in areas where extremes in ambient temperature may be present, since resulting errors in lung volume measurements may be as high as 5 percent. Fluctuations in barometric pressure usually produce less than 1 percent variability in spirometric tests. The BTPS correction for barometric pressure is unnecessary except at extremely high altitudes.

4–6. Determination of the percent of predicted normal values

a. After measuring the FVC and FEV_1 and correcting for temperature and pressure, an interpretation of these observed indices is appropriate. The decision as to whether spirometric tests are "normal" is usually made by comparing them to a set of published predicted (pred) normal values. Several sets of predicted normal values have been compiled, including those by Kory, Morris, Knudson, and Crapo. The reference standards of Knudson are required by OSHA (part 1910.1043, title 29, Code of Federal Regulations (29 CFR 1910.1043)) for the cotton dust industry. These predicted values will likely be incorporated into future OSHA standards which require spirometry testing as part of occupational health surveillance. A table of the predicted values to be used in calculations of the percent of predicted normal values is provided in appendix E.

b. In all studies of predicted normal values, several factors have been indentified that affect lung capacity and flow rates, including age, height, sex, and race. Even in the absence of superimposed disease processes, pulmonary function declines predictably with advancing age. Taller individuals tend to have larger lung volumes. In the measurement of height, it is important to have the subject in stocking feet to preclude the influence of variably-sized heels. Men generally have larger lung volumes than women of the same age and height. In addition, the FEV_1 and FVC of noncaucasians are approximately 15 percent lower than in whites of the same age, height, and sex. This difference has been noted for both blacks and those individuals of Asian descent. The explanation for this phenomenon is not clear, although differences in thoracic configuration and diaphragmatic position may account for differences in lung volume. Allowance of ethnic variation must be made to avoid errors in interpretation. Appendix E contains predicted values which are based on age, height, sex, and race. No ethnic correction factor is necessary for the FEV_1/FVC ratio since this is less affected by race.

c. The calculation of percent of predicted normal is demonstrated in appendix D. The observed FVC or FEV_1 (which has already been converted to BTPS) is divided by the appropriate predicted value based on the patient's age, height, sex, and race. This ratio is multiplied by 100 to obtain the percent of predicted normal FEV_1 and FVC. One widely used method to define the limits of normal spirometric indices is to set the lower limits of normal for FEV_1 and FVC at 80 percent of the predicted value. For the FEV_1/FVC ratio, greater than 70 percent has been considered normal. The relationship of lung volume and flow rate to the type of ventilatory impairment is summarized in table 4–2. Spirometric guidelines for assessing the degree of ventilatory impairment are provided in table 4–3.

d. Setting the lower limit of normality at 80 percent of the predicted value may result in a small proportion of the normal population being labeled as "abnormal" (e.g., elderly females). Recently, a method has been developed to determine if the patient's values fall within the 95 percent confidence intervals of the age-, sex-, race-, and height-specific population values. Although more statistically valid in that it accounts for variability of a measurement within a normal population, the 95 percent confidence interval method has been in clinical use for a relatively brief period of time. The 95 percent confidence interval assumes both a constant variance for all ages and heights and a normal distribution about the regression line. These assumptions are not true in all reference populations. Another method for defining normality establishes lower 95th percentile values for FEV_1 and FVC based on age, height, and sex. Until a consensus develops, the more traditional 80 percent of predicted methodology is recommended for the interpretation of normality.

4–7. Calculation of changes in followup spirograms

a. Although comparison of an individual's test results to a set of reference standards is useful, an even more desirable approach is to compare the patient's present values to his or her own previous performance. This approach provides greater sensitivity for detecting decrements in lung function, since the coefficient of variation for an individual on a given test is much smaller than the population coefficient of

Table 4–2
Relationship of lung volume and flow rate to type of ventilatory impairment

Interpretation	FVC	FEV_1	(FEV_1/FVC)%
Normal	Normal	Normal	Normal
Airway obstruction	Normal or low	Low	Low
Lung restriction	Low	Normal	Normal
Both obstruction and restriction	Low	Low	Low

SOURCE: Extracted from the Manual of Spirometry in Occupational Medicine, E. P. Horvath (editor), National Institute for Occupational Safety and Health, which was adapted and reprinted from *Chronic Obstructive Pulmonary Disease*, 5th Edition, American Lung Association, 1977.

Table 4–3
Spirometric guidelines for assessing degree of ventilatory impairment

Interpretation	Obstructive disease		Restrictive disease
	(FEV_1/FVC)%	$\frac{FEV_{1\ obs}}{FEV_{1\ pred}}$ %	$\frac{FVC_{obs}}{FVC_{pred}}$ %
Normal	≥ 0.70	≥ 0.80	≥ 0.80
Mild	0.61-0.69	0.66-0.79	0.66-0.79
Moderate	0.45-0.60	0.51-0.65	0.51-0.65
Severe	<0.45	≤ 0.50	≤ 0.50

SOURCE: Extracted from the Manual of Spirometry in Occupational Medicine, E. P. Horvath (editor), National Institute for Occupational Safety and Health, which was adapted from Kanner, R. E. and Morris, A. H., (editors), *Clinical Pulmonary Function Testing*, Intermountain Thoracic Society, Salt Lake City, Utah, 1975.

variation for the same test. Spirometry performed over the course of a workshift or from day-to-day can detect acute transient decrements in lung functions. Longitudinal studies performed over longer intervals (e.g., annually) may discover more insidious, chronic changes at the earliest possible stage.

b. When comparing current spirometric values to previous values, the technician may express the difference as an absolute change in liters or as a percent change. For example, in an annual respiratory surveillance program for asbestos workers, a 24-year-old woman is found to have an FVC of 3.59 liters. Her previous year's FVC was 4.17 liters. The calculation for absolute and percent change are as follows:

$$\text{Absolute change} = \text{Previous FVC} - \text{Current FVC}$$
$$= 4.17 - 3.59$$
$$= 0.58 \text{ liters or a loss of } 0.58 \text{ liters}$$

$$\text{Percent change} = \frac{\text{Previous FVC} - \text{Current FVC}}{\text{Previous FVC}} \times 100$$
$$= \frac{4.17 - 3.59}{4.17} \times 100$$
$$= 13.9 \text{ percent or a decline of } 13.9 \text{ percent}$$

The annual percent change in FEV_1, FVC, and (FEV_1/FVC)% should be calculated and recorded as described in chapter 5.

c. There are many etiologies, other than occupational or nonoccupational lung disorders, for longitudinal decrements in FVC and FEV_1. Cross-sectional studies of normal populations have indicated that both FEV_1 and FVC may decrease by 30 mL each year due to normal aging. Seasonal and diurnal variations in lung volumes and flow rates have been observed. Cigarette smoking may transiently alter certain pulmonary function tests, particularly forced expiratory flow rates. Recent use of aerosolized bronchodilators can produce misleading results. Large fluctuations in ambient temperature over the course of a workshift, which may not be completely compensated for by the usual BTPS correction factors, can result in spurious changes in FEV_1. It is important to emphasize, however, that inconsistent techniques with fluctuating patient effort are the single most important source of variability in test results. Adherence to the procedures described in chapter 3 should minimize variability due to inconsistent technique, fluctuating patient effort, and spirometer inaccuracy.

d. The following guidelines are helpful for interpreting the results of followup spirometry

tests. An annual percentage decline in FEV_1 or FVC of greater than 10 percent should be regarded as potentially abnormal. Similarly, an annual decrease in (FEV_1/FVC)% greater than 5 percent should also be considered abnormal.

e. Changes observed during a single workshift are also used to monitor occupational exposure. For instance, the cotton dust standard emphasizes that a decrement in the FEV_1 of 5 percent or greater over the course of a workshift is significant and requires further investigation. If persistent, it requires preventive intervention.

f. Any abnormal results in either baseline or followup spirometry should be verified by repeat testing with careful attention to patient preparation and technique.

g. Pulmonary function tests are nonspecific; a diagnosis can seldom be made based on spirometric findings alone. The total clinical presentation must be considered when evaluating abnormal spirometry tests, including the respiratory and occupational health histories, physical examination, chest radiograph, and appropriate laboratory studies. It is seldom justifiable to deny a worker employment or transfer the worker to another job solely on the basis of minimally abnormal spirometry. Smoking, nonoccupational pulmonary disease, and other variables noted above are common causes of alterations in pulmonary function.

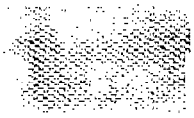
CHAPTER 5
RECORDKEEPING

5–1. Introduction

This chapter sets out the recordkeeping requirements associated with the use of spirometry in occupational health surveillance and the spirometry technician's proficiency.

5–2. Calibration

Daily or weekly equipment checks described in [illegible] recorded on DA Form



5–3. Spirometry test results

a. A tracing of the patient's forced expiratory maneuver (spirogram) is necessary to determine whether the patient has performed the test properly. The three acceptable spirograms produced by the patient must be incorporated into the patient's medical record for future medical review, along with any manual calculations or microprocessor results obtained by the technician. As a minimum, the following information should be recorded on each spirometry tracing: Patient's name, social security number, age, height, sex, and race; room or spirometer temperature; the technician's name; and an evaluation of patient effort (poor, good, or excellent). Any potentially disqualifying factors (recent cigarette, meal, lower respiratory tract infection, or bronchodilating medication) will also be noted on the spirometry tracing.

b. Spirometric results will be recorded on DA Form 5551–R (Spirometry Flow Sheet). Local reproduction of this form is authorized on 8½- by 11-inch paper. (A copy of DA Form 5551–R is located at the end of this publication.) The FEV_1 and FVC should be expressed in liters rounded to 2 decimal places (e.g., 5.61 liters). The (FEV_1/FVC)% and all percent of predicted normals are rounded to 1 decimal place (e.g., 85.4%). Changes in spirometric values over time should be expressed as a percent change—either an increase (+) or a decrease (−) in volume or flow. The technician should always record an assessment of subject cooperation. This flow sheet should be retained in the medical record along with three acceptable spirograms for each spirometry examination.

5–4. Technician training and qualification

The supervisor of each spirometry technician must maintain documentation that the technician has completed a NIOSH-approved course in spirometry and has been qualified to perform spirometry within the previous 3 years. Training requirements and qualification procedures are provided in chapter 6.

CHAPTER 6
TRAINING AND QUALIFICATION REQUIREMENTS FOR SPIROMETRY TECHNICIANS

6–1. General characteristics

The process of obtaining acceptable, reproducible spirograms calls for technicians gifted with both leadership and sensitivity for the patient's welfare. The patient must expend considerable effort to produce a valid spirogram. This exertion must be repeated 3 to 5 times during a complete spirometry examination. The technician, therefore, must be sensitive to any discomfort or fatigue which the patient may experience. At the same time, the technician must also be forceful, encouraging, and enthusiastic while coaching the patient to extract the best possible forced expiratory maneuvers. These demands on the personality of the spirometry technician require that the technician have the following characteristics:

a. The ability to impart concise and understandable instructions to the patient.

b. Willingness to administer the test with strict adherence to detailed procedures.

c. The ability to be patient with test patients, and to be sensitive to the welfare of the patient while demanding the very best effort on each test.

d. Sufficient education to feel comfortable with mathematical calculations, equipment calibration, and the use of standing operating procedures.

6–2. Initial training and qualification

a. As a minimum, every individual performing spirometry as a part of occupational health surveillance for workers exposed to hazardous pulmonary substances above the action levels must complete a training course for spirometry technicians. The curriculum of this course must be NIOSH-approved and taught by qualified health care personnel. Many of the course requirments established by the NIOSH Division of Training and Manpower Development are listed in appendix F. Technicians may fulfill this training requirement in one of two ways:

(1) Attendance at one of the existing NIOSH-approved courses offered by private institutions.

(2) Attendance at an Army-developed course for spirometry technicians which has received NIOSH approval.

Appendix F contains the NIOSH address for course approval applications. NIOSH also maintains a list of approved courses with addresses of course directors.

b. A certificate of course completion must be maintained for each technician performing spirometry in the occupational health clinic. Completion of a NIOSH-approved course in spirometry is a minimum training requirement. Further training and experience with knowledgeable technicians may be desirable before allowing the newly-trained technician to perform spirometry unsupervised. Each new technician must be qualified to conduct spirometry testing as described in paragraph 6–3*b* before performing spirometry in the MTF.

6–3. Quality assurance procedures for technician proficiency

The following procedures will be established to ensure adequate technician proficiency and sufficient quality assurance.

a. A supervisor knowledgeable in the performance and interpretation of spirometry testing should randomly review spirometry examinations in several medical records for each technician on an annual basis. This review should include—

(1) An evaluation of spirogram quality (see table 3–1).

(2) An assessment of the completeness of demographic data.

(3) A judgment as to the accuracy of calculations from the tracings.

(4) A check to see that appropriate predicted values were used and that three acceptable tracings were included in the medical record.

(5) An assessment of the adequacy of calibration records.

b. A supervisor knowledgeable in the performance and interpretation of spirometry testing should conduct a formal qualification test for each spirometry technician at 3-year intervals. This procedure should consist of an actual spirometry examination with the supervisor as patient. Attention should be focused on patient preparation, technique, coaching, tracing acceptability, and accuracy of calculations. The technician should also be asked to demonstrate

calibration procedures to the supervisor as described in chapter 3. The supervisor should discuss any deficiencies or areas for improvement with the technician at the conclusion of the test.

c. Written documentation of the annual medical records review (*a* above) and triennial qualification test (*b* above) must be maintained by the technician's supervisor with copies of these evaluations provided to the technician (para 5–4). The need for remedial training should be addressed by the supervisor after each review or qualification test.

CHAPTER 7
SPIROMETER SPECIFICATIONS

7–1. Introduction

The ATS and NIOSH have developed minimum spirometer specifications for respiratory surveillance programs. OSHA has incorporated these specifications into the cotton dust standard (29 CFR 1910.1043) and will likely require these instrument specifications in future OSHA standards. For this reason, any spirometer used for occupational health surveillance must meet the minimum requirements outlined in this chapter. For more complete information on the rationale behind these requirements, see the "ATS Statement—Snowbird Workshop on Standardization of Spirometry" listed in appendix B.

7–2. Requirements for volume and flow

a. The spirometer must be capable of measuring volumes up to at least 7 liters (after BTPS correction) independent of flow rate for flows between 0 to 12 liters per second.

b. The FVC and FEV_1 accuracy must be within ±3 percent of the calibrated volume or ±50 mL, whichever is greater.

c. The spirometer must be capable of accumulating volume for at least 10 seconds at a paper speed of 20 mm per second or greater.

d. The resistance to airflow at 12 liters per second must be less than 1.5 cm of water per liter per second.

7–3. Recorder requirements

a. The spirometer must be capable of generating tracings for incorporation into the medical record. The instrument used must provide a tracing of volume versus time or flow versus volume for the entire forced expiration.

b. For volume versus time tracings, the recorder must be capable of displaying the entire FVC maneuver at a constant speed for at least 10 seconds after the start of the maneuver.

c. The recorder must have a paper speed of at least 20 mm per second.

d. Volume sensitivity of the recorder must be at least 10 mm per liter of volume and flow sensitivity must be at least 4 mm per liter per second of flow.

e. For volume versus time tracings, the recorder must be capable of being activated and up-to-speed before forced expiration has begun.

7–4. Spirometer or user requirements

a. Many spirometers have microprocessor units which calculate FVC, FEV_1, and percent of predicted normal values. These microprocessor units are capable of correcting for room or spirometer temperature. Technicians must ensure that BTPS corrections are performed by themselves or by the microprocessor before the results are recorded in the medical record.

b. Many microprocessors can calculate extrapolated volumes and detect hesitant expiratory efforts. Technicians must ensure that the start of test or zero time point used for calculating the FEV_1 is consistent with the back extrapolation technique described in chapter 4. This may be done by periodically calculating the FEV_1 by hand and comparing the result to the microprocessor value. (Note: Different FEV_1 values may be obtained when different criteria for start of test are applied to the same tracing.)

c. A microprocessor may serve as a useful aid in expediting calculations and packaging data. The quality of testing is solely the technician's responsibility. The accuracy of data obtained is only as good as the technician's attention, perseverance, and care.

