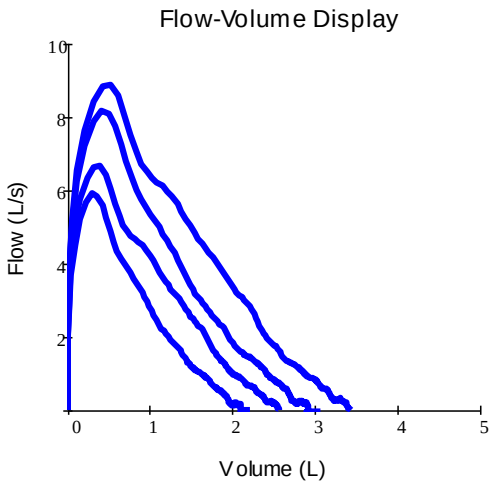
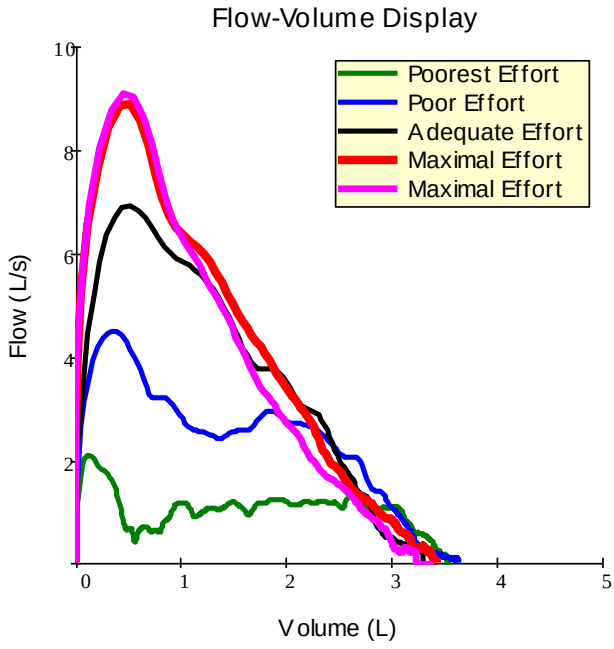
How to Obtain a Good Spirometry Test Result

How to obtain a good spirometry test? The spirometry technician is the single most important component in obtaining a good or valid spirometry test result. The technician must be able to explain, demonstrate, and coach a subject as to how to perform the spirometry test. After each maneuver, the technician must evaluate the subject effort and identify problems by observing the subject and the flow-volume and volume-time curves.

Two measures are the most important parameters from spirometry. The FVC is the total volume of air that can be forcefully exhaled. The FEV_1 is the volume of air that can be exhaled in one second of a forced exhalation.



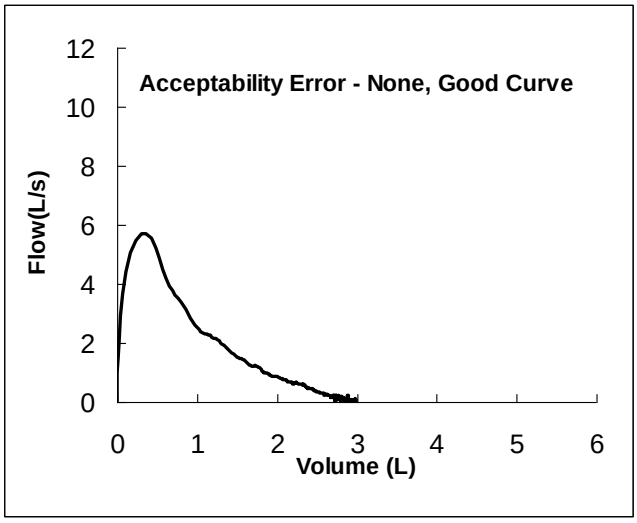
The single most important instruction is to take in a deep breath and **COMPLETELY** fill the lungs. A maximal inhalation must be obtained before the forced exhalation. Once a subject achieves a maximal inhalation the curves will all have the same size. If you observe varying sizes, but the same shapes, this is a good indication that the subject is varying their inhalation volume. On the left is example where differing volumes of air were inhaled. These flow-volume curves all have the same shapes but different sizes – a clear indication that a maximal inhalation has not been achieved. The FVC and FEV_1 values will also not be repeatable. If a subject does not inhale completely, their FVC and FEV_1 values will be low, falsely indicating a restrictive lung disease pattern.

