



## Calibration Factors And Time-and-Distance Guidelines For Use of Theatrical Fog Equipment

Bog Fog, K-razy Haze, Training Smoke XD,  
Backwood Bay, Faze Haze, Training Smoke  
FR, Amusement Park Fluid, Velocity, Cryo  
Freeze, Quick Blast, Training Smoke Q,  
Techno Fog, Beam Splitter, Neutronic Haze,  
DaFiddy, Base-H

Prepared for:  
**Froggy's Fog**  
Columbia, Tennessee

Prepared by:  
**ENVIRON International Corporation**  
Westford, Massachusetts

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# 1 Introduction

In 1997-99, at the request of Actors' Equity Association (AEA) and the League of American Theaters and Producers (LATP) and with the support of the Equity-League Pension and Health Trust Funds, investigators from the Mount Sinai School of Medicine (Mt. Sinai) and ENVIRON International Corporation (ENVIRON) conducted a study to evaluate whether the use of smoke, fog, haze, and pyrotechnics special effects in theatrical musical productions is associated with a negative health impact in actors. This effort was initiated in response to ongoing concerns by actors that the use of these theatrical effects may have an impact on their health. The results of this study were presented in the report *Health Effects Evaluation of Theatrical Smoke, Haze, and Pyrotechnics* (Mt. Sinai and ENVIRON 2000).

The results of the Mt. Sinai/ENVIRON study indicate that there are certain health effects associated with actors exposed to elevated or peak levels of glycol smoke/fog and mineral oil. However, as long as peak exposures are avoided, actors' health, vocal abilities, and careers should not be harmed. Pyrotechnics as used on Broadway at the time of the study did not have an observable effect on actors' health.

Mt. Sinai and ENVIRON recommended the following peak guidance levels with respect to glycols and mineral oil:

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

Comparable guidance levels were developed for glycerol in a subsequent study (ENVIRON 2001b):

- Glycerol should be used in a manner such that an actor's exposure does not exceed a peak concentration of **50 mg/m<sup>3</sup>**.
- For chronic exposures to glycerol, the existing standards established for glycerin mists (**10 mg/m<sup>3</sup>** as an eight-hour TWA) should also be protective for actors in theatrical productions.

To ensure that peak smoke, fog, and haze levels are below these guidelines, one option available to productions is to conduct show-specific testing at their theatres using an aerosol monitor. In order to conduct this testing, calibration data must be developed for each equipment/fluid combination. These calibration data are necessary to convert the readings of the aerosol monitor to glycol, mineral oil, or glycerol concentrations. A compilation of calibration factors approved for use in evaluating compliance with the peak guidance levels is provided on the Actors Equity web site (<http://www.actorsequity.org/library/library.asp?cat=33>).

ENVIRON was retained by Froggy's Fog to develop calibration factors and time-and-distance guidelines for the following equipment-fluid combinations listed in Appendix A.

## 2 Testing Methodology

### 2.1 Sampling Equipment and Materials

Monitoring of short-term concentrations was performed using portable real-time aerosol monitors (*personal* DataRAM Model PDR-1000) manufactured by Thermo Scientific. The PDR-1000 is a high sensitivity (i.e., photometric) monitor that uses a light scattering sensing chamber to measure the concentration of airborne particulate matter (liquid or solid), providing a direct and continuous readout as well as electronic logging of the data.

The PDR-1000 aerosol monitors as obtained are calibrated to Arizona road dust over a measurement range of 0.001 to 400 mg/m<sup>3</sup>. In order to be utilized to measure short-term glycol, oil mist, or glycerol concentrations, the monitors were first calibrated for the smoke or haze machines and fluids being used. Calibration of the aerosol monitors was conducted by collecting simultaneous measurements with a series of sampling pumps and PDR-1000 aerosol monitors, mounted on tripods.

Gilian BDx-II and Gilian GilAir 3 sampling pumps were used to draw air through collection media. The calibration sampling was conducted in conjunction with operating the PDR-1000 aerosol monitor.

For fluids containing glycols, OSHA Versatile Sampler (OVS) traps were used as the collection media, each containing two sections of XAD-7 resin (200-mg front section, 100-mg back section, separated by a polyurethane foam [PUF] plug). The XAD-7 resin was used to collect both the particulate and vapor phase of the glycol aerosol. A 13-mm glass fiber filter (GFF) plug precedes the front section and a PUF plug follows the back section. This sampling is based on a variation of NIOSH Method 5523 (NIOSH 1996; Pendergrass 1999). Bulk fluid samples are also collected and submitted for laboratory analysis to determine which species of glycols are present.

For fluids containing glycerols, air samples were collected on 37 mm 2-piece cassettes containing tared 5µm polyvinyl chloride (PVC) filters. The sampling method is based on NIOSH Method 0500.

For fluids containing mineral oil, air samples were collected on 37 mm 2-piece cassettes containing tared 5µm polyvinyl chloride (PVC) filters. Bulk fluid samples are also collected and submitted for laboratory analysis to be used as a calibration standard. The sampling method is based on NIOSH Method 5026.

The testing was performed at a rented industrial space in Columbia, Tennessee.

### 2.2 Aerosol Monitor Calibration Procedure

A series of tripod assemblies was used for calibrating the aerosol monitors, each consisting of a sampling pump, flexible tubing, sampling media, and an aerosol monitor. The height of the tripod was approximately five feet, corresponding with the breathing zone of a typical actor. For low fog machines, testing assemblies were placed at floor level. The room ventilation fans were

turned off during each run; no major movement occurred in the testing room during each run that would affect fog dispersion.

- a. The sampling pumps were calibrated to 2 liters per minute (LPM) (OVS traps) or 3 LPM (cassettes) using a BIOS Defender pump calibrator. The aerosol monitor was zeroed, the data logging function of the aerosol monitor was turned on, and the data logging time for the aerosol monitors were synchronized.
- b. The fog machines were positioned on a table to allow a release of fog at a height of four feet. Low fog machines and the Martin K-1 hazer were positioned on the floor. The tripods were placed at various distances from the smoke machine release nozzle to achieve a range of exposure concentrations.
- c. The sampling pumps were turned on, followed by the fog machines, allowing sustained fog generation to occur. After a period of approximately five to twenty minutes, the machines and pumps were simultaneously turned off.
- d. The sampling media were capped and labeled to identify the type of fog machine and fluid, sampling location, and other sampling specifics. After being capped and labeled, OVS traps were placed in a freezer.
- e. Various fans and ceiling vents were used between runs to clear residual aerosols from the testing area air by room ventilation.

The collection media and bulk fluid samples, along with appropriate field blanks, were submitted for analysis to Analytics Laboratory of Richmond, Virginia, an American Industrial Hygiene Association (AIHA) accredited laboratory.