CHAPTER 8
USE OF SPIROMETRY IN THE MEDICAL EVALUATION OF THE RESPIRATOR USER

8–1. Introduction

a. A large number of different respiratory protective devices are in use at Army installations throughout the world. The classification and use of respiratory protective devices are discussed extensively in TB MED 502. Although these devices protect the user from exposure to hazardous pulmonary environments, the respirator creates several unique physiologic burdens for the user. Air-purifying respirators may significantly increase airway resistance on inspiration. Pressure-demand supplied-air respirators may cause increased expiratory airway resistance. Open-circuit self-contained breathing apparatuses (SCBAs) contain cylinders which may weigh up to 35 pounds. These cylinders are carried by the mask wearer, and may reduce work capacity by up to 20 percent. Regulators on current SCBAs do not supply the high instantaneous flow rates that may be required during fire fighting or rescue operations thus impairing work capacity further. All of these factors increase the work of breathing for the respirator wearer.

b. The excess work of breathing is usually well tolerated by young, healthy workers. However, older workers with reduced pulmonary reserve may experience discomfort or find that the added work of breathing is intolerable. Workers with severely abnormal spirometry often will have great difficulty in wearing a respirator. However, the relationship between spirometry and the ability to perform heavy work while wearing a respirator is erratic, particularly in the case of asymptomatic mild obstructive or restrictive lung disease detected by spirometry. This is not surprising since the load imposed by the respirator is reflected more directly on the muscles used for inspiration and expiration. Workers with well-preserved muscles of respiration, in spite of mild decrements detected on spirometry, may tolerate wearing a respirator quite well. However, workers with compromised function of the respiratory musculature may find wearing a respirator intolerable.

c. The point to emphasize is that patient's performance on spirometry cannot be used in isolation of other factors when deciding if the worker is medically or physiologically suited to wear a respirator. The level of work required, frequency of respirator use, and past problems associated with wearing a respirator must be factored in the evaluation. *Spirometry should be used as a screening tool to identify that population of workers who (by virtue of lung function alone) may have difficulty wearing a respirator.*

8–2. Approach

TB MED 502 states that workers should not be assigned to tasks requiring respirators until it has been determined by medical evaluation that they are physically and physiologically able to perform their work while wearing a respirator. Spirometry tests have been recommended as part of this medical evaluation. The question most often asked is: How frequently should spirometry testing be done and on whom? This question is one of medical judgment and cannot be answered in absolute terms. In general, however, every individual who routinely wears respiratory protection as part of his or her duties should have a baseline spirometry examination in the medical record. The frequency of spirometry examinations thereafter will depend on the medical and occupational history obtained at yearly intervals, as well as the general health of the patient:

a. Has the patient had any problems breathing while wearing the respirator during the past year?

b. Have any newly acquired respiratory symptoms appeared?

c. Has the patient developed cardiovascular disease in the intervening period?

d. Have recent examinations shown the patient's lung function declining at a greater rate than expected?

The answers to these questions and many more must be factored into a decision about how frequently tests should be done. In healthy, young asymptomatic patients without respiratory disease, repeat spirometry testing at 3- to 5-year intervals appears reasonable. (Note: Individuals exposed above the action level to hazardous pulmonary substances (e.g., asbestos) may require spirometry on an annual basis, regardless of their age or health. *The distinction here is between spirometry for "medical fitness" to wear a respirator versus spirometry as a part*

of "medical surveillance" for job-related hazardous exposures.) Regardless of how often spirometry testing is performed, it is prudent to review the medical status of the routine respirator user on an annual basis. Further information about the medical evaluation of respirator users may be obtained from the American National Standards Institute (ANSI) Standard Z88.6.

8–3. Guidelines

Having generated the spirometry tracings, the physician may now ask how to interpret these data in the context of the respirator user. The following guidelines will protect the truly impaired individual while not likely disqualifying medically suited personnel:

a. Individuals with spirometry tests within normal range (see table 4–3) have no pulmonary contraindications to wearing a respirator.

b. Individuals with percent of predicted FEV_1 or FVC between 60 and 80 percent should be further evaluated with a "use" test. This evaluation should consist of the worker wearing the respirator and performing representative work activities over a period of time. The physician (or the physician's designated representative) should observe the worker and question him or her regarding any signs or symptoms of respiratory distress. A note should be made in the medical record as to the test results and a conclusion as to the medical suitability of the worker to wear a respirator.

c. Individuals with percent of predicted FEV_1 or FVC less than 60 percent should be restricted from duties where respirator use is frequent and work loads are heavy. The physician should coordinate with the personnel office to ensure that the job requirements do not exceed the worker's physiologic limitations.

APPENDIX A
REFERENCES

Section I
Required Publication

AR 25–400–2 (The Modern Army Recordkeeping System (MARKS)). Cited in paragraph 5–2.

TB MED 502 (Respiratory Protection Program). Cited in paragraph 1–5*b*, 8–1*a*, and 8–2.

Section II
Related Publications*

AR 40–5 (Preventive Medicine)

AR 40–48 (Nonphysician Health Care Providers)

DOD Manual 6055.5–M (Occupational Health Surveillance Manual). Copies may be obtained from the Commander, U.S. Army Environmental Hygiene Agency, ATTN: HSHB–O, Aberdeen Proving Ground, MD 21010–5422.

ANSI Standard Z88.6–1984 (American National Standard for Respiratory Protection—Respirator Use—Physical Qualifications for Personnel). Copies can be obtained from the American National Standards Institute Incorporated, 1430 Broadway, New York, NY 10018.

NIOSH Publication (Manual of Spirometry in Occupational Medicine, E. P. Horvath, ed., November 1981). This manual was prepared in part under NIOSH Purchase Order No. 79–3788. Copies of this publication (GPO: 1984–759–103–1040) can be obtained from the Superintendent of Documents, Government Printing Office, WASH DC 20402.

Section III
Prescribed Forms

DA Form 5550–R (Spirometer Calibration Log). Prescribed in paragraph 5–2.

DA Form 5551–R (Spirometer Flow Sheet). Prescribed in paragraph 5–3*b*.

*A related publication is merely a source of additional information. The user does not have to read it to understand this bulletin.

APPENDIX B
SELECTED BIBLIOGRAPHY

ATS Statement—Snowbird Workshop on Standardization of Spirometry, Reed M. Gardner, Chairman, Medical Devices Committee of American Thoracic Society. *American Review of Respiratory Disease.* 119:831–838, 1979.

Crapo, R. O., Morris, A. H., Gardner, R. M., "Reference Spirometric Values Using Techniques and Equipment that Meet ATS Recommendations." *Am. Rev. Res. Dis.* 123:659–664, 1981.

Harber, P., "Medical Evaluation for Respirator Use," *Journal of Occupational Medicine* 26:496–502, 1984.

Kory, R. et. al. "VA-Army Cooperative Study of Pulmonary Function. I. Clinical Spirometry in Normal Men." *Am. J. Med.* 30:243, 1961.

Knudson, R. et. al. "The Maximal Expiratory Flow-Volume Curve: Normal Standards, Variability, and Effects of Age." *Am. Rev. Res. Dis.* 113:587, 1976.

Miller, A., "The Use of Pulmonary Function Tests in the Evaluation of Disease: Separating Normal from Abnormal:" *Immunology and Allergy Practice* 5:305–315, 1983.

Morris, J. et. al. "Spirometric Standards for Healthy, Non-smoking Adults." *Am. Rev. Res. Dis.* 103:57–67, 1971.

Pennock, B. E., et al., "Changes in Measured Spirometric Indices: What is Significant?" *Chest* 80:97–99, 1981.

Townsend, M. C., and Belk, H. D., "Development of a Standardized Pulmonary Function Evaluation Program in Industry." *Journal of Occupational Medicine* 26:657–661, 1984.

Zenz, Carl (Ed.), Occupational Medicine: Principles and Practical Applications, 2nd ed. Yearbook Medical Publishers, Chicago, IL. In press.

APPENDIX C
SUBSTANCES FOR WHICH SPIROMETRY TESTING IS RECOMMENDED

For the substances listed which do not have legal standards for medical examination, the recommendations in DOD 6055.5–M may be implemented. Spirometry is indicated particularly for those unprotected workers who are exposed to one-half or more of the recommended exposure limit.

ALLYL CHLORIDE
AMMONIA
ANTIMONY
ASBESTOS
BENZOYL PEROXIDE
BENZYL CHLORIDE
BERYLLIUM
BORON TRIFLUORIDE
CADMIUM
CARBARYL (SEVIN; 1–NAPHTHY–N–METHYL CARBAMATE)
CARBON BLACK
CARBON DISULFIDE
CHLORINE
B–CHLOROPRENE (2–CHLORO–1, 3–BUTADIENE)
CHROMIC ACID AND CHROMIUM (IV)
CRESOL (CRESYLIC ACID, MIXED O, M, P ISOMERS)
ETHYLENE DIBROMIDE (1, 2–DIBROMOETHANE)
ETHYLENE DICHLORIDE (1, 2–DICHLOROETHANE)
ETHYLENE OXIDE
FIBROUS GLASSZINC OXIDE
FORMALDEHYDE
GLYCIDYL ETHERS (2, 3–EPOXYPROPL ETHERS)
HYDROGEN CYANIDE AND CYANIDE SALTS
HYDROGEN FLUORIDE
HYDROGEN SULFIDE
ISOPROPYL ALCOHOL
4, 4^1–METHYLENE BIS (2–CHLOROANILINE) (MOCA)
METHYLENE CHLORIDE (DICHLOROMETHANE)
METHYL (N–AMYL) KETONE (2–HEPTANONE)
NICKEL CARBONYL
NICKEL (INORGANIC)
NITRIC ACID
NITROGEN OXIDES
ORGANIC TIN COMPOUNDS
PHOSGENE (CARBONYL CHLORIDE)
SILICA (CRYSTALLINE)
SODIUM HYDROXIDE
SULFUR DIOXIDE
SULFURIC ACID
TOLUENE–2, 4–DIISOCYANATE (TDI) (AND ALL ORGANIC ISOCYNATES)
1, 1, 1–TRICHLOROETHYLENE
TUNGSTEN AND CEMENTED TUNGSTEN CARBIDE
VANADIUM
VINYL ACETATE
VINYL CHLORIDE (CHLOROETHANE)
XYLENE
ZINC OXIDE

APPENDIX D
SPIROMETRY CALCULATION OUTLINE

D–1. *Measure* FVC in each tracing from baseline to plateau.

D–2. *Select* largest FVC from the three acceptable tracings.

D–3. *Measure* FEV_1 in each curve. Use back extrapolation if necessary to determine zero time point.

D–4. *Select* largest FEV_1 from the three tracings. (Usually found on the same curve as the largest FVC).

D–5. *Determine* BTPS conversion factor from table using room temperature.

D–6. *Multiply:*

$FEV_{1(spirogram)} \times \text{BTPS conversion factor} = FEV_{1\ obs(BTPS)}$

$FVC_{(spirogram)} \times \text{BTPS conversion factor} = FVC_{obs(BTPS)}$

D–7. *Determine* FEV_1 predicted and FVC predicted from the tables in appendix E, using race, sex, height, and age.

D–8. *Divide:*

$FEV_{1\ obs} \div FEV_{1\ pred} \times 100 = FEV_1\%$ predicted normal

$FVC_{obs} \div FVC_{pred} \times 100 = FVC\%$ predicted normal

D–9. For $(FEV_1/FVC)\%$ *divide:*

$FEV_{1\ obs} \div FVC_{obs} \times 100 = (FEV_1/FVC)\%$

NOTE: Use the largest FEV_1 and FVC in this calculation, even if they do not come from the same curve.

D–10. *Summary:*

$FEV_{1(spirogram)} \times \text{BTPS conversion factor} = FEV_{1\ obs(BTPS)}$

$FVC_{(spirogram)} \times \text{BTPS conversion factor} = FVC_{obs(BTPS)}$

$FEV_{1\ obs} \div FVC_{obs} \times 100 = (FEV_1/FVC)\%$

$FEV_{1\ obs} \div FEV_{1pred} \times 100 = FEV_1\%$ predicted normal

$FVC_{obs} \div FVC_{pred} \times 100 = FVC\%$ predicted normal

APPENDIX E
PREDICTED VALUES

The source for tables E–1 through E–8 is 29 CFR 1910.1043.