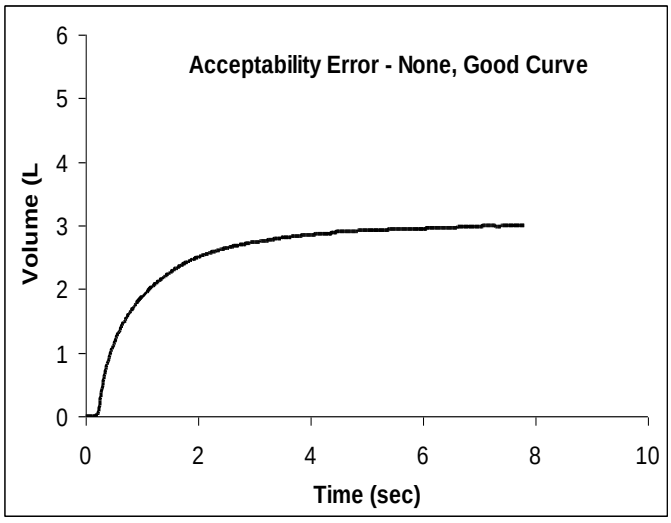


The second most important instruction is to blast the air out at first. If a subject does not blast the air out, flow limitation will not occur and the flow-volume curves will have varying peak flows (highest flow values for the curves). An example of a subject who is varying their effort is shown on the left. The green curve represents a very minimal effort, the blue curve is slightly better, and the black curve is probably adequate. Notice that the pink and red maximal effort curves are the same or on top of each other. When the curves are the same it is an indication that flow limitation probably has occurred or a maximal effort has been achieved. In the example on the left, the FVC will be repeatable but the FEV_1 will not be repeatable. If a subject does not maximally exhale, the FEV_1 and the FEV_1/FVC% will be low, falsely indicating an obstructive lung disease pattern.

Both the volume-time and flow-volume curves are needed to evaluate a maneuver. The flow-volume curve is most useful for evaluating the initial portion of the curve or the initial effort, where the subject must blast the air out at first. The volume-time curve is most useful in evaluating the ending portion of the maneuver or whether the subject has exhaled for a sufficient time and achieved a plateau in the

volume-time curve (no change in volume for one second). Below is an example of a good or acceptable maneuver and has no acceptability errors.

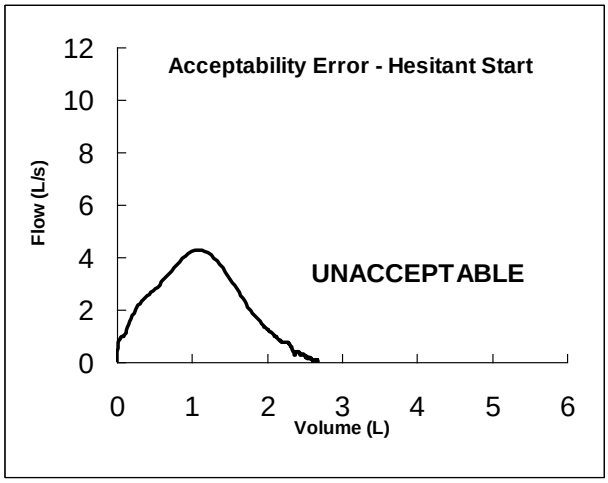


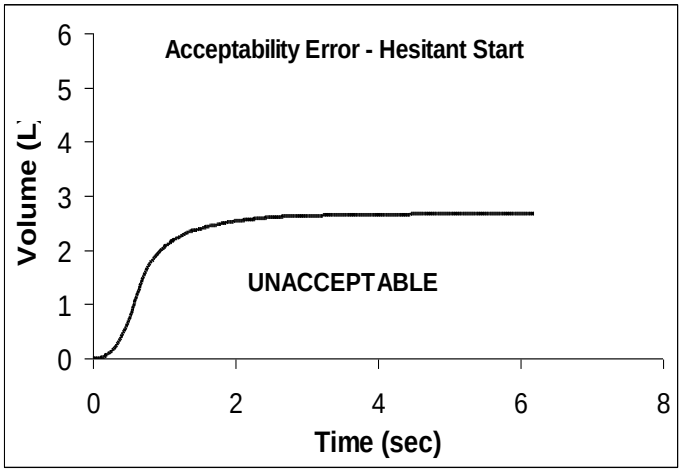


The flow-volume curve on the left has a rapid rise in the flow and is smooth through-out the maneuver. The peak flow is about twice the numeric value of the FVC (6 and 3). The volume-time curve on the right also has a rapid rise and is smooth through-out the maneuver. The exhalation lasts for about 8 seconds (longer than the minimum of 6 seconds) and there is a one second plateau in the volume-time curve.