### **2.3 Laboratory Analysis**

All sample analyses were conducted by using validated analytical methodologies, as described in the ENVIRON Air Sampling Protocol (ENVIRON 2001a).

Samples were analyzed for glycols using a variation of NIOSH Method 5523, which involves the use of a gas chromatograph with a flame ionization detector (GC/FID). The NIOSH Method 5523 was extended to a validated level of quantification (LOQ) of 5.0 to 15.0 micrograms ( $\mu\text{g}$ ) of each individual glycol per sample.

Samples were analyzed gravimetrically for glycerols using NIOSH Method 0500. A LOQ of 10  $\mu\text{g}$  per sample was used.

Samples were analyzed by infrared spectrophotometry for mineral oil using NIOSH Method 5026. A LOQ of 50  $\mu\text{g}$  per sample was used.

### **2.4 Time-and-Distance Monitoring Procedure**

To measure the levels of glycol, glycerol, or mineral oil present at different distances from the release point, a series of five tripods equipped with aerosol monitors positioned at breathing height (approximately 5 ft above ground) were used. Each fog or haze machine was turned on for durations ranging from 5 to 120 seconds, allowing sustained fog generation to occur, and

then turned off. The aerosol monitors collected logged data on the fog levels as the concentrations gradually dissipated. For low fog machines, tripods were also placed at various heights off of the floor at a set distance from the smoke machine to represent breathing heights of actors in various positions (e.g. lying down, sitting, kneeling, and standing).

### 3 Results and Discussion

#### 3.1 Aerosol Monitor Calibration

Total glycol, glycerol, and mineral oil concentrations were calculated from the analytical data. For glycols, only the glycol species measured in the bulk solution were included. For glycol species that were measured in the bulk solution, and were detected in the air sample but not above the LOQ, one half of the LOQ for that glycol species was conservatively used in calculating the total glycol concentration. To develop a calibration curve for each fluid, the average aerosol monitor readings during the period of time in which air was drawn through the sampling media for each air sample were calculated and plotted against the total glycol, glycerol, or mineral oil concentration data.

The calibration curves for the fifty equipment-fluid combinations tested are shown in Appendix C. First order regression curves are also shown on these figures. The calibration factors, calculated from the slopes of these regressions, are summarized in Appendix B.

For determining the calibration factor for any fluid containing two or more distinct chemical constituents, the calibration factors were initially determined for each constituent, and the most conservative calibration factor was used when conducting time and distance testing for the fluid as a whole.

#### 3.2 Use of Calibration Factors

The real-time aerosol monitor readings can be converted to glycol concentrations using the appropriate calibration factor for the fluid, as follows:

$$CONC = C \times PDR$$

where:

*CONC* = air concentration of total glycols, mg/m<sup>3</sup>

*C* = aerosol monitor calibration factor (mg/m<sup>3</sup>)/ (mg/m<sup>3</sup> aerosol)

*PDR* = aerosol monitor reading, mg/m<sup>3</sup> aerosol

For example, an uncalibrated reading of 100 mg/m<sup>3</sup> on the aerosol monitor would correspond to a glycol concentration of 107 mg/m<sup>3</sup> for the Chauvet 1800 Flex/Bog Fog combination. These calculated concentrations can then be compared with the peak guidance levels. The peak guidance level for glycols of 40 mg/m<sup>3</sup> would correspond to an uncalibrated aerosol monitor reading of 37.4 mg/m<sup>3</sup> for the Chauvet 1800 Flex/Bog Fog combination.

#### 3.3 Time-and-Distance Guidelines

For various distances from the cue release point, Appendix C provides the average time (in seconds) after the end of the cue release after which the glycol, glycerol, or oil mist concentrations will have fallen below the guidance levels. Thus, in order to prevent peak exposures to actors, the blocking and choreography should be arranged such that actors are not situated within a particular distance from the front of the fog release point until the amount of



time listed in Appendix C has elapsed following the end of the cue. For example, if a production is using the Chauvet 1800 Flex/Bog Fog combination at full output with 15-second cue duration, an actor should not be situated within five to 25 feet from the front of the cue release point until at least 70 seconds following the end of the cue release.

It should be reiterated that the Time-and-Distance Guidelines provided in Appendix C are intended to allow a production to use the tested equipment and fluid combinations without conducting monitoring. However, these Guidelines may not be appropriate for all productions. Tables in Appendix C are based on the fog machine being positioned approximately four feet above the ground, and being operated to achieve 5 to 120 seconds of continuous fog generation. Productions may want to use different configurations for positioning the machine (e.g., different heights), provide on-stage ventilation, or generate fog for a shorter or longer period of time. In addition, many productions may have other stage-specific conditions (e.g., on-stage activities and props that enhance dispersion) that would allow actors to be present in areas that are restricted under these Guidelines but which, in fact, do not exceed the guidance levels. In those cases, production-specific monitoring would be recommended to determine whether peak exposure may occur.

## 4 References

- ENVIRON International Corporation (ENVIRON). 2001a. Evaluation of short-term exposures to theatrical smoke and haze: Air sampling protocol. Prepared for Equity-League Pension and Health Trust Funds. May 14.
- ENVIRON International Corporation (ENVIRON). 2001b. Theatrical Haze and Fog Testing for Mamma Mia!, Winter Garden Theatre. Prepared for Mamma Mia! Broadway and Nina Lannan Associates. November 12.
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- National Institute for Occupational Safety and Health (NIOSH). 1996. Method 5523: Glycols, Issue 1. NIOSH Manual of Analytical Methods (NMAM). Fourth Edition. May 15.
- Pendergrass, S.M. 1999. Determination of glycols in air: Development of sampling and analytical methodology and application to theatrical smokes. AIHA Journal, 60:452-457.