Table E-1
Predicted FEV_1 for white males

	HEIGHT IN INCHES																							
AGE	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
16	2.81	2.92	3.04	3.16	3.27	3.39	3.51	3.62	3.74	3.86	3.97	4.09	4.21	4.32	4.44	4.56	4.68	4.79	4.91	5.03	5.14	5.26	5.38	5.49	5.61
17	2.85	2.97	3.08	3.20	3.32	3.43	3.55	3.67	3.79	3.90	4.02	4.14	4.25	4.37	4.49	4.60	4.72	4.84	4.95	5.07	5.19	5.30	5.42	5.54	5.65
18	2.90	3.01	3.13	3.25	3.36	3.48	3.60	3.71	3.83	3.95	4.06	4.18	4.30	4.41	4.53	4.65	4.77	4.88	5.00	5.12	5.23	5.35	5.47	5.58	5.70
19	2.94	3.06	3.17	3.29	3.41	3.52	3.64	3.76	3.88	3.99	4.11	4.23	4.34	4.46	4.58	4.69	4.81	4.93	5.04	5.16	5.28	5.39	5.51	5.63	5.74
20	2.99	3.10	3.22	3.34	3.45	3.57	3.69	3.80	3.92	4.04	4.15	4.27	4.39	4.50	4.62	4.74	4.86	4.97	5.09	5.21	5.32	5.44	5.56	5.67	5.79
21	3.03	3.15	3.26	3.38	3.50	3.61	3.73	3.85	3.97	4.08	4.20	4.32	4.43	4.55	4.67	4.78	4.90	5.02	5.13	5.25	5.37	5.48	5.60	5.72	5.83
22	3.08	3.19	3.31	3.43	3.54	3.66	3.78	3.89	4.01	4.13	4.24	4.36	4.48	4.59	4.71	4.83	4.95	5.06	5.18	5.30	5.41	5.53	5.65	5.76	5.88
23	3.12	3.24	3.35	3.47	3.59	3.70	3.82	3.94	4.06	4.17	4.29	4.41	4.52	4.64	4.76	4.87	4.99	5.11	5.22	5.34	5.46	5.57	5.69	5.81	5.92
24	3.17	3.28	3.40	3.52	3.63	3.75	3.87	3.98	4.10	4.22	4.33	4.45	4.57	4.68	4.80	4.92	5.04	5.15	5.27	5.39	5.50	5.62	5.74	5.85	5.97
25	2.91	3.05	3.18	3.31	3.44	3.58	3.71	3.84	3.97	4.10	4.24	4.37	4.50	4.63	4.76	4.90	5.03	5.16	5.29	5.42	5.56	5.69	5.82	5.95	6.08
26	2.89	3.02	3.15	3.28	3.42	3.55	3.68	3.81	3.94	4.08	4.21	4.34	4.47	4.60	4.74	4.87	5.00	5.13	5.27	5.40	5.53	5.66	5.79	5.93	6.06
27	2.86	2.99	3.12	3.26	3.39	3.52	3.65	3.79	3.92	4.05	4.18	4.31	4.45	4.58	4.71	4.84	4.97	5.11	5.24	5.37	5.50	5.63	5.77	5.90	6.03
28	2.83	2.97	3.10	3.23	3.36	3.49	3.63	3.76	3.89	4.02	4.15	4.29	4.42	4.55	4.68	4.81	4.95	5.08	5.21	5.34	5.48	5.61	5.74	5.87	6.00
29	2.81	2.94	3.07	3.20	3.34	3.47	3.60	3.73	3.86	4.00	4.13	4.26	4.39	4.52	4.66	4.79	4.92	5.05	5.18	5.32	5.45	5.58	5.71	5.84	5.98
30	2.78	2.91	3.04	3.18	3.31	3.44	3.57	3.70	3.84	3.97	4.10	4.23	4.36	4.50	4.63	4.76	4.89	5.03	5.16	5.29	5.42	5.55	5.69	5.82	5.95
31	2.75	2.88	3.02	3.15	3.28	3.41	3.55	3.68	3.81	3.94	4.07	4.21	4.34	4.47	4.60	4.73	4.87	5.00	5.13	5.26	5.39	5.53	5.66	5.79	5.92
32	2.73	2.86	2.99	3.12	3.25	3.39	3.52	3.65	3.78	3.91	4.05	4.18	4.31	4.44	4.57	4.71	4.84	4.97	5.10	5.24	5.37	5.50	5.63	5.76	5.90
33	2.70	2.83	2.96	3.09	3.23	3.36	3.49	3.62	3.76	3.89	4.02	4.15	4.28	4.42	4.55	4.68	4.81	4.94	5.08	5.21	5.34	5.47	5.60	5.74	5.87
34	2.67	2.80	2.94	3.07	3.20	3.33	3.46	3.60	3.73	3.86	3.99	4.12	4.26	4.39	4.52	4.65	4.79	4.92	5.05	5.18	5.31	5.45	5.58	5.71	5.84
35	2.64	2.78	2.91	3.04	3.17	3.31	3.44	3.57	3.70	3.83	3.97	4.10	4.23	4.36	4.49	4.63	4.76	4.89	5.02	5.15	5.29	5.42	5.55	5.68	5.81
36	2.62	2.75	2.88	3.01	3.15	3.28	3.41	3.54	3.67	3.81	3.94	4.07	4.20	4.33	4.47	4.60	4.73	4.86	5.00	5.13	5.26	5.39	5.52	5.66	5.79
37	2.59	2.72	2.85	2.99	3.12	3.25	3.38	3.52	3.65	3.78	3.91	4.04	4.18	4.31	4.44	4.57	4.70	4.84	4.97	5.10	5.23	5.36	5.50	5.63	5.76
38	2.56	2.70	2.83	2.96	3.09	3.22	3.36	3.49	3.62	3.75	3.88	4.02	4.15	4.28	4.41	4.54	4.68	4.81	4.94	5.07	5.21	5.34	5.47	5.60	5.73
39	2.54	2.67	2.80	2.93	3.07	3.20	3.33	3.46	3.59	3.73	3.86	3.99	4.12	4.25	4.39	4.52	4.65	4.78	4.91	5.05	5.18	5.31	5.44	5.57	5.71
40	2.51	2.64	2.77	2.91	3.04	3.17	3.30	3.43	3.57	3.70	3.83	3.96	4.09	4.23	4.36	4.49	4.62	4.76	4.89	5.02	5.15	5.28	5.42	5.55	5.68
41	2.48	2.61	2.75	2.88	3.01	3.14	3.28	3.41	3.54	3.67	3.80	3.94	4.07	4.20	4.33	4.46	4.60	4.73	4.86	4.99	5.12	5.26	5.39	5.52	5.65
42	2.46	2.59	2.72	2.85	2.98	3.12	3.25	3.38	3.51	3.64	3.78	3.91	4.04	4.17	4.30	4.44	4.57	4.70	4.83	4.97	5.10	5.23	5.36	5.49	5.63
43	2.43	2.56	2.69	2.82	2.96	3.09	3.22	3.35	3.49	3.62	3.75	3.88	4.01	4.15	4.28	4.41	4.54	4.67	4.81	4.94	5.07	5.20	5.33	5.47	5.60
44	2.40	2.53	2.67	2.80	2.93	3.06	3.19	3.33	3.46	3.59	3.72	3.85	3.99	4.12	4.25	4.38	4.52	4.65	4.78	4.91	5.04	5.18	5.31	5.44	5.57
45	2.37	2.51	2.64	2.77	2.90	3.04	3.17	3.30	3.43	3.56	3.70	3.83	3.96	4.09	4.22	4.36	4.49	4.62	4.75	4.88	5.02	5.15	5.28	5.41	5.54
46	2.35	2.48	2.61	2.74	2.88	3.01	3.14	3.27	3.40	3.54	3.67	3.80	3.93	4.06	4.20	4.33	4.46	4.59	4.73	4.86	4.99	5.12	5.25	5.39	5.52
47	2.32	2.45	2.58	2.72	2.85	2.98	3.11	3.25	3.38	3.51	3.64	3.77	3.91	4.04	4.17	4.30	4.43	4.57	4.70	4.83	4.96	5.09	5.23	5.36	5.49
48	2.29	2.43	2.56	2.69	2.82	2.95	3.09	3.22	3.35	3.48	3.61	3.75	3.88	4.01	4.14	4.27	4.41	4.54	4.67	4.80	4.94	5.07	5.20	5.33	5.46
49	2.27	2.40	2.53	2.66	2.80	2.93	3.06	3.19	3.32	3.46	3.59	3.72	3.85	3.98	4.12	4.25	4.38	4.51	4.64	4.78	4.91	5.04	5.17	5.30	5.44
50	2.24	2.37	2.50	2.64	2.77	2.90	3.03	3.16	3.30	3.43	3.56	3.69	3.82	3.96	4.09	4.22	4.35	4.49	4.62	4.75	4.88	5.01	5.15	5.28	5.41
51	2.21	2.34	2.48	2.61	2.74	2.87	3.01	3.14	3.27	3.40	3.53	3.67	3.80	3.93	4.06	4.19	4.33	4.46	4.59	4.72	4.85	4.99	5.12	5.25	5.38
52	2.19	2.32	2.45	2.58	2.71	2.85	2.98	3.11	3.24	3.37	3.51	3.64	3.77	3.90	4.03	4.17	4.30	4.43	4.56	4.70	4.83	4.96	5.09	5.22	5.36
53	2.16	2.29	2.42	2.55	2.69	2.82	2.95	3.08	3.22	3.35	3.48	3.61	3.74	3.88	4.01	4.14	4.27	4.40	4.54	4.67	4.80	4.93	5.06	5.20	5.33
54	2.13	2.26	2.40	2.53	2.66	2.79	2.92	3.06	3.19	3.32	3.45	3.58	3.72	3.85	3.98	4.11	4.25	4.38	4.51	4.64	4.77	4.91	5.04	5.17	5.30
55	2.10	2.24	2.37	2.50	2.63	2.77	2.90	3.03	3.16	3.29	3.43	3.56	3.69	3.82	3.95	4.09	4.22	4.35	4.48	4.61	4.75	4.88	5.01	5.14	5.27
56	2.08	2.21	2.34	2.47	2.61	2.74	2.87	3.00	3.13	3.27	3.40	3.53	3.66	3.79	3.93	4.06	4.19	4.32	4.46	4.59	4.72	4.85	4.98	5.12	5.25
57	2.05	2.18	2.31	2.45	2.58	2.71	2.84	2.98	3.11	3.24	3.37	3.50	3.64	3.77	3.90	4.03	4.16	4.30	4.43	4.56	4.69	4.82	4.96	5.09	5.22
58	2.02	2.16	2.29	2.42	2.55	2.68	2.82	2.95	3.08	3.21	3.34	3.48	3.61	3.74	3.87	4.00	4.14	4.27	4.40	4.53	4.67	4.80	4.93	5.06	5.19
59	2.00	2.13	2.26	2.39	2.53	2.66	2.79	2.92	3.05	3.19	3.32	3.45	3.58	3.71	3.85	3.98	4.11	4.24	4.37	4.51	4.64	4.77	4.90	5.03	5.17
60	1.97	2.10	2.23	2.37	2.50	2.63	2.76	2.89	3.03	3.16	3.29	3.42	3.55	3.69	3.82	3.95	4.08	4.22	4.35	4.48	4.61	4.74	4.88	5.01	5.14
61	1.94	2.07	2.21	2.34	2.47	2.60	2.74	2.87	3.00	3.13	3.26	3.40	3.53	3.66	3.79	3.92	4.06	4.19	4.32	4.45	4.58	4.72	4.85	4.98	5.11
62	1.92	2.05	2.18	2.31	2.44	2.58	2.71	2.84	2.97	3.10	3.24	3.37	3.50	3.63	3.76	3.90	4.03	4.16	4.29	4.43	4.56	4.69	4.82	4.95	5.09
63	1.89	2.02	2.15	2.28	2.42	2.55	2.68	2.81	2.95	3.08	3.21	3.34	3.47	3.61	3.74	3.87	4.00	4.13	4.27	4.40	4.53	4.66	4.79	4.93	5.06
64	1.86	1.99	2.13	2.26	2.39	2.52	2.65	2.79	2.92	3.05	3.13	3.31	3.45	3.58	3.71	3.84	3.98	4.11	4.24	4.37	4.50	4.64	4.77	4.90	5.03
65	1.83	1.97	2.10	2.23	2.36	2.50	2.63	2.76	2.89	3.02	3.16	3.29	3.42	3.55	3.68	3.82	3.95	4.08	4.21	4.34	4.48	4.61	4.74	4.87	5.00
66	1.81	1.94	2.07	2.20	2.34	2.47	2.60	2.73	2.86	3.00	3.13	3.26	3.39	3.52	3.66	3.79	3.92	4.05	4.19	4.32	4.45	4.58	4.71	4.85	4.98
67	1.78	1.91	2.04	2.18	2.31	2.44	2.57	2.71	2.84	2.97	3.10	3.23	3.37	3.50	3.63	3.76	3.89	4.03	4.16	4.29	4.42	4.55	4.69	4.82	4.95
68	1.75	1.89	2.02	2.15	2.28	2.41	2.55	2.68	2.81	2.94	3.07	3.21	3.34	3.47	3.60	3.73	3.87	4.00	4.13	4.26	4.40	4.53	4.66	4.79	4.92
69	1.73	1.86	1.99	2.12	2.26	2.32	2.52	2.65	2.78	2.92	3.05	3.18	3.31	3.44	3.58	3.71	3.84	3.97	4.10	4.24	4.37	4.50	4.63	4.76	4.90

**NOTE: ALL VALUES ARE AT BTPS

Table E-2
Predicted FVC for white males

	HEIGHT IN INCHES																							
AGE	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
16	3.23	3.36	3.49	3.61	3.74	3.87	4.00	4.12	4.25	4.38	4.50	4.63	4.76	4.88	5.01	5.14	5.27	5.39	5.52	5.65	5.77	5.90	6.03	6.15	6.28
17	3.31	3.44	3.57	3.69	3.82	3.95	4.07	4.20	4.33	4.45	4.58	4.71	4.84	4.96	5.09	5.22	5.34	5.47	5.60	5.72	5.85	5.98	6.11	6.23	6.36
18	3.39	3.52	3.64	3.77	3.90	4.02	4.15	4.28	4.41	4.53	4.66	4.79	4.91	5.04	5.17	5.29	5.42	5.55	5.68	5.80	5.93	6.06	6.18	6.31	6.44
19	3.47	3.59	3.72	3.85	3.98	4.10	4.23	4.36	4.48	4.61	4.74	4.86	4.99	5.12	5.25	5.37	5.50	5.63	5.75	5.88	6.01	6.13	6.26	6.39	6.52
20	3.55	3.67	3.80	3.93	4.05	4.18	4.31	4.43	4.56	4.69	4.82	4.94	5.07	5.20	5.32	5.45	5.58	5.70	5.83	5.96	6.09	6.21	6.34	6.47	6.59
21	3.62	3.75	3.88	4.00	4.13	4.26	4.39	4.51	4.64	4.77	4.89	5.02	5.15	5.27	5.40	5.53	5.66	5.78	5.91	6.04	6.16	6.29	6.42	6.54	6.67
22	3.70	3.83	3.96	4.08	4.21	4.34	4.46	4.59	4.72	4.84	4.97	5.10	5.23	5.35	5.48	5.61	5.73	5.86	5.99	6.11	6.24	6.37	6.50	6.62	6.75
23	3.78	3.91	4.03	4.16	4.29	4.41	4.54	4.67	4.80	4.92	5.05	5.18	5.30	5.43	5.56	5.68	5.81	5.94	6.07	6.19	6.32	6.45	6.57	6.70	6.83
24	3.86	3.98	4.11	4.24	4.37	4.49	4.62	4.75	4.87	5.00	5.13	5.25	5.38	5.51	5.64	5.76	5.89	6.02	6.14	6.27	6.40	6.52	6.65	6.78	6.91
25	3.56	3.72	3.89	4.05	4.22	4.38	4.55	4.71	4.88	5.04	5.21	5.37	5.54	5.70	5.87	6.03	6.20	6.36	6.53	6.69	6.86	7.02	7.19	7.35	7.52
26	3.53	3.69	3.86	4.02	4.19	4.35	4.52	4.68	4.85	5.01	5.18	5.34	5.51	5.67	5.84	6.00	6.17	6.33	6.50	6.66	6.83	7.00	7.16	7.33	7.49
27	3.50	3.66	3.83	3.99	4.16	4.32	4.49	4.65	4.82	4.98	5.15	5.32	5.48	5.65	5.81	5.98	6.14	6.31	6.47	6.64	6.80	6.97	7.13	7.30	7.46
28	3.47	3.64	3.80	3.97	4.13	4.30	4.46	4.63	4.79	4.96	5.12	5.29	5.45	5.62	5.78	5.95	6.11	6.28	6.44	6.61	6.77	6.94	7.10	7.27	7.43
29	3.44	3.61	3.77	3.94	4.10	4.27	4.43	4.60	4.76	4.93	5.09	5.26	5.42	5.59	5.75	5.92	6.08	6.25	6.41	6.58	6.74	6.91	7.07	7.24	7.40
30	3.41	3.58	3.74	3.91	4.07	4.24	4.40	4.57	4.73	4.90	5.06	5.23	5.39	5.56	5.72	5.89	6.05	6.22	6.38	6.55	6.71	6.88	7.04	7.21	7.37
31	3.38	3.55	3.71	3.88	4.04	4.21	4.37	4.54	4.70	4.87	5.03	5.20	5.36	5.53	5.69	5.86	6.02	6.19	6.35	6.52	6.68	6.85	7.02	7.18	7.35
32	3.35	3.52	3.68	3.85	4.01	4.18	4.34	4.51	4.67	4.84	5.00	5.17	5.34	5.50	5.67	5.83	6.00	6.16	6.33	6.49	6.66	6.82	6.99	7.15	7.32
33	3.32	3.49	3.66	3.82	3.99	4.15	4.32	4.48	4.65	4.81	4.98	5.14	5.31	5.47	5.64	5.80	5.97	6.13	6.30	6.46	6.63	6.79	6.96	7.12	7.29
34	3.30	3.46	3.63	3.79	3.96	4.12	4.29	4.45	4.62	4.78	4.95	5.11	5.28	5.44	5.61	5.77	5.94	6.10	6.27	6.43	6.60	6.76	6.93	7.09	7.26
35	3.27	3.43	3.60	3.76	3.93	4.09	4.26	4.42	4.59	4.75	4.92	5.08	5.25	5.41	5.58	5.74	5.91	6.07	6.24	6.40	6.57	6.73	6.90	7.06	7.23
36	3.24	3.40	3.57	3.73	3.90	4.06	4.23	4.39	4.56	4.72	4.89	5.05	5.22	5.38	5.55	5.71	5.88	6.04	6.21	6.37	6.54	6.71	6.87	7.04	7.20
37	3.21	3.37	3.54	3.70	3.87	4.03	4.20	4.36	4.53	4.69	4.86	5.03	5.19	5.36	5.52	5.69	5.85	6.02	6.18	6.35	6.51	6.68	6.84	7.01	7.17
38	3.18	3.35	3.51	3.68	3.84	4.01	4.17	4.34	4.50	4.67	4.83	5.00	5.16	5.33	5.49	5.66	5.82	5.99	6.15	6.32	6.48	6.65	6.81	6.98	7.14
39	3.15	3.32	3.48	3.65	3.81	3.98	4.14	4.31	4.47	4.64	4.80	4.97	5.13	5.30	5.46	5.63	5.79	5.96	6.12	6.29	6.45	6.62	6.78	6.95	7.11
40	3.12	3.29	3.45	3.62	3.78	3.95	4.11	4.28	4.44	4.61	4.77	4.94	5.10	5.27	5.43	5.60	5.76	5.93	6.09	6.26	6.42	6.59	6.75	6.92	7.08
41	3.09	3.26	3.42	3.59	3.75	3.92	4.08	4.25	4.41	4.58	4.74	4.91	5.07	5.24	5.40	5.57	5.73	5.90	6.06	6.23	6.39	6.56	6.73	6.89	7.06
42	3.06	3.23	3.39	3.56	3.72	3.89	4.05	4.22	4.38	4.55	4.71	4.88	5.05	5.21	5.38	5.54	5.71	5.87	6.04	6.20	6.37	6.53	6.70	6.86	7.03
43	3.03	3.20	3.37	3.53	3.70	3.86	4.03	4.19	4.36	4.52	4.69	4.85	5.02	5.18	5.35	5.51	5.68	5.84	6.01	6.17	6.34	6.50	6.67	6.83	7.00
44	3.01	3.17	3.34	3.50	3.67	3.83	4.00	4.16	4.33	4.49	4.66	4.82	4.99	5.15	5.32	5.48	5.65	5.81	5.98	6.14	6.31	6.47	6.64	6.80	6.97
45	2.98	3.14	3.31	3.47	3.64	3.80	3.97	4.13	4.30	4.46	4.63	4.79	4.96	5.12	5.29	5.45	5.62	5.78	5.95	6.11	6.28	6.44	6.61	6.77	6.94
46	2.95	3.11	3.28	3.44	3.61	3.77	3.94	4.10	4.27	4.43	4.60	4.76	4.93	5.09	5.26	5.42	5.59	5.75	5.92	6.08	6.25	6.42	6.58	6.75	6.91
47	2.92	3.08	3.25	3.41	3.58	3.74	3.91	4.07	4.24	4.40	4.57	4.74	4.90	5.07	5.23	5.40	5.56	5.73	5.89	6.06	6.22	6.39	6.55	6.72	6.88
48	2.89	3.06	3.22	3.39	3.55	3.72	3.88	4.05	4.21	4.38	4.54	4.71	4.87	5.04	5.20	5.37	5.53	5.70	5.86	6.03	6.19	6.36	6.52	6.69	6.85
49	2.86	3.03	3.19	3.36	3.52	3.69	3.85	4.02	4.18	4.35	4.51	4.68	4.84	5.01	5.17	5.34	5.50	5.67	5.83	6.00	6.16	6.33	6.49	6.66	6.82
50	2.83	3.00	3.16	3.33	3.49	3.66	3.82	3.99	4.15	4.32	4.48	4.65	4.81	4.98	5.14	5.31	5.47	5.64	5.80	5.97	6.13	6.30	6.46	6.63	6.79
51	2.80	2.97	3.13	3.30	3.46	3.63	3.79	3.96	4.12	4.29	4.45	4.62	4.78	4.95	5.11	5.28	5.44	5.61	5.77	5.94	6.10	6.27	6.44	6.60	6.77
52	2.77	2.94	3.10	3.27	3.43	3.60	3.76	3.93	4.09	4.26	4.42	4.59	4.76	4.92	5.09	5.25	5.42	5.58	5.75	5.91	6.08	6.24	6.41	6.57	6.74
53	2.74	2.91	3.08	3.24	3.41	3.57	3.74	3.90	4.07	4.23	4.40	4.56	4.73	4.89	5.06	5.22	5.39	5.55	5.72	5.88	6.05	6.21	6.38	6.54	6.71
54	2.72	2.88	3.05	3.21	3.38	3.54	3.71	3.87	4.04	4.20	4.37	4.53	4.70	4.86	5.03	5.19	5.36	5.52	5.69	5.85	6.02	6.18	6.35	6.51	6.68
55	2.69	2.85	3.02	3.18	3.35	3.51	3.68	3.84	4.01	4.17	4.34	4.50	4.67	4.83	5.00	5.16	5.33	5.49	5.66	5.82	5.99	6.15	6.32	6.48	6.65
56	2.66	2.82	2.99	3.15	3.32	3.48	3.65	3.81	3.98	4.14	4.31	4.47	4.64	4.80	4.97	5.13	5.30	5.46	5.63	5.79	5.96	6.13	6.29	6.46	6.62
57	2.63	2.79	2.96	3.12	3.29	3.45	3.62	3.78	3.95	4.11	4.28	4.45	4.61	4.78	4.94	5.11	5.27	5.44	5.60	5.77	5.93	6.10	6.26	6.43	6.59
58	2.60	2.77	2.93	3.10	3.26	3.43	3.59	3.76	3.92	4.09	4.25	4.42	4.58	4.75	4.91	5.08	5.24	5.41	5.57	5.74	5.90	6.07	6.23	6.40	6.56
59	2.57	2.74	2.90	3.07	3.23	3.40	3.56	3.73	3.89	4.06	4.22	4.39	4.55	4.72	4.88	5.05	5.21	5.38	5.54	5.71	5.87	6.04	6.20	6.37	6.53
60	2.54	2.71	2.87	3.04	3.20	3.37	3.53	3.70	3.86	4.03	4.19	4.36	4.52	4.69	4.85	5.02	5.18	5.35	5.51	5.68	5.84	6.01	6.17	6.34	6.50
61	2.51	2.68	2.84	3.01	3.17	3.34	3.50	3.67	3.83	4.00	4.16	4.33	4.49	4.66	4.82	4.99	5.15	5.32	5.48	5.65	5.81	5.98	6.15	6.31	6.48
62	2.48	2.65	2.81	2.98	3.14	3.31	3.47	3.64	3.80	3.97	4.13	4.30	4.47	4.63	4.80	4.96	5.13	5.29	5.46	5.62	5.79	5.95	6.12	6.28	6.45
63	2.45	2.62	2.79	2.95	3.12	3.28	3.45	3.61	3.78	3.94	4.11	4.27	4.44	4.60	4.77	4.93	5.10	5.26	5.43	5.59	5.76	5.92	6.09	6.25	6.42
64	2.43	2.59	2.76	2.92	3.09	3.25	3.42	3.58	3.75	3.91	4.08	4.24	4.41	4.57	4.74	4.90	5.07	5.23	5.40	5.56	5.73	5.89	6.06	6.22	6.39
65	2.40	2.56	2.73	2.89	3.06	3.22	3.39	3.55	3.72	3.88	4.05	4.21	4.38	4.54	4.71	4.87	5.04	5.20	5.37	5.53	5.70	5.86	6.03	6.19	6.36
66	2.37	2.53	2.70	2.86	3.03	3.19	3.36	3.52	3.69	3.85	4.02	4.18	4.35	4.51	4.68	4.84	5.01	5.17	5.34	5.50	5.67	5.84	6.00	6.17	6.33
67	2.34	2.50	2.67	2.83	3.00	3.16	3.33	3.49	3.66	3.82	3.99	4.16	4.32	4.49	4.65	4.82	4.98	5.15	5.31	5.48	5.64	5.81	5.97	6.14	6.30
68	2.31	2.48	2.64	2.81	2.97	3.14	3.30	3.47	3.63	3.80	3.96	4.13	4.29	4.46	4.62	4.79	4.95	5.12	5.28	5.45	5.61	5.78	5.94	6.11	6.27
69	2.28	2.45	2.61	2.78	2.94	3.11	3.27	3.44	3.60	3.77	3.93	4.10	4.26	4.43	4.59	4.76	4.92	5.09	5.25	5.42	5.58	5.75	5.91	6.08	6.24