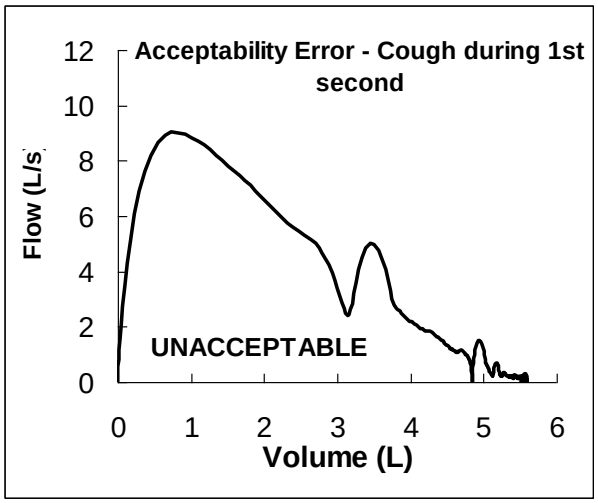
To obtain valid test results, you must attempt to obtain a repeatable test, or at least two more maneuvers of the same size and shape as the above flow-volume and volume-time curves. Specifically, you must obtain at least 3 acceptable maneuvers and a repeatable FVC and FEV_1 to within 150 ml. A repeatable test is one indication that a maximal inhalation was obtained. A maximum of 8 maneuvers should be performed, as after 8 maneuvers subject fatigue may make obtaining a maximal effort difficult.

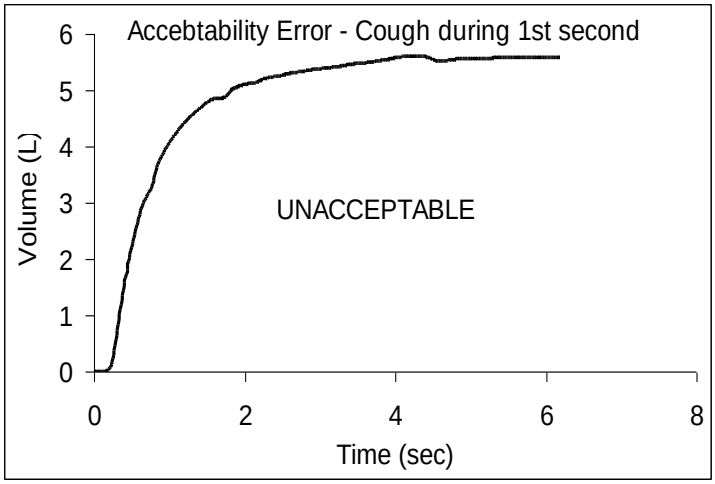
There are several common unacceptable maneuvers that are described below. The first unacceptable maneuver example is excessive hesitation. The flow-volume curve on the left has a rounded shape and the peak flow (maximal flow) occurs late in the maneuver (at about 1 liter). The volume time curve has a slow rise or slight bend at the beginning. When you observe these curve shapes, you should coach "blast the air out at first" to obtain a better maneuver. If there is too much hesitation (large extrapolated volume), the curve cannot be used as the FEV_1 may be falsely elevated.



