

# **TECHNIQUE AND EQUIPMENT PITFALLS IN SPIROMETRY TESTING: SERIOUS THREATS TO YOUR RESPIRATORY SURVEILLANCE PROGRAM**

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## **OUTLINE**

- **SPIROMETRY EVALUATION IN THE OCCUPATIONAL SETTING**
- **DATA LIMITATIONS OF MANY SPIROMETERS**
- **ERRORS THAT INFLATE TEST RESULTS**
- **ERRORS THAT REDUCE TEST RESULTS**
- **EXAMPLES**

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## SPIROMETRY EVALUATION IN THE OCCUPATIONAL SETTING

### 1. Compare one test result with reference value

- Above cut-off level required by employer to perform job or wear respirator? \*\*; or
- Normal or impaired? - periodic medical assessment

\*\* Volumes may be under-recorded, especially for those with large lungs – test may focus on exceeding cut-off. Graphs usually saved – unfortunately may become next year’s “baseline.”

### 2. Examine multiple test results for rate of change over time

*Technical errors cause false positives and negatives for both types of evaluation*

## DATA LIMITATIONS OF MANY SPIROMETERS

1. Many save only 3 “best” curves (highest sum of FEV1 + FVC); and
2. Most report largest recorded FVC and FEV1, per ATS and OSHA.  
*So.... Falsely inflated values will be reported, rather than lower accurate values.*
3. Often must delete curve so it won’t be saved, sometimes with no real-time graph;
4. If saved, often cannot delete curve unless delete test session and start new test.

*So.... Need to know that technical errors can inflate results, and Recognize which curves to delete.*

## ERRORS THAT INFLATE TEST RESULTS

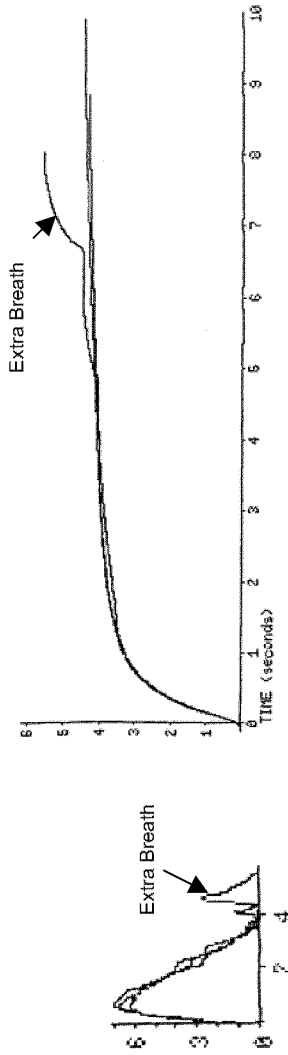
### 1. Poor testing technique:

- a) Extra breath through the nose (Figure 1),
- b) Slightly submaximal expiratory effort (negative effort dependence of the FEV1) (Figure 2), and
- c) Accept/save curve with large hesitation, even when flagged by spirometer (Figure 3).

### 2. Flow-type spirometer malfunctions during subject testing, even though calibration successfully set or checked earlier in the day:

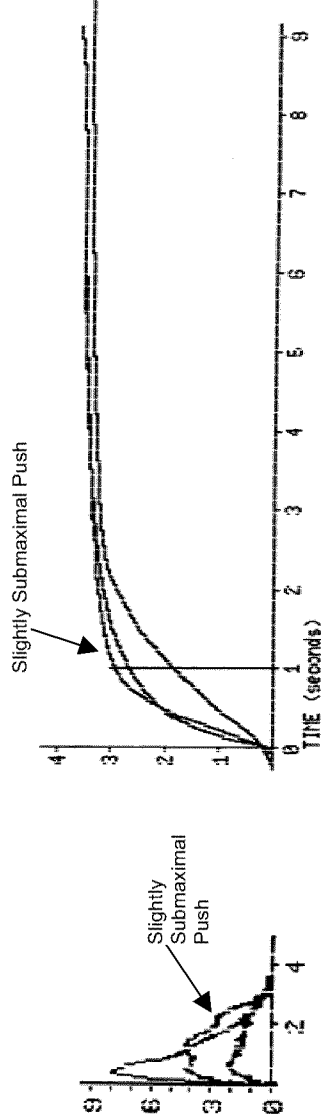
- a) Inaccurate zeroing of sensor, performed before each expiration (Figure 4); or
- b) Sensor characteristics change between expirations due to warming, deposition of mucus, or condensation of water vapor (Figure 5).