**NOTE: ALL VALUES ARE AT BTPS

Table E-3
Predicted FEV_1 for white females

	HEIGHT IN INCHES																							
AGE	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
16	2.29	2.36	2.43	2.50	2.57	2.63	2.70	2.77	2.84	2.91	2.98	3.05	3.11	3.18	3.25	3.32	3.39	3.46	3.53	3.59	3.66	3.73	3.80	3.87	3.94
17	2.38	2.45	2.51	2.58	2.65	2.72	2.79	2.86	2.93	2.99	3.06	3.13	3.20	3.27	3.34	3.41	3.47	3.54	3.61	3.68	3.75	3.82	3.89	3.95	4.02
18	2.46	2.53	2.60	2.67	2.74	2.80	2.87	2.94	3.01	3.08	3.15	3.22	3.28	3.35	3.42	3.49	3.56	3.63	3.70	3.76	3.83	3.90	3.97	4.04	4.11
19	2.55	2.62	2.68	2.75	2.82	2.89	2.96	3.03	3.10	3.16	3.23	3.30	3.37	3.44	3.51	3.58	3.64	3.71	3.78	3.85	3.92	3.99	4.06	4.12	4.19
20	2.42	2.49	2.56	2.63	2.70	2.76	2.83	2.90	2.97	3.04	3.11	3.18	3.24	3.31	3.38	3.45	3.52	3.59	3.66	3.72	3.79	3.86	3.93	4.00	4.07
21	2.40	2.47	2.54	2.61	2.67	2.74	2.81	2.88	2.95	3.02	3.09	3.15	3.22	3.29	3.36	3.43	3.50	3.57	3.63	3.70	3.77	3.84	3.91	3.98	4.05
22	2.38	2.45	2.52	2.58	2.65	2.72	2.79	2.86	2.93	3.00	3.06	3.13	3.20	3.27	3.34	3.41	3.48	3.54	3.61	3.68	3.75	3.82	3.89	3.96	4.02
23	2.36	2.43	2.49	2.56	2.63	2.70	2.77	2.84	2.91	2.97	3.04	3.11	3.18	3.25	3.32	3.39	3.46	3.52	3.59	3.66	3.73	3.80	3.87	3.94	4.00
24	2.34	2.41	2.47	2.54	2.61	2.68	2.75	2.82	2.89	2.95	3.02	3.09	3.16	3.23	3.30	3.37	3.43	3.50	3.57	3.64	3.71	3.78	3.85	3.91	3.98
25	2.32	2.38	2.45	2.52	2.59	2.66	2.73	2.80	2.86	2.93	3.00	3.07	3.14	3.21	3.28	3.34	3.41	3.48	3.55	3.62	3.69	3.76	3.82	3.89	3.96
26	2.29	2.36	2.43	2.50	2.57	2.64	2.71	2.77	2.84	2.91	2.98	3.05	3.12	3.19	3.25	3.32	3.39	3.46	3.53	3.60	3.67	3.73	3.80	3.87	3.94
27	2.27	2.34	2.41	2.48	2.55	2.62	2.69	2.75	2.82	2.89	2.96	3.03	3.10	3.17	3.23	3.30	3.37	3.44	3.51	3.58	3.65	3.71	3.78	3.85	3.92
28	2.25	2.32	2.39	2.46	2.53	2.60	2.66	2.73	2.80	2.87	2.94	3.01	3.08	3.14	3.21	3.28	3.35	3.42	3.49	3.56	3.62	3.69	3.76	3.83	3.90
29	2.23	2.30	2.37	2.44	2.51	2.57	2.64	2.71	2.78	2.85	2.92	2.99	3.05	3.12	3.19	3.26	3.33	3.40	3.47	3.53	3.60	3.67	3.74	3.81	3.88
30	2.21	2.28	2.35	2.42	2.49	2.55	2.62	2.69	2.76	2.83	2.90	2.97	3.03	3.10	3.17	3.24	3.31	3.38	3.45	3.51	3.58	3.65	3.72	3.79	3.86
31	2.19	2.26	2.33	2.40	2.46	2.53	2.60	2.67	2.74	2.81	2.88	2.94	3.01	3.08	3.15	3.22	3.29	3.36	3.42	3.49	3.56	3.63	3.70	3.77	3.84
32	2.17	2.24	2.31	2.37	2.44	2.51	2.58	2.65	2.72	2.79	2.85	2.92	2.99	3.06	3.13	3.20	3.27	3.33	3.40	3.47	3.54	3.61	3.68	3.75	3.81
33	2.15	2.22	2.28	2.35	2.42	2.49	2.56	2.63	2.70	2.76	2.83	2.90	2.97	3.04	3.11	3.18	3.25	3.31	3.38	3.45	3.52	3.59	3.66	3.73	3.79
34	2.13	2.20	2.26	2.33	2.40	2.47	2.54	2.61	2.68	2.74	2.81	2.88	2.95	3.02	3.09	3.16	3.22	3.29	3.36	3.43	3.50	3.57	3.64	3.70	3.77
35	2.11	2.17	2.24	2.31	2.38	2.45	2.52	2.59	2.65	2.72	2.79	2.86	2.93	3.00	3.07	3.13	3.20	3.27	3.34	3.41	3.48	3.55	3.61	3.68	3.75
36	2.08	2.15	2.22	2.29	2.36	2.43	2.50	2.56	2.63	2.70	2.77	2.84	2.91	2.98	3.04	3.11	3.18	3.25	3.32	3.39	3.46	3.52	3.59	3.66	3.73
37	2.06	2.13	2.20	2.27	2.34	2.41	2.48	2.54	2.61	2.68	2.75	2.82	2.89	2.96	3.02	3.09	3.16	3.23	3.30	3.37	3.44	3.50	3.57	3.64	3.71
38	2.04	2.11	2.18	2.25	2.32	2.39	2.45	2.52	2.59	2.66	2.73	2.80	2.87	2.93	3.00	3.07	3.14	3.21	3.28	3.35	3.41	3.48	3.55	3.62	3.69
39	2.02	2.09	2.16	2.23	2.30	2.36	2.43	2.50	2.57	2.64	2.71	2.78	2.84	2.91	2.98	3.05	3.12	3.19	3.26	3.32	3.39	3.46	3.53	3.60	3.67
40	2.00	2.07	2.14	2.21	2.28	2.34	2.41	2.48	2.55	2.62	2.69	2.76	2.82	2.89	2.96	3.03	3.10	3.17	3.24	3.30	3.37	3.44	3.51	3.58	3.65
41	1.98	2.05	2.12	2.19	2.25	2.32	2.39	2.46	2.53	2.60	2.67	2.73	2.80	2.87	2.94	3.01	3.08	3.15	3.21	3.28	3.35	3.42	3.49	3.56	3.63
42	1.96	2.03	2.10	2.16	2.23	2.30	2.37	2.44	2.51	2.58	2.64	2.71	2.78	2.85	2.92	2.99	3.06	3.12	3.19	3.26	3.33	3.40	3.47	3.54	3.60
43	1.94	2.01	2.07	2.14	2.21	2.28	2.35	2.42	2.49	2.55	2.62	2.69	2.76	2.83	2.90	2.97	3.04	3.10	3.17	3.24	3.31	3.38	3.45	3.52	3.58
44	1.92	1.99	2.05	2.12	2.19	2.26	2.33	2.40	2.47	2.53	2.60	2.67	2.74	2.81	2.88	2.95	3.01	3.08	3.15	3.22	3.29	3.36	3.43	3.49	3.56
45	1.90	1.96	2.03	2.10	2.17	2.24	2.31	2.38	2.44	2.51	2.58	2.65	2.72	2.79	2.86	2.92	2.99	3.06	3.13	3.20	3.27	3.34	3.40	3.47	3.54
46	1.87	1.94	2.01	2.08	2.15	2.22	2.29	2.35	2.42	2.49	2.56	2.63	2.70	2.77	2.83	2.90	2.97	3.04	3.11	3.18	3.25	3.31	3.38	3.45	3.52
47	1.85	1.92	1.99	2.06	2.13	2.20	2.27	2.33	2.40	2.47	2.54	2.61	2.68	2.75	2.81	2.88	2.95	3.02	3.09	3.16	3.23	3.29	3.36	3.43	3.50
48	1.83	1.90	1.97	2.04	2.11	2.18	2.24	2.31	2.38	2.45	2.52	2.59	2.66	2.72	2.79	2.86	2.93	3.00	3.07	3.14	3.20	3.27	3.34	3.41	3.48
49	1.81	1.88	1.95	2.02	2.09	2.15	2.22	2.29	2.36	2.43	2.50	2.57	2.63	2.70	2.77	2.84	2.91	2.98	3.05	3.11	3.18	3.25	3.32	3.39	3.46
50	1.79	1.86	1.93	2.00	2.07	2.13	2.20	2.27	2.34	2.41	2.48	2.55	2.61	2.68	2.75	2.82	2.89	2.96	3.03	3.09	3.16	3.23	3.30	3.37	3.44
51	1.77	1.84	1.91	1.98	2.04	2.11	2.18	2.25	2.32	2.39	2.46	2.52	2.59	2.66	2.73	2.80	2.87	2.94	3.00	3.07	3.14	3.21	3.28	3.35	3.42
52	1.75	1.82	1.89	1.95	2.02	2.09	2.16	2.23	2.30	2.37	2.43	2.50	2.57	2.64	2.71	2.78	2.85	2.91	2.98	3.05	3.12	3.19	3.26	3.33	3.39
53	1.73	1.80	1.86	1.93	2.00	2.07	2.14	2.21	2.28	2.34	2.41	2.48	2.55	2.62	2.69	2.76	2.83	2.89	2.96	3.03	3.10	3.17	3.24	3.31	3.37
54	1.71	1.78	1.84	1.91	1.98	2.05	2.12	2.19	2.26	2.32	2.39	2.46	2.53	2.60	2.67	2.74	2.80	2.87	2.94	3.01	3.08	3.15	3.22	3.28	3.35
55	1.69	1.75	1.82	1.89	1.96	2.03	2.10	2.17	2.23	2.30	2.37	2.44	2.51	2.58	2.65	2.71	2.78	2.85	2.92	2.99	3.06	3.13	3.19	3.26	3.33
56	1.66	1.73	1.80	1.87	1.94	2.01	2.08	2.14	2.21	2.28	2.35	2.42	2.49	2.56	2.62	2.69	2.76	2.83	2.90	2.97	3.04	3.10	3.17	3.24	3.31
57	1.64	1.71	1.78	1.85	1.92	1.99	2.06	2.12	2.19	2.26	2.33	2.40	2.47	2.54	2.60	2.67	2.74	2.81	2.88	2.95	3.02	3.08	3.15	3.22	3.29
58	1.62	1.69	1.76	1.83	1.90	1.97	2.03	2.10	2.17	2.24	2.31	2.38	2.45	2.51	2.58	2.65	2.72	2.79	2.86	2.93	2.99	3.06	3.13	3.20	3.27
59	1.60	1.67	1.74	1.81	1.88	1.94	2.01	2.08	2.15	2.22	2.29	2.36	2.42	2.49	2.56	2.63	2.70	2.77	2.84	2.90	2.97	3.04	3.11	3.18	3.25
60	1.58	1.65	1.72	1.79	1.86	1.92	1.99	2.06	2.13	2.20	2.27	2.34	2.40	2.47	2.54	2.61	2.68	2.75	2.82	2.88	2.95	3.02	3.09	3.16	3.23
61	1.56	1.63	1.70	1.77	1.83	1.90	1.97	2.04	2.11	2.18	2.25	2.31	2.38	2.45	2.52	2.59	2.66	2.73	2.79	2.86	2.93	3.00	3.07	3.14	3.21
62	1.54	1.61	1.68	1.74	1.81	1.88	1.95	2.02	2.09	2.16	2.22	2.29	2.36	2.43	2.50	2.57	2.64	2.70	2.77	2.84	2.91	2.98	3.05	3.12	3.18
63	1.52	1.59	1.65	1.72	1.79	1.86	1.93	2.00	2.07	2.13	2.20	2.27	2.34	2.41	2.48	2.55	2.62	2.68	2.75	2.82	2.89	2.96	3.03	3.10	3.16
64	1.50	1.57	1.63	1.70	1.77	1.84	1.91	1.98	2.05	2.11	2.18	2.25	2.32	2.39	2.46	2.53	2.59	2.66	2.73	2.80	2.87	2.94	3.01	3.07	3.14
65	1.48	1.54	1.61	1.68	1.75	1.82	1.89	1.96	2.02	2.09	2.16	2.23	2.30	2.37	2.44	2.50	2.57	2.64	2.71	2.78	2.85	2.92	2.98	3.05	3.12
66	1.45	1.52	1.59	1.66	1.73	1.80	1.87	1.93	2.00	2.07	2.14	2.21	2.28	2.35	2.41	2.48	2.55	2.62	2.69	2.76	2.83	2.89	2.96	3.03	3.10
67	1.43	1.50	1.57	1.64	1.71	1.78	1.85	1.91	1.98	2.05	2.12	2.19	2.26	2.33	2.39	2.46	2.53	2.60	2.67	2.74	2.81	2.87	2.94	3.01	3.08
68	1.41	1.48	1.55	1.62	1.69	1.76	1.82	1.89	1.96	2.03	2.10	2.17	2.24	2.30	2.37	2.44	2.51	2.58	2.65	2.72	2.78	2.85	2.92	2.99	3.06
69	1.39	1.46	1.53	1.60	1.67	1.73	1.80	1.87	1.94	2.01	2.08	2.15	2.21	2.28	2.35	2.42	2.49	2.56	2.63	2.69	2.76	2.83	2.90	2.97	3.04