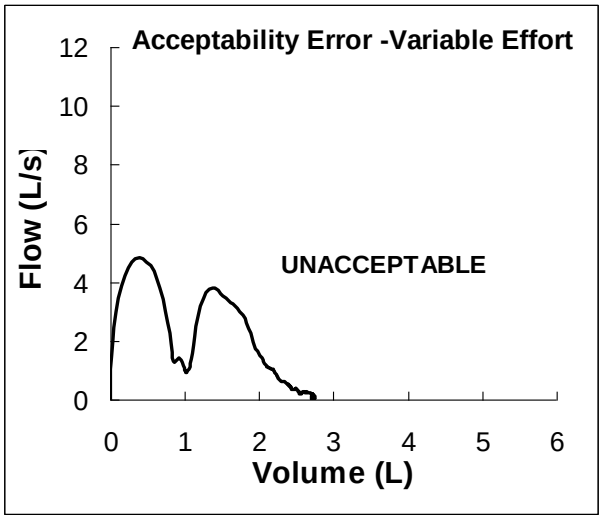


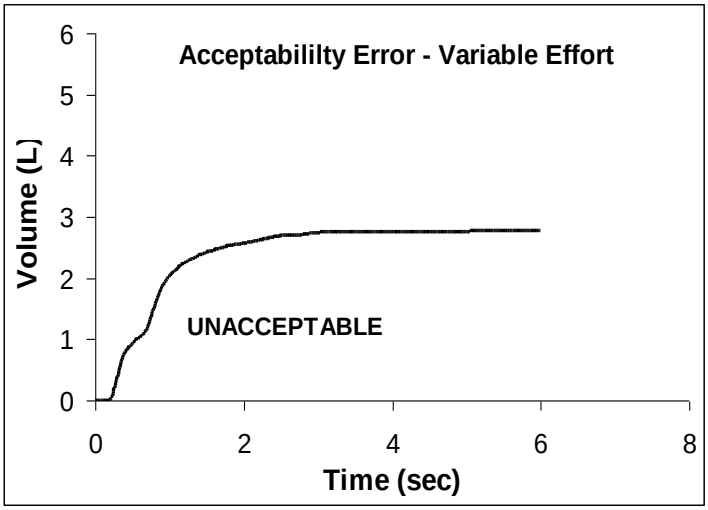
In the next unacceptable maneuver example there is a cough during the first second of exhalation. Notice the cough is obvious in the flow-volume curve but not as obvious in the volume-time curve. Recall that the flow-volume curve is most useful in evaluating the initial portion of the maneuver for events like a cough that occur during the first second of exhalation.



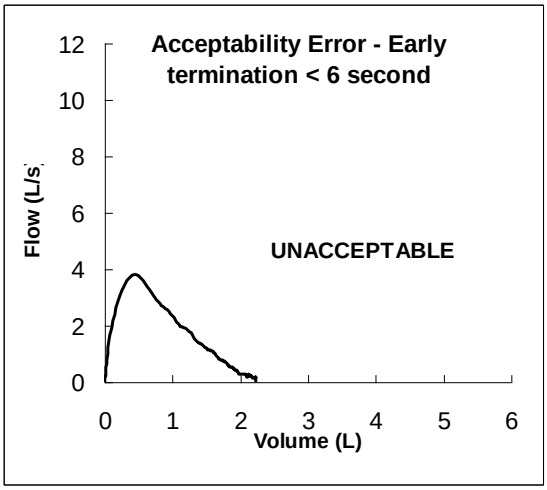


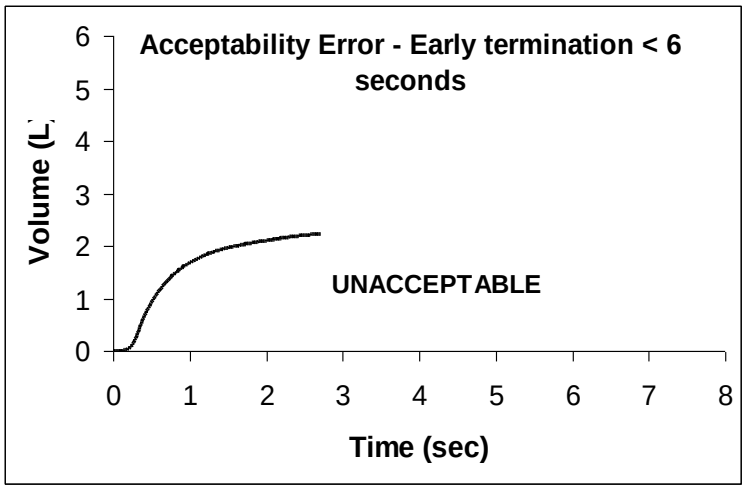
The next unacceptable maneuver example is a variable effort where a maximal effort is not continued through-out the maneuver. This unacceptable maneuver is more evident on the flow-volume curve but is also obvious on the volume-time curve. This differs from the cough as the length of time of the lower or irregular flow is longer. If you observe this pattern, you should coach "blast the air out" to obtain a better maneuver.



