Innovation In Industrial and Environmental Hygiene

INTERCHANGEABILITY OF DETECTOR TUBES AND PUMPS

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Interchangeability of detector tubes and pumps has long been debated among manufacturers of detector tube systems. MSA/AUER tested detector tube pump models from two major manufacturers to determine if detector tube accuracy is, in fact, adversely affected by sampling with an outside manufacturer's pump. MSA/AUER test results are described.

For years, colorimetric detector tubes have been the methodology of choice for detecting toxic substances in air. Detector tubes were first used at Harvard University in 1917, where a tube was developed to detect carbon monoxide.[1] In 1935, Yant (from MSA), Littlefield, and Berger published a report for the U. S. Bureau of Mines on "A Detector for Quantitative Estimation of Low Concentration of Hydrogen Sulfide."[2] Since then, colorimetric detector tubes have been developed for many substances. Currently, MSA/AUER offers over 70 different tubes for detecting over 150 atmospheric hazards.

Quick, inexpensive, and reliable, detector tubes verify exposure in almost any place where a potential hazard may exist. For instance, chlorine is a strong oxidizer used in detergents, sanitizers, cleaners, and household bleaches; therefore, anywhere these products are manufactured or used is a potential area to monitor with a chlorine detector tube. With an appropriate sampling line, a carbon monoxide detector tube is ideal for testing flue gas, while a phosphine detector tube detects the fumigant phosphine in grain silos. MSA/AUER detector tubes are used to detect toxic substances in such industries as plastics, mining, chemical, pharmaceuticals, agricultural, dry cleaning, paint, detergent, petroleum, rubber, refrigeration, and aviation.

THE DETECTOR TUBE SYSTEM: PRINCIPLES OF COLORIMETRIC DETECTOR TUBE SAMPLING

Detector tubes are glass tubes filled with treated chemicals. The chemical within each tube is a colorimetric reactive compound either impregnated on paper or adsorbed onto a medium such as fine grain silica gel, silica glass, silica sand, or activated alumina. Hermetically sealed, the reagent reacts quantitatively when exposed to a particular gas or vapor; if the hazard is present, the chemical layer in the tube changes color, with the length of stain or color intensity indicating the concentration of the toxic substance in the sample volume. With the exception of CO Color, which reacts semi-quantitatively, all MSA/AUER tubes are calibrated so that the length of the color change corresponds to a scale printed on the tube for accurate reading of concentrations in parts per million (ppm), % gas, or mg/m^3.

For instantaneous short-term sampling, the user simply snaps off the tip of the tube and attaches it to a detector tube pump. The most commonly used pump is the manually operated constant volume bellows style pump, which draws a sample of 100 ml of air per stroke by creating suction (i.e., negative pressure) through compression of an elastic chamber. Instructions accompanying each detector tube dictate the correct number of pump strokes and length of time required per stroke to attain the desired sample volume. These parameters are not constant because chemicals vary in amount of time required for complete reaction; also, resistance of detector tube types can differ depending on particle size and compaction of the chemical bed.

Operation of the bellows type pump is simple. For example, with the MSA Kwik-Draw® Pump, the user grasps the hand grip and pushes a knob to activate the spring-loaded bellows. An easy-to-read stroke counter shows the exact number of strokes performed and provides a positive stop when the stroke is fully compressed.

The Kwik-Draw® Deluxe Pump has a unique end-of-stroke indicator that "winks" after the precise volume of air is drawn, confirming that enough air has been sampled for a successful reading. Similarly, the AUER Gas-Tester® II H Detector Tube Pump features an end-of-stroke indicator that changes color when the defined sample is drawn through the tube.

The tube with pump is referred to as the detector tube system. Accuracy of measurements in a detector tube system depends largely on two critical functions of the detector tube pump: flow rate and sample volume. As a result, most tube manufacturers calibrate tubes and pumps for use as one system. So, while detection of toxic substances using detector tube systems is a relatively simple process, wisdom traditionally cautioned against interchanging one manufacturer's detector tube with another manufacturer's detector tube pump.