**NOTE: ALL VALUES ARE AT BTPS

Table E-4
Predicted FVC for white females

AGE	HEIGHT IN INCHES																								
	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
16	2.45	2.53	2.61	2.70	2.78	2.86	2.95	3.03	3.12	3.20	3.23	3.37	3.45	3.54	3.62	3.70	3.79	3.87	3.95	4.04	4.12	4.21	4.29	4.37	4.46
17	2.54	2.62	2.71	2.79	2.87	2.96	3.04	3.12	3.21	3.29	3.38	3.46	3.54	3.63	3.71	3.79	3.88	3.96	4.05	4.13	4.21	4.30	4.38	4.47	4.55
18	2.63	2.71	2.80	2.88	2.96	3.05	3.13	3.22	3.30	3.38	3.47	3.55	3.64	3.72	3.80	3.89	3.97	4.05	4.14	4.22	4.31	4.39	4.47	4.56	4.64
19	2.72	2.81	2.89	2.97	3.06	3.14	3.22	3.31	3.39	3.48	3.56	3.64	3.73	3.81	3.89	3.98	4.06	4.15	4.23	4.31	4.40	4.48	4.57	4.65	4.73
20	2.77	2.86	2.95	3.05	3.14	3.24	3.33	3.42	3.52	3.61	3.71	3.80	3.89	3.99	4.08	4.18	4.27	4.36	4.46	4.55	4.65	4.74	4.83	4.93	5.02
21	2.74	2.84	2.93	3.03	3.12	3.21	3.31	3.40	3.50	3.59	3.68	3.78	3.87	3.97	4.06	4.15	4.25	4.34	4.44	4.53	4.62	4.72	4.81	4.91	5.00
22	2.72	2.82	2.91	3.00	3.10	3.19	3.29	3.38	3.47	3.57	3.66	3.76	3.85	3.94	4.04	4.13	4.23	4.32	4.41	4.51	4.60	4.70	4.79	4.88	4.98
23	2.70	2.79	2.89	2.98	3.08	3.17	3.26	3.36	3.45	3.55	3.64	3.73	3.83	3.92	4.02	4.11	4.20	4.30	4.39	4.49	4.58	4.67	4.77	4.86	4.96
24	2.68	2.77	2.87	2.96	3.05	3.15	3.24	3.34	3.43	3.52	3.62	3.71	3.81	3.90	3.99	4.09	4.18	4.28	4.37	4.46	4.56	4.65	4.75	4.84	4.93
25	2.66	2.75	2.84	2.94	3.03	3.13	3.22	3.31	3.41	3.50	3.60	3.69	3.78	3.88	3.97	4.07	4.16	4.25	4.35	4.44	4.54	4.63	4.72	4.82	4.91
26	2.63	2.73	2.82	2.92	3.01	3.10	3.20	3.29	3.39	3.48	3.57	3.67	3.76	3.86	3.95	4.04	4.14	4.23	4.33	4.42	4.51	4.61	4.70	4.80	4.89
27	2.61	2.71	2.80	2.89	2.99	3.08	3.18	3.27	3.36	3.46	3.55	3.65	3.74	3.83	3.93	4.02	4.12	4.21	4.30	4.40	4.49	4.59	4.68	4.77	4.87
28	2.59	2.68	2.78	2.87	2.97	3.06	3.15	3.25	3.34	3.44	3.53	3.62	3.72	3.81	3.91	4.00	4.09	4.19	4.28	4.38	4.47	4.56	4.66	4.75	4.85
29	2.57	2.66	2.76	2.85	2.94	3.04	3.13	3.23	3.32	3.41	3.51	3.60	3.70	3.79	3.88	3.98	4.07	4.17	4.26	4.35	4.45	4.54	4.64	4.73	4.82
30	2.55	2.64	2.73	2.83	2.92	3.02	3.11	3.20	3.30	3.39	3.49	3.58	3.67	3.77	3.86	3.96	4.05	4.14	4.24	4.33	4.43	4.52	4.61	4.71	4.80
31	2.52	2.62	2.71	2.81	2.90	2.99	3.09	3.18	3.28	3.37	3.46	3.56	3.65	3.75	3.84	3.93	4.03	4.12	4.22	4.31	4.40	4.50	4.59	4.69	4.78
32	2.50	2.60	2.69	2.78	2.88	2.97	3.07	3.16	3.25	3.35	3.44	3.54	3.63	3.72	3.82	3.91	4.01	4.10	4.19	4.29	4.38	4.48	4.57	4.66	4.76
33	2.48	2.57	2.67	2.76	2.86	2.95	3.04	3.14	3.23	3.33	3.42	3.51	3.61	3.70	3.80	3.89	3.98	4.08	4.17	4.27	4.36	4.45	4.55	4.64	4.74
34	2.46	2.55	2.65	2.74	2.83	2.93	3.02	3.12	3.21	3.30	3.40	3.49	3.59	3.68	3.77	3.87	3.96	4.06	4.15	4.24	4.34	4.43	4.53	4.62	4.71
35	2.44	2.53	2.62	2.72	2.81	2.91	3.00	3.09	3.19	3.28	3.38	3.47	3.56	3.66	3.75	3.85	3.94	4.03	4.13	4.22	4.32	4.41	4.50	4.60	4.69
36	2.41	2.51	2.60	2.70	2.79	2.88	2.98	3.07	3.17	3.26	3.35	3.45	3.54	3.64	3.73	3.82	3.92	4.01	4.11	4.20	4.29	4.39	4.48	4.58	4.67
37	2.39	2.49	2.58	2.67	2.77	2.86	2.96	3.05	3.14	3.24	3.33	3.43	3.52	3.61	3.71	3.80	3.90	3.99	4.08	4.18	4.27	4.37	4.46	4.55	4.65
38	2.37	2.46	2.56	2.65	2.75	2.84	2.93	3.03	3.12	3.22	3.31	3.40	3.50	3.59	3.69	3.78	3.87	3.97	4.06	4.16	4.25	4.34	4.44	4.53	4.63
39	2.35	2.44	2.54	2.63	2.72	2.82	2.91	3.01	3.10	3.19	3.29	3.38	3.48	3.57	3.66	3.76	3.85	3.95	4.04	4.13	4.23	4.32	4.42	4.51	4.60
40	2.33	2.42	2.51	2.61	2.70	2.80	2.89	2.98	3.08	3.17	3.27	3.36	3.45	3.55	3.64	3.74	3.83	3.92	4.02	4.11	4.21	4.30	4.39	4.49	4.58
41	2.30	2.40	2.49	2.59	2.68	2.77	2.87	2.96	3.06	3.15	3.24	3.34	3.43	3.53	3.62	3.71	3.81	3.90	4.00	4.09	4.18	4.28	4.37	4.47	4.56
42	2.28	2.38	2.47	2.56	2.66	2.75	2.85	2.94	3.03	3.13	3.22	3.32	3.41	3.50	3.60	3.69	3.79	3.88	3.97	4.07	4.16	4.26	4.35	4.44	4.54
43	2.26	2.35	2.45	2.54	2.64	2.73	2.82	2.92	3.01	3.11	3.20	3.29	3.39	3.48	3.58	3.67	3.76	3.86	3.95	4.05	4.14	4.23	4.33	4.42	4.52
44	2.24	2.33	2.43	2.52	2.61	2.71	2.80	2.90	2.99	3.08	3.18	3.27	3.37	3.46	3.55	3.65	3.74	3.84	3.93	4.02	4.12	4.21	4.31	4.40	4.49
45	2.22	2.31	2.40	2.50	2.59	2.69	2.78	2.87	2.97	3.06	3.16	3.25	3.34	3.44	3.53	3.63	3.72	3.81	3.91	4.00	4.10	4.19	4.28	4.38	4.47
46	2.19	2.29	2.38	2.48	2.57	2.66	2.76	2.85	2.95	3.04	3.13	3.23	3.32	3.42	3.51	3.60	3.70	3.79	3.89	3.98	4.07	4.17	4.26	4.36	4.45
47	2.17	2.27	2.36	2.45	2.55	2.64	2.74	2.83	2.92	3.02	3.11	3.21	3.30	3.39	3.49	3.58	3.68	3.77	3.86	3.96	4.05	4.15	4.24	4.33	4.43
48	2.15	2.24	2.34	2.43	2.53	2.62	2.71	2.81	2.90	3.00	3.09	3.18	3.28	3.37	3.47	3.56	3.65	3.75	3.84	3.94	4.03	4.12	4.22	4.31	4.41
49	2.13	2.22	2.32	2.41	2.50	2.60	2.69	2.79	2.88	2.97	3.07	3.16	3.26	3.35	3.44	3.54	3.63	3.73	3.82	3.91	4.01	4.10	4.20	4.29	4.38
50	2.11	2.20	2.29	2.39	2.48	2.58	2.67	2.76	2.86	2.95	3.05	3.14	3.23	3.33	3.42	3.52	3.61	3.70	3.80	3.89	3.99	4.08	4.17	4.27	4.36
51	2.08	2.18	2.27	2.37	2.46	2.55	2.65	2.74	2.84	2.93	3.02	3.12	3.21	3.31	3.40	3.49	3.59	3.68	3.78	3.87	3.96	4.06	4.15	4.25	4.34
52	2.06	2.16	2.25	2.34	2.44	2.53	2.63	2.72	2.81	2.91	3.00	3.10	3.19	3.28	3.38	3.47	3.57	3.66	3.75	3.85	3.94	4.04	4.13	4.22	4.32
53	2.04	2.13	2.23	2.32	2.42	2.51	2.60	2.70	2.79	2.89	2.98	3.07	3.17	3.26	3.36	3.45	3.54	3.64	3.73	3.83	3.92	4.01	4.11	4.20	4.30
54	2.02	2.11	2.21	2.30	2.39	2.49	2.58	2.68	2.77	2.86	2.96	3.05	3.15	3.24	3.33	3.43	3.52	3.62	3.71	3.80	3.90	3.99	4.09	4.18	4.27
55	2.00	2.09	2.18	2.28	2.37	2.47	2.56	2.65	2.75	2.84	2.94	3.03	3.12	3.22	3.31	3.41	3.50	3.59	3.69	3.78	3.88	3.97	4.06	4.16	4.25
56	1.97	2.07	2.16	2.26	2.35	2.44	2.54	2.63	2.73	2.82	2.91	3.01	3.10	3.20	3.29	3.38	3.48	3.57	3.67	3.76	3.85	3.95	4.04	4.14	4.23
57	1.95	2.05	2.14	2.23	2.33	2.42	2.52	2.61	2.70	2.80	2.89	2.99	3.08	3.17	3.27	3.36	3.46	3.55	3.64	3.74	3.83	3.93	4.02	4.11	4.21
58	1.93	2.02	2.12	2.21	2.31	2.40	2.49	2.59	2.68	2.78	2.87	2.96	3.06	3.15	3.25	3.34	3.43	3.53	3.62	3.72	3.81	3.90	4.00	4.09	4.19
59	1.91	2.00	2.10	2.19	2.28	2.38	2.47	2.57	2.66	2.75	2.85	2.94	3.04	3.13	3.22	3.32	3.41	3.51	3.60	3.69	3.79	3.88	3.98	4.07	4.16
60	1.89	1.98	2.07	2.17	2.26	2.36	2.45	2.54	2.64	2.73	2.83	2.92	3.01	3.11	3.20	3.30	3.39	3.48	3.58	3.67	3.77	3.86	3.95	4.05	4.14
61	1.86	1.96	2.05	2.15	2.24	2.33	2.43	2.52	2.62	2.71	2.80	2.90	2.99	3.09	3.18	3.27	3.37	3.46	3.56	3.65	3.74	3.84	3.93	4.03	4.12
62	1.84	1.94	2.03	2.12	2.22	2.31	2.41	2.50	2.59	2.69	2.78	2.88	2.97	3.06	3.16	3.25	3.35	3.44	3.53	3.63	3.72	3.82	3.91	4.00	4.10
63	1.82	1.91	2.01	2.10	2.20	2.29	2.38	2.48	2.57	2.67	2.76	2.85	2.95	3.04	3.14	3.23	3.32	3.42	3.51	3.61	3.70	3.79	3.89	3.98	4.08
64	1.80	1.89	1.99	2.08	2.17	2.27	2.36	2.46	2.55	2.64	2.74	2.83	2.93	3.02	3.11	3.21	3.30	3.40	3.49	3.58	3.68	3.77	3.87	3.96	4.05
65	1.78	1.87	1.96	2.06	2.15	2.25	2.34	2.43	2.53	2.62	2.72	2.81	2.90	3.00	3.09	3.19	3.28	3.37	3.47	3.56	3.66	3.75	3.84	3.94	4.03
66	1.75	1.85	1.94	2.04	2.13	2.22	2.32	2.41	2.51	2.60	2.69	2.79	2.88	2.98	3.07	3.16	3.26	3.35	3.45	3.54	3.63	3.73	3.82	3.92	4.01
67	1.73	1.83	1.92	2.01	2.11	2.20	2.30	2.39	2.48	2.58	2.67	2.77	2.86	2.95	3.05	3.14	3.24	3.33	3.42	3.52	3.61	3.71	3.80	3.89	3.99
68	1.71	1.80	1.90	1.99	2.09	2.18	2.27	2.37	2.46	2.56	2.65	2.74	2.84	2.93	3.03	3.12	3.21	3.31	3.40	3.50	3.59	3.68	3.78	3.87	3.97
69	1.69	1.78	1.88	1.97	2.06	2.16	2.25	2.35	2.44	2.53	2.63	2.72	2.82	2.91	3.00	3.10	3.19	3.29	3.38	3.47	3.57	3.66	3.76	3.85	3.94

