DEVELOPMENT OF CALIBRATION FACTORS FOR MONITORING THEATRICAL SMOKE AND HAZE

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F I G U R E S

T A B L E S

EXECUTIVE SUMMARY

ENVIRON has developed a series of calibration factors that can be used in conjunction with a portable, real-time aerosol monitor to measure levels of theatrical smoke and haze. Calibrated aerosol monitors can be used to determine whether actors are potentially exposed to concentrations above the Peak Guidance levels recommended in the report *Health Effects Evaluation of Theatrical Smoke, Haze, and Pyrotechnics* (Mt. Sinai and ENVIRON 2000).

TABLE ES-1
Summary of Calibration Factors

Manufacturer	Machine	Fluid	Fluid type	Calibration factor	Ref
CITC	Fog Max	Natural Fogging Fluid	glycol	0.663	(4)
	Haze Max	Water Vapor Haze Fluid	glycerol	0.108	(4)
	Starhazer	High Performance Fluid	oil	0.867	(4)
High End Systems	F-100	Atmosphere HQ Fluid	glycol	1.38	(1)
	F-100	Atmosphere Stage Formula	glycol	0.253	(1)
	F-100	Atmosphere Cold Flow Formula	glycol	2.41	(1)
Le Maitre Special Effects	G100	Extra Quick Dissipating	glycol	3.17	(1)
	G100	Quick Dissipating	glycol	3.45	(1)
	G100	Regular Fog Fluid	glycol	4.17	(1)
	G150	Extra Quick Dissipating	glycol	3.17	(1)
	G150	Molecular Fog Fluid	glycol	2.58	(1)
	G150	Pro Beam (Long Lasting)	glycol	1.42	(4)
	G150	Quick Dissipating	glycol	3.45	(1)
	G150	Regular Fog Fluid	glycol	4.17	(1)
	G300	Molecular Fog Fluid	glycol	0.533	(4)
	G300	Pro Beam (Long Lasting)	glycol	0.667	(4)
	G300	Quick Dissipating	glycol	2.65	(4)
	G300	Regular Fog Fluid	glycol	0.304	(4)
	Neutron XS	Neutron Haze Fluid	glycerol	0.12	(2)
	Opti Mist Ranger	Mini Mist Canister	glycol	3.01	(1)
	Show Fogger Pro	Pro Beam (Long Lasting)	glycol	0.436	(4)
	Show Fogger Pro	Quick Dissipating	glycol	2.56	(4)
	Show Fogger Pro	Regular Fog Fluid	glycol	0.444	(4)
	Stage Fogger Pro	Molecular Fog Fluid	glycol	2.77	(4)
	Stage Fogger Pro	Pro Beam (Long Lasting)	glycol	1.36	(4)
	Stage Fogger Pro	Quick Dissipating	glycol	1.37	(4)
	Stage Fogger Pro	Regular Fog Fluid	glycol	0.995	(4)
Look Solutions / Theatre Effects	Tiny Fogger	Tiny Fogger Fluid	glycol	0.761	(4)
	Unique Hazer	Unique Fluid	glycol	0.299	(4)
	Viper II (NT)	Viper Fluid	glycol	1.46	(4)

TABLE ES-1
Summary of Calibration Factors

Manufacturer	Machine	Fluid	Fluid type	Calibration factor	Ref
Martin Professional	Jem Glaciator	Jem B2 Heavy Fog Fluid	glycol	3.41	(4)
	Jem ZR12-DMX	Jem Pro-Smoke Super Fluid	glycol	1.12	(4)
MDG Fog Generators	Mini-Max	MDG Dense Fluid	glycol	3.21	(1)
	MAX 300 Atmosphere	MDG Neutral Fluid	oil	0.784	(1)
Reel EFX, Inc.	DF-50	Diffusion Fluid	oil	0.784	(1)
Rosco Laboratories	1600	Rosco Clear Fog Fluid	glycol	1.82	(1)
	1600	Rosco Fog Fluid	glycol	1.27	(1)
	1600	Rosco Light Fog Fluid	glycol	1.375	(1)
	1600	Rosco Stage & Studio Fluid	glycol	1.56	(1)
	Alpha 900	Rosco Clear Fog Fluid	glycol	1.82	(1)
	Alpha 900	Rosco Fog Fluid	glycol	1.27	(1)
	Alpha 900	Rosco Light Fog Fluid	glycol	1.375	(1)
	Alpha 900	Rosco Stage & Studio Fluid	glycol	1.56	(1)
	Delta 3000	Rosco Clear Fog Fluid	glycol	1.43	(4)
	Delta 3000	Rosco Fog Fluid	glycol	1.00	(4)
	Delta 3000	Rosco Light Fog Fluid	glycol	1.35	(4)
	Delta 3000	Rosco Stage & Studio Fluid	glycol	1.97	(4)
	PF-1000	Rosco Clear Fog Fluid	glycol	1.82	(1)
	PF-1000	Rosco Fog Fluid	glycol	1.27	(1)
	PF-1000	Rosco Light Fog Fluid	glycol	1.375	(1)
	PF-1000	Rosco Stage & Studio Fluid	glycol	1.56	(1)
SFX	Fog Master FM-1	Aquafog Fluid	glycol	0.19	(3)
Smoke Factory	Tour Hazer	Tour Hazer Fog Fluid	glycol	0.299	(4)

References:
(1) *Equipment-Based Guidelines for the Use of Theatrical Smoke and Haze* (ENVIRON 2001a)
(2) *Theatrical Haze and Fog Testing for Mamma Mia!, Winter Garden Theatre* (ENVIRON 2001b)
(3) *Theatrical Smoke and Haze Testing for The Phantom of the Opera, Majestic Theatre* (ENVIRON 2002)
(4) This study

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

$$CONC = C \times PDR$$

where:

$CONC$ = air concentration of total glycols, mineral oil, or glycerin mist, mg/m^3
C = aerosol monitor calibration factor (from Table ES-1), $(mg/m^3)/(mg/m^3 \text{ aerosol})$
PDR = aerosol monitor reading, mg/m^3

These calculated concentrations can then be compared with the Peak Guidance levels:

- Glycols – 40 mg/m^3
- Mineral oil – 25 mg/m^3
- Glycerol – 50 mg/m^3

I. 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 determine whether the use of smoke, 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 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^3).
- Mineral oil should be used in a manner such that an actor's exposure does not exceed a peak concentration of 25 mg/m^3.
- For chronic exposures to mineral oil, the existing standards established for oil mists (5 mg/m^3 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 2001c):

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

In 2001, ENVIRON developed calibration factors for certain smoke and haze generating equipment and fluids (ENVIRON 2001b). These calibration factors, used in conjunction with real-time aerosol monitors, can be used to evaluate whether potential exposures to actors exceed the peak guidance levels. Following the release of ENVIRON's report, additional equipment manufacturers expressed interest in having calibration factors developed for their equipment, to support monitoring in productions using their equipment and fluids. This additional study was organized by the Entertainment Services and Technology Association (ESTA).

II. METHODS AND MATERIALS

A. Selection of Smoke and Haze-Generating Equipment and Fluids

The following types of chemicals used to produce theatrical effects were included in this study:

- Glycols – The glycol solutions evaluated in this study consist of mixtures of 1,3-butylene glycol (BG), diethylene glycol (DEG), propylene glycol (PG), dipropylene glycol (DPG), triethylene glycol (TEG), and water.
- Mineral oil
- Glycerol

The following smoke and haze-generating equipment manufacturers provided ENVIRON with the use of their machines and fluids for testing:

- CITC Special Effects, Lynnwood, Washington
- Le Maitre Special Effects, Port Huron, Michigan
- Look Solutions/Theatre Effects, Hagerstown, Maryland
- Martin Professional, Sunrise, Florida
- Rosco Laboratories, Stamford, Connecticut
- Smoke Factory, Wedemark, Germany

All of the equipment and fluids were shipped to Interesting Products in Chicago, Illinois, where the testing was conducted.

Table 1 summarizes the equipment and fluids included in this study. Calibration factors for additional machines could be developed at a later date, if requested.

TABLE 1 Summary of Smoke/Haze Machines and Fluids Tested			
Manufacturer	**Machine**	**Fluid**	**Type of Fluid**
CITC	FogMax	Natural Fogging Fluid	Glycol
	HazeMax	Water Vapor Haze	Glycerol
	StarHazer	High Performance Fluid	Oil
Le Maitre Special Effects	G150	Pro Beam (Long Lasting)	Glycol
	G300 Stage Fogger Pro	Regular Fog Fluid Quick Dissipating Pro Beam (Long Lasting) Molecular Fog Fluid	Glycol
	Show Fogger Pro	Regular Fog Fluid Quick Dissipating Pro Beam (Long Lasting)	Glycol
Look Solutions / Theatre Effects	Tiny Fogger	Tiny Fogger Fluid	Glycol
	Unique Hazer	Unique Fluid	Glycol
	Viper	Viper Fog Fluid	Glycol
Martin Professional	Jem Glaciator	Jem B2 Heavy Fog	Glycol
	Jem ZR12-DMX	Jem Pro-Smoke Super	Glycol
Rosco Laboratories	Delta 3000	Rosco Clear Fog Fluid Rosco Fog Fluid Rosco Light Fog Fluid Rosco Stage & Studio Fluid	Glycol
Smoke Factory	Tour-Hazer	Tour Hazer Fog	Glycol

B. Sampling Equipment and Materials

Monitoring of short-term concentrations was performed using portable real-time aerosol monitors (*personal*DataRAM Model PDR-1000) manufactured by Monitoring Instruments for the Environment, Inc. (MIE). The PDR-1000 is a high sensitivity nephelometric (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^3. In order to be utilized to measure short-term glycol or oil mist 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 GilAir-5 and SKC Aircheck Model 224-44XR sampling pumps were used to draw air through collection media. The type of collection media used depended on the analyte:

- For 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).

- For mineral oil, air was drawn through 37-mm polyvinyl chloride (PVC) membrane filters (5 µm pore size), which were analyzed by infrared spectrophotometry (IR) in conjunction with a custom bulk oil sample. This sampling is based on a custom NIOSH Method 5026 (NIOSH 1994b).

- For glycerol, air was drawn through preweighed 37-mm polyvinyl chloride (PVC) membrane filters (5 µm pore size), which were analyzed gravimetrically in accordance with NIOSH Method 0500 (NIOSH 1994a).

This calibration sampling was conducted in conjunction with operating the PDR-1000 aerosol monitors.

C. Aerosol Monitor Calibration Procedures

Four to six tripod assemblies were used for calibrating the aerosol monitors, each consisting of a sampling pump, flexible tubing, sampling media (OVS trap for glycols and cassettes for mineral oil and glycerol), and an aerosol monitor (see Figure 1). The height of each tripod was approximately five feet, corresponding with the breathing zone of a typical actor. The room ventilation fans were turned off during each run; no major movement occurred in the testing room during each run that would affect smoke dispersion.

a) The sampling pumps were calibrated to 2 liters per minute (LPM) using a BIOS DryCal pump calibrator. The aerosol monitors were zeroed, the data logging function of the aerosol monitor was turned on, and the data logging times for all of the aerosol monitors were synchronized.

b) The smoke machines were positioned on a bench to allow a release of smoke at a height of four to five feet. Hazers were placed 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 smoke or haze machines, allowing sustained smoke or haze generation to occur. After a period of approximately one minute, the machines and pumps were simultaneously turned off. Hazers were operated for longer periods of time, ranging from five to ten minutes.

d) For glycol fluids, the OVS traps were capped and labeled to identify the type of smoke machine, glycol fluid, sampling location, and other sampling specifics. After being capped and labeled, the OVS traps were placed in a cooler with ice packs. For mineral oil or glycerol fluids, the cassettes were capped and appropriately labeled.

e) Various fans 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.