## **Appendix A: Equipment/Fluid Combinations**

### Appendix A: Equipment/Fluid Combinations

<b>Machine</b>	<b>Fluid</b>
ADJ Fog Fury 3000	Backwood Bay
ADJ Fog Fury 3000	Bog Fog
ADJ Fog Fury 3000	Cryo Freeze
ADJ Fog Fury 3000	Quick Blast
ADJ Fog Fury 3000	Velocity
ADJ Fog Storm 1700 HD	Cryo Freeze
ADJ Fog Storm 1700 HD	Quick Blast
ADJ Fog Storm 1700 HD	Velocity
Antari 1520 RGB Upshot	Quick Blast
Antari DNG-200	Cryo Freeze
Antari F-5/F-5D Fazer	Faze Haze
Antari ICE	Cryo Freeze
Antari M-10	Bog Fog
Antari M-10	Cryo Freeze
Antari M-10	Quick Blast
Antari M-10	Velocity
Antari M-5	Amusement Park Fluid
Antari M-5	Backwood Bay
Antari M-5	Bog Fog
Antari M-5	Cryo Freeze
Antari M-5	Quick Blast
Antari M-5	Velocity
Antari M-8	Amusement Park Fluid
Antari M-8	Backwood Bay
Antari M-8	Bog Fog
Antari M-8	Cryo Freeze
Antari M-8	Quick Blast
Antari M-8	Velocity
Antari X-515	Amusement Park Fluid
Antari X-515	Backwood Bay
Antari X-515	Bog Fog
Antari X-515	Cryo Freeze
Antari X-515	Quick Blast
Antari X-515	Velocity
Antari Z-350	Beam Splitter
BHE 1550	Amusement Park Fluid
BHE 1550	Backwood Bay
BHE 1550	Bog Fog
BHE 1550	Cryo Freeze
BHE 1550	Quick Blast
BHE 1550	Velocity
Chauvet 1800 Flex	Amusement Park Fluid
Chauvet 1800 Flex	Backwood Bay
Chauvet 1800 Flex	Bog Fog
Chauvet 1800 Flex	Cryo Freeze

<b>Machine</b>	<b>Fluid</b>
Chauvet 1800 Flex	Quick Blast
Chauvet 1800 Flex	Techno
Chauvet 1800 Flex	Velocity
Chauvet AmHaze II	Faze Haze
Chauvet Geysler	Quick Blast
FireBase SG-1300	Training Smoke FR
FireBase SG-1300	Training Smoke Q
FireBase SG-1300	Training Smoke XD
FireBase SG-2600	Training Smoke FR
FireBase SG-2600	Training Smoke XD
FireBase SG-M1500	Training Smoke FR
FireBase SG-M1500	Training Smoke Q
FireBase SG-M1500	Training Smoke XD
FireBase SG-M1800	Training Smoke FR
FireBase SG-M1800	Training Smoke Q
FireBase SG-M1800	Training Smoke XD
FireBase SG-M3000	Training Smoke Q
FireBase SG-M3000	Training Smoke XD
hazebase Base Classic	Amusement Park Fluid
hazebase Base Classic	Backwood Bay
hazebase Base Classic	Bog Fog
hazebase Base Classic	Cryo Freeze
hazebase Base Classic	Quick Blast
hazebase Base Classic	Velocity
hazebase Base Hazer Pro	base hazer liquid
hazebase Base Hazer Pro	Faze Haze
hazebase High Power 220V	Backwood Bay
hazebase High Power 220V	Bog Fog
LeMaitre MVS	Neutronic Haze
LeMaitre Neutron XS	Neutronic Haze
Martin K-1	K-razy Haze
Martin Magnum 2000	Backwood Bay
Martin Magnum 2000	Bog Fog
Martin Magnum 2000	Cryo Freeze
Martin Magnum 2000	Quick Blast
Martin Magnum 2000	Velocity
Martin ZR-33	Cryo Freeze
Martin ZR-33	Quick Blast
Martin ZR-33	Velocity
Martin ZR-44	Backwood Bay
Martin ZR-44	Bog Fog
Martin ZR-44	Cryo Freeze
Martin ZR-44	Quick Blast
Martin ZR-44	Velocity
Reel EFX DF-50 Diffusion Hazer	DaFiddy
Robe Fog 1550 FT	Amusement Park Fluid

<b>Machine</b>	<b>Fluid</b>
Robe Fog 1550 FT	Backwood Bay
Robe Fog 1550 FT	Bog Fog
Robe Fog 1550 FT	Cryo Freeze
Robe Fog 1550 FT	Quick Blast
Robe Fog 1550 FT	Velocity
Ultratec G3000	Amusement Park Fluid
Ultratec G3000	Backwood Bay
Ultratec G3000	Bog Fog
Ultratec G3000	Cryo Freeze
Ultratec G3000	Quick Blast
Ultratec G3000	Velocity
Ultratec Radiance Hazer	Neutronic Haze

## **Appendix B: Calibration Factors**

**Appendix B: Calibration Factors**

<b>Machine</b>	<b>Fluid</b>	<b>Calibration Factor</b>
ADJ Fog Fury 3000	Backwood Bay	0.39
ADJ Fog Fury 3000	Bog Fog	1.62
ADJ Fog Fury 3000	Cryo Freeze	0.64
ADJ Fog Fury 3000	Quick Blast	0.64
ADJ Fog Fury 3000	Velocity	0.64
ADJ Fog Storm 1700 HD	Cryo Freeze	2.67
ADJ Fog Storm 1700 HD	Quick Blast	2.67
ADJ Fog Storm 1700 HD	Velocity	2.67
Antari 1520 RGB Upshot	Quick Blast	1.28
Antari DNG-200	Cryo Freeze	4.99
Antari F-5/F-5D Fazer	Faze Haze	0.69
Antari ICE	Cryo Freeze	2.54
Antari M-10	Bog Fog	2.62
Antari M-10	Cryo Freeze	2.46
Antari M-10	Quick Blast	2.46
Antari M-10	Velocity	2.46
Antari M-5	Amusement Park Fluid	1.41
Antari M-5	Backwood Bay	1.41
Antari M-5	Bog Fog	1.03
Antari M-5	Cryo Freeze	1.74
Antari M-5	Quick Blast	1.74
Antari M-5	Velocity	1.74
Antari M-8	Amusement Park Fluid	1.35
Antari M-8	Backwood Bay	1.35
Antari M-8	Bog Fog	1.29
Antari M-8	Cryo Freeze	2.65
Antari M-8	Quick Blast	2.65
Antari M-8	Velocity	2.65
Antari X-515	Amusement Park Fluid	1.07
Antari X-515	Backwood Bay	1.07
Antari X-515	Bog Fog	1.43
Antari X-515	Cryo Freeze	1.74
Antari X-515	Quick Blast	1.74
Antari X-515	Velocity	1.74
Antari Z-350	Beam Splitter	1.90
BHE 1550	Amusement Park Fluid	1.07
BHE 1550	Backwood Bay	1.07
BHE 1550	Bog Fog	1.43
BHE 1550	Cryo Freeze	1.74
BHE 1550	Quick Blast	1.74
BHE 1550	Velocity	1.74
Chauvet 1800 Flex	Amusement Park Fluid	1.00
Chauvet 1800 Flex	Backwood Bay	1.00
Chauvet 1800 Flex	Bog Fog	1.07
Chauvet 1800 Flex	Cryo Freeze	0.76