**NOTE: ALL VALUES ARE AT BTPS

Table E-5
Predicted FEV_1 for nonwhite males

AGE	HEIGHT IN INCHES																								
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
16	2.38	2.48	2.58	2.68	2.78	2.88	2.98	3.08	3.18	3.28	3.38	3.48	3.58	3.68	3.78	3.87	3.97	4.07	4.17	4.27	4.37	4.47	4.57	4.67	4.77
17	2.42	2.52	2.62	2.72	2.82	2.92	3.02	3.12	3.22	3.32	3.42	3.52	3.61	3.71	3.81	3.91	4.01	4.11	4.21	4.31	4.41	4.51	4.61	4.71	4.81
18	2.46	2.56	2.66	2.76	2.86	2.96	3.06	3.16	3.26	3.36	3.45	3.55	3.65	3.75	3.85	3.95	4.05	4.15	4.25	4.35	4.45	4.55	4.65	4.75	4.84
19	2.50	2.60	2.70	2.80	2.90	3.00	3.10	3.19	3.29	3.39	3.49	3.59	3.69	3.79	3.89	3.99	4.09	4.19	4.29	4.39	4.49	4.59	4.68	4.78	4.88
20	2.54	2.64	2.74	2.84	2.93	3.03	3.13	3.23	3.33	3.43	3.53	3.63	3.73	3.83	3.93	4.03	4.13	4.23	4.33	4.42	4.52	4.62	4.72	4.82	4.92
21	2.58	2.68	2.77	2.87	2.97	3.07	3.17	3.27	3.37	3.47	3.57	3.67	3.77	3.87	3.97	4.07	4.17	4.26	4.36	4.46	4.56	4.66	4.76	4.86	4.96
22	2.61	2.71	2.81	2.91	3.01	3.11	3.21	3.31	3.41	3.51	3.61	3.71	3.81	3.91	4.00	4.10	4.20	4.30	4.40	4.50	4.60	4.70	4.80	4.90	5.00
23	2.65	2.75	2.85	2.95	3.05	3.15	3.25	3.35	3.45	3.55	3.65	3.74	3.84	3.94	4.04	4.14	4.24	4.34	4.44	4.54	4.64	4.74	4.84	4.94	5.04
24	2.69	2.79	2.89	2.99	3.09	3.19	3.29	3.39	3.49	3.58	3.68	3.78	3.88	3.98	4.08	4.18	4.28	4.38	4.48	4.58	4.68	4.78	4.88	4.97	5.07
25	2.48	2.59	2.70	2.81	2.93	3.04	3.15	3.26	3.38	3.49	3.60	3.71	3.82	3.94	4.05	4.16	4.27	4.39	4.50	4.61	4.72	4.84	4.95	5.06	5.17
26	2.45	2.57	2.68	2.79	2.90	3.02	3.13	3.24	3.35	3.46	3.58	3.69	3.80	3.91	4.03	4.14	4.25	4.36	4.48	4.59	4.70	4.81	4.92	5.04	5.15
27	2.43	2.54	2.66	2.77	2.88	2.99	3.11	3.22	3.33	3.44	3.55	3.67	3.78	3.89	4.00	4.12	4.23	4.34	4.45	4.56	4.68	4.79	4.90	5.01	5.13
28	2.41	2.52	2.63	2.75	2.86	2.97	3.08	3.19	3.31	3.42	3.53	3.64	3.76	3.87	3.98	4.09	4.20	4.32	4.43	4.54	4.65	4.77	4.88	4.99	5.10
29	2.39	2.50	2.61	2.72	2.83	2.95	3.06	3.17	3.28	3.40	3.51	3.62	3.73	3.85	3.96	4.07	4.18	4.29	4.41	4.52	4.63	4.74	4.86	4.97	5.08
30	2.36	2.48	2.59	2.70	2.81	2.92	3.04	3.15	3.26	3.37	3.49	3.60	3.71	3.82	3.93	4.05	4.16	4.27	4.38	4.50	4.61	4.72	4.83	4.94	5.06
31	2.34	2.45	2.56	2.68	2.79	2.90	3.01	3.13	3.24	3.35	3.46	3.57	3.69	3.80	3.91	4.02	4.14	4.25	4.36	4.47	4.59	4.70	4.81	4.92	5.03
32	2.32	2.43	2.54	2.65	2.77	2.88	2.99	3.10	3.22	3.33	3.44	3.55	3.66	3.78	3.89	4.00	4.11	4.23	4.34	4.45	4.56	4.67	4.79	4.90	5.01
33	2.29	2.41	2.52	2.63	2.74	2.86	2.97	3.08	3.19	3.30	3.42	3.53	3.64	3.75	3.87	3.98	4.09	4.20	4.31	4.43	4.54	4.65	4.76	4.88	4.99
34	2.27	2.38	2.50	2.61	2.72	2.83	2.94	3.06	3.17	3.28	3.39	3.51	3.62	3.73	3.84	3.95	4.07	4.18	4.29	4.40	4.52	4.63	4.74	4.85	4.97
35	2.25	2.36	2.47	2.58	2.70	2.81	2.92	3.03	3.15	3.26	3.37	3.48	3.60	3.71	3.82	3.93	4.04	4.16	4.27	4.38	4.49	4.61	4.72	4.83	4.94
36	2.23	2.34	2.45	2.56	2.67	2.79	2.90	3.01	3.12	3.24	3.35	3.46	3.57	3.68	3.80	3.91	4.02	4.13	4.25	4.36	4.47	4.58	4.69	4.81	4.92
37	2.20	2.31	2.43	2.54	2.65	2.76	2.88	2.99	3.10	3.21	3.32	3.44	3.55	3.66	3.77	3.89	4.00	4.11	4.22	4.34	4.45	4.56	4.67	4.78	4.90
38	2.18	2.29	2.40	2.52	2.63	2.74	2.85	2.97	3.08	3.19	3.30	3.41	3.53	3.64	3.75	3.86	3.98	4.09	4.20	4.31	4.42	4.54	4.65	4.76	4.87
39	2.16	2.27	2.38	2.49	2.61	2.72	2.83	2.94	3.05	3.17	3.28	3.39	3.50	3.62	3.73	3.84	3.95	4.06	4.18	4.29	4.40	4.51	4.63	4.74	4.85
40	2.13	2.25	2.36	2.47	2.58	2.69	2.81	2.92	3.03	3.14	3.26	3.37	3.48	3.59	3.71	3.82	3.93	4.04	4.15	4.27	4.38	4.49	4.60	4.72	4.83
41	2.11	2.22	2.33	2.45	2.56	2.67	2.78	2.90	3.01	3.12	3.23	3.35	3.46	3.57	3.68	3.79	3.91	4.02	4.13	4.24	4.36	4.47	4.58	4.69	4.80
42	2.09	2.20	2.31	2.42	2.54	2.65	2.76	2.87	2.99	3.10	3.21	3.32	3.43	3.55	3.66	3.77	3.88	4.00	4.11	4.22	4.33	4.44	4.56	4.67	4.78
43	2.06	2.18	2.29	2.40	2.51	2.63	2.74	2.85	2.96	3.07	3.19	3.30	3.41	3.52	3.64	3.75	3.86	3.97	4.09	4.20	4.31	4.42	4.53	4.65	4.76
44	2.04	2.15	2.27	2.38	2.49	2.60	2.72	2.83	2.94	3.05	3.16	3.28	3.39	3.50	3.61	3.73	3.84	3.95	4.06	4.17	4.29	4.40	4.51	4.62	4.74
45	2.02	2.13	2.24	2.36	2.47	2.58	2.69	2.80	2.92	3.03	3.14	3.25	3.37	3.48	3.59	3.70	3.81	3.93	4.04	4.15	4.26	4.38	4.49	4.60	4.71
46	2.00	2.11	2.22	2.33	2.44	2.56	2.67	2.78	2.89	3.01	3.12	3.23	3.34	3.46	3.57	3.68	3.79	3.90	4.02	4.13	4.24	4.35	4.47	4.58	4.69
47	1.97	2.08	2.20	2.31	2.42	2.53	2.65	2.76	2.87	2.98	3.10	3.21	3.32	3.43	3.54	3.66	3.77	3.88	3.99	4.11	4.22	4.33	4.44	4.55	4.67
48	1.95	2.06	2.17	2.29	2.40	2.51	2.62	2.74	2.85	2.96	3.07	3.18	3.30	3.41	3.52	3.63	3.75	3.86	3.97	4.09	4.20	4.31	4.42	4.53	4.64
49	1.93	2.04	2.15	2.26	2.38	2.49	2.60	2.71	2.82	2.94	3.05	3.16	3.27	3.39	3.50	3.61	3.72	3.84	3.95	4.06	4.17	4.28	4.40	4.51	4.62
50	1.90	2.02	2.13	2.24	2.35	2.47	2.58	2.69	2.80	2.91	3.03	3.14	3.25	3.36	3.48	3.59	3.70	3.81	3.92	4.04	4.15	4.26	4.37	4.49	4.60
51	1.88	1.99	2.11	2.22	2.33	2.44	2.55	2.67	2.78	2.89	3.00	3.12	3.23	3.34	3.45	3.56	3.68	3.79	3.90	4.01	4.13	4.24	4.35	4.46	4.58
52	1.86	1.97	2.08	2.19	2.31	2.42	2.53	2.64	2.76	2.87	2.98	3.09	3.21	3.32	3.43	3.54	3.65	3.77	3.88	3.99	4.10	4.22	4.33	4.44	4.55
53	1.83	1.95	2.06	2.17	2.28	2.40	2.51	2.62	2.73	2.85	2.96	3.07	3.18	3.29	3.41	3.52	3.63	3.74	3.86	3.97	4.08	4.19	4.30	4.42	4.53
54	1.81	1.92	2.04	2.15	2.26	2.37	2.49	2.60	2.71	2.82	2.93	3.05	3.16	3.27	3.38	3.50	3.61	3.72	3.83	3.95	4.06	4.17	4.28	4.39	4.51
55	1.79	1.90	2.01	2.13	2.24	2.35	2.46	2.57	2.69	2.80	2.91	3.02	3.14	3.25	3.36	3.47	3.59	3.70	3.81	3.92	4.03	4.15	4.26	4.37	4.48
56	1.77	1.88	1.99	2.10	2.22	2.33	2.44	2.55	2.66	2.78	2.89	3.00	3.11	3.23	3.34	3.45	3.56	3.67	3.79	3.90	4.01	4.12	4.24	4.35	4.46
57	1.74	1.86	1.97	2.08	2.19	2.30	2.42	2.53	2.64	2.75	2.87	2.98	3.09	3.20	3.31	3.43	3.54	3.65	3.76	3.88	3.99	4.10	4.21	4.33	4.44
58	1.72	1.83	1.94	2.06	2.17	2.28	2.39	2.51	2.62	2.73	2.84	2.96	3.07	3.18	3.29	3.40	3.52	3.63	3.74	3.85	3.97	4.08	4.19	4.30	4.41
59	1.70	1.81	1.92	2.03	2.15	2.26	2.37	2.48	2.60	2.71	2.82	2.93	3.04	3.16	3.27	3.38	3.49	3.61	3.72	3.83	3.94	4.05	4.17	4.28	4.39
60	1.67	1.79	1.90	2.01	2.12	2.24	2.35	2.46	2.57	2.68	2.80	2.91	3.02	3.13	3.25	3.36	3.47	3.58	3.70	3.81	3.92	4.03	4.14	4.26	4.37
61	1.65	1.76	1.88	1.99	2.10	2.21	2.32	2.44	2.55	2.66	2.77	2.89	3.00	3.11	3.22	3.34	3.45	3.56	3.67	3.78	3.90	4.01	4.12	4.23	4.35
62	1.63	1.74	1.85	1.97	2.08	2.19	2.30	2.41	2.53	2.64	2.75	2.86	2.98	3.09	3.20	3.31	3.42	3.54	3.65	3.76	3.87	3.99	4.10	4.21	4.32
63	1.61	1.72	1.83	1.94	2.05	2.17	2.28	2.39	2.50	2.62	2.73	2.84	2.95	3.06	3.18	3.29	3.40	3.51	3.63	3.74	3.85	3.96	4.08	4.19	4.30
64	1.58	1.69	1.81	1.92	2.03	2.14	2.26	2.37	2.48	2.59	2.71	2.82	2.93	3.04	3.15	3.27	3.38	3.49	3.60	3.72	3.83	3.94	4.05	4.16	4.28
65	1.56	1.67	1.78	1.90	2.01	2.12	2.23	2.35	2.46	2.57	2.68	2.79	2.91	3.02	3.13	3.24	3.36	3.47	3.58	3.69	3.80	3.92	4.03	4.14	4.25
66	1.54	1.65	1.76	1.87	1.99	2.10	2.21	2.32	2.43	2.55	2.66	2.77	2.88	3.00	3.11	3.22	3.33	3.45	3.56	3.67	3.78	3.89	4.01	4.12	4.23
67	1.51	1.63	1.74	1.85	1.96	2.07	2.19	2.30	2.41	2.52	2.64	2.75	2.86	2.97	3.09	3.20	3.31	3.42	3.53	3.65	3.76	3.87	3.98	4.10	4.21
68	1.49	1.60	1.72	1.83	1.94	2.05	2.16	2.28	2.39	2.50	2.61	2.73	2.84	2.95	3.06	3.17	3.29	3.40	3.51	3.62	3.74	3.85	3.96	4.07	4.19
69	1.47	1.58	1.69	1.80	1.92	2.03	2.14	2.25	2.37	2.48	2.59	2.70	2.81	2.93	3.04	3.15	3.26	3.38	3.49	3.60	3.71	3.83	3.94	4.05	4.16

**NOTE: ALL VALUES ARE AT BTPS

Table E-6
Predicted FVC for nonwhite males

AGE	HEIGHT IN INCHES																						
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
16	2.75	2.86	2.96	3.07	3.18	3.29	3.40	3.50	3.61	3.72	3.83	3.94	4.04	4.15	4.26	4.37	4.48	4.58	4.69	4.80	4.91	5.02	5.12	5.23	5.34
17	2.81	2.92	3.03	3.14	3.25	3.35	3.46	3.57	3.68	3.79	3.89	4.00	4.11	4.22	4.33	4.43	4.54	4.65	4.76	4.87	4.97	5.08	5.19	5.30	5.41
18	2.88	2.99	3.10	3.20	3.31	3.42	3.53	3.64	3.74	3.85	3.96	4.07	4.18	4.28	4.39	4.50	4.61	4.72	4.82	4.93	5.04	5.15	5.26	5.36	5.47
19	2.95	3.05	3.16	3.27	3.38	3.49	3.59	3.70	3.81	3.92	4.03	4.13	4.24	4.35	4.46	4.57	4.67	4.78	4.89	5.00	5.11	5.21	5.32	5.43	5.54
20	3.01	3.12	3.23	3.34	3.45	3.55	3.66	3.77	3.88	3.98	4.09	4.20	4.31	4.42	4.52	4.63	4.74	4.85	4.96	5.06	5.17	5.28	5.39	5.50	5.60
21	3.08	3.19	3.30	3.40	3.51	3.62	3.73	3.84	3.94	4.05	4.16	4.27	4.37	4.48	4.59	4.70	4.81	4.91	5.02	5.13	5.24	5.35	5.45	5.56	5.67
22	3.15	3.25	3.36	3.47	3.58	3.69	3.79	3.90	4.01	4.12	4.23	4.33	4.44	4.55	4.66	4.77	4.87	4.98	5.09	5.20	5.30	5.41	5.52	5.63	5.74
23	3.21	3.32	3.43	3.54	3.64	3.75	3.86	3.97	4.08	4.18	4.29	4.40	4.51	4.62	4.72	4.83	4.94	5.05	5.16	5.26	5.37	5.48	5.59	5.70	5.80
24	3.28	3.39	3.49	3.60	3.71	3.82	3.93	4.03	4.14	4.25	4.36	4.47	4.57	4.68	4.79	4.90	5.01	5.11	5.22	5.33	5.44	5.55	5.65	5.76	5.87
25	3.02	3.16	3.30	3.44	3.58	3.73	3.87	4.01	4.15	4.29	4.43	4.57	4.71	4.85	4.99	5.13	5.27	5.41	5.55	5.69	5.83	5.97	6.11	6.25	6.39
26	3.00	3.14	3.28	3.42	3.56	3.70	3.84	3.98	4.12	4.26	4.40	4.54	4.68	4.82	4.96	5.10	5.24	5.38	5.52	5.67	5.81	5.95	6.09	6.23	6.37
27	2.97	3.11	3.25	3.40	3.54	3.68	3.82	3.96	4.10	4.24	4.38	4.52	4.66	4.80	4.94	5.08	5.22	5.36	5.50	5.64	5.78	5.92	6.06	6.20	6.34
28	2.95	3.09	3.23	3.37	3.51	3.65	3.79	3.93	4.07	4.21	4.35	4.49	4.63	4.77	4.91	5.05	5.19	5.34	5.48	5.62	5.76	5.90	6.04	6.18	6.32
29	2.92	3.07	3.21	3.35	3.49	3.63	3.77	3.91	4.05	4.19	4.33	4.47	4.61	4.75	4.89	5.03	5.17	5.31	5.45	5.59	5.73	5.87	6.01	6.15	6.29
30	2.90	3.04	3.18	3.32	3.46	3.60	3.74	3.88	4.02	4.16	4.30	4.44	4.58	4.72	4.86	5.01	5.15	5.29	5.43	5.57	5.71	5.85	5.99	6.13	6.27
31	2.88	3.02	3.16	3.30	3.44	3.58	3.72	3.86	4.00	4.14	4.28	4.42	4.56	4.70	4.84	4.98	5.12	5.26	5.40	5.54	5.68	5.82	5.96	6.10	6.24
32	2.85	2.99	3.13	3.27	3.41	3.55	3.69	3.83	3.97	4.11	4.25	4.39	4.53	4.68	4.82	4.96	5.10	5.24	5.38	5.52	5.66	5.80	5.94	6.08	6.22
33	2.83	2.97	3.11	3.25	3.39	3.53	3.67	3.81	3.95	4.09	4.23	4.37	4.51	4.65	4.79	4.93	5.07	5.21	5.35	5.49	5.63	5.77	5.91	6.05	6.19
34	2.80	2.94	3.08	3.22	3.36	3.50	3.64	3.78	3.92	4.06	4.20	4.35	4.49	4.63	4.77	4.91	5.05	5.19	5.33	5.47	5.61	5.75	5.89	6.03	6.17
35	2.78	2.92	3.06	3.20	3.34	3.48	3.62	3.76	3.90	4.04	4.18	4.32	4.46	4.60	4.74	4.88	5.02	5.16	5.30	5.44	5.58	5.72	5.86	6.00	6.14
36	2.75	2.89	3.03	3.17	3.31	3.45	3.59	3.73	3.87	4.02	4.16	4.30	4.44	4.58	4.72	4.86	5.00	5.14	5.28	5.42	5.56	5.70	5.84	5.98	6.12
37	2.73	2.87	3.01	3.15	3.29	3.43	3.57	3.71	3.85	3.99	4.13	4.27	4.41	4.55	4.69	4.83	4.97	5.11	5.25	5.39	5.53	5.67	5.81	5.96	6.10
38	2.70	2.84	2.98	3.12	3.26	3.40	3.54	3.69	3.83	3.97	4.11	4.25	4.39	4.53	4.67	4.81	4.95	5.09	5.23	5.37	5.51	5.65	5.79	5.93	6.07
39	2.68	2.82	2.96	3.10	3.24	3.38	3.52	3.66	3.80	3.94	4.08	4.22	4.36	4.50	4.64	4.78	4.92	5.06	5.20	5.34	5.48	5.63	5.77	5.91	6.05
40	2.65	2.79	2.93	3.07	3.21	3.36	3.50	3.64	3.78	3.92	4.06	4.20	4.34	4.48	4.62	4.76	4.90	5.04	5.18	5.32	5.46	5.60	5.74	5.88	6.02
41	2.63	2.77	2.91	3.05	3.19	3.33	3.47	3.61	3.75	3.89	4.03	4.17	4.31	4.45	4.59	4.73	4.87	5.01	5.16	5.30	5.44	5.58	5.72	5.86	6.00
42	2.60	2.74	2.88	3.03	3.17	3.31	3.45	3.59	3.73	3.87	4.01	4.15	4.29	4.43	4.57	4.71	4.85	4.99	5.13	5.27	5.41	5.55	5.69	5.83	5.97
43	2.58	2.72	2.86	3.00	3.14	3.28	3.42	3.56	3.70	3.84	3.98	4.12	4.26	4.40	4.54	4.68	4.83	4.97	5.11	5.25	5.39	5.53	5.67	5.81	5.95
44	2.56	2.70	2.84	2.98	3.12	3.26	3.40	3.54	3.68	3.82	3.96	4.10	4.24	4.38	4.52	4.66	4.80	4.94	5.08	5.22	5.36	5.50	5.64	5.78	5.92
45	2.53	2.67	2.81	2.95	3.09	3.23	3.37	3.51	3.65	3.79	3.93	4.07	4.21	4.35	4.50	4.64	4.78	4.92	5.06	5.20	5.34	5.48	5.62	5.76	5.90
46	2.51	2.65	2.79	2.93	3.07	3.21	3.35	3.49	3.63	3.77	3.91	4.05	4.19	4.33	4.47	4.61	4.75	4.89	5.03	5.17	5.31	5.45	5.59	5.73	5.87
47	2.48	2.62	2.76	2.90	3.04	3.18	3.32	3.46	3.60	3.74	3.88	4.02	4.17	4.31	4.45	4.59	4.73	4.87	5.01	5.15	5.29	5.43	5.57	5.71	5.85
48	2.46	2.60	2.74	2.88	3.02	3.16	3.30	3.44	3.58	3.72	3.86	4.00	4.14	4.28	4.42	4.56	4.70	4.84	4.98	5.12	5.26	5.40	5.54	5.68	5.82
49	2.43	2.57	2.71	2.85	2.99	3.13	3.27	3.41	3.55	3.69	3.84	3.98	4.12	4.26	4.40	4.54	4.68	4.82	4.96	5.10	5.24	5.38	5.52	5.66	5.80
50	2.41	2.55	2.69	2.83	2.97	3.11	3.25	3.39	3.53	3.67	3.81	3.95	4.09	4.23	4.37	4.51	4.65	4.79	4.93	5.07	5.21	5.35	5.49	5.63	5.78
51	2.38	2.52	2.66	2.80	2.94	3.08	3.22	3.36	3.51	3.65	3.79	3.93	4.07	4.21	4.35	4.49	4.63	4.77	4.91	5.05	5.19	5.33	5.47	5.61	5.75
52	2.36	2.50	2.64	2.78	2.92	3.06	3.20	3.34	3.48	3.62	3.76	3.90	4.04	4.18	4.32	4.46	4.60	4.74	4.88	5.02	5.16	5.30	5.45	5.59	5.73
53	2.33	2.47	2.61	2.75	2.89	3.03	3.18	3.32	3.46	3.60	3.74	3.88	4.02	4.16	4.30	4.44	4.58	4.72	4.86	5.00	5.14	5.28	5.42	5.56	5.70
54	2.31	2.45	2.59	2.73	2.87	3.01	3.15	3.29	3.43	3.57	3.71	3.85	3.99	4.13	4.27	4.41	4.55	4.69	4.83	4.97	5.12	5.26	5.40	5.54	5.68
55	2.28	2.42	2.56	2.70	2.85	2.99	3.13	3.27	3.41	3.55	3.69	3.83	3.97	4.11	4.25	4.39	4.53	4.67	4.81	4.95	5.09	5.23	5.37	5.51	5.65
56	2.26	2.40	2.54	2.68	2.82	2.96	3.10	3.24	3.38	3.52	3.66	3.80	3.94	4.08	4.22	4.36	4.50	4.64	4.79	4.93	5.07	5.21	5.35	5.49	5.63
57	2.23	2.37	2.52	2.66	2.80	2.94	3.08	3.22	3.36	3.50	3.64	3.78	3.92	4.06	4.20	4.34	4.48	4.62	4.76	4.90	5.04	5.18	5.32	5.46	5.60
58	2.21	2.35	2.49	2.63	2.77	2.91	3.05	3.19	3.33	3.47	3.61	3.75	3.89	4.03	4.17	4.31	4.46	4.60	4.74	4.88	5.02	5.16	5.30	5.44	5.58
59	2.19	2.33	2.47	2.61	2.75	2.89	3.03	3.17	3.31	3.45	3.59	3.73	3.87	4.01	4.15	4.29	4.43	4.57	4.71	4.85	4.99	5.13	5.27	5.41	5.55
60	2.16	2.30	2.44	2.58	2.72	2.86	3.00	3.14	3.28	3.42	3.56	3.70	3.84	3.98	4.13	4.27	4.41	4.55	4.69	4.83	4.97	5.11	5.25	5.39	5.53
61	2.14	2.28	2.42	2.56	2.70	2.84	2.98	3.12	3.26	3.40	3.54	3.68	3.82	3.96	4.10	4.24	4.38	4.52	4.66	4.80	4.94	5.08	5.22	5.36	5.50
62	2.11	2.25	2.39	2.53	2.67	2.81	2.95	3.09	3.23	3.37	3.51	3.66	3.80	3.94	4.08	4.22	4.36	4.50	4.64	4.78	4.92	5.06	5.20	5.34	5.48
63	2.09	2.23	2.37	2.51	2.65	2.79	2.93	3.07	3.21	3.35	3.49	3.63	3.77	3.91	4.05	4.19	4.33	4.47	4.61	4.75	4.89	5.03	5.17	5.31	5.45
64	2.06	2.20	2.34	2.48	2.62	2.76	2.90	3.04	3.18	3.33	3.47	3.61	3.75	3.89	4.03	4.17	4.31	4.45	4.59	4.73	4.87	5.01	5.15	5.29	5.43
65	2.04	2.18	2.32	2.46	2.60	2.74	2.88	3.02	3.16	3.30	3.44	3.58	3.72	3.86	4.00	4.14	4.28	4.42	4.56	4.70	4.84	4.98	5.12	5.27	5.41
66	2.01	2.15	2.29	2.43	2.57	2.71	2.85	3.00	3.14	3.28	3.42	3.56	3.70	3.84	3.98	4.12	4.26	4.40	4.54	4.68	4.82	4.96	5.10	5.24	5.38
67	1.99	2.13	2.27	2.41	2.55	2.69	2.83	2.97	3.11	3.25	3.39	3.53	3.67	3.81	3.95	4.09	4.23	4.37	4.51	4.65	4.79	4.94	5.08	5.22	5.36
68	1.96	2.10	2.24	2.38	2.52	2.67	2.81	2.95	3.09	3.23	3.37	3.51	3.65	3.79	3.93	4.07	4.21	4.35	4.49	4.63	4.77	4.91	5.05	5.19	5.33
69	1.94	2.08	2.22	2.36	2.50	2.64	2.78	2.92	3.06	3.20	3.34	3.48	3.62	3.76	3.90	4.04	4.18	4.32	4.46	4.61	4.75	4.89	5.03	5.17	5.31