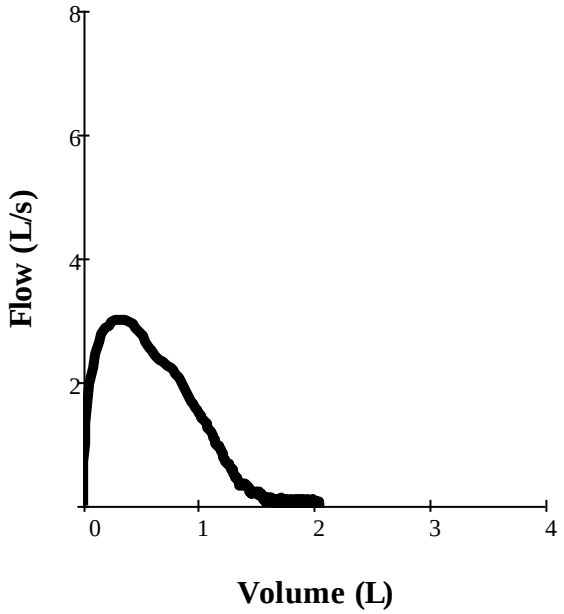


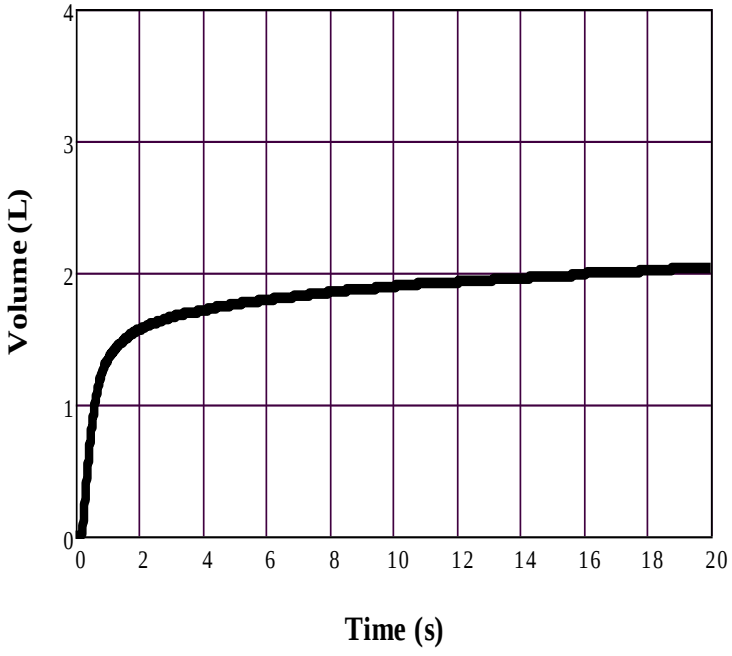
The next unacceptable curve example is early termination where the subject does not exhale for 6 seconds and there is no plateau in the volume-time curve. Early termination of the maneuver can result in a falsely low FVC and a more normal $FEV_1/FVC\%$. So, the subject must exhale until their lungs are completely empty. Notice that the volume-time curve is most useful for detecting early termination which is seen later in the maneuver and is less obvious on the flow-volume curve.