<b>Machine</b>	<b>Fluid</b>	<b>Calibration Factor</b>
Chauvet 1800 Flex	Quick Blast	0.76
Chauvet 1800 Flex	Techno	2.94
Chauvet 1800 Flex	Velocity	0.76
Chauvet AmHaze II	Faze Haze	0.83
Chauvet Geyser	Quick Blast	1.62
FireBase SG-1300	Training Smoke FR	0.58
FireBase SG-1300	Training Smoke Q	1.69
FireBase SG-1300	Training Smoke XD	0.86
FireBase SG-2600	Training Smoke FR	0.99
FireBase SG-2600	Training Smoke XD	3.11
FireBase SG-M1500	Training Smoke FR	1.07
FireBase SG-M1500	Training Smoke Q	1.74
FireBase SG-M1500	Training Smoke XD	1.43
FireBase SG-M1800	Training Smoke FR	1.35
FireBase SG-M1800	Training Smoke Q	2.65
FireBase SG-M1800	Training Smoke XD	1.29
FireBase SG-M3000	Training Smoke Q	2.46
FireBase SG-M3000	Training Smoke XD	2.62
hazebase Base Classic	Amusement Park Fluid	0.58
hazebase Base Classic	Backwood Bay	0.58
hazebase Base Classic	Bog Fog	0.86
hazebase Base Classic	Cryo Freeze	1.69
hazebase Base Classic	Quick Blast	1.69
hazebase Base Classic	Velocity	1.69
hazebase Base Hazer Pro	base hazer liquid	0.43
hazebase Base Hazer Pro	Faze Haze	0.76
hazebase High Power 220V	Backwood Bay	0.99
hazebase High Power 220V	Bog Fog	3.11
LeMaitre MVS	Neutronic Haze	0.35
LeMaitre Neutron XS	Neutronic Haze	0.09
Martin K-1	K-razy Haze	0.49
Martin Magnum 2000	Backwood Bay	0.93
Martin Magnum 2000	Bog Fog	1.21
Martin Magnum 2000	Cryo Freeze	1.01
Martin Magnum 2000	Quick Blast	1.01
Martin Magnum 2000	Velocity	1.01
Martin ZR-33	Cryo Freeze	2.20
Martin ZR-33	Quick Blast	2.20
Martin ZR-33	Velocity	2.20
Martin ZR-44	Backwood Bay	0.77
Martin ZR-44	Bog Fog	1.40
Martin ZR-44	Cryo Freeze	0.95
Martin ZR-44	Quick Blast	0.95
Martin ZR-44	Velocity	0.95
Reel EFX DF-50 Diffusion Hazer	DaFiddy	0.40
Robe Fog 1550 FT	Amusement Park Fluid	1.07

<b>Machine</b>	<b>Fluid</b>	<b>Calibration Factor</b>
Robe Fog 1550 FT	Backwood Bay	1.07
Robe Fog 1550 FT	Bog Fog	1.43
Robe Fog 1550 FT	Cryo Freeze	1.74
Robe Fog 1550 FT	Quick Blast	1.74
Robe Fog 1550 FT	Velocity	1.74
Ultratec G3000	Amusement Park Fluid	1.07
Ultratec G3000	Backwood Bay	1.07
Ultratec G3000	Bog Fog	0.88
Ultratec G3000	Cryo Freeze	2.96
Ultratec G3000	Quick Blast	2.96
Ultratec G3000	Velocity	2.96
Ultratec Radiance Hazer	Neutronic Haze	1.06

**Appendix C:  
Calibration Factor and Time and Distance  
Testing Results for Each Equipment/Fluid  
Combination**



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## Calibration Factor and Time-and-Distance Guidelines

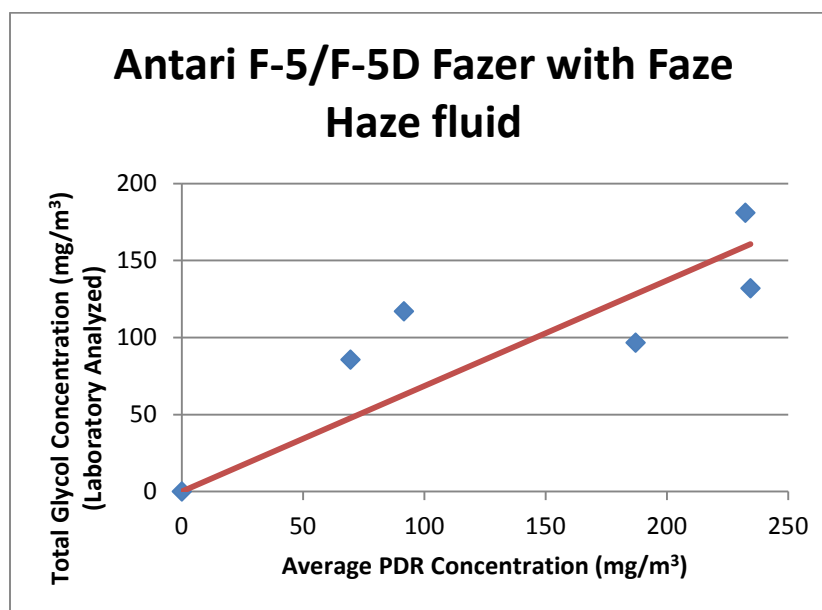
### Antari F-5/F-5D Fazer with Faze Haze Fluid

Prepared for Froggy's Fog by ENVIRON International Corporation

ENVIRON developed calibration factors and Time-and-Distance guidelines for the use of Froggy's Fog Faze Haze fluid in an Antari F-5/F-5D Fazer haze generator.

Faze Haze is a glycol-based fog fluid. Calibration factors were developed to allow a Thermo Scientific PDR-1000 aerosol monitor to be used to measure concentrations glycols in the air after being released from the F-5/F-5D Fazer.

The measured concentrations should be compared against the peak exposure guidance level for glycols, which is 40 mg/m<sup>3</sup>. The calibration curve for glycols is shown below:



**Figure 1.** Calibration curve for Antari F-5/F-5D Fazer with Faze Haze fluid, based on glycol laboratory data. Calibration factor, based on slope of curve, is 0.69 (mg/m<sup>3</sup> glycol) / (mg/m<sup>3</sup> aerosol).

Summary of Calibration Factor				
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor
Antari	F-5/F-5D Fazer	Faze Haze	Glycol	0.69

**Time and Distance Guidelines.** For various distances from the cue release point, the following table provides the average time (in seconds) after the end of the cue release after which the glycol concentrations will have fallen below the guidance levels. Thus, in order to prevent peak exposures to actors, the blocking and choreography should be arranged such that actors are not situated within a particular distance from the front of the fog release point until the amount of time listed in this table has elapsed following the end of the cue. For example, if a production is using the Antari F-5/F-5D Fazer/Faze Haze combination operating at an output setting of 65 and a fan setting of 50 with 60-second cue duration, an actor should not be situated within five to 15 feet from the front of the cue release point until at least 10 seconds following the end of the cue release.