**Figure 1: Extra Breath**



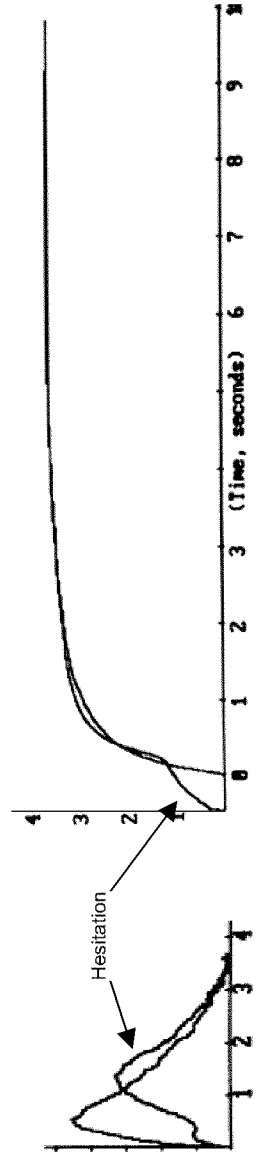
|              | FVC (L) | % Pred | FEV1/FVC% | % Pred |
|--------------|---------|--------|-----------|--------|
| Good Effort  | 4.78    | 96     | 74        | 93     |
| Extra Breath | 5.96    | 119    | 59        | 75     |

**Figure 2: Slightly Submaximal Expiratory Effort (Negative Effort Dependence of FEV1)**



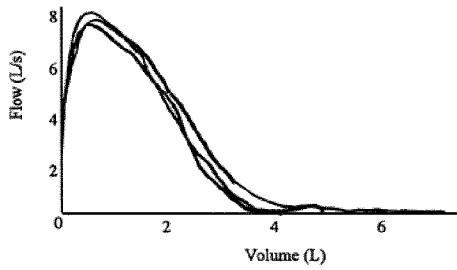
|             | FEV1 | % Pred | FEV1/FVC | % Pred |
|-------------|------|--------|----------|--------|
| Good Effort | 2.90 | 99     | 74       | 90     |
| Submax Push | 3.13 | 106    | 79       | 96     |

**Figure 3: Excessive Hesitation**

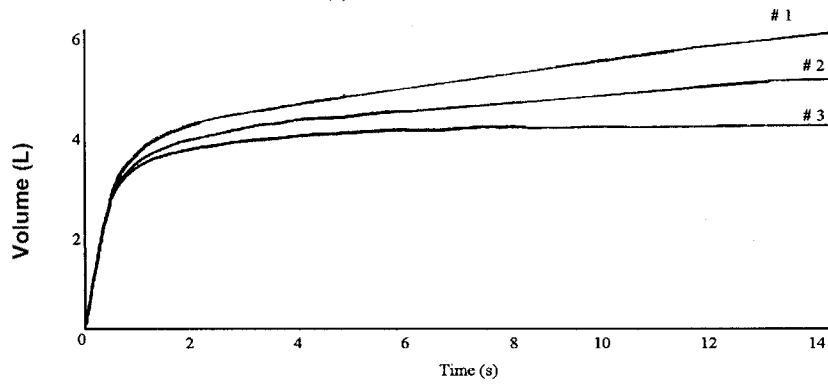


|                  | FEV1 | % Pred | FEV1/FVC5 | % Pred |
|------------------|------|--------|-----------|--------|
| Good Effort      | 3.23 | 109    | 82        | 101    |
| Large Hesitation | 3.34 | 112    | 83        | 102    |

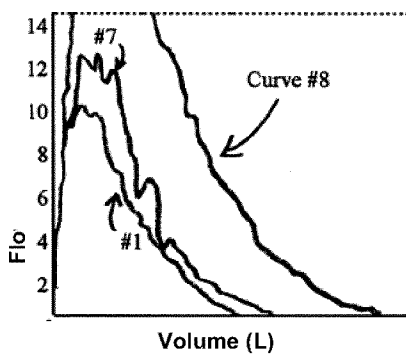
**Figure 4: Zero Flow Error: Screen Pneumotach**



