BY **KARL G. RULING**

Following manufacturer's instructions

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A little fog can catch the light and help give volume to a performance space.

AS PROMISED IN THE LAST ISSUE of TSP News, "Standards as High as an Elephant's Eye!" the fifth edition of the *Introduction to Modern Atmospheric Effects* has been published. Earlier this year, *ANSI E1.23, Entertainment Technology – Design and Execution of Theatrical Fog Effects*, a reaffirmation of the 2010 standard, was approved by ANSI's Board of Standards Review and published. What the two documents have in common, besides being about theatrical fog, is that they tell the reader to follow the manufacturer's instructions for any fog-making equipment the reader is using.

> **"[If you don't follow instructions] You are the manufacturer of a unique effect, and need to do all the things that would be considered due diligence for a manufacturer."**

This is perhaps a no-brainer (Would any American National Standard say, "Ignore the instructions"?), but following the instructions seems to be one of the last things some people want to do. Modern fog machines are so simple to use, you can get something out of them if you put in some fluid, plug them in, look for any lights on them to turn on or off after a few minutes, and then press a button. So who needs to read instructions? Except for dry ice fog machines, which, if they have no low-water shut-off, will destroy themselves if you turn them on before putting in the fluid, the machines are pretty reliable. Besides, if it breaks, it'll probably be after the show and someone else's problem. Simple!

Simple, except that if you don't follow the manufacturer's instructions, what do you know about what comes out of the machine? Probably fog, or you'd reach for the user manual fast, but is it the fog that the machine manufacturer intended for the machine to produce, or is it a fog that is not so good, that really shouldn't be breathed by anyone? Fog machine manufacturers have a material interest in making sure that what their machines produce is neither hazardous nor obnoxious. They write the instructions to tell you how the machine should or shall be operated so that what is produced is, as Safex Chemie, the original glycol fog machine manufacturer, starting 42 years ago, puts it, "*ungiftigen und reizlosen*," non-poisonous and non-irritating. If you don't follow instructions, what do you get? Do you know? You are on your own. You are the

manufacturer of a unique effect, and need to do all the things that would be considered due diligence for a manufacturer.

The impetus for this article is the practice of using third-party fog fluids in glycol/glycerin/mineral oil fog machines, fluids that generally are prohibited or not recommended in the fog machine manufacturer's instructions. However, the health issues of not following instructions apply to all commercially manufactured fog machines.

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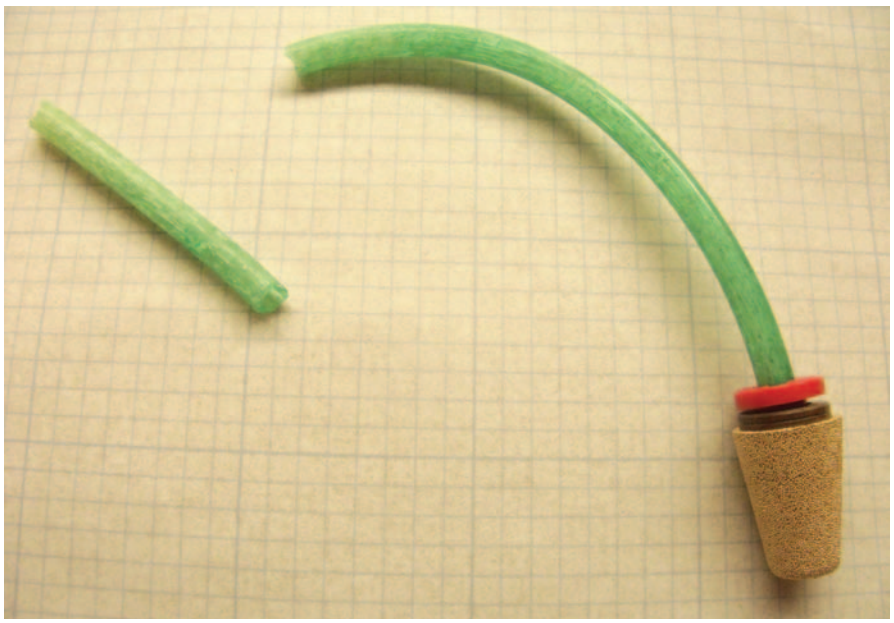

I did not use the recommended fluid in my glycol party fogger. The fluid hose has turned green, crystallized, and crumbled. Was this because of a poor fluid/machine match?