Summary of Time-and-Distance Guidelines for Fog Generation							
Antari F-5/F-5D Fazer with Faze Haze Fluid							
Release Duration (secs)	Fan Speed	Output Setting	Time (in sec) After Which Air Concentrations Are Below Guidance Level (40 mg/m <sup>3</sup> )				
			5 ft	10 ft	15 ft	20 ft	25 ft
30	100	100	0	0	0	0	0
60	100	100	10	10	10	0	0
120	100	100	10	10	10	0	0
30	100	65	0	0	0	0	0
60	100	65	0	0	0	0	0
120	100	65	0	0	0	0	0
30	100	25	0	0	0	0	0
60	100	25	0	0	0	0	0
120	100	25	0	0	0	0	0
30	50	100	10	10	10	0	0
60	50	100	20	20	20	0	0
120	50	100	20	20	20	0	0
30	50	65	10	10	10	0	0
60	50	65	10	10	10	0	0
120	50	65	10	10	10	0	0
30	20	100	30	30	30	0	0
60	20	100	30	30	30	0	0
120	20	100	30	30	30	0	0
30	20	65	30	30	30	0	0
60	20	65	30	30	30	0	0
120	20	65	30	30	30	0	0

It should be reiterated that the Time-and-Distance Guidelines provided above are intended to allow a production to use the tested equipment and fluid combinations without conducting monitoring. However, these Guidelines may not be appropriate for all productions. Productions may want to use different configurations for positioning the machine (e.g., different heights), provide on-stage ventilation, or generate fog for a shorter or longer period of time. In addition, many productions may have other stage-specific conditions (e.g., on-stage activities and props that enhance dispersion) that would allow actors to be present in areas that are restricted under these Guidelines but which, in fact, do not exceed the guidance levels. In those cases, production-specific monitoring would be recommended to evaluate whether peak exposure may occur.





# Calibration Factor and Time-and-Distance Guidelines

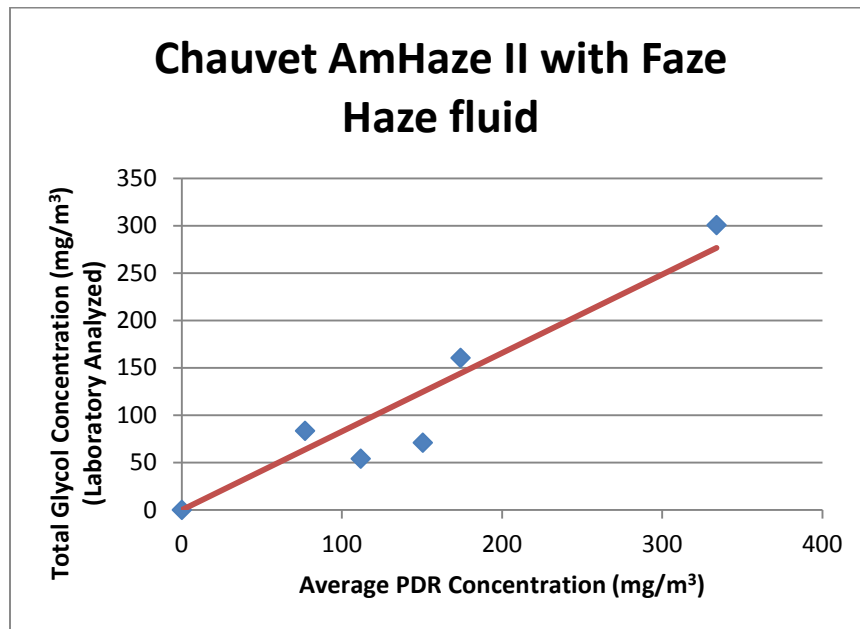
## Chauvet AmHaze II with Faze Haze Fluid

Prepared for Froggy's Fog by ENVIRON International Corporation

ENVIRON developed calibration factors and Time-and-Distance guidelines for the use of Froggy's Fog Faze Haze fluid in a Chauvet AmHaze II haze generator.

Faze Haze is a glycol-based fog fluid. Calibration factors were developed to allow a Thermo Scientific PDR-1000 aerosol monitor to be used to measure concentrations glycols in the air after being released from the AmHaze II.

The measured concentrations should be compared against the peak exposure guidance level for glycols, which is 40 mg/m<sup>3</sup>. The calibration curve for glycols is shown below:



**Figure 1.** Calibration curve for Chauvet AmHaze II with Faze Haze fluid, based on glycol laboratory data. Calibration factor, based on slope of curve, is 0.83 (mg/m<sup>3</sup> glycol) / (mg/m<sup>3</sup> aerosol).

Summary of Calibration Factor				
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor
Chauvet	AmHaze II	Faze Haze	Glycol	0.83

**Time and Distance Guidelines.** For various distances from the cue release point, the following table provides the average time (in seconds) after the end of the cue release after which the glycol concentrations will have fallen below the guidance levels. Thus, in order to prevent peak exposures to actors, the blocking and choreography should be arranged such that actors are not situated within a particular distance from the front of the fog release point until the amount of time listed in this table has elapsed following the end of the cue. For example, if a production is using the Chauvet AmHaze II/Faze Haze combination operating at an output setting of 65% and a fan setting of 100 with 60-second cue duration, an actor should not be situated within four feet from the front of the cue release point until at least 20 seconds following the end of the cue release.

Summary of Time-and-Distance Guidelines for Fog Generation						
Chauvet AmHaze II with Faze Haze fluid						
Release Duration (secs)	Fan Speed	Output Setting	Time (in sec) After Which Air Concentrations Are Below Guidance Level (40 mg/m <sup>3</sup> )			
			4 ft	8 ft	12 ft	16 ft
30	100	100%	20	0	0	0
60	100	100%	20	0	0	0
120	100	100%	20	30	0	0
30	100	65%	20	0	0	0
60	100	65%	20	0	0	0
120	100	65%	20	0	0	0
30	100	25%	0	0	0	0
60	100	25%	10	0	0	0
120	100	25%	10	0	0	0
30	50	100%	30	30	0	0
60	50	100%	40	40	0	0
120	50	100%	40	40	30	0
30	50	65%	30	30	0	0
60	50	65%	30	30	0	0
120	50	65%	30	30	0	0
30	1	100%	50	50	40	0
60	1	100%	50	50	40	0
120	1	100%	50	50	40	0
30	1	65%	50	50	40	0
60	1	65%	50	50	40	0
120	1	65%	50	50	40	0

It should be reiterated that the Time-and-Distance Guidelines provided above are intended to allow a production to use the tested equipment and fluid combinations without conducting monitoring. However, these Guidelines may not be appropriate for all productions. Productions may want to use different configurations for positioning the machine (e.g., different heights), provide on-stage ventilation, or generate fog for a shorter or longer period of time. In addition, many productions may have other stage-specific conditions (e.g., on-stage activities and props that enhance dispersion) that would allow actors to be present in areas that are restricted under these Guidelines but which, in fact, do not exceed the guidance levels. In those cases, production-specific monitoring would be recommended to evaluate whether peak exposure may occur.