D. Laboratory Analyses

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

1. Glycols

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 4.0 micrograms (μg) of each individual glycol per sample.

2. Mineral Oil

Mineral oil samples were analyzed using a custom NIOSH Method 5026, which involves analysis using infrared spectrophotometry, with a bulk mineral oil sample used instead of a stock mineral oil standard. A maximum LOQ of 50 μg per sample was used.

3. Glycerol

Glycerin mist samples were analyzed gravimetrically using NIOSH Method 0500. A maximum LOQ of 10 μg per sample was used.

Figure 1. Experimental set-up for aerosol monitor calibration, consisting of a tripod with sampling pump, OVS tube for sampling glycols, and aerosol monitor.

(a) CITC FogMax

(b) CITC Haze-Max

(c) CITC StarHazer

(d) Jem Glaciator

(e) Jem ZR12-DMX

(f) Le Maitre G150

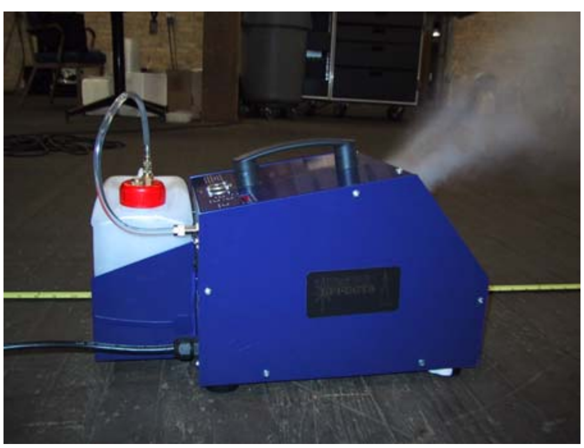
Figure 2. Smoke and haze generating equipment tested

(g) Le Maitre G300

(h) Le Maitre Show Fogger Pro

(i) Le Maitre Stage Fogger

(j) Look Solutions/Theatre Effects Tiny Fogger

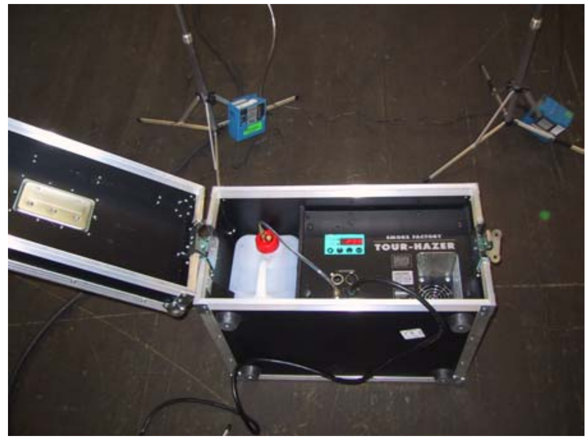


(k) Look Solutions/Theatre Effects Unique Hazer

(l) Look Solutions/Theatre Effects Viper II (NT)

Figure 2 (cont.). Smoke and haze generating equipment tested

(m) Rosco Delta 3000



(n) Smoke Factory Tour-Hazer

Figure 2 (cont.). Smoke and haze generating equipment tested

III. RESULTS AND DISCUSSION

A. Aerosol Monitor Calibration

Total glycol concentrations were calculated from the analytical data. 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 glycol fluid, the average aerosol monitor readings during the period of time in which air was drawn through the OVS trap for each air sample were calculated and plotted against the total glycol concentration data.

To develop a calibration factor for each mineral oil and glycerol fluid, the average aerosol monitor readings during the period of time in which air was drawn through the sampling cassette for each air sample were calculated and plotted against the oil mist or glycerin mist concentration data.

The calibration curves for all of the equipment-fluid combinations tested are shown in Figures 3 to 27. First order regression curves are also shown on these figures. The calibration factors, calculated from the slopes of these regressions, are summarized in Table 2.

TABLE 2
Summary of Calibration Factors

Manufacturer	Machine	Fluid	Fluid type	Calibration factor	Ref
CITC	Fog Max	Natural Fogging Fluid	glycol	0.663	(4)
	Haze Max	Water Vapor Haze Fluid	glycerol	0.108	(4)
	Starhazer	High Performance Fluid	oil	0.867	(4)
High End Systems	F-100	Atmosphere HQ Fluid	glycol	1.38	(1)
	F-100	Atmosphere Stage Formula	glycol	0.253	(1)
	F-100	Atmosphere Cold Flow Formula	glycol	2.41	(1)
Le Maitre Special Effects	G100	Extra Quick Dissipating	glycol	3.17	(1)
	G100	Quick Dissipating	glycol	3.45	(1)
	G100	Regular Fog Fluid	glycol	4.17	(1)
	G150	Extra Quick Dissipating	glycol	3.17	(1)
	G150	Molecular Fog Fluid	glycol	2.58	(1)
	G150	Pro Beam (Long Lasting)	glycol	1.42	(4)
	G150	Quick Dissipating	glycol	3.45	(1)
	G150	Regular Fog Fluid	glycol	4.17	(1)
	G300	Molecular Fog Fluid	glycol	0.533	(4)
	G300	Pro Beam (Long Lasting)	glycol	0.667	(4)
	G300	Quick Dissipating	glycol	2.65	(4)
	G300	Regular Fog Fluid	glycol	0.304	(4)
	Neutron XS	Neutron Haze Fluid	glycerol	0.12	(2)
	Opti Mist Ranger	Mini Mist Canister	glycol	3.01	(1)