Dry ice fog machines are often considered by people who don't read the instructions as perfectly safe, idiot-proof, but a check of the instruction manuals for four commercially produced dry ice machines shows that all of them have warnings about handling and storing dry ice to avoid frostbite, eye injury, and explosions, and also about using the machines with adequate ventilation, since high levels of carbon dioxide can suffocate people and pets—events sure to spoil any Halloween party. The two larger machines also have instructions for changing the water and cleaning the tanks at least once a week. Why? To keep the fog clean, since the fog is made of droplets of water from the tank. While the acidity and heat might help control bacteria and fungus growth, using fresh water and cleaning the tank regularly are reasonable steps to ensure that the fog isn't loaded with microbes.

Water is an exceptionally cheap fog fluid; the fog fluid for glycol, glycerin, and mineral oil fog machines costs much more. To save money or for convenience, people often buy third-party fog fluids or will mix their own from bulk chemicals. Third-party fluids can cost about a third as much as the specified fluids, and if you mix your own, you can cut your fluid costs to about a tenth—and over the years, I have gotten emails from people wanting to mix their own fluids for a variety of reasons, including using vegetable oil so that the fog would be organic. Saving 90% on the price of a liter of fog fluid is a powerful inducement (and maybe being able to call it "organic" is, too), but most fog machine instructions either say that you must not or should not use anything but the fluid specified; to use third party or brew-your-own fluids you have to disregard at least part of the instructions. You now no longer have any guarantee, implied or explicit, on the part of the fog machine manufacturer that what the machine produces is safe to breathe. Most instructions tell you that using foreign fluids can be dangerous and damage the equipment, and that using them immediately voids the warranty and releases the manufacturer and dealer from any liability.

This should be obvious. Would any manufacturer claim responsibility for equipment that is not used as intended, in ways a manufacturer cannot reasonably foresee? There are an infinite number of things a person could pour into a fog machine; the simplest way to ensure that the machine functions as intended is to specify a limited set of fluids that can be used and prohibiting the rest. Ensuring that the fog produced with this limited set is *ungiftigen und reizlosen* is a reasonable task for the fog machine manufacturer.

In writing this article, I reviewed the reference material for my articles "Safe Smoke: Glycol-Based Fogs" and "Clearing the Air About Fog" in the April 1995 and April 1996 issues of *Lighting Dimensions* and *TCI* respectively. It's a couple of floppy disks of interviews and a stack of paper, about a hand-span's thickness in the file cabinet, documenting the research done back in the early 1990s to address the concerns of Broadway performers, and the earlier tests the fog machine manufacturers had done on their own to ensure that their fog machines and fluids were reasonably safe for people. One of the concerns was that fog machines might cook the fog fluids into toxic chemicals such as formaldehyde and acrolein. That's a possible outcome of poor machine design or a bad machine/fluid match and can be demonstrated with a hot plate in the lab, but HETA 90-355-2449, which documents the results of NIOSH investigations done in 1991 and 1993 on *Miss Saigon*, *Les*

Miserables, *Phantom of the Opera*, and *Grand Hotel* on Broadway, reports virtually no contaminants. Acrolein was not found at all. Formaldehyde was found at levels lower than 0.04 parts per million, typical of the levels commonly found in non-industrial work places that have no fog machines in operation. (Incidentally, HETA 90-355-2449 recommends following the fog equipment manufacturer's instructions.)

"When you use a fluid that is not recommended by the fog machine manufacturer, you are on your own."

Much has been written in the literature about the importance of the temperature of the heat exchanger for heated fog machines relative to the boiling points of the fog fluid chemicals used in them. Dipropylene glycol boils at 233° C, triethylene glycol at 280° C, glycerin at 290° C, and pure alkane mineral oil at about 350° C; using mineral oil in a machine designed for dipropylene glycol might result in squirting hot oil, while using dipropylene glycol in a mineral oil machine might indeed result in toxic decomposition products.

I would argue that time also is as important as temperature in avoiding decomposition products. I'm thinking of the difference between stir-frying vegetables and letting them soak in smoking-hot oil; chemical transformations take time. The heat exchangers of fog machines are often hotter than these boiling points, but the fluid is pumped through fast and doesn't stay in contact with the heat long. This makes fluid viscosity important, since thicker fluid will have a longer contact time in the heat exchanger. A fluid that is almost pure glycerin has the viscosity of pancake syrup; a fluid that is mostly water and only a little glycerin flows like water. A machine made for one is not going to work the same with the other.

