NEW APPROACHES AND TECHNOLOGIES IN PERSONAL SAMPLING PUMPS

APPLICATION NOTE ITI-089

I. Introduction

The technology used in personal sampling pumps has not changed much over the past 20 years.

- There are still battery life/memory problems associated with Nickel Cadmium (NiCad) rechargeable batteries.
- Pre- and post-flow rate measurements are still conducted today. These measurements are based on calibration procedures that were established in the late 1960s and early 1970s, prior to even “Back EMF Flow Control” use in air sampling pumps.
- Comprehensive, consistent reporting and data management have always been a time-consuming recordkeeping process.
- With the introduction of programmable data logging pumps the need to interface with them is necessary to utilize them to their full potential.
- The complexities associated with low flow sampling using a high flow pump have been around since the beginning. An external low flow adapter must be used to put the pump into a constant pressure condition and it is simply assumed that the low flow adapter flow rate remains constant while sampling is conducted.

II. Smart Battery Management System™ Technology

Knowing how much battery runtime is available under actual operating conditions when sampling is crucial to ensure completion of samples. It is not an easy task to determine pump runtime from a pump performance curve and percent battery life (a measurement of battery voltage) remaining on a pump. Many samples are never completed due to the batteries not having enough runtime charge capacity to run for the intended duration of the sample. Charging times for the widely used NiCad battery technology are long and single and multi-unit chargers are expensive.

TSI® designed the *"Smart Battery Management System™"* technology, that allows you to see remaining runtime in minutes right on the pump screen under actual sampling conditions. This new battery system is based on a battery charge capacity measurement in milliamps (mA), not a simple and unreliable battery voltage measurement. As a NiCad battery decays, its battery curve flattens out after about an hour of discharge and remains that way through most of the battery's discharge cycle (see Figure 1). This results in a very misleading reading of percent battery remaining with battery voltage as the measurement.

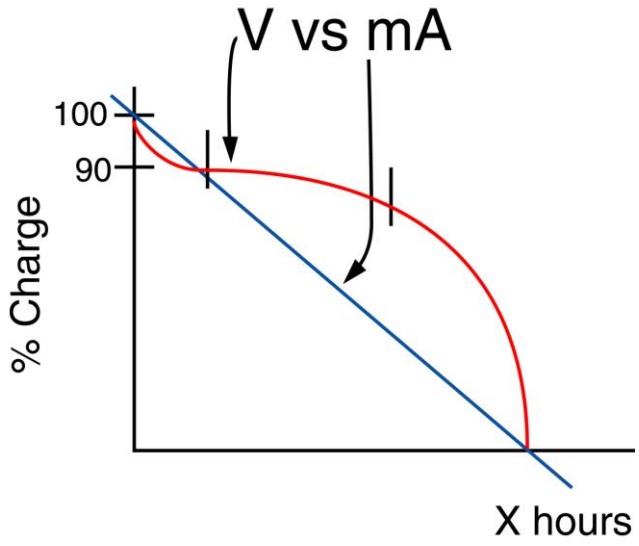

Figure 1 – Battery Decay Curve

The Smart Battery Management System™ technology uses a microprocessor in the battery pack that measures the battery's charge state (mA) and total charge capacity. It measures the current rate of drain (mA) on the battery under actual sampling conditions (flow rate and back pressure) to show how long (in minutes) the battery can deliver. Have you ever had a pump do that for you before?

The most commonly used battery technology is NiCad, and it has memory and charging time issues. TSI SIDEPAK™ pumps use Nickel Metal Hydride (NiMH) battery technology that does not have the memory and charging issues associated with NiCad batteries. TSI has put the battery charging circuitry inside the pump so that an external power supply is all that is needed to charge the battery. And there are multiple NiMH battery options as well.

There are very few Industrial Hygienists who have not lost a sample due to NiCad batteries that have developed a memory and no longer have enough runtime charge capacity to complete that sample. It's time consuming and costly to lose samples.

Let's take a look at the approximate time and cost of an incomplete sample. This is based on conducting three samples per work shift and the Industrial Hygienist's time through determination of the sample failure.

