

# LIGHTING DIMENSIONS

Safe smoke:  
glycol-based fogs

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GLYCOL/WATER FOGS ARE AMONG THE SAFEST THEATRICAL EFFECTS ONE CAN USE. THE AMOUNTS OF CHEMICALS USED IN THE FOG ARE LOW AND THE CHEMICALS ARE BENIGN. THERE IS NO CREDIBLE EVIDENCE OF ILLNESS CAUSED BY GLYCOL-BASED FOGS.

# Safe smoke

## GLYCOL-BASED FOGS

"Apparently, no one has heard that all chemical foggers, including Rosco, JEM, SFX, produce a potentially carcinogenic gas," wrote one man on the Internet's Stagecraft mailing list a few months ago, demonstrating both the power and the danger of the Internet. Contrary to the story this person was repeating, glycol/water fogs produced by the machines and fluids of the major fog machine manufacturers are among the safest theatrical effects one can use. The amounts of chemicals used in the fog are low and the chemicals are benign. There is no credible evidence of illness caused by glycol-based fogs. At the request of Actors' Equity Association and the League of American Theatres and Producers, the National Institute for Occupational Safety and Health recently conducted a study of fog use on several Broadway productions (HETA 90-355-2449). The report documents the results of surveys done in 1991 and 1993 in which air samples were taken on *Miss Saigon*, *Les Miserables*, *The Phantom of the Opera*, and *Grand Hotel*. The air samples revealed extremely low concentrations of glycols used in the fog fluids, quite low in comparison to any applicable Occupational Safety and Health Administration Permissible Exposure Limits, American Conference

of Governmental Industrial Hygienists Threshold Limit Values, and NIOSH Recommended Exposure Limits, and virtually no contaminants. Acrolein, a hazardous compound that might be produced by overheating the fog fluids, was not found. Formaldehyde, another potential decomposition product, was found at levels lower than 0.04 parts per million, well below OSHA and ACGIH exposure limits, typical of the levels commonly found in non-industrial work places, and 1/100 the average level of formaldehyde found in studies of the air in mobile homes.

Several major fog manufacturers have also brought NIOSH or other independent investigators into their demo rooms to evaluate the fogs. In the showroom of one US manufacturer, normal levels of fog produced maximum concentrations of propylene glycol and triethylene glycol-two of the most popular fog chemicals-of 2.9 mg/m<sup>3</sup> and 4.8 mg/m<sup>3</sup>, respectively. A very heavy fog produced concentrations of 9.6 and 24.2 mg/m<sup>3</sup>. No acrolein was found, and formaldehyde was found in only three of the six samples-and in two of those three samples at levels lower than that found in the control samples taken in the office outside the demo room. This suggests that the formaldehyde was present in the environment and not created by the smoke. The investigators noted that there are no OSHA, NIOSH, or ACGIH exposure limits set for the glycols, but their chemical similarity to ethylene glycol suggests that compound's ACGIH threshold limit value of 127 mg/m<sup>3</sup> would be appropriate-far higher than

the concentrations found.

An environmental testing lab testing a British manufacturer's fog in the company's demo room found levels of 4.6 and less than 3.0 mg/m<sup>3</sup> of propylene and triethylene glycol, respectively.

The fog was so dense it obscured the furniture, walls, and exit

signs. A person could just barely see his/her hand at

arm's length. There

is no British standard for

maximum exposure to

triethylene glycol in the air,

but there is one for propylene

glycol, and the chemicals

are similar enough that the

researchers judged the

propylene standard should be applied:

470 mg/m<sup>3</sup> eight-hour, time-weighted

average. A Professional Lighting and

Sound Association document evaluating

glycol fogs uses a more conservative

Health and Safety Executive Guide

that sets a limit of 10 mg/m<sup>3</sup> averaged

over an eight-hour period for all the

glycols commonly used in fogs. The

concentration can be increased for

shorter periods, so the exposure limit

for five hours-a very long concert or

night in a club-would be 16 mg/m<sup>3</sup>.

It is highly unlikely that any club or

concert would use fog so heavy as to

approach this higher concentration,

since half this amount makes exit signs

and performers invisible.

The lack of maximum exposure limits

for most of the glycols used in fog fluids

has led to charges that not enough is

known about these compounds. Glycol

fog manufacturers are fairly tight-lipped

about their products and testing-users

are familiar with a major manufacturer's material safety data sheet that calls the ingredients a trade secret-but manufacturers were willing to send me information for this article, information that creates a pile of abstracts, test results, and surveys of the scientific literature on my desk better than 2" tall. A tremendous amount is known about the glycols used in the fog fluids. They have been extensively tested on mammals, and used for about half a century in industry. More than a generation of workers have spent their lives working with these compounds and being exposed to them in a variety of ways. They are used in antifreeze, inks, plastics, pharmaceuticals, foods, animal feed, and cosmetics. Triethylene glycol has been used as an air sterilizer in hospital air-conditioning systems. As with anything, large enough quantities can be fatal, but the levels required to kill with these glycols are absurdly high. Studies have shown that levels of 5,000 mg/m<sup>3</sup> of triethylene glycol, for six hours a day for four days, have been required to kill rats. Rats and monkeys have been exposed continuously to atmospheres laden with propylene glycol and triethylene glycol (about 200 mg/m<sup>3</sup> and 50mg/m<sup>3</sup>) for up to 18 months with no ill effects other than some drying of the skin. "The exposed ones actually had fewer diseases. They think it's because these compounds have fairly effective anti-bacterial and anti-viral activity when they are in the air, so those animals had fewer infec-

tions," says Dr. James P. Kehrer, head of the Division of Pharmacology and Toxicology at the University of Texas at Austin.