**NOTE: ALL VALUES ARE AT BTPS

Table E-7
Predicted FEV_1 for nonwhite females

	HEIGHT IN INCHES																								
AGE	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
16	1.95	2.01	2.06	2.12	2.18	2.24	2.30	2.36	2.41	2.47	2.53	2.59	2.65	2.71	2.76	2.82	2.88	2.94	3.00	3.06	3.11	3.17	3.23	3.29	3.35
17	2.02	2.08	2.14	2.20	2.25	2.31	2.37	2.43	2.49	2.54	2.60	2.66	2.72	2.78	2.84	2.89	2.95	3.01	3.07	3.13	3.19	3.24	3.30	3.36	3.42
18	2.09	2.15	2.21	2.27	2.33	2.38	2.44	2.50	2.56	2.62	2.68	2.73	2.79	2.85	2.91	2.97	3.03	3.08	3.14	3.20	3.26	3.32	3.37	3.43	3.49
19	2.16	2.22	2.28	2.34	2.40	2.46	2.51	2.57	2.63	2.69	2.75	2.81	2.86	2.92	2.98	3.04	3.10	3.16	3.21	3.27	3.33	3.39	3.45	3.51	3.56
20	2.06	2.12	2.17	2.23	2.29	2.35	2.41	2.47	2.52	2.58	2.64	2.70	2.76	2.82	2.87	2.93	2.99	3.05	3.11	3.17	3.22	3.28	3.34	3.40	3.46
21	2.04	2.10	2.16	2.21	2.27	2.33	2.39	2.45	2.51	2.56	2.62	2.68	2.74	2.80	2.86	2.91	2.97	3.03	3.09	3.15	3.21	3.26	3.32	3.38	3.44
22	2.02	2.08	2.14	2.20	2.26	2.31	2.37	2.43	2.49	2.55	2.60	2.66	2.72	2.78	2.84	2.90	2.95	3.01	3.07	3.13	3.19	3.25	3.30	3.36	3.42
23	2.00	2.06	2.12	2.18	2.24	2.30	2.35	2.41	2.47	2.53	2.59	2.65	2.70	2.76	2.82	2.88	2.94	3.00	3.05	3.11	3.17	3.23	3.29	3.34	3.40
24	1.99	2.04	2.10	2.16	2.22	2.28	2.34	2.39	2.45	2.51	2.57	2.63	2.69	2.74	2.80	2.86	2.92	2.98	3.04	3.09	3.15	3.21	3.27	3.33	3.39
25	1.97	2.03	2.08	2.14	2.20	2.26	2.32	2.38	2.43	2.49	2.55	2.61	2.67	2.73	2.78	2.84	2.90	2.96	3.02	3.08	3.13	3.19	3.25	3.31	3.37
26	1.95	2.01	2.07	2.13	2.18	2.24	2.30	2.36	2.42	2.48	2.53	2.59	2.65	2.71	2.77	2.82	2.88	2.94	3.00	3.06	3.12	3.17	3.23	3.29	3.35
27	1.93	1.99	2.05	2.11	2.17	2.22	2.28	2.34	2.40	2.46	2.52	2.57	2.63	2.69	2.75	2.81	2.87	2.92	2.98	3.04	3.10	3.16	3.22	3.27	3.33
28	1.91	1.97	2.03	2.09	2.15	2.21	2.26	2.32	2.38	2.44	2.50	2.56	2.61	2.67	2.73	2.79	2.85	2.91	2.96	3.02	3.08	3.14	3.20	3.26	3.31
29	1.90	1.96	2.01	2.07	2.13	2.19	2.25	2.31	2.36	2.42	2.48	2.54	2.60	2.65	2.71	2.77	2.83	2.89	2.95	3.00	3.06	3.12	3.18	3.24	3.30
30	1.88	1.94	2.00	2.05	2.11	2.17	2.23	2.29	2.35	2.40	2.46	2.52	2.58	2.64	2.70	2.75	2.81	2.87	2.93	2.99	3.04	3.10	3.16	3.22	3.28
31	1.86	1.92	1.98	2.04	2.09	2.15	2.21	2.27	2.33	2.39	2.44	2.50	2.56	2.62	2.68	2.74	2.79	2.85	2.91	2.97	3.03	3.09	3.14	3.20	3.26
32	1.84	1.90	1.96	2.02	2.08	2.13	2.19	2.25	2.31	2.37	2.43	2.48	2.54	2.60	2.66	2.72	2.78	2.83	2.89	2.95	3.01	3.07	3.13	3.18	3.24
33	1.83	1.88	1.94	2.00	2.06	2.12	2.18	2.23	2.29	2.35	2.41	2.47	2.53	2.58	2.64	2.70	2.76	2.82	2.87	2.93	2.99	3.05	3.11	3.17	3.22
34	1.81	1.87	1.92	1.98	2.04	2.10	2.16	2.22	2.27	2.33	2.39	2.45	2.51	2.57	2.62	2.68	2.74	2.80	2.86	2.92	2.97	3.03	3.09	3.15	3.21
35	1.79	1.85	1.91	1.96	2.02	2.08	2.14	2.20	2.26	2.31	2.37	2.43	2.49	2.55	2.61	2.66	2.72	2.78	2.84	2.90	2.96	3.01	3.07	3.13	3.19
36	1.77	1.83	1.89	1.95	2.01	2.06	2.12	2.18	2.24	2.30	2.35	2.41	2.47	2.53	2.59	2.65	2.70	2.76	2.82	2.88	2.94	3.00	3.05	3.11	3.17
37	1.75	1.81	1.87	1.93	1.99	2.05	2.10	2.16	2.22	2.28	2.34	2.40	2.45	2.51	2.57	2.63	2.69	2.75	2.80	2.86	2.92	2.98	3.04	3.09	3.15
38	1.74	1.79	1.85	1.91	1.97	2.03	2.09	2.14	2.20	2.26	2.32	2.38	2.44	2.49	2.55	2.61	2.67	2.73	2.79	2.84	2.90	2.96	3.02	3.08	3.14
39	1.72	1.78	1.84	1.89	1.95	2.01	2.07	2.13	2.18	2.24	2.30	2.36	2.42	2.48	2.53	2.59	2.65	2.71	2.77	2.83	2.88	2.94	3.00	3.06	3.12
40	1.70	1.76	1.82	1.88	1.93	1.99	2.05	2.11	2.17	2.23	2.28	2.34	2.40	2.46	2.52	2.58	2.63	2.69	2.75	2.81	2.87	2.92	2.98	3.04	3.10
41	1.68	1.74	1.80	1.86	1.92	1.97	2.03	2.09	2.15	2.21	2.27	2.32	2.38	2.44	2.50	2.56	2.62	2.67	2.73	2.79	2.85	2.91	2.97	3.02	3.08
42	1.66	1.72	1.78	1.84	1.90	1.96	2.01	2.07	2.13	2.19	2.25	2.31	2.36	2.42	2.48	2.54	2.60	2.66	2.71	2.77	2.83	2.89	2.95	3.01	3.06
43	1.65	1.71	1.76	1.82	1.88	1.94	2.00	2.06	2.11	2.17	2.23	2.29	2.35	2.40	2.46	2.52	2.58	2.64	2.70	2.75	2.81	2.87	2.93	2.99	3.05
44	1.63	1.69	1.75	1.80	1.86	1.92	1.98	2.04	2.10	2.15	2.21	2.27	2.33	2.39	2.45	2.50	2.56	2.62	2.68	2.74	2.80	2.85	2.91	2.97	3.03
45	1.61	1.67	1.73	1.79	1.84	1.90	1.96	2.02	2.08	2.14	2.19	2.25	2.31	2.37	2.43	2.49	2.54	2.60	2.66	2.72	2.78	2.84	2.89	2.95	3.01
46	1.59	1.65	1.71	1.77	1.83	1.88	1.94	2.00	2.06	2.12	2.18	2.23	2.29	2.35	2.41	2.47	2.53	2.58	2.64	2.70	2.76	2.82	2.88	2.93	2.99
47	1.58	1.63	1.69	1.75	1.81	1.87	1.93	1.98	2.04	2.10	2.16	2.22	2.28	2.33	2.39	2.45	2.51	2.57	2.62	2.68	2.74	2.80	2.86	2.92	2.97
48	1.56	1.62	1.67	1.73	1.79	1.85	1.91	1.97	2.02	2.08	2.14	2.20	2.26	2.32	2.37	2.43	2.49	2.55	2.61	2.67	2.72	2.78	2.84	2.90	2.96
49	1.54	1.60	1.66	1.71	1.77	1.83	1.89	1.95	2.01	2.06	2.12	2.18	2.24	2.30	2.36	2.41	2.47	2.53	2.59	2.65	2.71	2.76	2.82	2.88	2.94
50	1.52	1.58	1.64	1.70	1.76	1.81	1.87	1.93	1.99	2.05	2.11	2.16	2.22	2.28	2.34	2.40	2.45	2.51	2.57	2.63	2.69	2.75	2.80	2.86	2.92
51	1.50	1.56	1.62	1.68	1.74	1.80	1.85	1.91	1.97	2.03	2.09	2.15	2.20	2.26	2.32	2.38	2.44	2.50	2.55	2.61	2.67	2.73	2.79	2.85	2.90
52	1.49	1.54	1.60	1.66	1.72	1.78	1.84	1.89	1.95	2.01	2.07	2.13	2.19	2.24	2.30	2.36	2.42	2.48	2.54	2.59	2.65	2.71	2.77	2.83	2.89
53	1.47	1.53	1.59	1.64	1.70	1.76	1.82	1.88	1.93	1.99	2.05	2.11	2.17	2.23	2.28	2.34	2.40	2.46	2.52	2.58	2.63	2.69	2.75	2.81	2.87
54	1.45	1.51	1.57	1.63	1.68	1.74	1.80	1.86	1.92	1.98	2.03	2.09	2.15	2.21	2.27	2.33	2.38	2.44	2.50	2.56	2.62	2.67	2.73	2.79	2.85
55	1.43	1.49	1.55	1.61	1.67	1.72	1.78	1.84	1.90	1.96	2.02	2.07	2.13	2.19	2.25	2.31	2.37	2.42	2.48	2.54	2.60	2.66	2.72	2.77	2.83
56	1.42	1.47	1.53	1.59	1.65	1.71	1.76	1.82	1.88	1.94	2.00	2.06	2.11	2.17	2.23	2.29	2.35	2.41	2.46	2.52	2.58	2.64	2.70	2.76	2.81
57	1.40	1.46	1.51	1.57	1.63	1.69	1.75	1.81	1.86	1.92	1.98	2.04	2.10	2.15	2.21	2.27	2.33	2.39	2.45	2.50	2.56	2.62	2.68	2.74	2.80
58	1.38	1.44	1.50	1.55	1.61	1.67	1.73	1.79	1.85	1.90	1.96	2.02	2.08	2.14	2.20	2.25	2.31	2.37	2.43	2.49	2.55	2.60	2.66	2.72	2.78
59	1.36	1.42	1.48	1.54	1.59	1.65	1.71	1.77	1.83	1.89	1.94	2.00	2.06	2.12	2.18	2.24	2.29	2.35	2.41	2.47	2.53	2.59	2.64	2.70	2.76
60	1.34	1.40	1.46	1.52	1.58	1.64	1.69	1.75	1.81	1.87	1.93	1.98	2.04	2.10	2.16	2.22	2.28	2.33	2.39	2.45	2.51	2.57	2.63	2.68	2.74
61	1.33	1.38	1.44	1.50	1.56	1.62	1.68	1.73	1.79	1.85	1.91	1.97	2.03	2.08	2.14	2.20	2.26	2.32	2.38	2.43	2.49	2.55	2.61	2.67	2.72
62	1.31	1.37	1.42	1.48	1.54	1.60	1.66	1.72	1.77	1.83	1.89	1.95	2.01	2.07	2.12	2.18	2.24	2.30	2.36	2.42	2.47	2.53	2.59	2.65	2.71
63	1.29	1.35	1.41	1.46	1.52	1.58	1.64	1.70	1.76	1.81	1.87	1.93	1.99	2.05	2.11	2.16	2.22	2.28	2.34	2.40	2.46	2.51	2.57	2.63	2.69
64	1.27	1.33	1.39	1.45	1.51	1.56	1.62	1.68	1.74	1.80	1.86	1.91	1.97	2.03	2.09	2.15	2.20	2.26	2.32	2.38	2.44	2.50	2.55	2.61	2.67
65	1.25	1.31	1.37	1.43	1.49	1.55	1.60	1.66	1.72	1.78	1.84	1.90	1.95	2.01	2.07	2.13	2.19	2.25	2.30	2.36	2.42	2.48	2.54	2.60	2.65
66	1.24	1.29	1.35	1.41	1.47	1.53	1.59	1.64	1.70	1.76	1.82	1.88	1.94	1.99	2.05	2.11	2.17	2.23	2.29	2.34	2.40	2.46	2.52	2.58	2.64
67	1.22	1.28	1.34	1.39	1.45	1.51	1.57	1.63	1.69	1.74	1.80	1.86	1.92	1.98	2.03	2.09	2.15	2.21	2.27	2.33	2.38	2.44	2.50	2.56	2.62
68	1.20	1.26	1.32	1.38	1.43	1.49	1.55	1.61	1.67	1.73	1.78	1.84	1.90	1.96	2.02	2.08	2.13	2.19	2.25	2.31	2.37	2.42	2.48	2.54	2.60
69	1.18	1.24	1.30	1.36	1.42	1.47	1.53	1.59	1.65	1.71	1.77	1.82	1.88	1.94	2.00	2.06	2.12	2.17	2.23	2.29	2.35	2.41	2.47	2.52	2.58