Time

IH Lab consult =	10 minutes/sample
Pre-Calibration of pump (including prep time for calibration standard) =	15 minutes/sample
Selection and preparation of sample media from IH Lab =	10 minutes/sample
Sample Report Preparation through start of sample =	20 minutes/sample
Sample indoctrination and pump set-up on employee =	10 minutes/sample
Checking sample intermittently throughout the sample event =	30 minutes/sample
Total Time =	**95 minutes/sample (1.6 hours)**

Cost

Average IH Salary =	$60 K/year
Benefits 35 % of Salary =	$20 K/year
Average burdened IH Salary =	$80 K/year
Therefore Average IH: (2080 hours/year)/$80 K/year =	$38.46/hour
If Total Time = 1.6 hours/sample @ $38.46/hour then cost =	$61.50

Note: *Consultants bill out for an average of $100–$150/hour. As such their cost could be as much as $160–$240 for each failed sample.*

Benefits of the Smart Battery Management System™ Technology are simple:

- You know how much runtime you have before you start sampling
- You are not guessing about or estimating how long the pump will run
- NiMH battery technology is used
- The charging circuitry is in the pump
- NiMH batteries have faster charging times
- There is no need for expensive battery chargers
- Multiple battery options
- **No other industrial hygiene equipment manufacturer has this battery technology!**

III. Advanced Flow Control and Data Logging

Pre- and post-flow rate measurements are taken every time air sampling is conducted with a pump. These measurements are tedious and time-consuming and provide no information of actual flow rate during sampling. They can only provide an estimate of flow rate based on pump setup (see Figure 2). Nor, can they account for flow interruptions that may occur during a sample event. The estimated average sample flow rate is calculated from these pre- and post-flow measurements. Data integrity is based on these flow measurements. However, there is no flow rate information collected during sampling, thus, reducing sample confidence. Unintended flow interruptions during sampling cannot be accounted for using pre- and post-flow rate measurements, again adding more uncertainty and less confidence in sample results. What you don't know can literally ruin your results.

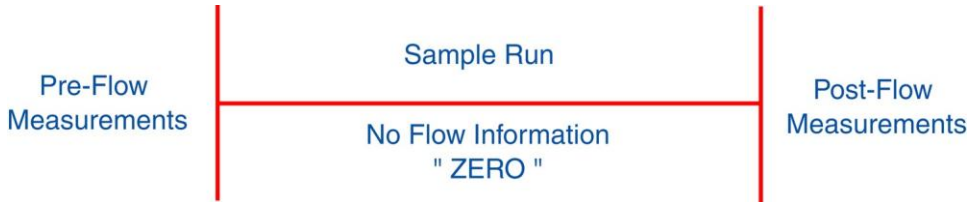

Figure 2 – Estimated Flow During Sampling

TSI solved these issues by directly measuring, controlling and data logging the flow rate during sampling with advanced Thin-Film Flowmeter technology. Now, instead of estimating flow rates before and after sampling, you are directly measuring, controlling and data logging the flow rate during the sample (see Figure). You can account for unintended flow interruptions in this way.

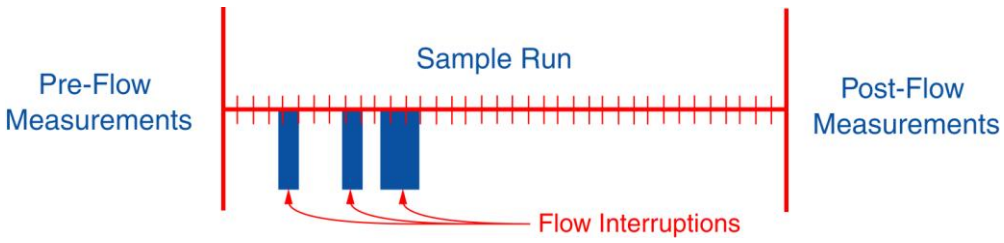

Figure 3 – Direct Measurement of Flow During Sampling

Sure you want to continue to conduct pre- and post-flow measurements as a matter of procedure and prescribed industrial hygiene practice. However, when you compare logged flow rate vs. pre- and post-flow measurements you will see the following two scenarios:

- **Scenario 1:** if the pre- and post-flow measurements are within ±5% of each other and are relatively close to the data logged flow rate, and there were not any data logged flow interruptions, the two sets of flow rate data will be similar to each other. You could choose either set of flow rate information, although you know empirically, that the data logged flow rate information is the most correct because it was collected during the sample.
- **Scenario 2:** if the pre- and post-flow measurements are within ±5% of each other and are not close to the data logged flow rate, there were data logged flow interruptions that occurred. At this point you know for sure that the data logged flow rate is the correct data set to use. You know because the data logged information shows when the flow interruptions occurred and the impact on flow rate that these interruptions had.