Perhaps most interesting are the results of the health part of the NIOSH Broadway study. The study was commissioned by Equity because the union received complaints from the actors about their working conditions, and the 1991 NIOSH survey did find significantly more complaints of excessive sneezing, coughing, and wheezing from the actors on shows using smoke than from actors on shows not using smoke. However, the 1993 survey took a group of the actors from the shows using smoke and a group from shows that used no smoke and measured their peak expiratory flow rate—the maximum amount of air per minute they could exhale—over a two-week period. Of the 30 actors in the sample who were in shows with smoke, three had measurable symptoms of asthma; of the 20 actors on non-smoke shows, two had symptoms of asthma. "Based on the results of this study, there is no evidence that theatrical smoke, at the levels found in the theaters studied, is a cause of occupational asthma among performers," concludes the NIOSH report.

"This is a very emotional issue," says Matthew McFarland, senior safety and health consultant with Corporate Safety and Health Consultants, a consulting group to the League of American Theatres and Producers. "The actors see the fog. It is visible to them. If they're getting sick, they assign it to this thing floating in the air. Plus, there are doctors out there telling them that

they are in a smoke production and it's affecting them. I've never spoken to any of those doctors; I don't know what they're basing that on."

There is the argument that highly sensitive people might be affected by the smoke, that some people may be allergic to the glycols. "The allergenic potential of these compounds is virtually zero," says Kehrer. "Now, getting to whether some people are sensitive-yes. Some people are going to see a fog or smoke-and I don't mean to minimize it, these are real reactions-and they're going to think 'Gosh, there is something here. I can feel it. I can taste it. I have a little bit of this irritation thing.' And their brain starts adding to that, and they have a real reaction. That real reaction can cause physical problems. Is it medical? Yes, it is a medical response. Is that toxicology? I say no."

One effect that people in glycol fogs may feel, and which is real, is a slight drying of the mouth and eyes. Glycols are hygroscopic and bind with water, making normal air dry, and dry air drier. The drying effect is limited and transitory. Kehrer describes the effect as "similar to being in Las Vegas at high noon on July 4th and jogging outside a little bit. It's really dry, and that can irritate your eyes and so forth. It's less irritating than cigarette smoke-quite a bit less. It's not an irritant in the sense of a damaging irritant."

While the fluids and machines manufactured by major companies-who take their business seriously enough to be active in PLASA and the Entertainment Services and Technology Association-are safe when properly used, there are

health concerns with machines and fluids made by other, less well known companies, who do not take design and quality control as seriously. "Some people who do not care for anything can ruin the reputation of the companies who do care," says Florian von Hofen, president of Smoke Factory. Adrian Segeren of Le Maitre Special Effects simply notes that there are too many "bathtub manufacturers" of fog fluids. "Temperature is a really big concern," says High End Systems CEO Lowell Fowler. There is ample research cited by several of the manufacturers that high temperatures can break down the fog fluid and form hazardous products such as acrolein and formaldehyde, both carcinogens. Seven hundred degrees Fahrenheit is usually cited as the absolute maximum temperature, and major manufacturers stay lower than that by a wide margin. "Manufacturers should be able to tell you the temperature of their products," says Fowler. High End's F-100 machine has been measured by an independent testing lab to heat the fluid to less than 400°F. Some machines, such as the Martin Magnum Pro 2000, have redundant circuits to ensure that the heat exchanger does not get too hot if the primary thermostat fails. However, there have been machines sold that run at 700° and above, and there was at least one machine at a recent trade show that appeared to have no thermostat at all. "Those are the machines that are really dangerous," says von Hofen. "Never, ever buy a no-name product

concerning the fluid, because people throw in everything," says von Hofen.

The major manufacturers use water, triethylene glycol, propylene glycol, butylene glycol, dipropylene glycol, and glycerin in their fluids, with water and the first four compounds being the most common ingredients. But ethylene and diethylene glycol occasionally show up in no-name fog fluids. These are not highly toxic, but are less safe than the other glycols, and should be avoided.

"We have fluids on the market here from France," says von Hofen in Germany.

"We have big wholesalers who even print a certificate on the cans which says 'We can guarantee that this is not dangerous to health,' and so on. Then you make an analysis of it and you find that something like 56% of it is diethylene glycol. It is important if you buy liquid to know the real manufacturer."

Only food-grade or high-grade component chemicals should be used in a fog fluid-technical grade is not good enough-and the fluid has to be handled so that "food grade" stays good enough for food. "A lot of times people ask for 55-gallon barrels of fog fluid," says Fowler. "We can't sell them that because we don't know what procedures they would use to pump the fluid out of the drums. We know we can control what goes into the bottles we use."

Virtually all the fog machine manufacturers recommend that only the fluids designed for their machines be used in them. The interim NIOSH report published after the 1991 survey indirectly supports this by recommending that users follow the manufacturer's instructions.

"It's not just a machine and a fluid;

the two are meant to work together," says Fowler. Undoubtedly, the recommendation helps sell brand-name fluid, but it also makes sense. The machines have been designed and tested for a fluid of a particular composition and viscosity. Manufacturers know that their fluids in their machines will not be overheated, will not dissolve seals, jam valves, or corrode fittings. There is no way they can reasonably be expected to verify that all other fluids will work as well in their machines.

The fog industry is relatively young, but it is maturing. In January, ESTA's Technical Standards Committee announced the formation of a Fog and Smoke Working Group covering glycol, mineral oil, and water-based technologies. Initial interests of the group are to increase the entertainment industry's understanding of the different technologies, their capabilities, and suitable applications; creating and maintaining a program of standards definition and training that promotes safety and effective use; and establishing a research program regarding fog fluid. Atmospheric effects are an important part of live entertainment today, and this group should help keep the air appropriately and safely cloudy.

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