TABLE 2 Summary of Calibration Factors					
Manufacturer	**Machine**	**Fluid**	**Fluid type**	**Calibration factor**	**Ref**
Le Maitre Special Effects (cont.)	Show Fogger Pro	Pro Beam (Long Lasting)	glycol	0.436	(4)
	Show Fogger Pro	Quick Dissipating	glycol	2.56	(4)
	Show Fogger Pro	Regular Fog Fluid	glycol	0.444	(4)
	Stage Fogger Pro	Molecular Fog Fluid	glycol	2.77	(4)
	Stage Fogger Pro	Pro Beam (Long Lasting)	glycol	1.36	(4)
	Stage Fogger Pro	Quick Dissipating	glycol	1.37	(4)
	Stage Fogger Pro	Regular Fog Fluid	glycol	0.995	(4)
Look Solutions / Theatre Effects	Tiny Fogger	Tiny Fogger Fluid	glycol	0.761	(4)
	Unique Hazer	Unique Fluid	glycol	0.299	(4)
	Viper II (NT)	Viper Fluid	glycol	1.46	(4)
Martin Professional	Jem Glaciator	Jem B2 Heavy Fog Fluid	glycol	3.41	(4)
	Jem ZR12-DMX	Jem Pro-Smoke Super Fluid	glycol	1.12	(4)
MDG Fog Generators	Mini-Max	MDG Dense Fluid	glycol	3.21	(1)
	MAX 300 Atmosphere	MDG Neutral Fluid	oil	0.784	(1)
Reel EFX, Inc.	DF-50	Diffusion Fluid	oil	0.784	(1)
Rosco Laboratories	1600	Rosco Clear Fog Fluid	glycol	1.82	(1)
	1600	Rosco Fog Fluid	glycol	1.27	(1)
	1600	Rosco Light Fog Fluid	glycol	1.375	(1)
	1600	Rosco Stage & Studio Fluid	glycol	1.56	(1)
	Alpha 900	Rosco Clear Fog Fluid	glycol	1.82	(1)
	Alpha 900	Rosco Fog Fluid	glycol	1.27	(1)
	Alpha 900	Rosco Light Fog Fluid	glycol	1.375	(1)
	Alpha 900	Rosco Stage & Studio Fluid	glycol	1.56	(1)
	Delta 3000	Rosco Clear Fog Fluid	glycol	1.43	(4)
	Delta 3000	Rosco Fog Fluid	glycol	1.00	(4)
	Delta 3000	Rosco Light Fog Fluid	glycol	1.35	(4)
	Delta 3000	Rosco Stage & Studio Fluid	glycol	1.97	(4)
	PF-1000	Rosco Clear Fog Fluid	glycol	1.82	(1)
	PF-1000	Rosco Fog Fluid	glycol	1.27	(1)
	PF-1000	Rosco Light Fog Fluid	glycol	1.375	(1)
	PF-1000	Rosco Stage & Studio Fluid	glycol	1.56	(1)
SFX	Fog Master FM-1	Aquafog Fluid	glycol	0.19	(3)
Smoke Factory	Tour Hazer	Tour Hazer Fog Fluid	glycol	0.299	(4)

References:
(1) *Equipment-Based Guidelines for the Use of Theatrical Smoke and Haze* (ENVIRON 2001b)
(2) *Theatrical Haze and Fog Testing for Mamma Mia!, Winter Garden Theatre* (ENVIRON 2001c)
(3) *Theatrical Smoke and Haze Testing for The Phantom of the Opera, Majestic Theatre* (ENVIRON 2002)
(4) This study

B. Use of Calibration Factors

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

$$CONC = C \times PDR$$

where:

CONC = air concentration of total glycols, mineral oil, or glycerin mist, mg/m^3
C = aerosol monitor calibration factor (from Table 2), $(mg/m^3)/(mg/m^3$ aerosol)
PDR = aerosol monitor reading, mg/m^3

These calculated concentrations can then be compared with the peak guidance levels.

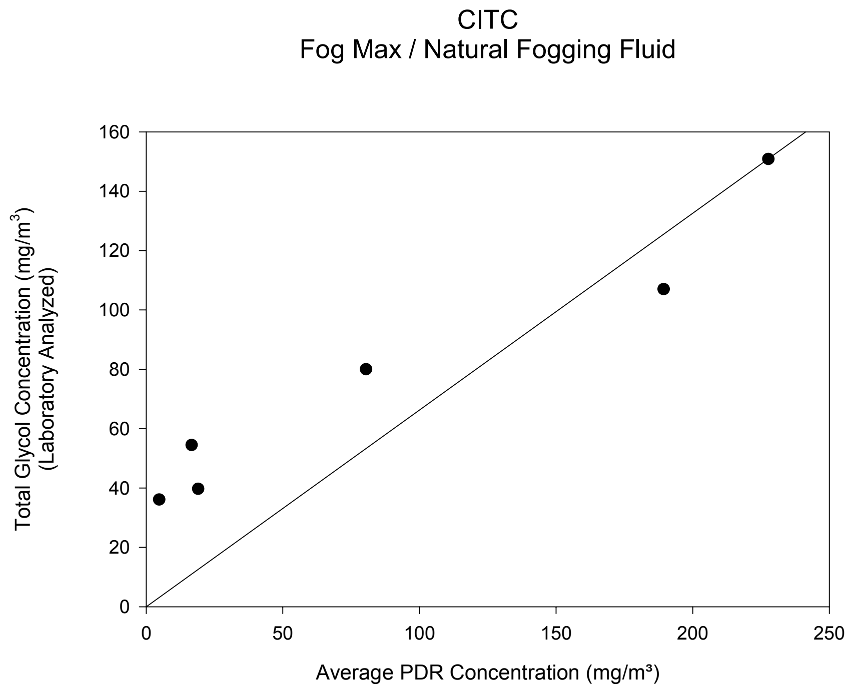


Figure 3. Calibration curve for Natural Fogging Fluid in CITC Fog Max. Calibration factor, based on slope of curve, is 0.663 (mg/m^3 glycols)/(mg/m^3 aerosol).

