Sample-draw Cautions, Warnings, and Limitations

1. Overview of gas detection sampling techniques

PhD Plus and PhD Ultra gas detectors may be used as either "diffusion" or "sample-draw" type monitoring devices.

In normal operation, the detector is worn on the belt, used with a shoulder strap, or held by hand. Once turned on, the detector monitors continuously. The air sampled enters the sensor compartment by diffusing through vents in the sensor compartment cover. Normal air movements are enough to carry the sample to the sensors, and refresh the air sampled at the sensor face. This type of "diffusion" operation monitors only the atmosphere which immediately surrounds the detector.

It is possible to use the detector to monitor remote locations by using a sample-draw kit. Two types are available: one that is powered by a motorized pump, or one which is powered by a hand-operated squeeze-bulb. In each case the remote gas sample is drawn in through a length of tubing and exhausted into the sensor compartment. A hand-aspirated (manual) sample-draw kit is included as a standard accessory with all PhD Plus and PhD Ultra detectors.

Remote sample-draw systems are essential for a number of applications. Common uses include pre-entry checks, sampling through "pick holes" or other narrow aperture openings, and sampling the atmosphere at a specific point or level. Other uses of sample-draw kits include physical "conditioning" of the sampled atmosphere before it arrives at the sensor face. Examples of conditioning include filtering of particulates, exclusion of liquids, as well as moderating temperature and humidity.

It is very important to understand that all sample-draw kits - *whatever the brand of manufacture* - are subject to the same cautions and limitations! In all cases misuse, or failure to follow manufacturer guidelines in testing sample-draw kits prior to use, may lead to dangerously inaccurate readings.

2. What are the limitations

The sensors installed in an atmospheric monitor can only detect substances or contaminants which actually reach the sensors. In order for the instrument to accurately determine the concentration of contaminants present in the atmosphere being sampled, the sample must actually reach the sensors, the concentration of contaminants reaching the sensors must be the same as the concentration of contaminants in the area being sampled, and the sensors must have time to stabilize fully in the atmosphere being sampled in order to register a valid reading. Any failure in the sample-draw system which prevents the successful completion of any of these requirements can lead to dangerously inaccurate readings. Mechanisms of failure include leakage in sample-draw system components, failure of the pump mechanism, improper assembly, or absorbance of the contaminants being measured by sampledraw system components.

Since most mechanisms of failure produce readings which are lower rather than higher than actual, if a failure in the sample-draw system has occurred, it is not likely to draw the attention of the user unless it is discovered beforehand.

It is critically important to follow manufacturer guidelines in order to determine that the sample-draw system is fully functional prior to use!