But back to the stack of literature: Actually, I have a whole file drawer full of papers on fog machines, fog fluids, fog fluid chemicals, air sampling reports, epidemiological studies, and so on, much of it collected for the Fog & Smoke Working Group's standards and *Introduction to Modern Atmospheric Effects*. However, nowhere in that drawer are reports documenting the presence or absence of decomposition products produced when fog fluid from manufacturer A is put into a machine from manufacturer B made for manufacturer B fluid. No fog machine manufacturer has paid for and published those tests. It would not be in the manufacturer's financial interests, and the list of possible combinations to test is endless, a veritable bottomless pit of expense. The data's not there in the tests of Broadway shows, either. Thirty dollars a liter sounds like a significant savings, but it's nothing compared to a Broadway show's other running costs, and few production managers are going to say that the savings are worth compromising the reliability of the equipment and complicating getting it serviced.

My argument here is not that using third-party fluids or home-brew fluids will result in damaged equipment and unsafe fog. My argument here is that finding reliable data saying that they will not is difficult. When you use a fluid that is not recommended by the fog machine manufacturer, you are on your own. You are the manufacturer of a unique effect, and you have all the responsibilities of a manufacturer. This is indeed what *ANSI E1.23* says:

> **3.4.2 Commercially manufactured standard equipment**
> Commercially manufactured standard equipment shall be used according to the following clauses 3.4.2.1 through 3.4.2.3. *Any commercially manufactured standard equipment not used according to these clauses shall be considered custom equipment, and the party making the modification to the equipment or to the operating procedure shall be considered the manufacturer of the custom equipment.* [Emphasis added.]
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> **3.4.3 Custom equipment**
> Custom-made equipment shall be permitted to be used if the stipulations of clauses 3.4.3.1 through 3.4.3.3 are met.
>
> **3.4.3.1** The manufacturer of the custom-made equipment gives written assurance of the safety of the equipment and its suitability for making theatrical fog.
>
> **3.4.3.2** The manufacturer of the custom-made equipment provides written instructions per *ANSI E1.14* on how to use the equipment.
>
> **3.4.3.3** The equipment is used according to the manufacturer's instructions.

That looks like a lot, but it is all do-able, although it is significantly more work than simply using commercially made equipment according to the instructions.

If you are using an unauthorized fluid, made by a third-party, what assurance do you have that it does not contain pathogens or toxic contaminants, and that running it through a fog machine does not create toxic byproducts? An assurance that the fog fluid is clean, made from only the best quality chemicals is not enough. What assurance do you have that it does not change as it is run through the fog machine? Is there a reasonable argument? Is there test data? If not, are you willing to conduct or pay for the tests yourself? Please note that the existence of calibration factors for the use of an aerosol meter or time-distance tables to control exposure does not necessarily mean that tests have been done to check for decomposition products. They only mean that the chemical density/light scattering of an average droplet has been determined.

If you are making your own fluid, you need to ask these same questions of yourself. Even if the fog produced contains no contaminants, no toxic decomposition products, is it a fog that won't bother people and that will not leave a problematic residue? Peanut oil might make a vegan organic fog and helps support farmers, but peanut oil fog is going to be a serious

problem for people with peanut allergies and might make the theatre smell like an Asian lunch counter. Besides that, coating everything with edible oil is probably the start of a housekeeping nightmare.

In any case, you need to document your answers. If you are ever questioned about a fog effect, you don't want to look like you are making up answers as you go along. However, even more importantly, you want to document this so that you seriously consider the fog effect and whether it is appropriate and safe. When things go wrong, it is usually because of a fundamental lack of planning, not simply because, as Donald Rumsfeld famously said, "Stuff happens."

ANSI E1.23 is not a long standard—only 24 pages total—but it covers a lot more than simply the consideration of what kind of fluid to use in what machine. Fundamentally, it is a planning document that asks a fog effect designer to decide what kind of effect is wanted, to consider the equipment and materials needed to accomplish it, to decide how the effect is going to be maintained and monitored, and to determine who is going to do all this—and to write this all down so that the plan can be shared with others, discussed, and reviewed to make sure that the effect is being done according to plan. It's all a lot easier if you simply follow instructions.

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