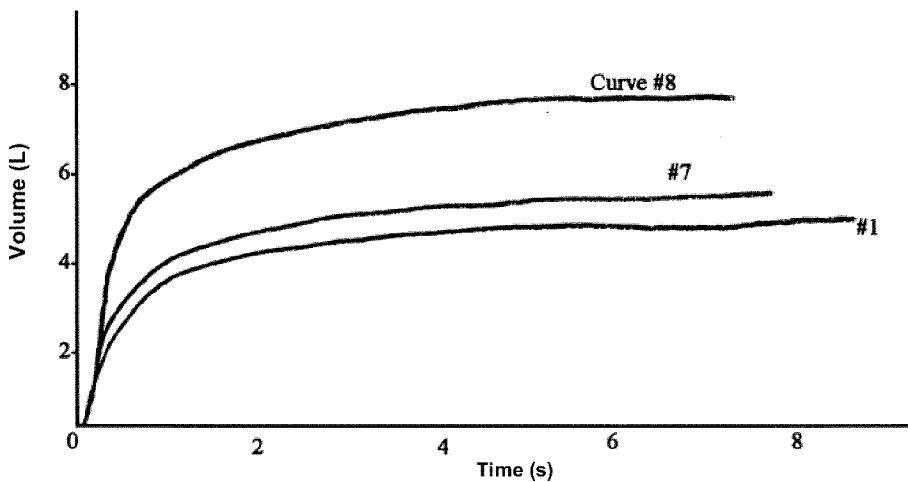
| 57 yo 68" WM  | Obs    | Pred          | %Pred  |
|---------------|--------|---------------|--------|
| Best FVC (L)  | 7.48   | 3.67          | 204%   |
| Best FEV1 (L) | 3.52   | 2.89          | 122%   |
| FEV1/FVC (%)  | 47.1   | 78.8          | 60%    |
| FVC Reprod =  | 2.50 L | FEV1 Reprod = | 0.19 L |



**Figure 5: Condensation/ Mucus Deposition: Screen Pneumotach**



| 46 yr 72" WM   | Obs          | Pred | %Pred |
|----------------|--------------|------|-------|
| Best FVC (L)   | 7.59         | 5.28 | 144%  |
| Best FEV1 (L)  | 5.82         | 4.30 | 135%  |
| Best PEF (L/s) | 15.9         | 9.59 | 166%  |
| FEV1/FVC %     | 76.7         | 81.1 | 95%   |
| FVC Reprod     | 2.29 L       |      |       |
| FEV1 Reprod    | 1.95 L       |      |       |
| PEF Reprod     | 3.91 L (25%) |      |       |



## ERRORS THAT *REDUCE* TEST RESULTS

### 1. Leaks in volume spirometer or breathing tubes:

- Reduce FVCs significantly but are *not visible in spiograms* until leak is very large (Figure 6);
- Checking for leaks at least daily in the calibration check is essential.

### 2. Errors in testing technique (usually visible in tracing):

- Small inspiration (Figure 7-2)
- Weak push (Figure 7-3)
- Tongue in mouthpiece (Figure 7-4)
- Early termination (Figure 7-6)
- Glottis Closure (Figure 7-7)