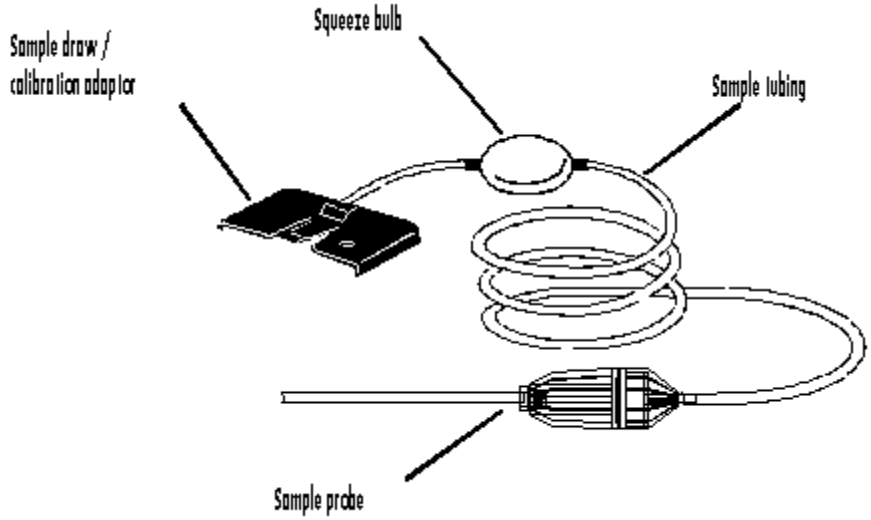

Figure 1.1. Hand-aspirated (squeeze-bulb) sample-draw kit

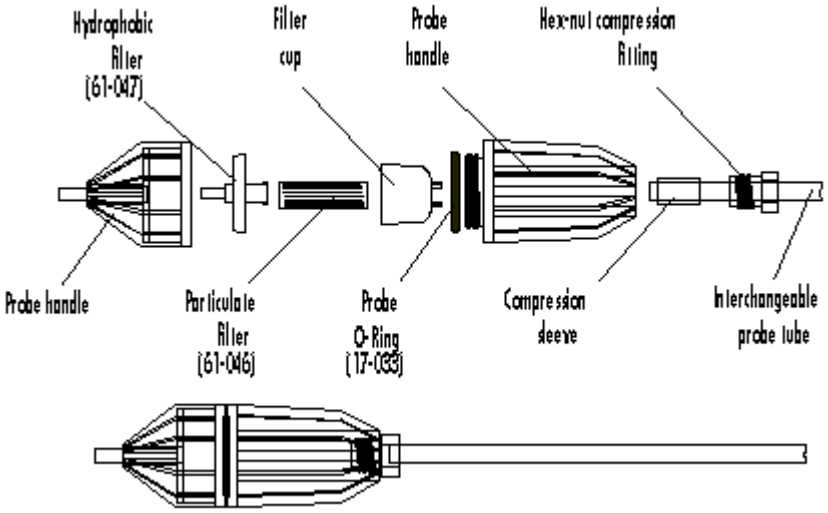

Figure 1.2. Sample probe assembly

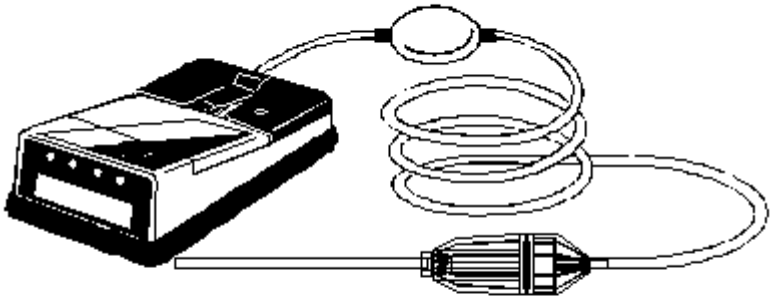

Figure 1.3. Hand-aspirated sample-draw kit attached to detector

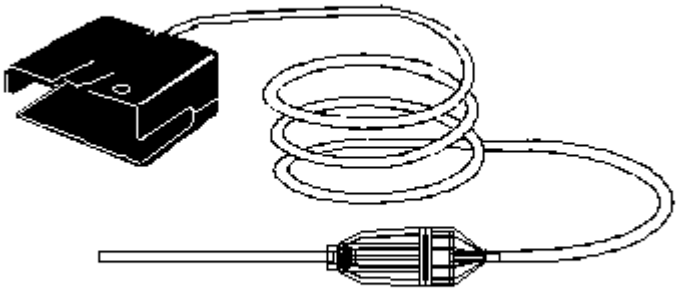

Figure 1.4. Motorized sample-draw pump and probe assembly

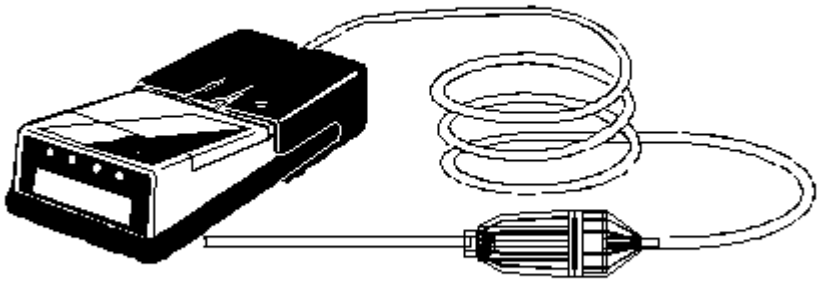

Figure 1.5. Motorized sample-draw pump attached to detector

2.1. Leakage

In order for the instrument to accurately determine the concentration of contaminants present in the atmosphere being sampled, there can be no leakage in the sample-draw system! If there is a leak in the sample-draw system, the sample can be diluted by whatever atmosphere is present in the immediate vicinity of the leak. In the case of most leakage, the sample is diluted by an influx of atmosphere downstream from the sampled location. Since this usually means the sample is diluted with "fresher" air than the atmosphere being sampled, the dilution results in lower than actual readings for toxic and combustible gases, and higher than actual readings if the atmosphere being sampled is oxygen deficient.

Leakage can be due to improper assembly of sample-draw system components, or cuts, abrasions or other damage to the components themselves. Sample-draw kits should always be tested for leakage by blocking the end of the sample-draw probe prior to use. In the case of hand-aspirated sample-draw kits, when the bulb is squeezed it should remain deflated until the blockage is removed. In the case of motorized pumps the blockage should trigger a low-flow alarm, and the pump should shut-down until the blockage is removed and the motorized pump is manually reset.