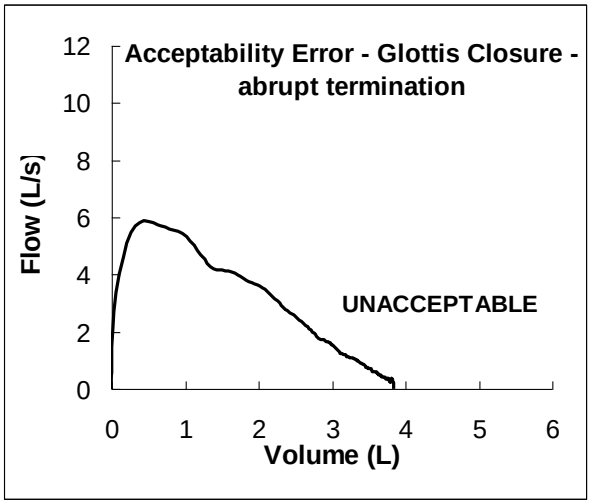


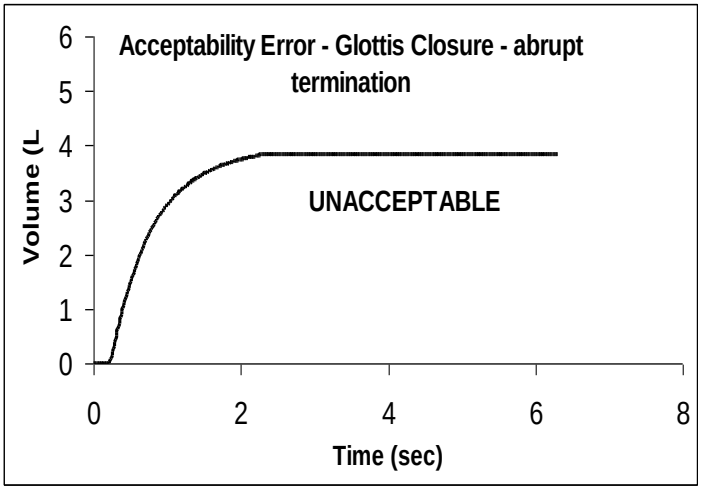
There are subjects, particularly those with airways obstruction that may require considerable time to reach a plateau in their volume-time curve. If these subject exhale for 15 seconds without reaching a plateau, you may terminate the maneuver as shown in the example below. Notice in this example, the subject has exhaled for 20 seconds before reaching a plateau. The slightly more air that would be exhaled after 20 seconds is not enough to change the results significantly.



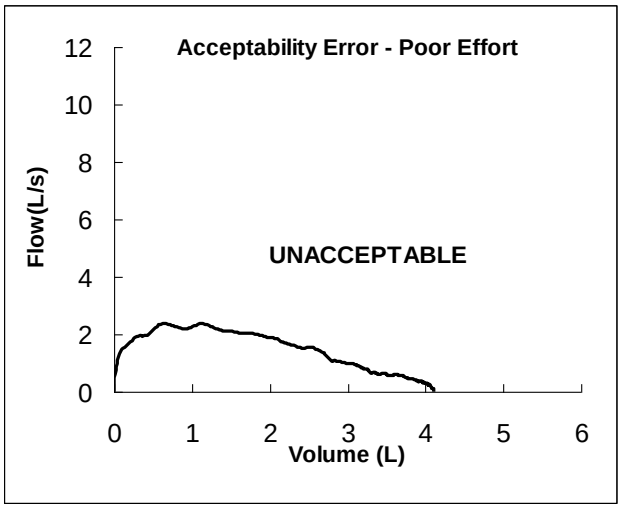


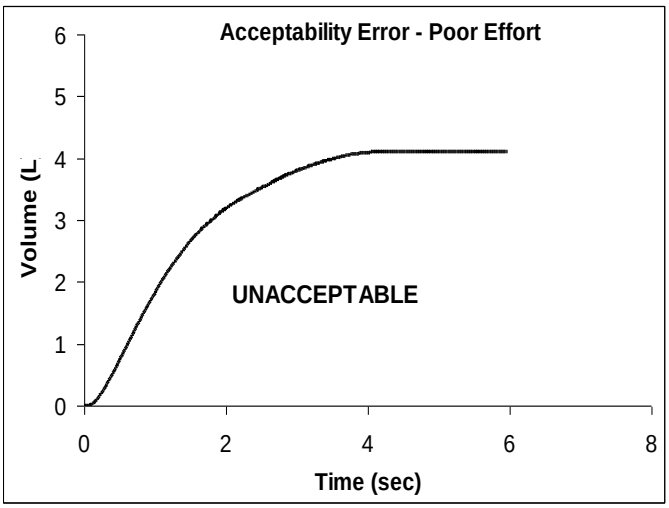
The next unacceptable curve example is abrupt termination or volume abruptly stops coming out of the lungs. The sudden termination of flow can be caused by glottis closure or simply an abrupt cessation of the flow. You need to obtain another maneuver and coach "try not to stop blowing" to obtain a better maneuver. However, some subjects may have a difficult time avoiding closing their glottis. Notice that the volume-time curve is most useful for detecting early termination which is seen later in the maneuver.