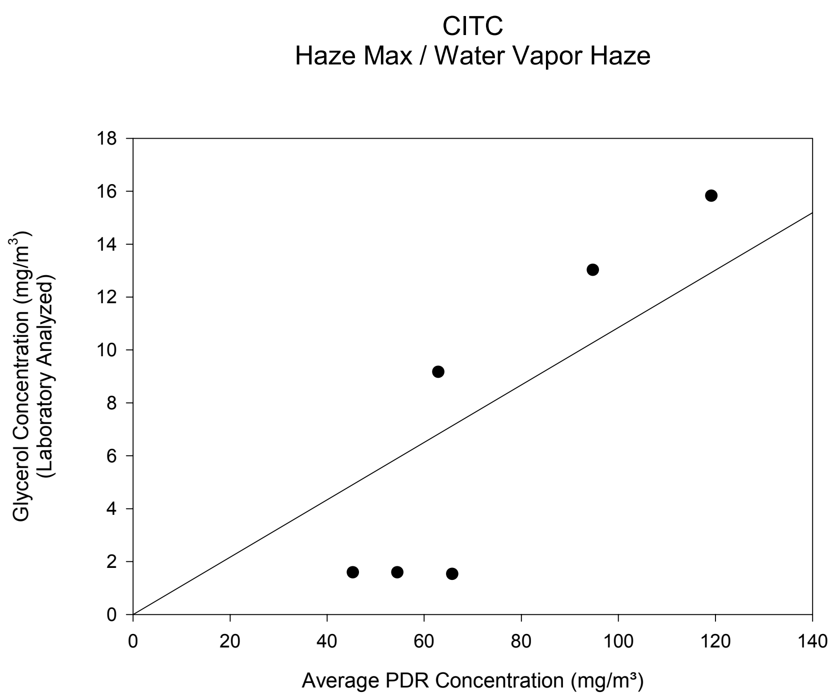


Figure 4. Calibration curve for Water Vapor Haze Fluid in CITC Haze Max. Calibration factor, based on slope of curve, is 0.108 (mg/m^3 glycerol)/(mg/m^3 aerosol).

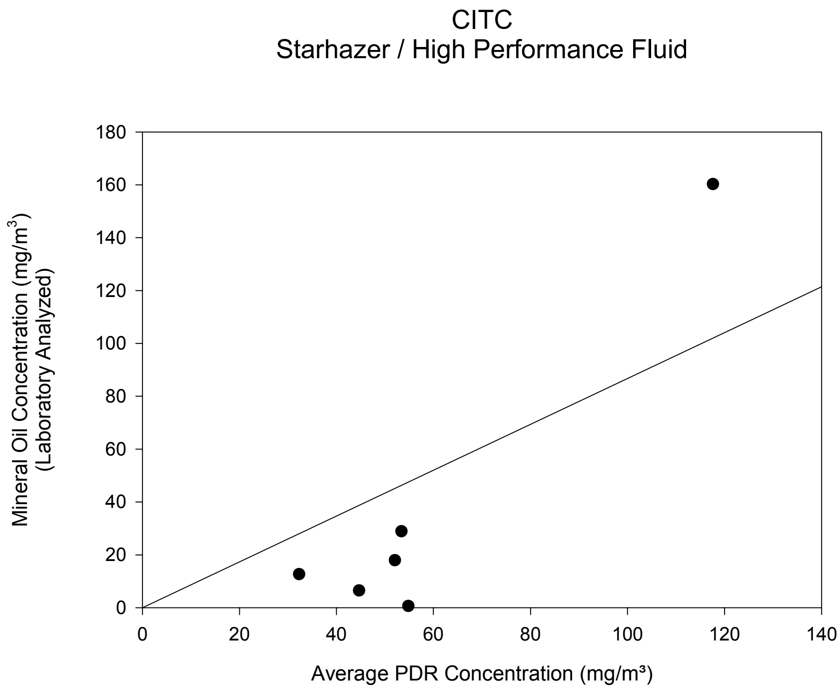


Figure 5. Calibration curve for High Performance Fluid in CITC Starhazer. Calibration factor, based on slope of curve, is 0.867 (mg/m^3 mineral oil)/(mg/m^3 aerosol).

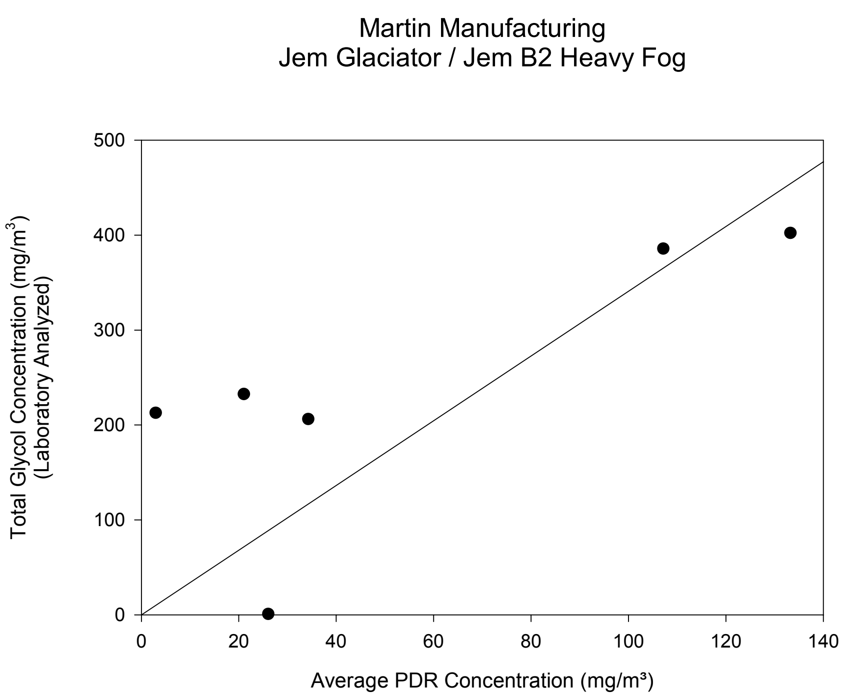


Figure 6. Calibration curve for Jem B2 Heavy Fog Fluid in Martin Professional Glaciator. Calibration factor, based on slope of curve, is 3.41 (mg/m^3 glycols)/(mg/m^3 aerosol).