## Calibration Factor and Time-and-Distance Guidelines

### hazebase Base Hazer Pro with Faze Haze Fluid

Prepared for Froggy's Fog by ENVIRON International Corporation

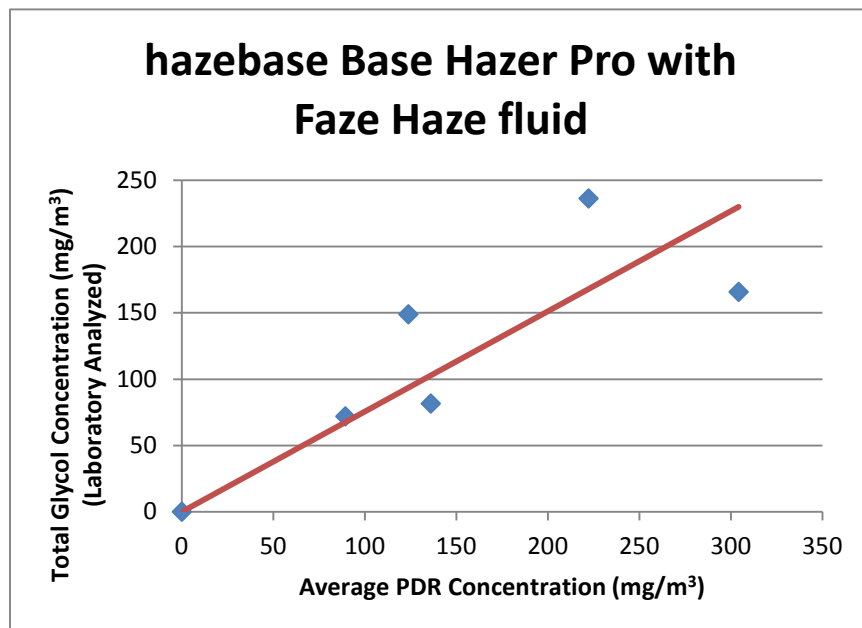
ENVIRON developed calibration factors and Time-and-Distance guidelines for the use of Froggy's Fog Faze Haze fluid in a hazebase Base Hazer Pro haze generator.

Faze Haze is a glycol-based fog fluid. Calibration factors were developed to allow a Thermo Scientific PDR-1000 aerosol monitor to be used to measure concentrations glycols in the air after being released from the Base Hazer Pro.

The measured concentrations should be compared against the peak exposure guidance level for glycols, which is 40 mg/m<sup>3</sup>.



The calibration curve for glycols is shown below:



**Figure 1.** Calibration curve for hazebase Base Hazer Pro with Faze Haze fluid, based on glycol laboratory data. Calibration factor, based on slope of curve, is 0.76 (mg/m<sup>3</sup> glycol) / (mg/m<sup>3</sup> aerosol).

<b>Summary of Calibration Factor</b>
--------------------------------------

Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor
hazebase	Base Hazer Pro	Faze Haze	Glycol	0.76

**Time and Distance Guidelines.** For various distances from the cue release point, the following table provides the average time (in seconds) after the end of the cue release after which the glycol concentrations will have fallen below the guidance levels. Thus, in order to prevent peak exposures to actors, the blocking and choreography should be arranged such that actors are not situated within a particular distance from the front of the fog release point until the amount of time listed in this table has elapsed following the end of the cue. For example, if a production is using the hazebase Base Hazer Pro/Faze Haze combination operating at an output setting of 99 and a fan setting of 99 with 60-second cue duration, an actor should not be situated within four to 16 feet from the front of the cue release point until at least 10 seconds following the end of the cue release.

Summary of Time-and-Distance Guidelines for Fog Generation hazebase Base Hazer Pro with Faze Haze Fluid							
Release Duration (secs)	Fan Speed	Output Setting	Time (in sec) After Which Air Concentrations Are Below Guidance Level (40 mg/m <sup>3</sup> )				
			4 ft	8 ft	12 ft	16 ft	20 ft
30	99	99	10	10	10	10	0
60	99	99	10	10	10	10	0
120	99	99	10	10	10	10	0
30	99	65	0	0	0	0	0
60	99	65	0	0	0	0	0
120	99	65	0	0	0	0	0
30	50	99	10	10	10	0	0
60	50	99	10	10	10	0	0
120	50	99	20	20	20	20	20
30	50	65	10	10	10	0	0
60	50	65	10	10	10	0	0
120	50	65	10	10	10	0	0
30	1	99	10	0	0	0	0
60	1	99	20	0	0	0	0
120	1	99	20	10	10	0	0
30	1	65	10	0	0	0	0
60	1	65	10	0	0	0	0
120	1	65	10	10	10	0	0

It should be reiterated that the Time-and-Distance Guidelines provided above are intended to allow a production to use the tested equipment and fluid combinations without conducting monitoring. However, these Guidelines may not be appropriate for all productions. Productions may want to use different configurations for positioning the machine (e.g., different heights), provide on-stage ventilation, or generate fog for a shorter or longer period of time. In addition, many productions may have other stage-specific conditions (e.g., on-stage activities and props that enhance dispersion) that would allow actors to be present in areas that are restricted under these Guidelines but which, in fact, do not exceed the guidance levels. In those cases, production-specific monitoring would be recommended to evaluate whether peak exposure may occur.

## **Appendix D: Safety Data Sheets**



# Phaze Haze

## Safety Data Sheet

according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 /  
Rules and Regulations

**Froggy's Fog LLC**  
302 Rutherford Lane  
Columbia, TN 38401  
United States  
Phone: (615) 469-4906  
Version: 1.0  
Revision Date: 10/20/2014

### SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY

#### 1.1. Product Identifier

**Product Name:** Phaze Haze

#### 1.2. Intended Use of the Product

**Use of the Substance/Mixture:** Theatrical Fog/Haze

#### 1.3. Name, Address, and Telephone of the Responsible Party

**Froggy's Fog LLC**  
302 Rutherford Lane  
Columbia, TN 38401  
1-615-469-4906

[www.froggysfog.com](http://www.froggysfog.com)

#### 1.4. Emergency Telephone Number

Chemtrec: (800) 424-9300

### SECTION 2: HAZARDS IDENTIFICATION

#### 2.1. Classification of the Substance or Mixture

##### Classification (GHS-US)

Not classified

#### 2.2. Label Elements

##### GHS-US Labeling

No labeling required

#### 2.3. Other Hazards

**Other Hazards Not Contributing to the Classification:** Exposure may aggravate those with pre-existing eye, skin, or respiratory conditions.