**NOTE: ALL VALUES ARE AT BTPS

Table E-8
Predicted FVC for nonwhite females

HEIGHT IN INCHES

AGE	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
16	2.08	2.15	2.22	2.29	2.36	2.43	2.51	2.58	2.65	2.72	2.79	2.86	2.93	3.00	3.08	3.15	3.22	3.29	3.36	3.43	3.50	3.57	3.65	3.72	3.79
17	2.16	2.23	2.30	2.37	2.44	2.51	2.58	2.66	2.73	2.80	2.87	2.94	3.01	3.08	3.15	3.23	3.30	3.37	3.44	3.51	3.58	3.65	3.72	3.80	3.87
18	2.24	2.31	2.38	2.45	2.52	2.59	2.66	2.73	2.81	2.88	2.95	3.02	3.09	3.16	3.23	3.30	3.37	3.45	3.52	3.59	3.66	3.73	3.80	3.87	3.94
19	2.31	2.38	2.46	2.53	2.60	2.67	2.74	2.81	2.88	2.95	3.03	3.10	3.17	3.24	3.31	3.38	3.45	3.52	3.60	3.67	3.74	3.81	3.88	3.95	4.02
20	2.35	2.43	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39	3.47	3.55	3.63	3.71	3.79	3.87	3.95	4.03	4.11	4.19	4.27
21	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.29	3.37	3.45	3.53	3.61	3.69	3.77	3.85	3.93	4.01	4.09	4.17	4.25
22	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.03	3.11	3.19	3.27	3.35	3.43	3.51	3.59	3.67	3.75	3.83	3.91	3.99	4.07	4.15	4.23
23	2.30	2.38	2.46	2.54	2.62	2.70	2.78	2.85	2.93	3.01	3.09	3.17	3.25	3.33	3.41	3.49	3.57	3.65	3.73	3.81	3.89	3.97	4.05	4.13	4.21
24	2.28	2.36	2.44	2.52	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16	3.24	3.32	3.40	3.48	3.56	3.64	3.71	3.79	3.87	3.95	4.03	4.11	4.19
25	2.26	2.34	2.42	2.50	2.58	2.66	2.74	2.82	2.90	2.98	3.06	3.14	3.22	3.30	3.38	3.46	3.54	3.62	3.70	3.78	3.86	3.94	4.02	4.10	4.18
26	2.24	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52	3.60	3.68	3.76	3.84	3.92	4.00	4.08	4.16
27	2.22	2.30	2.38	2.46	2.54	2.62	2.70	2.78	2.86	2.94	3.02	3.10	3.18	3.26	3.34	3.42	3.50	3.58	3.66	3.74	3.82	3.90	3.98	4.06	4.14
28	2.20	2.28	2.36	2.44	2.52	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16	3.24	3.32	3.40	3.48	3.56	3.64	3.72	3.80	3.88	3.96	4.04	4.12
29	2.18	2.26	2.34	2.42	2.50	2.58	2.66	2.74	2.82	2.90	2.98	3.06	3.14	3.22	3.30	3.38	3.46	3.54	3.62	3.70	3.78	3.86	3.94	4.02	4.10
30	2.16	2.24	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52	3.60	3.68	3.76	3.84	3.92	4.00	4.08
31	2.15	2.23	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.02	3.10	3.18	3.26	3.34	3.42	3.50	3.58	3.66	3.74	3.82	3.90	3.98	4.06
32	2.13	2.21	2.29	2.37	2.45	2.53	2.61	2.69	2.77	2.85	2.93	3.01	3.09	3.17	3.25	3.33	3.41	3.49	3.57	3.65	3.73	3.81	3.88	3.96	4.04
33	2.11	2.19	2.27	2.35	2.43	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39	3.47	3.55	3.63	3.71	3.79	3.87	3.95	4.03
34	2.09	2.17	2.25	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.29	3.37	3.45	3.53	3.61	3.69	3.77	3.85	3.93	4.01
35	2.07	2.15	2.23	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.03	3.11	3.19	3.27	3.35	3.43	3.51	3.59	3.67	3.75	3.83	3.91	3.99
36	2.05	2.13	2.21	2.29	2.37	2.45	2.53	2.61	2.69	2.77	2.85	2.93	3.01	3.09	3.17	3.25	3.33	3.41	3.49	3.57	3.65	3.73	3.81	3.89	3.97
37	2.03	2.11	2.19	2.27	2.35	2.43	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39	3.47	3.55	3.63	3.71	3.79	3.87	3.95
38	2.02	2.10	2.18	2.25	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.29	3.37	3.45	3.53	3.61	3.69	3.77	3.85	3.93
39	2.00	2.08	2.16	2.24	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.11	3.19	3.27	3.35	3.43	3.51	3.59	3.67	3.75	3.83	3.91
40	1.98	2.06	2.14	2.22	2.30	2.38	2.46	2.54	2.62	2.70	2.78	2.86	2.94	3.02	3.10	3.18	3.26	3.34	3.42	3.50	3.58	3.66	3.74	3.82	3.90
41	1.96	2.04	2.12	2.20	2.28	2.36	2.44	2.52	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16	3.24	3.32	3.40	3.48	3.56	3.64	3.72	3.80	3.88
42	1.94	2.02	2.10	2.18	2.26	2.34	2.42	2.50	2.58	2.66	2.74	2.82	2.90	2.98	3.06	3.14	3.22	3.30	3.38	3.46	3.54	3.62	3.70	3.78	3.86
43	1.92	2.00	2.08	2.16	2.24	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52	3.60	3.68	3.76	3.84
44	1.90	1.98	2.06	2.14	2.22	2.30	2.38	2.46	2.54	2.62	2.70	2.78	2.86	2.94	3.02	3.10	3.18	3.26	3.34	3.42	3.50	3.58	3.66	3.74	3.82
45	1.88	1.96	2.04	2.12	2.20	2.28	2.36	2.44	2.52	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16	3.24	3.32	3.40	3.48	3.56	3.64	3.72	3.80
46	1.87	1.95	2.03	2.11	2.19	2.27	2.35	2.42	2.50	2.58	2.66	2.74	2.82	2.90	2.98	3.06	3.14	3.22	3.30	3.38	3.46	3.54	3.62	3.70	3.78
47	1.85	1.93	2.01	2.09	2.17	2.25	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.28	3.36	3.44	3.52	3.60	3.68	3.76
48	1.83	1.91	1.99	2.07	2.15	2.23	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.03	3.11	3.19	3.27	3.35	3.43	3.51	3.59	3.67	3.75
49	1.81	1.89	1.97	2.05	2.13	2.21	2.29	2.37	2.45	2.53	2.61	2.69	2.77	2.85	2.93	3.01	3.09	3.17	3.25	3.33	3.41	3.49	3.57	3.65	3.73
50	1.79	1.87	1.95	2.03	2.11	2.19	2.27	2.35	2.43	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39	3.47	3.55	3.63	3.71
51	1.77	1.85	1.93	2.01	2.09	2.17	2.25	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.29	3.37	3.45	3.53	3.61	3.69
52	1.75	1.83	1.91	1.99	2.07	2.15	2.23	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.03	3.11	3.19	3.27	3.35	3.43	3.51	3.59	3.67
53	1.73	1.81	1.89	1.97	2.05	2.13	2.21	2.29	2.37	2.45	2.53	2.61	2.69	2.77	2.85	2.93	3.01	3.09	3.17	3.25	3.33	3.41	3.49	3.57	3.65
54	1.72	1.80	1.88	1.96	2.04	2.12	2.20	2.28	2.36	2.44	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39	3.47	3.55	3.63
55	1.70	1.78	1.86	1.94	2.02	2.10	2.18	2.26	2.34	2.42	2.50	2.58	2.66	2.74	2.82	2.90	2.98	3.06	3.14	3.22	3.30	3.37	3.45	3.53	3.61
56	1.68	1.76	1.84	1.92	2.00	2.08	2.16	2.24	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52	3.60
57	1.66	1.74	1.82	1.90	1.98	2.06	2.14	2.22	2.30	2.38	2.46	2.54	2.62	2.70	2.78	2.86	2.94	3.02	3.10	3.18	3.26	3.34	3.42	3.50	3.58
58	1.64	1.72	1.80	1.88	1.96	2.04	2.12	2.20	2.28	2.36	2.44	2.52	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16	3.24	3.32	3.40	3.48	3.56
59	1.62	1.70	1.78	1.86	1.94	2.02	2.10	2.18	2.26	2.34	2.42	2.50	2.58	2.66	2.74	2.82	2.90	2.98	3.06	3.14	3.22	3.30	3.38	3.46	3.54
60	1.60	1.68	1.76	1.84	1.92	2.00	2.08	2.16	2.24	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52
61	1.59	1.67	1.74	1.82	1.90	1.98	2.06	2.14	2.22	2.30	2.38	2.46	2.54	2.62	2.70	2.78	2.86	2.94	3.02	3.10	3.18	3.26	3.34	3.42	3.50
62	1.57	1.65	1.73	1.81	1.89	1.97	2.05	2.13	2.21	2.29	2.37	2.45	2.53	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16	3.24	3.32	3.40	3.48
63	1.55	1.63	1.71	1.79	1.87	1.95	2.03	2.11	2.19	2.27	2.35	2.43	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39	3.46
64	1.53	1.61	1.69	1.77	1.85	1.93	2.01	2.09	2.17	2.25	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.29	3.37	3.45
65	1.51	1.59	1.67	1.75	1.83	1.91	1.99	2.07	2.15	2.23	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.03	3.11	3.19	3.27	3.35	3.43
66	1.49	1.57	1.65	1.73	1.81	1.89	1.97	2.05	2.13	2.21	2.29	2.37	2.45	2.53	2.61	2.69	2.77	2.85	2.93	3.01	3.09	3.17	3.25	3.33	3.41
67	1.47	1.55	1.63	1.71	1.79	1.87	1.95	2.03	2.11	2.19	2.27	2.35	2.43	2.51	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.15	3.23	3.31	3.39
68	1.45	1.53	1.61	1.69	1.77	1.85	1.93	2.01	2.09	2.17	2.25	2.33	2.41	2.49	2.57	2.65	2.73	2.81	2.89	2.97	3.05	3.13	3.21	3.29	3.37
69	1.44	1.52	1.60	1.68	1.76	1.84	1.91	1.99	2.07	2.15	2.23	2.31	2.39	2.47	2.55	2.63	2.71	2.79	2.87	2.95	3.03	3.11	3.19	3.27	3.35

**NOTE: ALL VALUES ARE AT BTPS

APPENDIX F
SPIROMETRY TECHNICIAN NIOSH-APPROVED TRAINING COURSE: MINIMUM STANDARDS

F–1. Address for course approval

a. Minimum standards for a NIOSH-approved course for spirometry technicians is given in paragraph F–2 through F–5. Further information about NIOSH-approved pulmonary function training courses may be obtained by writing to—

Director, Division of Training and Manpower Development
National Institute for Occupational Safety and Health
Robert A. Taft Laboratories
4676 Columbia Parkway
Cincinnati, OH 45226

b. Information concerning the locations of existing NIOSH-approved courses may be obtained by writing to the above address, or calling NIOSH at (Commercial) (513) 533-8241.

F–2. Course design

Each spirometry training course should be geared to the level of the spirometry technician. The course should consist of at least 16 hours of instruction, including—

a. At least 4 hours of formal lectures and/or audiovisual material.

b. At least 8 hours of small group practical instruction with no more than five students per instructor. During this time the student should be practicing the technique under supervised conditions.

c. At least 2 hours per student devoted to evaluation and testing of the student's spirometric skills.

F–3. Course content

The following topics should be covered:

a. Basic physiology of the forced expiratory maneuver and determinants of airflow limitation with emphasis on the relation to reproducibility of results.

b. Instrumentation requirements including calibration procedures, sources of error, and their correction.

c. Patient preparation and indications for postponing testing.

d. Performance of testing including worker coaching, recognition of improperly performed maneuvers, and corrective actions.

e. Data quality (i.e., what constitutes a valid spirogram) with emphasis on reproducibility.

f. Measurements of tracings and calculation of results.

F–4. Equipment

At least one spirometer and 3.0-liter (or larger) calibration syringe must be provided for every five students. The spirometer must meet the minimum specifications outlined in chapter 7.

F–5. Course director

The course technical director is the individual responsible for the content of this course and must be an active, participating supervisor of the course instructors. This course director must be either—

a. A physician who has training and experience with the technical procedures and equipment used for spirometry testing and in the diagnosis of occupational lung diseases, *or*

b. A health professional with an advanced degree in pulmonary physiology or related field who has training and experience with the technical procedures and equipment used for spirometry testing (e.g., Ph.D in pulmonary physiology, bioengineering, etc.), *or*

c. A health professional with licensure or professional certification in the pulmonary function testing field with documented experience under the supervision of other professionals noted in *a* or *b* above.

GLOSS

Section I
Abbreviations

ANSI .....American National Standards Institute
ATS .....American Thoracic Society
BTPS .....body temperature, ambient pressure, saturated with water vapor
C .....Celsius (temperature)
CFR .....Code of Federal Regulations
cm .....centimeter
DOD .....Department of Defense
F .....Fahrenheit (temperature)
FEV_1 .....forced expiratory volume in 1 second
(FEV_1/FVC)% ..... forced expiratory volume in 1 second expressed as a percentage of the forced vital capacity
FVC .....forced vital capacity
MEDDAC/MEDCEN U.S. Army Medical Department activity/medical center
mL .....milliliter
mm .....millimeter
MTF .....medical treatment facility
NIOSH .....National Institute for Occupational Safety and Health
obs .....observed
OSHA .....Occupational Safety and Health Administration
ppm .....parts per million
pred .....predicted
SCBA .....self-contained breathing apparatus
TLV .....threshold limit value
VC .....vital capacity

Section II
Terms

Back extrapolation

In the calculation of FEV_1: a method for determining the zero time point. (A straight line is drawn through the steepest portion of the volume time curve back to the baseline. Where this straight line intersects the baseline is the zero time point for calculating the FEV_1.)

ature.)

Calibration check

Periodic determination of a spirometer's ability to accurately measure volume. (Calibration checks should be performed using a syringe or other know volume source of three liters. The instrument should maintain an accuracy of ± 3 percent of the reading.)

End-of-test

That point during the forced expiratory maneuver when a plateau is noted on the tracing. (It is defined mathematically when the volume change in 0.5 seconds is less than 25 mL.)

Extrapolated volume

That volume determined by a line drawn through the zero time point perpendicular to the baseline. (The extrapolated volume is read when this perpendicular line intersects that volume curve; it should be less than 10 percent of the FVC or 100 mL, whichever is greater.)

Forced expiratory maneuver

Technique during spirometry when the subject takes the deepest possible inspiration from a normal breathing pattern and blows into the mouthpiece as hard, fast, and completely as possible. Also known as the FVC maneuver.

Forced expiratory volume in 1 second

Volume of air exhaled during the first second of the forced expiratory effort.

Forced vital capacity

The volume of air which can be exhaled forcefully after full inspiration.

Predicted normal values

Expected values for various lung volumes and flow rates derived from healthy populations.

Spirometry technician

A military or civilian worker who has been trained and qualified to perform spirometry testing in the MTF.

Valid spirometry examination

Consists of three acceptable spirograms free of coughing, hesitant or false starts, variable effort, early termination of expiration, excessive variability, and baseline artifact. (The two best FVCs do not vary more than ± 5% or ±100 mL, whichever is greater.)

Vital capacity

The maximal volume of air exhaled from the point of maximal inspiration.

Zero time point

In the measurement of FEV_1, the point selected as the start of the test through back extrapolation.

The proponent agency of this bulletin is the Office of The Surgeon General. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to HQDA (DASG-PSP), 5111 Leesburg Pike, Falls Church, VA 22041–3258.

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General, United States Army
Chief of Staff

Official:

R. L. DILWORTH
Brigadier General, United States Army
The Adjutant General

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SPIROMETER CALIBRATION LOG

For use of this form see TB MED 509; the proponent of this form is the Office of The Surgeon General

Date	Technician Name	Daily Calibration Check (Volume: 3.0 liters) (Range: 2.91 - 3.09 liters)		Weekly Leakage Check	Weekly Calibration Check (Time: 15 seconds) (Range: 14.85 - 15.15 seconds)		Remarks
		Spirometer	Microprocessor	(yes/no)	Spirometer	Microprocessor	

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TB MED 509

SPIROMETRY FLOW SHEET

For use of this form see TB MED 509; the proponent of this form is the Office of The Surgeon General

Name	Location	Job Title	Sex ☐ Male ☐ Female	Race	Social Security No.

Test Date	Spirometer Type	Age	Height	Observed Values (BTPS)			Predicted Values		Percent Predicted		Percent Changes Over Shift			Percent Changes Annually		
				FEV_1	FVC	$\frac{FEV_1}{FVC}$ %	FEV_1	FVC	FEV_1	FVC	Between	FEV_1	FVC	FEV_1	FVC	$\frac{FEV_1}{FVC}$ %

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U.S. GOVERNMENT PRINTING OFFICE:1986-181-030/45028

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