The last example is a poor effort where the subject fails to exhale forcefully. Notice that the numeric value for peak flow (largest flow on the flow-volume curve) is only 2; compared to the FVC (largest volume on both the flow-volume and volume-time curves) of 4, or much larger than peak flow of about 2. The peak flow should usually be close to twice the numeric value of the FVC, or in this example about 8. When there is a poor effort, it is likely that a maximal inhalation was not achieved. So, you should coach "take in a deeper breath and blast the air out at first" to obtain a better maneuver. A poor effort will likely result in a falsely low FEV_1 and FEV_1/FVC% or an incorrect classification of airways obstruction.





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After you have obtained at least 3 acceptable maneuvers, you must determine if you have a repeatable test. A repeatable test is when the largest and second largest FVC are within 150 ml, and the largest and second largest FEV_1 are within 150 ml. In the example below, there are three acceptable maneuvers, and both the FVC and FEV_1 are repeatable. So, you have a valid test. With a repeatable test, there is more confidence that the results are accurate.

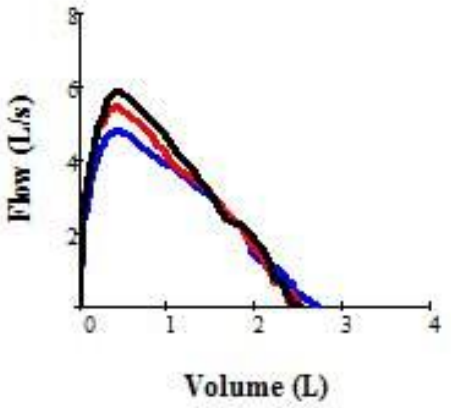
In the example below there are three acceptable maneuvers with the backextrapolated volume (BEV) less than 5% of the FVC or 150 ml, and the FVC's of 2.69 and 2.64 are repeatable (less than 150 ml) and the FEV_1 is also repeatable. So, no more maneuvers are needed as this is a valid test.

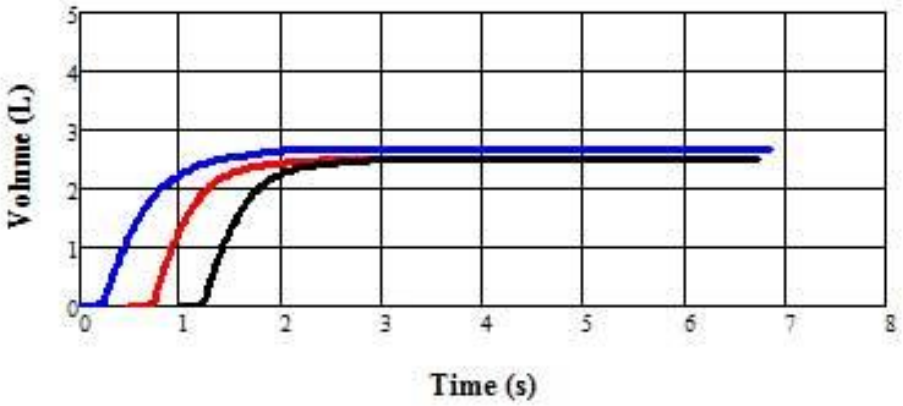
	FVC	FEV1	BEV
1st	2.69 L	2.43 L	56 ml
2nd	2.50 L	2.37 L	53 ml
3rd	2.64 L	2.52 L	67 ml

FVC and FEV1 Repeatability

2.69 - 2.64 = 0.05 or 50 ml

2.52 - 2.43 = 0.09 or 90 ml





Remember that you must first have the subject inhale completely, blast the air out, and continue to exhale until no more air is leaving the lungs (plateau in volume-time curve). You are the most important component in obtaining accurate spirometry results and must COACH to obtain at least three acceptable curves with a maximum 8 maneuvers. After you obtain three acceptable maneuvers, you now must check to see if you have a repeatable test. If the test is not repeatable, you must obtain more maneuvers until repeatability is achieved. The most likely cause of a non-repeatable test is an incomplete inhalation -- so, coach take in a deeper breath.

The online spirometry training web-site will provide additional examples of good and bad curves, and valid and invalid tests to help you coach better. Once you can recognize what caused an unacceptable curve, you can coach the subject to perform a better maneuver.