

ACTS FACTS

THE MONTHLY NEWSLETTER FROM

ARTS, CRAFTS AND THEATER SAFETY (ACTS)

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FOG, SMOKE & HAZE CHEMICAL AIR QUALITY STANDARDS

Editorial

ACTS has been concerned for some time about the air quality standards used to protect cast and crew from overexposure to the glycols, glycerin and mineral oil chemical mists used in theatrical fog, smoke and haze effects. These air quality limits are found in the American National Standards Institute standards ANSI E1.5* and ANSI E1.23.** The standards were developed and voted on by people with experience in special effects rather than expertise in occupational health. They chose to base their standards primarily on data from a single study.

THE STUDY. This study, done by Dr. Jacqueline Moline from Mount Sinai's Department of Community and Preventive Medicine and released in June, 2000*** used the data from medical evaluations of 439 adult actors performing in 16 Broadway musicals. The air-monitoring was done by ENVIRON International Corporation. The study's scope was limited to acute "local irritant effects of the respiratory tract and eyes" and the monitoring data was used to set exposure levels below those at which symptoms were reported. The study concluded:

... No significant acute change in voice quality, pulmonary function, or vocal cord appearance was found among Actors exposed to theatrical smoke, haze, or pyrotechnic agents. However, Actors with exposures to elevated or peak levels of glycols reported more symptoms than Actors with less exposure. In addition, some mild chronic effects in Actors with greater exposure to peak levels of glycols and mineral oil were observed. Page ES-3

One of the potential chronic effects found was the following:

Actors with the highest exposure to mineral oil had a statistically significant decrease in one pulmonary function parameter – forced vital capacity. This finding was surprising, as decreases in forced vital capacity are usually associated with interstitial lung processes or interference with taking a deep breath from external pressures, such as pleural thickening or obesity. While an effect was noted, it is important to note that Actors still have pulmonary function within the normal range. Page EN-5

I'm not sure singers would be happy with any decrease in pulmonary function. And it is unknown whether this change in lung capacity occurring repeatedly over a performing lifetime could cause a permanent chronic condition. Since the study did not intend to look for chronic effects, and yet found some, ACTS was curious about how much hard data there is on these chemicals.

HOW MUCH DATA EXISTS? To compile this information, we compared the toxicity data from Sigma-Aldrich Corporation's Safety Data Sheets (SDSs) for each of the chemicals. The tests listed on these SDSs are those required to be reported on the United Nation's version of the Globally Harmonized System SDSs. These SDSs must report either the results of the required tests, or must clearly state that the test have not been done. This information is charted on page 2 of this newsletter.

**COMPILATION OF TOXICITY DATA FROM SIGMA-ALDRICH SDSs
ON CHEMICALS USED IN FOG**

As of - May 8, 2015

1. TEG - **triethylene glycol** CAS# 112-27-6
2. MPG - **monopropylene glycol** (propylene glycol; 1,2-propanediol) CAS# 57-55-6
3. DEG - **diethylene glycol** CAS# 111-46-6
4. DPG - **dipropylene glycol(s)** CAS# 25265-71-8, 106-62-7, 110-98-5, 108-61-2
5. 1,2-B- **1,2-butylene glycol** (1,2-butanediol) CAS# 584-03-2
6. 1,3-B- **1,3-butylene glycol** (1,3-butanediol) CAS# 107-88-0
7. GLY - **glycerine** (glycerol; 1,2,3-propanetriol) CAS# 56-81-5
8. MOIL- **white mineral oil**, medicinal or food grade CAS# 8042-47-5