2.2. Hand-aspirated (squeeze-bulb) pumping mechanism failure

For manually aspirated systems, squeeze-bulbs are used to draw the sample through the tubing back to the sensors. Squeezing the bulb draws atmosphere into the sample-draw system. Each squeeze draws the sample further along the length of sample tubing connecting the squeeze-bulb with the sample probe. (With the bulbs included in Biosystems hand-aspirated sample-draw kits you should allow one squeeze for every one foot of tubing.) Bulbs should be regularly inspected for punctures, cuts, abrasions or cracks which might be the cause of leakage.

Squeeze-bulbs are equipped with one-way check valves in both ends of the bulb. The check valves are designed to allow the flow of atmosphere through the bulb in only one direction. In order for the bulb to function correctly, the check valves must function properly, and the bulb must be installed so that the flow is in the proper direction (i.e. towards the sensors). If the bulb is installed backwards, the flow would be away from the sensors back towards the end of the

sample probe. If the sample-draw kit is used while the bulb is installed in the wrong direction, the sensors would be responding to the atmosphere in the immediate vicinity of the detector, and not from the remote location, defeating the entire purpose of a remote sampling accessory!

Another potential failure mechanism is malfunction of one or both of the squeeze-bulb check valves. If the check valves fail by becoming stuck in the open or closed positions, atmosphere will not be drawn properly through the bulb. Depending on which of the check valves fail or become stuck in which position, the result can be either no net movement of gas in the tubing, or a squeeze-bulb that does not recover (reinflate) after being squeezed. In the latter case the failure will be obvious (the bulb remains deflated). In the former case, however, there is no outward evidence of failure.

The most common reason for check valves "sticking" is contamination of the ball/seat mechanism with fine particles or liquids, in some cases with subsequent corrosion of the ball and/or seat. *This is one of the reasons why sample-draw systems should never be used without the sample probe!* The sample probe assembly includes moisture barrier and particulate filters that are specifically designed to remove particles and prevent the passage of liquids beyond the probe handle.

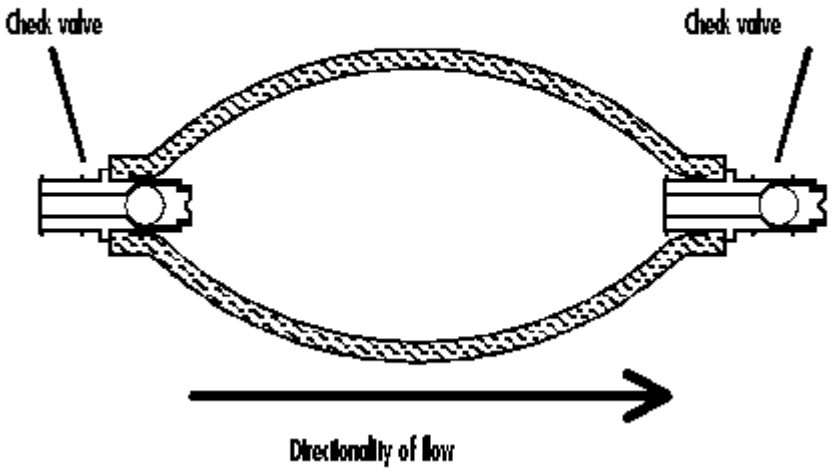

Figure 2.1. Squeeze-bulb from manual sample-draw kit

2.3. Motorized sample pump failure

In motorized sample-draw kits a pump which operates continuously whenever the instrument is turned on is used to draw the sample through the tubing back to the sensors. The motorized pump draws the sample further along the length of sample tubing at a rate of about one foot per second. The pump is continuously monitored by the instrument microprocessor for proper operation. A flashing "P" in the meter display indicates the pump is operating properly. Detectable electronic or low-flow fault conditions will trigger a pump malfunction alarm, and the display of an explanatory message. *Unfortunately, not all motorized pump failure mechanisms are electronically detectable!* Once again, it is critical to verify proper performance of the motorized pump and sample-draw kit components before use.