#### 2.4. Unknown Acute Toxicity (GHS-US)

No data available

### SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

#### 3.1. Substance

Not applicable

#### 3.2. Mixture

Name	Product Identifier	%	Classification (GHS-US)
Water	(CAS No) 7732-18-5	Proprietary	Not classified
Triethylene glycol	(CAS No) 112-27-6	Proprietary	Not classified
1,2-Propylene glycol	(CAS No) 57-55-6	Proprietary	Not classified

The specific chemical identity and/or exact percentage of composition has been withheld as a trade secret.

Full text of H-phrases: see section 16

### SECTION 4: FIRST AID MEASURES

#### 4.1. Description of First Aid Measures

**First-aid Measures General:** Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label where possible).

**First-aid Measures After Inhalation:** When symptoms occur: go into open air and ventilate suspected area. Obtain medical attention if breathing difficulty persists.

**First-aid Measures After Skin Contact:** Remove contaminated clothing. Drench affected area with water for at least 15 minutes. Obtain medical attention if irritation develops or persists.

**First-aid Measures After Eye Contact:** Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Obtain medical attention if pain, blinking or redness persist.

**First-aid Measures After Ingestion:** Rinse mouth. Do NOT induce vomiting. Seek medical attention.

#### 4.2. Most important symptoms and effects, both acute and delayed

**Symptoms/Injuries:** Not expected to present a significant hazard under anticipated conditions of normal use.

**Symptoms/Injuries After Inhalation:** None expected under normal conditions of use.

# Phaze Haze

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**Symptoms/Injuries After Skin Contact:** None expected under normal conditions of use.

**Symptoms/Injuries After Eye Contact:** None expected under normal conditions of use.

**Symptoms/Injuries After Ingestion:** None expected under normal conditions of use.

### 4.3. Indication of Any Immediate Medical Attention and Special Treatment Needed

If you feel unwell, seek medical advice (show the label where possible).

## SECTION 5: FIREFIGHTING MEASURES

### 5.1. Extinguishing Media

**Suitable Extinguishing Media:** Use extinguishing media appropriate for surrounding fire.

**Unsuitable Extinguishing Media:** Do not use a heavy water stream. Use of heavy stream of water may spread fire.

### 5.2. Special Hazards Arising From the Substance or Mixture

**Fire Hazard:** Not flammable.

**Explosion Hazard:** Product is not explosive.

**Reactivity:** Hazardous reactions will not occur under normal conditions.

### 5.3. Advice for Firefighters

**Precautionary Measures Fire:** Exercise caution when fighting any chemical fire.

**Firefighting Instructions:** Use water spray or fog for cooling exposed containers.

**Protection During Firefighting:** Do not enter fire area without proper protective equipment, including respiratory protection.

**Other information:** Do not allow run-off from fire fighting to enter drains or water courses.

## SECTION 6: ACCIDENTAL RELEASE MEASURES

### 6.1. Personal Precautions, Protective Equipment and Emergency Procedures

**General Measures:** Avoid prolonged contact with eyes, skin and clothing. Avoid breathing (vapors, mist, spray).

#### 6.1.1. For Non-emergency Personnel

**Protective Equipment:** Use appropriate personal protection equipment (PPE).

**Emergency Procedures:** Evacuate unnecessary personnel.

#### 6.1.2. For Emergency Responders

**Protective Equipment:** Equip cleanup crew with proper protection.

**Emergency Procedures:** Ventilate area.

### 6.2. Environmental Precautions

Prevent entry to sewers and public waters.

### 6.3. Methods and Material for Containment and Cleaning Up

**For Containment:** Contain any spills with dikes or absorbents to prevent migration and entry into sewers or streams.

**Methods for Cleaning Up:** Clear up spills immediately and dispose of waste safely. Absorb and/or contain spill with inert material, then place in suitable container.

### 6.4. Reference to Other Sections

See heading 8, Exposure Controls and Personal Protection.

## SECTION 7: HANDLING AND STORAGE

### 7.1. Precautions for Safe Handling

**Hygiene Measures:** Handle in accordance with good industrial hygiene and safety procedures. Wash hands and other exposed areas with mild soap and water before eating, drinking, or smoking and again when leaving work.

### 7.2. Conditions for Safe Storage, Including Any Incompatibilities

**Technical Measures:** Comply with applicable regulations.

**Storage Conditions:** Store in a dry, cool and well-ventilated place. Keep container closed when not in use. Keep/Store away from extremely high or low temperatures, direct sunlight, incompatible materials.

**Incompatible Products:** Strong acids. Strong bases. Strong oxidizers.

### 7.3. Specific End Use(s)

Theatrical Fog/Haze.

## SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

### 8.1. Control Parameters

No Occupational Exposure Limits (OELs) have been established for this product or its chemical components.

### 8.2. Exposure Controls

**Appropriate Engineering Controls** : Ensure adequate ventilation, especially in confined areas. Ensure all national/local regulations are observed.

# Phaze Haze

## Safety Data Sheet

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<b>Personal Protective Equipment</b>	: Not generally required. The use of personal protective equipment may be necessary as conditions warrant.
<b>Materials for Protective Clothing</b>	: Chemically resistant materials and fabrics.
<b>Hand Protection</b>	: Wear chemically resistant protective gloves.
<b>Eye Protection</b>	: Chemical goggles or safety glasses.
<b>Respiratory Protection</b>	: Use NIOSH-approved air-purifying or supplied-air respirator where airborne concentrations of vapor or mist are expected to exceed exposure limits.
<b>Other Information</b>	: When using, do not eat, drink or smoke.

## SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

### 9.1. Information on Basic Physical and Chemical Properties

<b>Physical State</b>	: Liquid
<b>Appearance</b>	: Clear.
<b>Odor</b>	: Odorless.
<b>Odor Threshold</b>	: No data available
<b>pH</b>	: Unknown
<b>Relative Evaporation Rate (butylacetate=1)</b>	: No data available
<b>Melting Point</b>	: No data available
<b>Freezing Point</b>	: -33°C (-27.4°F)
<b>Boiling Point</b>	: 101 °C (213.8°F)
<b>Flash Point</b>	: Does not flash
<b>Auto-ignition Temperature</b>	: No data available
<b>Decomposition Temperature</b>	: No data available
<b>Flammability (solid, gas)</b>	: No data available
<b>Vapor Pressure</b>	: No data available
<b>Relative Vapor Density at 20 °C</b>	: No data available
<b>Relative Density</b>	: No data available
<b>Specific Gravity</b>	: Not available
<b>Solubility</b>	: Soluble in water.
<b>Log Pow</b>	: No data available
<b>Log Kow</b>	: No data available
<b>Viscosity, Kinematic</b>	: No data available
<b>Viscosity, Dynamic</b>	: No data available
<b>Explosive Properties</b>	: No data available
<b>Oxidizing Properties</b>	: No data available
<b>Explosive Limits</b>	: Not applicable

9.2. **Other Information** No additional information available

## SECTION 10: STABILITY AND REACTIVITY

- 10.1 **Reactivity:** Hazardous reactions will not occur under normal conditions.
- 10.2 **Chemical Stability:** Stable under normal conditions.
- 10.3 **Possibility of Hazardous Reactions:** Hazardous polymerization will not occur.
- 10.4 **Conditions to Avoid:** Direct sunlight. Extremely high or low temperatures. Incompatible materials.
- 10.5 **Incompatible Materials:** Strong acids. Strong bases. Strong oxidizers.
- 10.6 **Hazardous Decomposition Products:** Carbon oxides (CO, CO<sub>2</sub>).

## SECTION 11: TOXICOLOGICAL INFORMATION

### 11.1. Information On Toxicological Effects

**Acute Toxicity** : Not classified

<b>Water (7732-18-5)</b>	
<b>LC50 Inhalation Rat (ppm)</b>	100000 ppm



# Phaze Haze

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<b>1,2-Propylene glycol (57-55-6)</b>	
LD50 Oral Rat	20000 mg/kg
LD50 Dermal Rabbit	20800 mg/kg
<b>Triethylene glycol (112-27-6)</b>	
LD50 Oral Rat	15000 mg/kg
LD50 Dermal Rabbit	> 20 ml/kg

**Skin Corrosion/Irritation:** Not classified

pH: unknown

**Serious Eye Damage/Irritation:** Not classified

pH: unknown

**Respiratory or Skin Sensitization:** Not classified

**Germ Cell Mutagenicity:** Not classified

**Carcinogenicity:** Not classified

**Reproductive Toxicity:** Not classified

**Specific Target Organ Toxicity (Single Exposure):** Not classified

**Specific Target Organ Toxicity (Repeated Exposure):** Not classified

**Aspiration Hazard:** Not classified

**Symptoms/Injuries After Inhalation:** None expected under normal conditions of use.

**Symptoms/Injuries After Skin Contact:** None expected under normal conditions of use.

**Symptoms/Injuries After Eye Contact:** None expected under normal conditions of use.

**Symptoms/Injuries After Ingestion:** None expected under normal conditions of use.

## SECTION 12: ECOLOGICAL INFORMATION

### 12.1. Toxicity

<b>1,2-Propylene glycol (57-55-6)</b>	
LC50 Fish 1	51600 mg/l (Exposure time: 96 h - Species: Oncorhynchus mykiss [static])
EC50 Daphnia 1	10000 mg/l (Exposure time: 24 h - Species: Daphnia magna)
EC50 Other Aquatic Organisms 1	19000 mg/l (Exposure time: 96 h - Species: Pseudokirchneriella subcapitata)
LC 50 Fish 2	41 (41 - 47) mg/l (Exposure time: 96 h - Species: Oncorhynchus mykiss [static])
EC50 Daphnia 2	1000 mg/l (Exposure time: 48 h - Species: Daphnia magna [Static])
<b>Triethylene glycol (112-27-6)</b>	
LC50 Fish 1	56200 - 63700 mg/l (Exposure time: 96 h - Species: Pimephales promelas [flow-through])
EC50 Daphnia 1	42426 mg/l (Exposure time: 48 h - Species: Daphnia magna)
LC 50 Fish 2	10000 mg/l (Exposure time: 96 h - Species: Lepomis macrochirus [static])

### 12.2. Persistence and Degradability

<b>Phaze Haze</b>	
Persistence and Degradability	Not established.

### 12.3. Bioaccumulative Potential

<b>Phaze Haze</b>	
Bioaccumulative Potential	Not established.

<b>1,2-Propylene glycol (57-55-6)</b>	
BCF fish 1	< 1

<b>Triethylene glycol (112-27-6)</b>	
Log Pow	-1.98 (at 25 °C)

**12.4. Mobility in Soil** No additional information available

### 12.5. Other Adverse Effects

**Other Information** : Avoid release to the environment.

## SECTION 13: DISPOSAL CONSIDERATIONS

### 13.1. Waste treatment methods

**Waste Disposal Recommendations:** Dispose of waste material in accordance with all local, regional, national, and international regulations.

# Phaze Haze

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### SECTION 14: TRANSPORT INFORMATION

In Accordance With ICAO/IATA/IMDG/DOT

**14.1. UN Number** Not regulated for transport

**14.2. UN Proper Shipping Name** Not regulated for transport

**14.3. Additional Information**

**Other information** : No supplementary information available.

**Transport by Sea** Not regulated for transport

**Air Transport** Not regulated for transport

### SECTION 15: REGULATORY INFORMATION

#### 15.1 US Federal Regulations

##### Water (7732-18-5)

Listed on the United States TSCA (Toxic Substances Control Act) inventory

##### 1,2-Propylene glycol (57-55-6)

Listed on the United States TSCA (Toxic Substances Control Act) inventory

##### EPA TSCA Regulatory Flag

Y2 - Y2 - indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

##### Triethylene glycol (112-27-6)

Listed on the United States TSCA (Toxic Substances Control Act) inventory

#### 15.2 US State Regulations

##### 1,2-Propylene glycol (57-55-6)

U.S. - Minnesota - Hazardous Substance List  
U.S. - New Jersey - Right to Know Hazardous Substance List  
U.S. - Pennsylvania - RTK (Right to Know) List  
U.S. - Texas - Effects Screening Levels - Long Term  
U.S. - Texas - Effects Screening Levels - Short Term

##### Triethylene glycol (112-27-6)

U.S. - Pennsylvania - RTK (Right to Know) List  
U.S. - Texas - Effects Screening Levels - Long Term  
U.S. - Texas - Effects Screening Levels - Short Term

### SECTION 16: OTHER INFORMATION

**Revision date** : 10/20/2014

**Other Information** : This document has been prepared in accordance with the SDS requirements of the OSHA Hazard Communication Standard 29 CFR 1910.1200.

*This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product*

SDS US (GHS HazCom) - US