3. If technician corrects test error, reduced values will be replaced by higher, more accurate, results.

Figure 6: Effects of Spirometer Leaks on Test Results

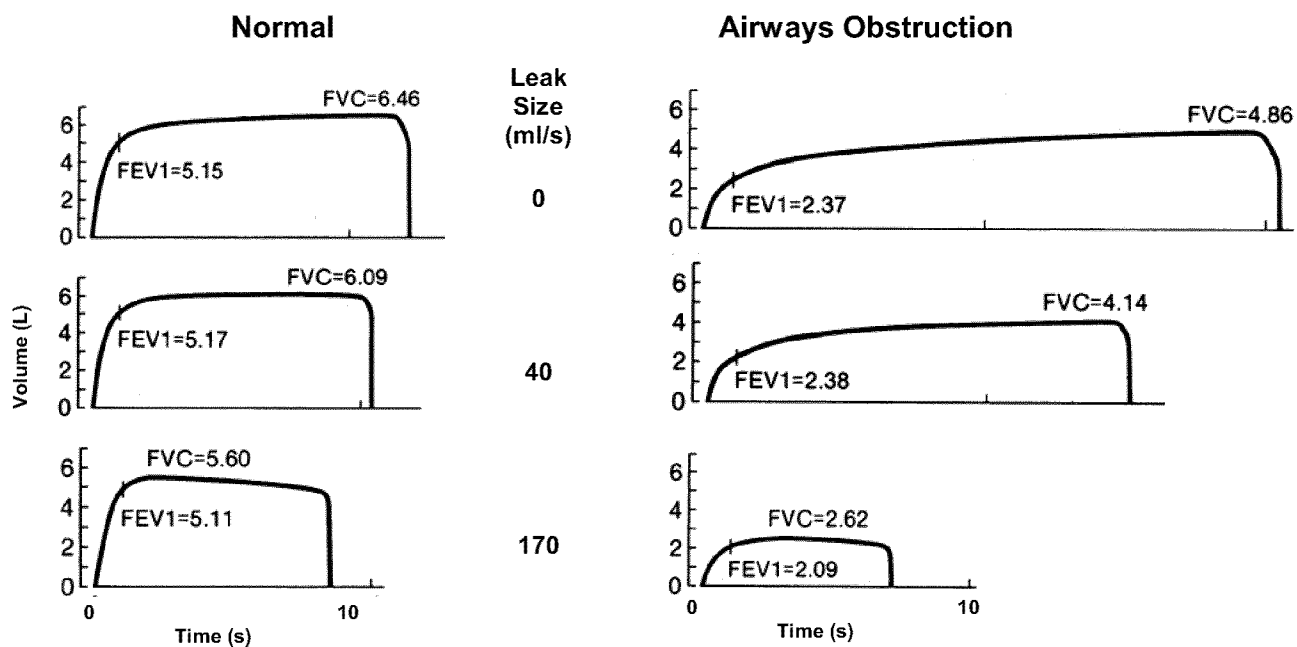
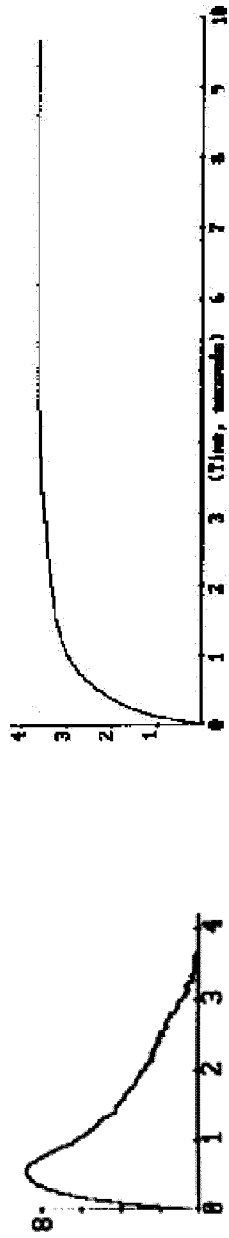
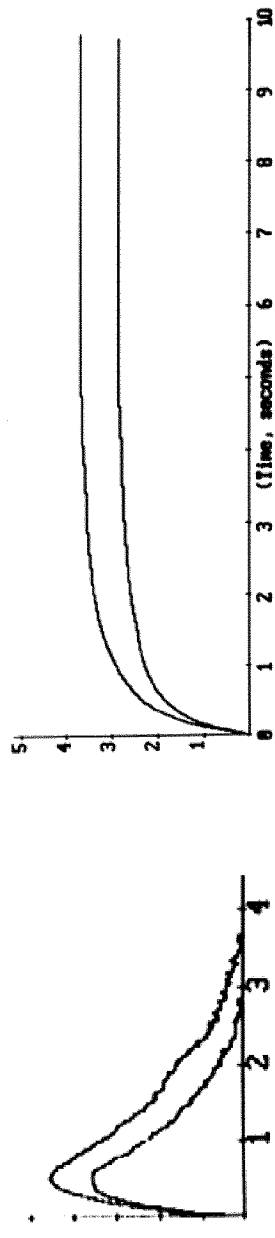


Figure 7-1. GOOD EFFORT



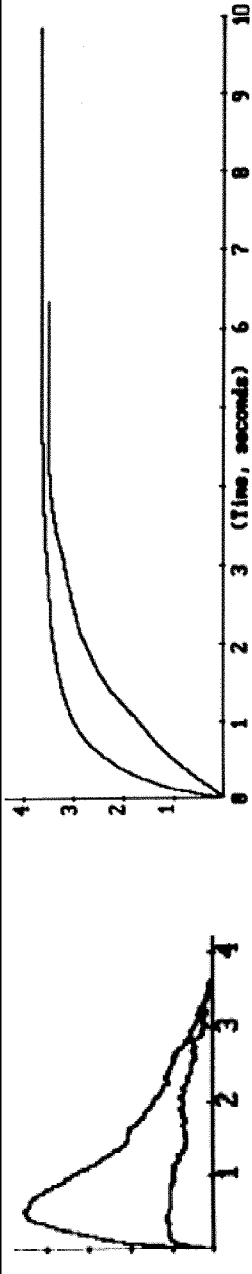
| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.93     | 107    |
| FEV1 (L)    | 3.23     | 109    |
| FEV1/FVC, % | 82       | 101    |

