NOVEMBER 1993

Fume Hood Scrubbers - Part II

What Are Scrubbers and How Do They Work?

by

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This Article is reprinted in its full length and unedited form from the November '93 issue of LABORATORY BUILDING DESIGN UPDATE, published by Source II Corporation, 550 West B Street, Suite 230, San Diego, CA 92101, (619) 232-0985

LABORATORY BUILDING DESIGN UPDATE

INTRODUCTION

Many laboratory designers and facility operators are beginning to consider some type of scrubber for their fume hoods. This is due, in part to concern for the environment, environmental health, and increasing government regulations. This is the second in a series of articles written to familiarize the reader with the aspects of laboratory fume hood scrubbers. In this article we will discuss how fume hood scrubbers operate and the types of scrubbers that are commercially available. In the previous article, "To Scrub or Not to Scrub?" (see Sept./Oct. issue of *LABORATORY BUILDING DESIGN UPDATE*) a classical industrial hygiene/industrial ventilation approach was used to decide whether source reduction or elimination in the fume hood before the contaminant is released into the airstream could be used to eliminate the hazard and if a scrubber is necessary.

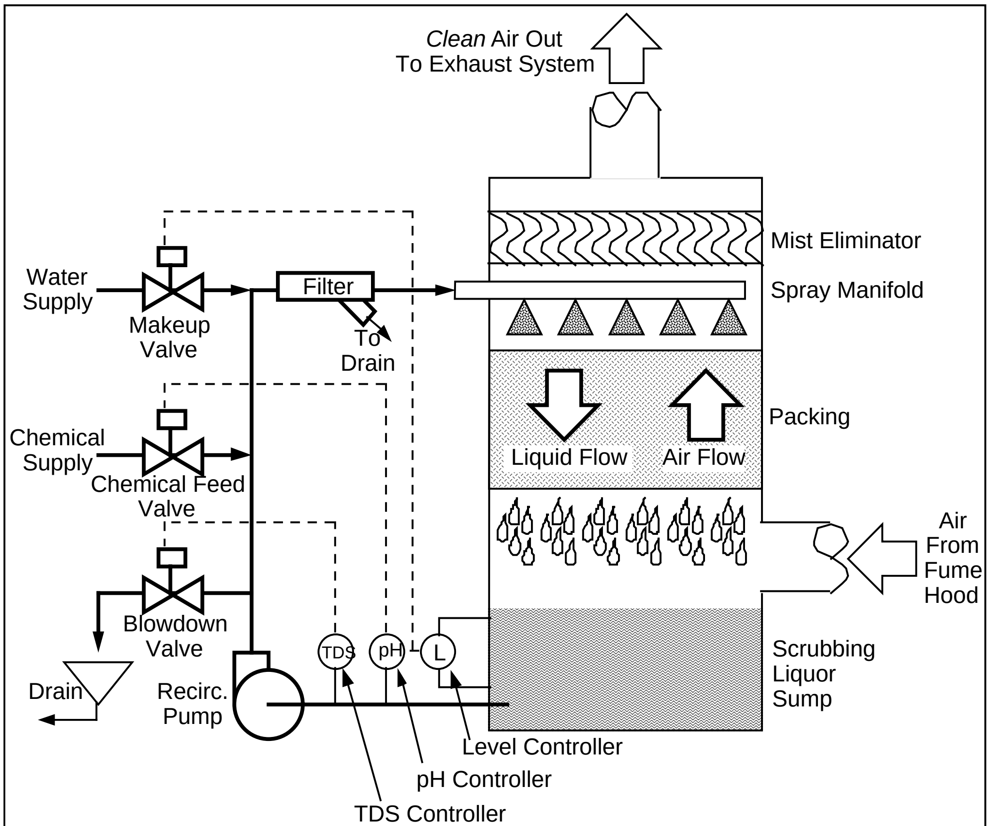

FIG.1: TYPICAL FUME HOOD SCRUBBER SCHEMATIC

HOW THEY WORK

For those familiar with industrial air pollution controls, a fume hood scrubber may appear to be a lab scale version of a typical packed bed liquid scrubber used in many chemical plants and other industries. Figure 1 shows a schematic of a typical fume hood scrubber.

