Spirometry Testing in Occupational Health Programs

Best Practices for Healthcare Professionals

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1. This guidance document is intended for medical personnel who oversee worker health programs, conduct spirometry tests, and/or interpret spirometry results.

2. The goal of the document is to help ensure the collection of accurate, valid spirometry results that are interpreted correctly.

3. Such spirometry assessments can be used to make well-informed decisions about worker respiratory health (including the need for medical referrals), and to conduct programs for prevention and early intervention.

Importance of Guidance Document


2. Most US employers do not process cotton, so many occupational medicine professionals were not supported when they tried to improve spirometry testing programs for workers.

3. Not mandatory compliance regulation, but this Guidance explicitly states what OSHA regards as best practice in occupational spirometry programs.

Changes Since 1978

1. Spirometers evolved – flow-type devices developed, many with limited real-time displays.


4. NHANES III research study, giving most accurate normal ranges for interpreting results: 1999

5. NIOSH spirometry course approval tightened up, Refreshers NIOSH-approved from 2009 on.
1.1 Spirometry Overview

Figure 1. Volume-time wave (left) and flow-volume wave (right).

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1.0 Introduction
1.1. Spirometry Overview

2.0 Accurately Measuring Worker Lung Function
2.1 Personnel Involved in Spirometry Testing
2.2 Equipment
2.3 Conducting Spirometry Tests
3.0 Interpreting Test Results
3.1 Comparing Worker Results with Normal Range (Reference Values)
3.2 Evaluating Results Over Time

4.0 Quality Assurance (QA) Reviews
5.0 Spirometry Procedure Manual
6.0 Recordkeeping
7.0 References
APPENDIX A — National Health and Nutrition Examination Survey III (NHANES III) Reference Values
APPENDIX B — Spirometry Procedure Manual Checklist

2.1 Spirometry Testing Personnel

“The most important quality of a pulmonary function technician is the motivation to do the very best test on every employee.

The technician must also be able to judge the degree of effort and cooperation of the subject.

The test results obtained by a technician who lacks these skills are not only useless, but also convey false information which could be harmful to the employee.”

- OSHA 2013

2.1.1 PHLCP Training

1. Spirometry program supervisors and directors need to: 1) understand what makes tests valid, and 2) recognize flawed results.

2. Effective PLHCP oversight helps correct problems quickly and repeat tests when needed.

3. OSHA recommends: supervisors and/or interpreters of results take NIOSH-approved spirometry courses or equivalent training so they can oversee programs effectively.

4. Such training must emphasize recognizing and trouble-shooting technical errors and how to interpret spirometry results.

APPENDIX B — Spirometry Procedure Manual Checklist

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2.1.1 Technician Training

- Some OSHA standards specifically require a spirometry training course for personnel who test workers covered by those standards.
- OSHA also recommends that:
  1) all persons conducting occupational spirometry tests should complete an initial NIOSH-approved spirometry course, and
  2) attend NIOSH-approved Refresher courses to maintain that certification over time.

2.2 Equipment

2.2.1 Selecting a Spirometer

1. Accuracy and precision
2. Validation testing by independent lab or manufacturer
3. Graphical displays during testing that are large enough to help tech coach effectively
4. Graphical displays on reports that are large enough to let interpreters evaluate test validity effectively
5. Features to look for in new spirometers

2.2.2 Checking Spirometer Cal

- Volume spirometer checks – leaks, accuracy when 3-L injected, quarterly linearity check
- Flow-type spirometer checks - accuracy when 3-L injected @ 6 L/s, 3 L/s, 0.5 L/s
- Care of cal syringe
- Save equipment maintenance and cal check records

Failure to pass all spirometer checks indicates that workers should not be tested until the cause of failure is identified and corrected, and the spirometer passes all of its calibration checks.

2.3 Conducting Tests

- Pre-test preparation
- Posture: Standing recommended
- Testing: Explain, demonstrate, coach

- Valid tests have:
  1. 3 acceptable curves (attempt up to 8)
  2. Repeatable FVC and FEV1
     - Highest – 2nd highest FVC is 0.15 L or less
     - Highest – 2nd highest FEV1 is 0.15 L or less
  3. Report largest FVC, largest FEV1, even if different curves
### Errors that must be deleted

- Cough
- Hesitation
- Small Inspiration

### Common errors giving low values

- No blast
- Maximal Effort

### End of Test Definition

**Valid end of test:**
1. Subject can’t/won’t continue;
2. Plateau achieved and subject tried to exhale for 6 or more sec;
3. Older or obstructed people usually >6 s, but should stop at 15 s.

### 3.0 Interpreting Test Results

- Compare worker to normal range
- Compare current FEV1 to previous FEV1s

When interpreting spirometry results, medical personnel should evaluate the technical quality of the test and not rely solely on numerical results and computer interpretations.

### 3.1 Compare Worker to Normal Range

**3.1.1 Select reference values**

OSHA recommends that spirometry results for workers in the United States be compared with NHANES III (Hankinson 1999) reference values unless an OSHA standard requires that a different reference set be used.

### 3.1.2 Race Adjustment of Predicted Values and LLN

- Racial group/ethnicity is based on self-report.
- NHANES III has race-specific values for Caucasian, African-American, and Hispanic workers, but not Asian-Americans.
- For Asian workers, apply 0.88 scaling factor to Caucasian FVC and FEV1 reference values. FEV1/FVC reference not adjusted.
- If use NHANES, “race-adjustment” factors not needed for non-Asians.

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### 3.2 Evaluating Results Over Time - 1

#### 3.2.1 Why look at change over time?
- Exposures may accelerate age-related loss
- A few diseases have rapid FEV1 decline
- Workers with baselines > 100% pred

#### 3.2.2 Technical and biological factors
- Standardize and avoid changes in test protocol and equipment
- Train technicians and perform QA reviews
- Maintain equipment and keep records
- Minimize biological variability

### 4.0 QA Reviews

- At least quarterly, review random sample of reports, all invalid tests, sample of those with FVC or FEV1 < LLN or > 130% pred
- Perform reviews more often for new techs or if problems found
- Feedback to technician on errors, coaching suggestions, spirometer settings
- Goal: at least 80% of total tests are technically valid – if less, retraining needed

### 3.2 Evaluating Results Over Time - 2

#### 3.2.3 Frequency of testing
- Varies with exposure, outcome, and regulations

#### 3.2.4 Values that suggest abnormality
- Evaluate only FEV1 over time
- 15% drop after aging effect may be excessive; maybe 10-15% if spirometers accurate, good technical quality, deleterious exposures

#### 3.2.5 Interpreting change over time
- Verify tests are good quality, adequate follow-up, multiple factors may affect change, further medical evaluation if repeat tests verify loss

### 6.0 Recordkeeping

- Spirometry Test Reports – part of medical record, save for 30 yrs after termination of employment
- Equipment Maintenance Records – support accuracy of spirometry tests from same date
- QC Log
- Spirometer hardware, software changes
- Personnel training and evaluation records