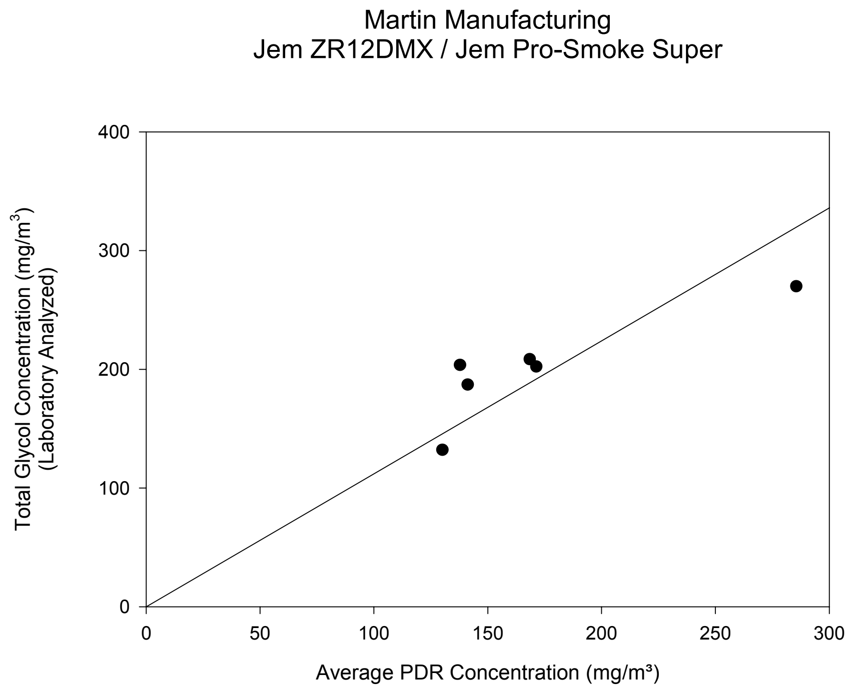


Figure 7. Calibration curve for Jem Pro-Smoke Super Fluid in Martin Professional ZR12-DMX. Calibration factor, based on slope of curve, is 1.12 (mg/m^3 glycols)/(mg/m^3 aerosol).

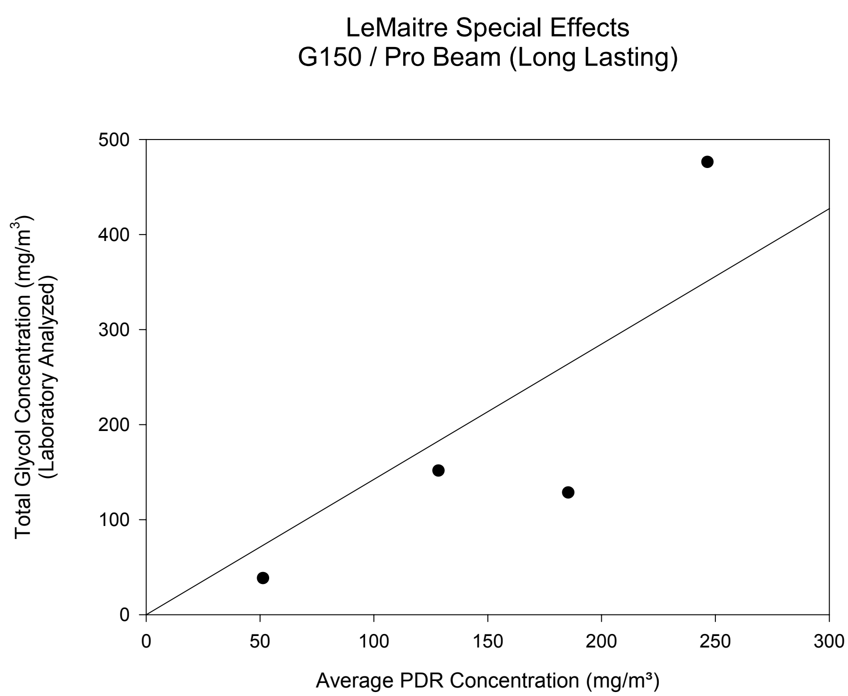


Figure 8. Calibration curve for Le Maitre Pro Beam (Long Lasting) Fluid in G150. Calibration factor, based on slope of curve, is 1.42 (mg/m^3 glycols)/(mg/m^3 aerosol).