Figure 7-2. SMALL INSPIRATION



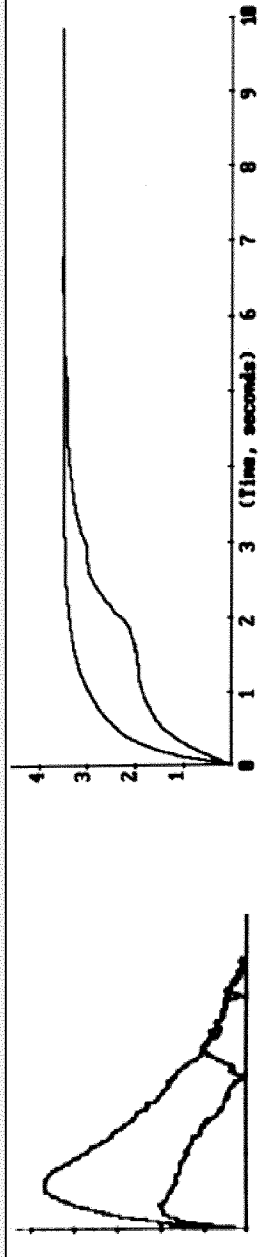
| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.11     | 85     |
| FEV1 (L)    | 2.48     | 83     |
| FEV1/FVC, % | 80       | 99     |

Figure 7-3. WEAK PUSH



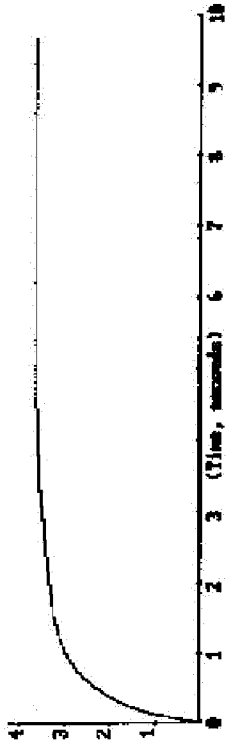
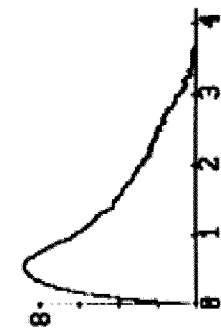
| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.83     | 105    |
| FEV1 (L)    | 1.86     | 63     |
| FEV1/FVC, % | 49       | 60     |

Figure 7-4. TONGUE IN MOUTHPIECE



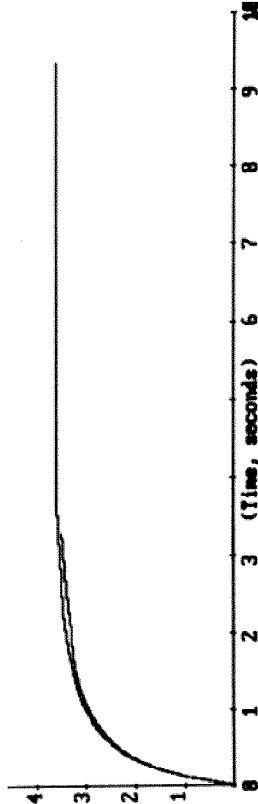
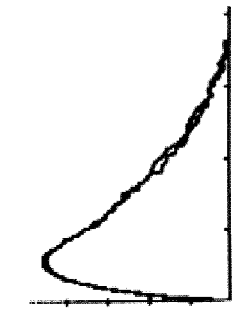
| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.85     | 105    |
| FEV1 (L)    | 2.02     | 68     |
| FEV1/FVC, % | 52       | 64     |