Failure of the pumping mechanism may occur in a number of ways. Failure can result from leaks in the tubing and external connections, or it may result from internal damage to pump components due to dust, dirt or liquids being sucked into the pumping mechanism. The operating mechanism within motorized pumps requires that flexible valves seat on polished surfaces. Proper seating becomes impossible when dust or dirt enters the pump head assembly. *Motorized sample-draw systems should never be used without the sample probe!* The sample probe assembly includes moisture barrier and particulate filters that are specifically designed to remove particles and prevent the passage of liquids beyond the probe handle. Pumps with significant internal "leaks" may sound perfectly normal during operation, and give no outward symptoms of malfunction. Fortunately, it is easy to verify proper performance. Simply block the end of the sample probe with your finger. The blockage should trigger a low-flow alarm, and the pump should shut-down. The low-flow alarms will remain activated until the blockage is removed and the motorized pump is manually reset.

2.4. Improper assembly

In order to function correctly, sample-draw kits must be properly assembled and properly attached to the instrument. Make sure the "O-rings" sealing the sections of the sample probe handle are clean, and that the sections of the sample probe are firmly screwed together. When using the manual sample draw kit, make sure that the slide-on sample-draw adaptor is properly seated on the instrument housing. Make sure the sample-draw adaptor is connected to the short length of tubing connected with the squeeze-bulb outlet, and that the sample probe is connected to the longer length of tubing connected with the squeeze-bulb inlet. In the case of motorized sample-draw pumps, make sure that the pump is slid fully into place over the sensor compartment. The instrument microprocessor continuously monitors the pump for proper performance. When the instrument is turned on a flashing "P" in the instrument display indicates that the pump is properly attached and functioning correctly.

2.5. Absorbance

Highly reactive or "corrosive" gases such as ammonia, chlorine, hydrogen cyanide and nitrogen dioxide tend to react quickly with or be absorbed by other substances. Since sample-draw kit components also tend to absorb these substances, Biosystems recommends that sample-draw kits not be used when monitoring for these types of gases.

Vapors associated with heavy fuels such as kerosene or jet fuel mixtures may also be absorbed by standard sample-draw kit components. In this case Biosystems recommends use of fuel-resistant polyurethane sample tubing rather than the standard Tygon® tubing normally supplied with sample-draw kits to minimize absorbance. Questions related to compatibility of sample draw kit components with specific contaminants should be directed to Biosystems' Technical Support Department at (860) 344-1079.

3. How to verify proper performance of hand-aspirated (squeeze-bulb) sample-draw kits

For manual sample-draw systems there is a very quick and effective way of confirming proper function. Simply connect the sample-draw assembly to the detector, place a finger over the end of the sample probe, and squeeze the bulb. In a properly functioning sample-draw system the bulb should deflate when squeezed, and remain deflated until the finger is removed.

If the bulb will not depress while being squeezed (with your finger blocking the end of the probe), the possible reasons are the bulb being installed backwards, a stuck closed outlet check valve, or a physical blockage between the bulb and sensor cover. If the bulb re-inflates while the end of the probe is still blocked, either there is a leak in the tubing, squeeze-bulb or other components of the system, or the check valves in the bulb are not functioning properly.

3.1. What to do if you fail the manual sample-draw kit function test

Check that all components are assembled properly. Look for visible damage to the tubing or other sample-draw system components. Make sure the "O-rings" sealing the sections of the sample probe handle are clean, and that the sections of the sample probe are firmly screwed together. Block the end of the sample probe with a finger and try again. *If you continue to fail, take the sample-draw kit out of service and do not use until function has been restored!*

4. How to verify proper performance of motorized pump sample-draw kits

Verifying proper performance of motorized sample-draw systems is very similar to verifying proper performance of hand-aspirated systems. Attach all sample-draw system components to the instrument, turn the instrument on, wait for the instrument to complete the electronic self test and warm-up cycle, then block the end of the sample probe with your finger. The blockage should trigger a low-flow alarm, and the pump should shut-down. The low flow alarms will remain activated until the blockage is removed and the motorized pump is manually reset. If the low-flow alarm is not triggered within a few seconds after placing a finger over the end of the probe, there is a leak in the system. Check that all components are assembled properly. Look for visible damage to the tubing or other sample-draw system components. Make sure the "O-rings" sealing the sections of the sample probe handle are clean, and that the sections of the sample probe are firmly screwed together. Block the end of the sample probe with a finger and try again. *If you continue to fail, take the motorized sample-draw pump out of service, and do not use until function has been restored!*

5. Summation

It is critical to verify proper sample-draw kit performance before use. Additional advice concerning the proper use of sample-draw kits may be found in Biosystems' PhD Plus and PhD Ultra Owners Manuals. These checks take only a few moments. Remember that failure to establish proper performance may lead to dangerously inaccurate readings.

Don't take a chance! Test your sample draw kits before every use.