COLORIMETRIC INDICATORS

Colorimetric indicators provide a means of quantifying air contamination with a reasonable degree of selectivity. Three types of indicators may be used: liquid reagents, chemically treated papers, and glass tubes containing chemically treated solids. The principle of operation is that contaminant in air reacts with a chemical reagent to cause a change in color, which is proportional to the amount of contaminant in the air. Liquid reagent devices are available that produce color changes that are fairly easy to observe. But handling liquids in the field may be awkward and inconvenient. Chemically treated papers are easy to use, but do not typically have a means of controlling the volume of air contacting the paper. Therefore, the accuracy may be affected by factors such as the amount of air movement over the paper.

Because of their ease of use and quick results, the glass tubes containing a chemically treated solid - known as colorimetric or detector tubes - are widely popular. They typically consist of a glass tube containing a granular carrier solid that has been impregnated with a specific chemical reagent. As contaminated air passes through the glass tube, the contaminant reacts with the reagent on the carrier solid to produce a color stain.

The air is drawn through the tube by either a hand pump or a battery-powered pump. Thus, the volume of air sampled can be controlled. There are two kinds of hand-operated pumps – bellows or piston. The bellows pump is spring-loaded and draws air in by collapsing a bellows and allowing it to expand. The piston pump pulls a spring-loaded piston in a cylinder to draw air into the expanding cylinder. Both types of pumps have pump stroke completion indicators.

It should be noted that detector tubes are designed and calibrated for use exclusively with the manufacturer's pump. To use a detector tube with another manufacturer's pump, even if the pump volume is the same, can lead to greatly inaccurate results.
OPERATION OF COLORIMETRIC INDICATOR TUBES

The tubes may operate in one of three ways as shown below. First (A), the pump may be operated until the length of the stain reaches a certain preset point. The number of pump strokes (i.e. the volume of air) required to reach this full stain is compared to a chart to determine the concentration of the contaminant in air. In this case, a high concentration of contaminant in air would require fewer strokes to reach full stain.

Secondly (B), a set number of pump strokes (volumes) of air will be drawn through the tube and the length of stain is compared to a calibration scale, often printed on the tube, to determine the concentration. For a set number of pump strokes, a high concentration would cause a longer stain.

Thirdly (C), a predetermined number of pump strokes of air are drawn through the tube and the degree or tint of the color change is compared to a chart to determine the concentration. For these tubes a high concentration would cause a deeper or darker color change after a set number of pump strokes. It is critical that the operator of the tube be familiar with the manufacturer's directions and knows which mode of operation is used.

Sample pumps must be checked for leaks to ensure that the appropriate volume of air is drawn through the tube. Also, the pump must be allowed to fully complete every pump stroke. Incomplete strokes or leaks in the system will cause less than the appropriate volume of sample air to pass through the tube, potentially resulting in a lower reading than is actually present.
The tubes may be specific for a certain gas or vapor or may detect groups of chemicals, such as alcohols or aromatic hydrocarbons. Tubes that are designed to detect one chemical will usually react with certain other chemicals (known as interferences) to produce a similar color change. The manufacture will provide a list of known interferences. In general, detector tubes provide an estimate of what and how much of a particular chemical is present.

LIMITATIONS OF COLORIMETRIC INDICATOR TUBES

Some limitations must be considered when detector tubes are used. Detector tube systems have rather poor accuracy, with errors ranging from 25% to 50% for many tubes. The National Institute for Occupational Safety and Health (NIOSH) tested and certified detector tubes at one time, but has since discontinued the practice. Manufacturers generally provide accuracy information with the instructions.

Because a chemical reaction is involved, detector tube accuracy may be affected by such factors as temperature, humidity and atmospheric pressure. Where temperature will significantly affect the performance of the tube, the manufacturer will include compensation factors in the instructions. Colder temperatures will usually slow down the reaction, so if detector tubes are to be used in cold weather, they should be stored in a warm place and carried next to the body. High temperatures may affect the rate of the chemical reaction and may reduce the shelf life as described below.

One source of error in the use of colorimetric tubes is the visual interpretation of the length or degree of color change. The leading edge of the stain may be uneven or may be lighter than the rest of the stain, calling for a judgment on the part of the operator as to what constitutes the end of the stain. The same difficulty applies to judging the degree or tint of color change, even when comparison charts are provided. When in doubt, it is advisable to use the most conservative (i.e. highest) reading so that more protection is provided to the responder and the public.

Detector tubes have a specific shelf life. Chemical reagents will deteriorate over time, even if the tube is not opened and exposed to air. Also, high temperatures
may cause the degradation of the reagent. The manufacturer will stamp an expiration date on each pack of tubes. Storing the tubes in a refrigerator may maintain or extend the shelf life, but expired tubes should not be used.

HAZMAT Kits

Each of the detector tube manufacturers offers a hazmat kit. These kits include a pump and several preselected types of tubes. The selected tubes respond to several common chemicals, but also to numerous interfering chemicals as well. This allows the same tube to indicate whether these other chemicals are present. These kits can be used to help classify unknowns at a hazmat release. They include a flow chart decision matrix that allows the user to rule out or identify classes of chemicals in a systematic process.

These kits are not intended to exactly identify the material involved if nothing else is known. But if they are used with preliminary information, they can help narrow down the choices responders have to choose from.

SUMMARY

Detector tubes offer a simple test to determine if a particular material is present at a hazardous materials incident. They also estimate how much may be present. But they have limitations and they must not be treated as absolutely accurate tests. So, if your team uses them, allow a reasonable safety factor for any decisions that are made based on their results.