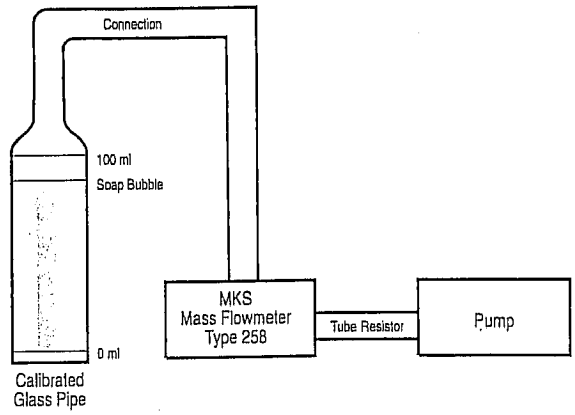
INTERCHANGEABILITY OF DETECTOR TUBES AND PUMPS

In 1973, the National Institute for Occupational Safety and Health (NIOSH) published a report on the interchangeability of detector tubes and pumps. This report concluded that, due to variability in pump sampling rates and in chemical reagent reaction rates, interchanging tubes and pumps of different manufacturers could result in significant errors. Citing data from tests with carbon monoxide as a contaminant, this report asserts that "a manufacturer's gas detector tube and sampling pump should be regarded as a single unit and accordingly should not be interchanged with other manufacturers' sampling pumps and gas detector tubes...."[3] Also, American National Standards Institute (ANSI) standard on detector tubes recognizes only combinations of tubes and pumps from one manufacturer. [4]

NIOSH standards for detector tube accuracy do not include specific requirements for pump flow, the most complex aspect of pump performance. Each individual pump stroke has a unique flow pattern and the prevailing view has been that flow patterns vary among pump models. Recently, MSA/AUER conducted a study to determine the impact of non-homogeneous pump strokes on detector tube system accuracy, thus reexamining the issue of detector tube and pump interchangeability.

Using specific test procedures as well as protocols based upon NIOSH testing (see Figure 1), MSA/AUER first evaluated the flow rate pattern of the MSA Kwik-Draw Pump. Figure 2 shows this pattern, generated by using a hot-wire anemometer and a resistor based on the European Standard prEN 1231[5] to simulate the resistance of a detector tube.

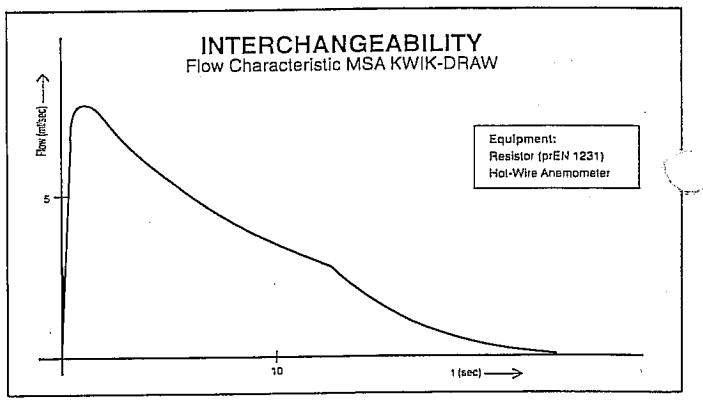
Figure 1. Schematic Diagram for Measurement of Sampling Volume and Flow Characteristic



Mass Flow Meter Type 258: Specifications

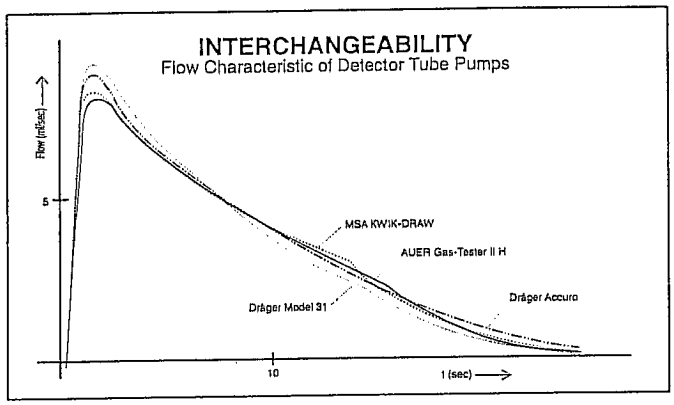
Input	± 15 VDC 150mA maximum
Output	0-5 VCE into > 10 kOhm
Response	500 msec Time Constant
Temperature Range	15°C to 40°C
Flow Range	1 ml/min to 1000 ml/min
Gas Pressure	150 psig maximum
Accuracy (including linearity)	± 0.5% of Final Signal
Resolution	0.1% of Final Signal

Figure 2. Characteristic Airflow of MSA's Kwik-Draw Pump



Under identical test conditions, MSA/AUER then tested the MSA Kwik-Draw Pump along with three other commercially available pumps: AUER Gas-Tester II H Pump, Dräger Model 31 Bellows Pump, and Dräger Accuro Pump. Figure 3 illustrates comparative flow rate patterns for these four pumps. The area under the curves represents the sampling volume per pump stroke.