Contaminated air from the fume hood enters the unit and passes through a packed bed then through the liquid spray section, a mist eliminator and then into the exhaust system for release outside the building. The scrubbing liquor is recirculated from the sump and back to the top of the system using a pump. The air and the scrubbing liquor pass in a countercurrent fashion for efficient gas/liquid contact. Water soluble gases, vapors and aerosols are dissolved into the scrubbing liquor. Removal efficiencies for most water soluble acid and base laden airstreams is 95-98%. Particulates are also captured quite effectively by this type of scrubber.

LIQUOR CONTROL

The scrubbing liquor is usually water and contains dissolved contaminants from the airstream, other dissolved minerals from the makeup water which are concentrated as the water evaporates into the airstream, and optionally, some neutralizing solution which is usually a weak acid or base depending on the contaminant to be neutralized.

Maintaining the scrubbing liquor involves three controllers. As the system operates, the air entering the scrubber absorbs water from the liquid stream and becomes saturated. The water consumed in this process needs to be replaced or the scrubber will run dry. This is accomplished using a level controller that opens and closes a water makeup valve to maintain the liquid level in the scrubber.

As mentioned earlier, as water evaporates from the system, minerals from the makeup water stream are concentrated. Acid/Base neutralization reactions also produce salts that become concentrated in the scrubbing liquor. The concentration of these minerals and salts are called Total Dissolved Solids or TDS. Most TDS compounds are strongly ionic and can be measured using a conductivity meter or TDS controller. To control TDS, scrubbing liquor is drained from the system using a blowdown valve. When this occurs, the makeup system replaces the blowdown with fresh water thereby maintaining a stable liquid and TDS level.

The liquor pH may also be controlled in a similar way using blowdown or by using a neutralizing chemical feed as shown in Figure 1. For example, if the airstream contains acid, a base may be used The amount of basic solution fed into the system is controlled by a pH controller.

Since the scrubber is so effective at capturing particulates, a filter is necessary to remove them from the system. The filter may be a cleanable or disposable type. To reduce maintenance, a fine mesh strainer can be used in place of the filter. A differential pressure switch connected across the strainer is then used to actuate a blowdown valve to automatically flush the strainer.

REMAINING NEUTRAL

Water soluble acids and bases are easily scrubbed and neutralized by this type of system.

An airstream containing a basic component such as Ammonia may be neutralized using a mild sulfuric acid solution. The chemical reaction is:

$$2NH_3 + H_2SO_4 \rightarrow [NH_4]_2SO_4$$

Most acids in the airstream may be neutralized using a mild sodium hydroxide or *caustic* solution. In the case of perchloric acid the chemical reaction is:

$$HClO_4 + NaOH \rightarrow NaClO_4 + H_20$$

Certain water soluble organic compounds such as mercaptans may also be “neutralized” using a mild caustic solution. In the case of Methyl Mercaptan the chemical reaction is:

$$CH_3\text{-}SH + NaOH \rightarrow CH_3\text{-}SNa + H_20$$

UNIT LOCATION

Typically, these units are configured vertically and are located next to the fume hood in a similar configuration as Figure 1. They may handle up to approximately three hoods. Another form is the top mount version which has the packing, spray manifold and mist eliminator sections located on top of the hood and the sump and liquid handling portion underneath of the hood for a compact arrangement taking up no more space than the hood itself. These units may also be remotely located. However, the closer you can place the scrubber to the fume hood, the better off you will be when considering corrosion of the ductwork between the hood and scrubber.

CONCLUSION

Fume hood scrubbers can effectively reduce concentrations of certain water soluble acid, base and organic contaminants exhausted from a fume hood. If you are concerned about duct corrosion, hazardous stack emissions or other environmental factors associated with a fume hood you may want to consider a scrubber.

COMING NEXT:

The subject of the next and final article in this series will cover gas-phase and particulate filters for laboratory fume hoods. Their theory of operation, advantages and disadvantages will be discussed in detail.