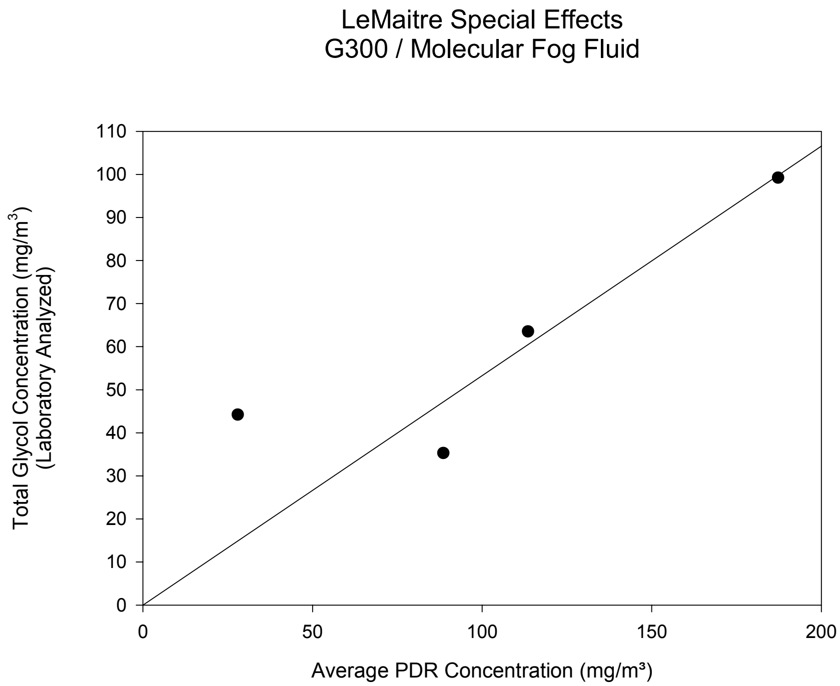


Figure 9. Calibration curve for Le Maitre Molecular Fog Fluid in G300. Calibration factor, based on slope of curve, is 0.533 (mg/m^3 glycols)/(mg/m^3 aerosol).

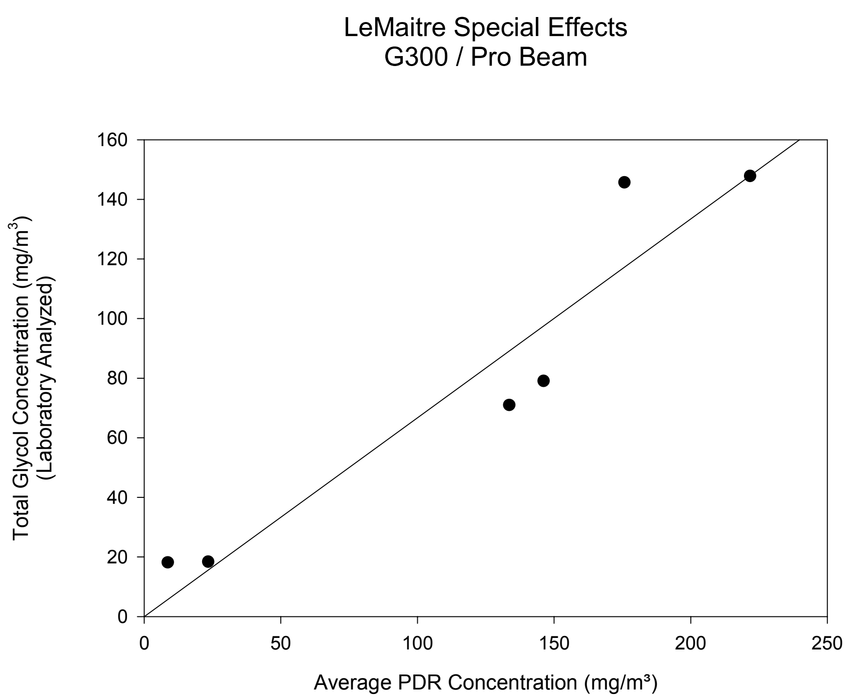


Figure 10. Calibration curve for Le Maitre Pro Beam (Long Lasting) Fluid in G300. Calibration factor, based on slope of curve, is 0.667 (mg/m^3 glycols)/(mg/m^3 aerosol).

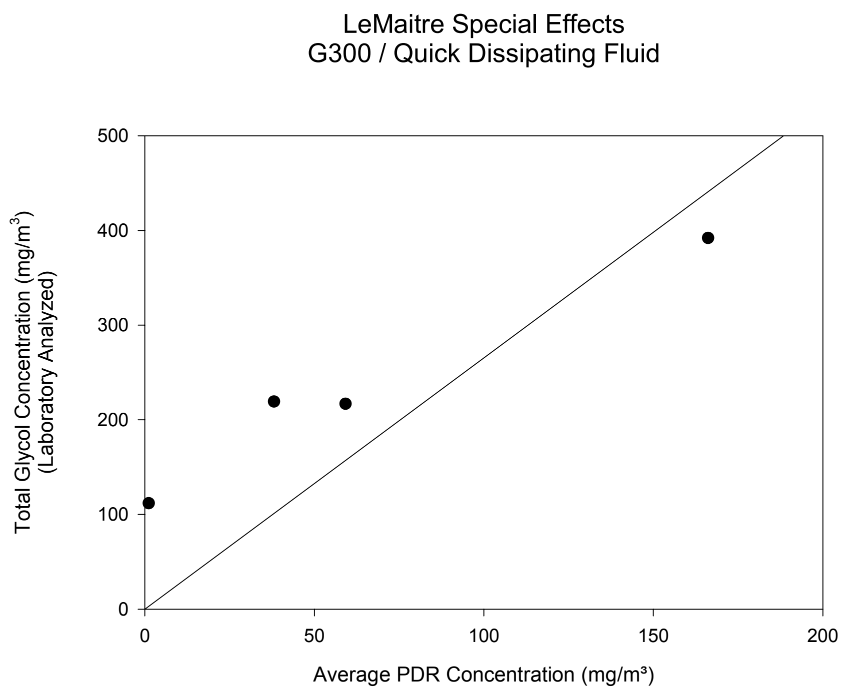


Figure 11. Calibration curve for Le Maitre Quick Dissipating Fluid in G300. Calibration factor, based on slope of curve, is 2.65 (mg/m^3 glycols)/(mg/m^3 aerosol).