Test ¹	TEG 1	MPG 2	DEG 3	DPG 4	1,2-B 5	1,3-B 6	GLY 7	MOIL 8
Acute ingestion	rat data category 5 ²	rat data category 5	human toxic	rat data category 5	rat data category 5	rat data category 5	rat data category 5	no data
Acute inhalation	mouse disorder ³	no data	no data	rat toxic category 2 ⁴	no data	no data	no data	no data
Respiratory sensi- tization	no data	no data	no data	no data	no data	no data	no data	no data
Skin sensitization	no data	no data	guinea pig negative	guinea pig negative	no data	no data	no data	no data
Germ cell mutagen	no data	no data	no data	negative	no data	no data	no data	no data
Cancer	no data	no data	no data	no data	no data	no data	no data	no data
Reproductive	animals adverse	no data	no data	rat data adverse	no data	no data	no data	no data
Developmental	rat major adverse	no data	no data	no data	no data	rat adverse wt. gain	no data	no data
STOT⁵-single dose	no data	no data	no data	no data	no data	no data	no data	no data
STOT⁵-repeated	no data	no data	human kidney dam.	no data	no data	no data	no data	no data
Aspiration hazard	no data	no data	no data	no data	no data	no data	no data	human lipoid pneumonia

- 1 The SDS acute eye and skin tests are left out and sensitization is divided into skin and respiratory since inhalation is the route of interest.
2. Category 5 is the least toxic category and only requires a label to read "May be harmful if swallowed." Categories 4 to 1 are progressively more toxic and require stronger symbols, signal words and warnings.
3. This disorder refers to a study of triethylene glycol by inhalation which resulted in depressed breathing rates.
4. This could be an error on the SDS since this would make 1,3- butylene glycol a serious respiratory hazard.
- 5 Specific Target Organ Toxicity

LACK OF DATA. The lack of test data on these chemicals is stunning. While all but one of the chemicals have been tested for acute ingestion toxicity (LD50), this test is not useful in determining inhalation hazards. For example, drinking mineral oil only causes a laxative effect, but inhalation or aspiration (see the table) can cause lipid pneumonia which can be fatal.

ACTS found clinical data on use of propylene glycol in asthma inhalers showing that some patients have allergic or irritant reactions to even these very small, sporadic doses. But the standard SDS tests for respiratory sensitization appear not to have been done on any of the chemicals. Acute respiratory toxicity tests were only reported for two of the chemicals and both showed adverse effects. Reproductive and developmental tests were reported for only three of the chemicals and all three showed adverse effects. Triethylene glycol in particular caused major developmental damage in rats.

THE DR. MOLINE STANDARDS. Mt. Sinai and ENVIRON study recommendations are:

- The use of glycols should be such that an Actor's exposure does not exceed 40 milligrams per cubic meter (mg/m^3).
- Mineral oil should be used in a manner such that an Actor's exposure does not exceed a peak concentration of $25 \text{ mg}/\text{m}^3$.
- For chronic exposures to mineral oil, the existing standards established for oil mists ($5 \text{ mg}/\text{m}^3$ as an eight-hour time-weighted average) should also be protective for Actors in theatrical productions.

OTHER STANDARDS. The major agency in the U.S. for setting occupational standards is the American Conference of Governmental Industrial Hygienists. The ACGIH has no standards for any of the six glycols and they recently withdrew their standard for glycerin due to insufficient data! Their standard for large particle (inhalable) mineral oil is the same as that of the ANSI E1.23 standard, but mineral oil haze is usually in a smaller (respirable) aerosol, often as small as one micron (μ). The ACGIH default standard for this mist (the "particulates not otherwise specified" or PNOS limit) would be lower and more protective than the Moline or the ANSI E1.23 limits.

The table below also includes the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs). These standards are so out of date that OSHA, itself, recommends using better standards.*** OSHA's only oil mist standard is for "Particulates Not Otherwise Regulated" (PNOR) which limits exposure to $5 \text{ mg}/\text{m}^3$ for respirable aerosols. This PNOR standard also applies to Glycerin. OSHA has no standards for the glycols. The industry standards, ACGIH standards and OSHA standards are compared below:

VARIOUS STANDARDS FOR FOG, SMOKE AND HAZE CHEMICALS

<u>Source</u>	<u>All glycols</u>	<u>glycerine</u>	<u>oil mist (highly refined)</u>
Moline	$40 \text{ mg}/\text{m}^3$ (peak) $5 \text{ mg}/\text{m}^3$ TWA	no standard set	$25 \text{ mg}/\text{m}^3$ (peak)
ANSI E1.5	$40 \text{ mg}/\text{m}^3$ (peak) $10 \text{ mg}/\text{m}^3$ TWA	$50 \text{ mg}/\text{m}^3$ (peak) $10 \text{ mg}/\text{m}^3$ TWA	
ANSI E1.23	refers to E1.5	refers to E1.5	refers to OSHA which is $5 \text{ mg}/\text{m}^3$ PEL-TWA
ACGIH	No glycol TLVs	Withdrawn due to lack of data	$5 \text{ mg}/\text{m}^3$ inhalable ($10\text{-}100\mu^*$) $3 \text{ mg}/\text{m}^3$ respirable ($< 10\mu^*$)
OSHA	No glycol PELs	$5 \text{ mg}/\text{m}^3$ respirable	$5 \text{ mg}/\text{m}^3$ respirable

* particle size diameter in microns

In addition to these standards, two of the glycols, diethylene and propylene glycol, have limits set by a division of the American Industrial Hygiene Association (AIHA). These are both 10 mg/m³, 8-hour limits that do not apply to the other glycols. And no AIHA peak limits could be found.

SUMMARY CONCLUSIONS

1. GLYCOLS

- * ACTS finds no sound scientific basis for setting the peak limits for the glycols at 40 mg/m³.
- * ACTS only finds the 8-hour (TWA) standard for diethylene and propylene glycols is supported by a proper standard setting agency. The other glycols cannot be assumed to be of equal toxicity.

2. GLYCERIN. ACTS can find no sound scientific basis for the setting either the peak or the 8-hour average exposure limits for glycerine at the levels in the ANSI standards.

3. MINERAL OIL. Since the mineral oil haze is usually in the respirable size or smaller, and since the ACGIH PNOS standard for this particle would be 3 mg/m³, ACTS believes that use of the less protective 5 mg/m³ respirable OSHA PEL in ANSI E1.23 is not best practice.

4. WORKER'S RIGHTS. Theatrical and entertainment workers exposed to any of these chemical effects have a right to know both what is known and what is *not* known about them. They should be informed that there is very little acute inhalation data and almost no long term, chronic data on these chemicals. They should be aware that workplace air quality standards are usually set by panels of experts, not by a single doctor in a single study or by special effects people. And all workplace air quality standards are designed to protect most healthy adult workers. By definition, children, the elderly and people with various physical limitations are not covered by these workplace standards.

5. PUBLIC POLICY. Theatergoers also should be informed when chemicals will get into the audience areas and how little is known about their effects.

* ANSI E1.5 – 2009 (R2014), Entertainment Technology – Theatrical Fog Made With Aqueous Solutions Of Di- and Trihydric Alcohols

** ANSI E1.23 – 2010 (R2015), Entertainment Technology – Design and Execution of Theatrical Fog Effects

*** Health Effects Evaluation of Theatrical Smoke, Haze and Pyrotechnics. Prepared for: Equity-League Pension and Health Trust Fund, Jacqueline M. Moline, M.D., M.Sc. And Anne L. Golden, Ph.D., Department of Community and Preventive Medicine, Mount Sinai School of Medicine and Joseph H. Highland, Ph.D., et al., ENVIRON International Corporation, June 6, 2000

**** See <https://www.osha.gov/dsg/annotated-pels/>

ACTS FACTS sources: the *Federal Register (FR)*, the *Mortality and Morbidity Weekly Report (MMWR)*, *Environmental Health Perspectives (EHP)*, and many other publications. Call for further information on sources. Editor: Monona Rossol; Research: Tobi Zausner, Sharon Campbell, Robert Pearl, Brian Lee, Pamela Dale, Kathy Hulce, Pat F. Sheffield, Janet Sellery; Staff: Kathy Frost, John Fairlie, OES.

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