In either scenario, you can decide to use the data logged flow rate over the pre- and post-flow measurements.

By directly measuring, controlling and data logging flow, you have much more accurate information. The flow rate and the sample time give the total amount of air sampled. By utilizing the logged flow rate data collected during sampling, increases that data integrity of your exposure monitoring sample results.

The benefits are simple:

- You are directly measuring, controlling and data logging the flow rate during the sample.
- You can account for unintended flow interruptions.
- Data logging the flow rate during sampling increases the accuracy, data integrity and confidence to your sample results
- **Why guess when you can measure!**

IV. Internal Bypass and Low Flow Sampling

When conducting low flow sampling with a high flow pump, you must use an external low flow adapter (LFA) to do so, thereby putting the pump into a “constant pressure” condition. In addition to the external LFA, you must also use an external calibrator to set low flow rates on the sorbent tubes. The added components and complexity make low flow sampling more difficult and add another component of uncertainty to this type of sampling. There is a big difference in sampling performance depending on where the LFA is placed in the sampling train.

In the “constant pressure” configuration you have created two branches or air inlets (the sorbent tube branch and the LFA branch) where air flow may enter the system and go to the pump. Using these pre- and post-flow rate measurements you have no idea if the flow in these two branches remains constant or not during sampling. Depending on where the external LFA is placed on the sampling train will greatly affect if the branch remains constant when there is a pinched tube (flow interruption) or not. This leads to more flow rate uncertainty and less confidence in your sample results. Let’s look at two sample pump scenarios (see Figures 4 and 5) when using external LFAs and the impact that their position has on the flow rate remaining constant during sampling:

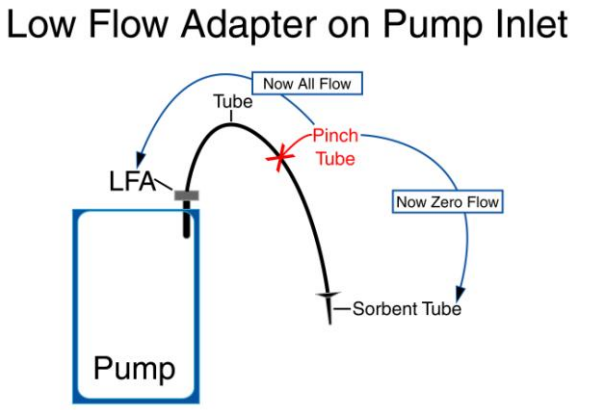

Figure 4

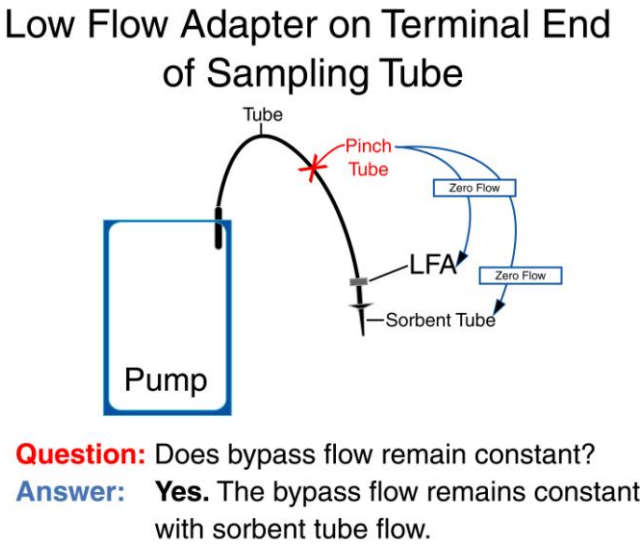

Figure 5

To resolve this issue TSI has put an internal low flow bypass along with the Thin-Film Flowmeter Technology in the same pump. The result is a pump that has no need for an external LFA or calibrator to set the sorbent tube flow rate. Simply engage the internal low-flow bypass, set the desired flow rate on the pump and start sampling. The internal Thin-Film Flowmeter takes over and precisely measures and controls the flow at the selected flow set point, while data logging the flow for the duration of the sample period. TSI's SIDEPAK™ SP730 Personal Sampling Pump is the only pump that can measure, control and data log through its full range of flow adjustment (0.020 to 3.0 L/min).