Figure 7-5. GOOD EFFORT



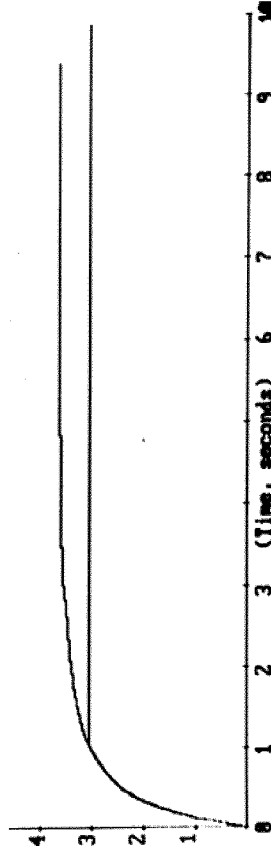
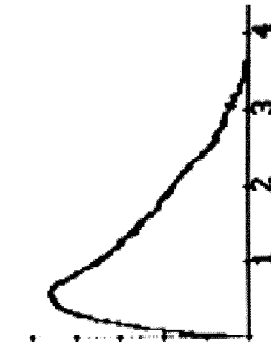
| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.93     | 107    |
| FEV1 (L)    | 3.23     | 109    |
| FEV1/FVC, % | 82       | 101    |

Figure 7-6. EARLY TERMINATION



| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.77     | 103    |
| FEV1 (L)    | 3.16     | 106    |
| FEV1/FVC, % | 84       | 104    |

Figure 7-7. GLOTTIS CLOSURE

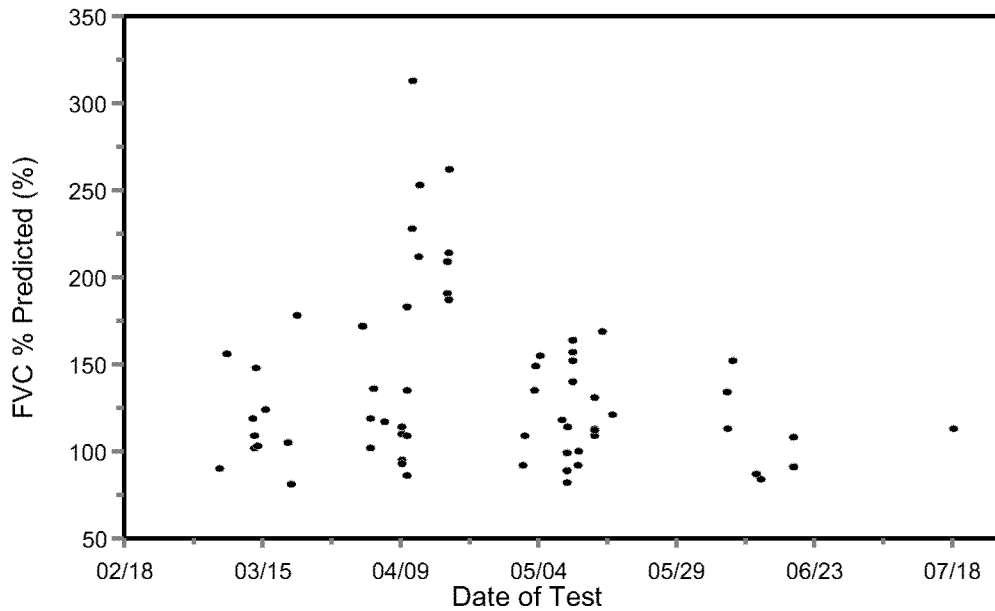


| Parameter   | Observed | % Pred |
|-------------|----------|--------|
| FVC (L)     | 3.31     | 90     |
| FEV1 (L)    | 3.27     | 110    |
| FEV1/FVC, % | 99       | 122    |

**Example 1: FAILURE OF MEDICAL SCREENING FOR RESPIRATOR USE**

- Spirometries conducted on 62 employees in a manufacturing plant.
- Employees were aged 20 - 62, median = 41.6 yr, 63% current smokers, 84 % male.
- 50% of employees tested had both FEV1 and FVC > 120 % of Predicted.
- Spirometer was frequently calibrated, plot of FVC % predicted shown below. Some probable zero flow errors, some possible moisture condensation; spirometer not holding its calibration.
- Test results are uninformative.

**FVC % Pred by Date and Time of Test**



**EXAMPLE 2: FAILURE OF A MEDICAL SURVEILLANCE PROGRAM**

Management Summary Report  
Employee Spirometry Testing  
12/31/99

|  |    |        |
|--|----|--------|
| Employees receiving annual spirometry test                     | 31 | (100%) |
| • Annual PFT values in normal range                            | 5  | ( 15%) |
| • Annual PFT values abnormal                                   | 1  | ( 3%)  |
| • Annual test FVC or FEV1 decreased more than 15% in past year | 20 | ( 65%) |