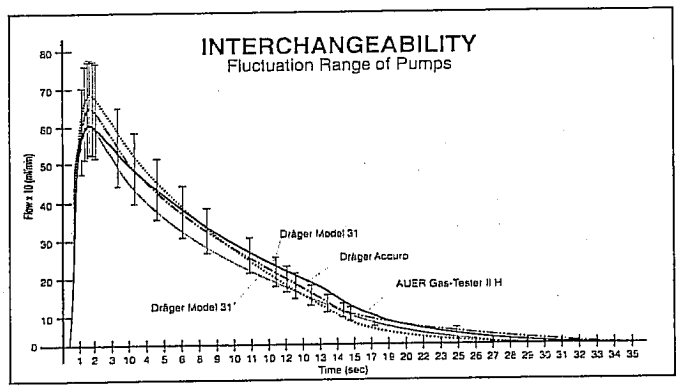
Figure 3. Characteristic Airflow of Four Commercially Available Pumps



Flow patterns demonstrated a minor variance of 2%, i.e., 2 ml as a total difference between individual segments of the curve. Therefore, there is a significant concurrence of flow patterns among the four pumps tested. Repeated testing resulted in a reproducibility error of ± 3%.

In the absence of U. S. and European standards for pump flow accuracy, MSA/AUER then applied German Standard DIN 33882 to a test of four pumps. This standard requires that fluctuation of flow patterns shall not exceed ± 20%.[6] Figure 4 shows flow patterns of three models (with two sets of data for Dräger Model 31) with a deviations fluctuation band of ± 20%.

Figure 4. Flow Curves of Three Commercially Available Pumps with Calculated Deviation of ± 20% per DIN 33882



It is evident that all four pumps readily met the DIN 33882 standard for pump accuracy. In addition, further tests showed that the pump flow pattern for each model varied ± 5% from batch to batch and after use. Thus, the fluctuation among bellows pumps of the same type is often greater than among bellows pumps from different manufacturers.

This investigation concluded that current hand-operated bellows detector tube pump design delivers pump performance virtually identical across the market. In light of the insignificant variations in response of four commercially available bellows detector tube pumps and the fact that all four pumps met established standards for pump accuracy, there is no technical argument against interchangeability of bellows type pumps as long as certain technical criteria are met.

MSA/AUER'S CONTROLLED INTERCHANGEABILITY POLICY

As a result of this study, MSA/AUER recently initiated a new policy of *Controlled Interchangeability of MSA/AUER Detector Tubes and Pumps with Other Manufacturers' Tubes and Pumps.* This policy states that as long as a bellows style pump meets the following criteria, it may be used with any detector tube designed for use with that kind of pump:

1. The characteristics of the pump - volume per stroke, sampling time, and flow - must be within the same accuracy range.
2. The detector tubes must have an outer diameter of 7 mm and be factory-calibrated with a pump that meets the criteria of (1) above.
3. The manufacturer of tubes and pumps must operate under a certified Quality Assurance program.

Any pump which meets the above criteria is interchangeable. Any pump which does NOT meet these criteria should not be used interchangeably.

Based on these criteria, the following pumps are interchangeable:

- MSA Kwik-Draw Pumps
- AUER Gas-Tester II H Pump
- Dräger Model 31 Bellows Pump
- Dräger Accuro Pump

Based upon testing by NIOSH as well as theoretical data, MSA/AUER does not recommend the interchangeability of products other than those named above.

Since these pumps are interchangeable, the tubes designed for use with one pump can be used with any of these pumps, regardless of the tube's characteristics. As a result of this interchangeability, there are, quite simply, more tubes from which to choose. Now, tubes that only MSA/AUER manufactures are available for use with Dräger Accuro Pumps and Model 31 Bellows Pumps; likewise, tubes that only Dräger makes can be used with MSA Kwik Draw Pumps and AUER Gas-Tester II H Pumps.

SUMMARY

Through rigorous testing of four commercially available detector tube pumps, MSA/AUER has demonstrated that while the historic argument against interchanging one manufacturer's detector tubes with another manufacturer's detector tube pump has sound technical basis for certain combinations of detector tubes and pumps, it is no longer valid for the combinations described in this paper. Taking the lead in addressing the issue of interchangeability, MSA/AUER has established that, as long as certain technical criteria are met, interchangeability is acceptable and, for some applications, desirable.

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ABOUT THE AUTHOR

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