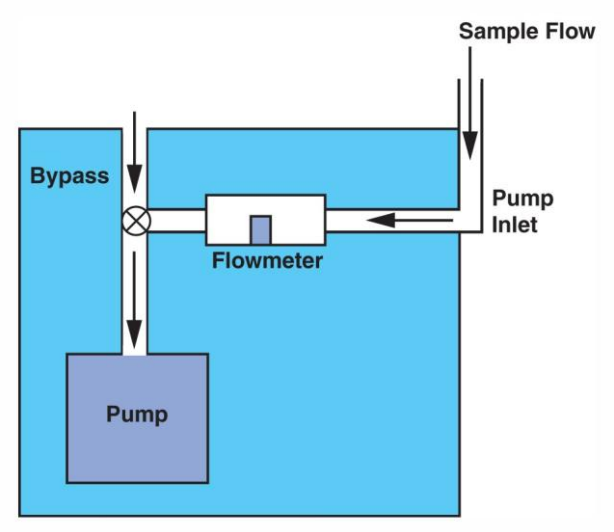

Figure 6 – Internal Low Flow Bypass

This is the only pump on the market that can log both low and high flow rate samples.

The benefits of using the internal low flow bypass and the Thin-Film Flowmeter:

- Save time and money
  - No need to use an external LFA
    - Eliminate the added components and complexity
  - No need to use an external calibrator to set low flow rates
    - No assumptions of flow as it is directly measured, controlled and logged
  - Constant bypass is maintained
  - Flow interruption information available
    - This is the only pump on the market that can log both low and high flow rate samples
    - It's sorbent tube heaven!

V. TRAKPRO™ Data Analysis Software

Comprehensive report generation is easy with TRAKPRO™ Data Analysis Software. Simply start with the Template Editor and then merge a logged Pump Data File to create a comprehensive Report File. TRAKPRO™ software even gives you a graph of logged flow rate over the duration of the sample period for easy viewing and flow rate validation.

The ability to pre-program up to five custom sampling protocols using TRAKPRO™ software from a PC is so versatile via the multi-mode programming feature.

You can program for:

- Start/stop – day/date sampling
- Total time sampling
- Total volume sampling
- Intermittent sampling

You can also, manually data log samples right from the keypad of the pumps. In any case, once the sampling is completed, you download right to your PC via the USB port. Now, using TRAKPRO™ software you can easily create comprehensive reports and graphs. Industrial Hygiene Labs need the following information:

- Accurate flow rate
- Duration of sample
- Start/stop/date information
- Sample volume

You can very easily transmit this information directly to the IH Lab via an attachment to an e-mail. How is this possible? The Industrial Hygiene Lab can directly download TRAKPRO™ Data Analysis Software from the TSI website at no charge and use it to receive and work with your sample data and reports.

The benefits of using TRAKPRO™ software:

- Save time and money
  - As there is no need to hand write reports
  - Always use a consistent and comprehensive format
- Pump versatility, run up to five preset sampling programs from the keypad of the pump
- Easily communicate results electronically

VI. Conclusion

TSI's new technological advances:

- TSI's *Smart Battery Management System*™ technology
- Thin-Film Flowmeter Technology to measure, control and log the flow
- Internal Bypass System
- TRAKPRO™ Data Analysis Software

New technology TSI SIDEPAK™ Personal Sampling Pumps have advanced beyond what has traditionally been available in the marketplace. What you have are new approaches and technologies for the selection and use of personal sampling pumps. This gives you an opportunity to see for yourself what the SIDEPAK™ Personal Sampling Pumps have to offer your sampling program. TSI is always working hard to provide you with new tools.

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