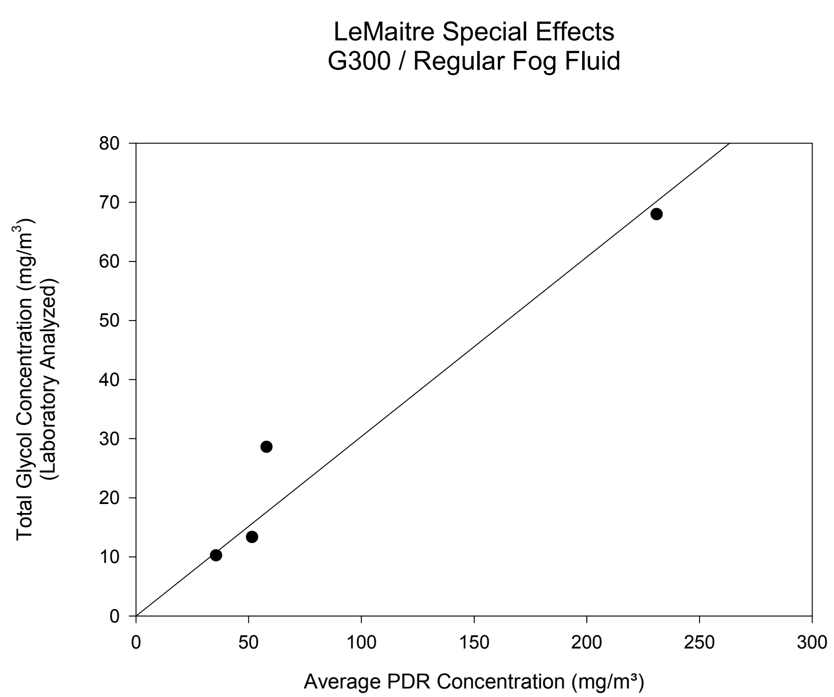


Figure 12. Calibration curve for Le Maitre Regular Fog Fluid in G300. Calibration factor, based on slope of curve, is 0.304 (mg/m^3 glycols)/(mg/m^3 aerosol).

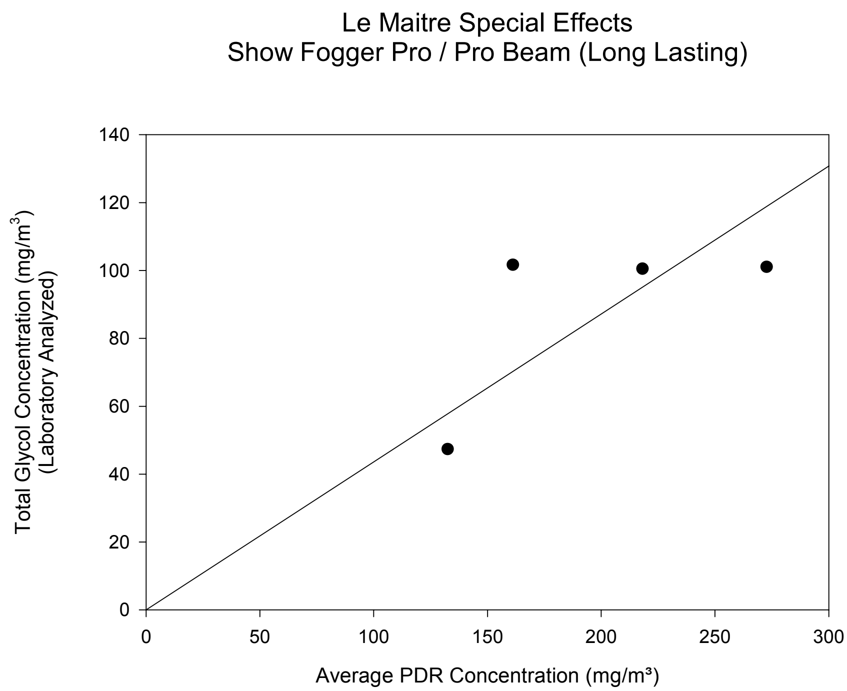


Figure 13. Calibration curve for Le Maitre Pro Beam (Long Lasting) Fluid in Show Fogger Pro. Calibration factor, based on slope of curve, is 0.436 (mg/m^3 glycols)/(mg/m^3 aerosol).

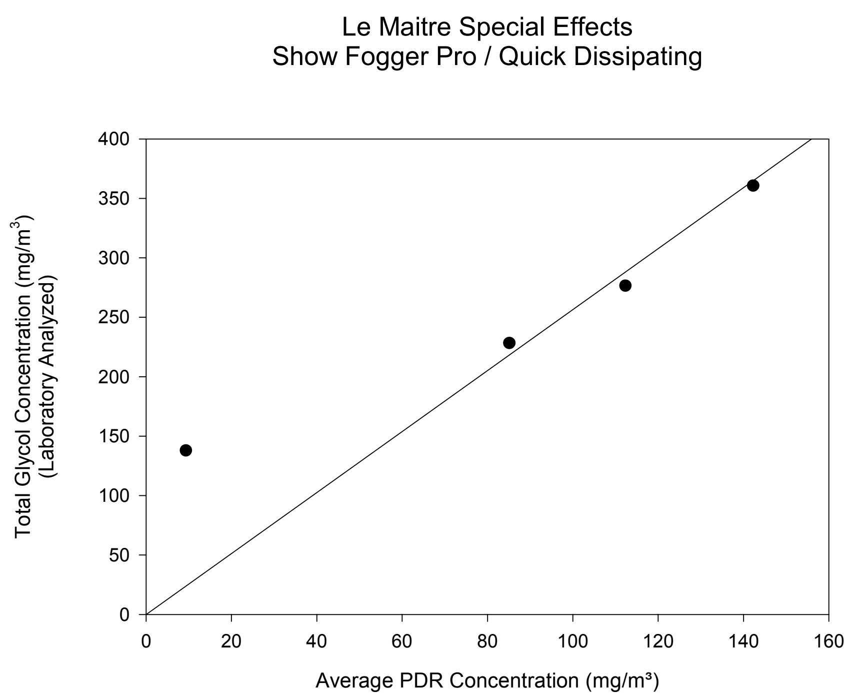


Figure 14. Calibration curve for Le Maitre Quick Dissipating Fog Fluid in Show Fogger Pro. Calibration factor, based on slope of curve, is 2.56 (mg/m^3 glycols)/(mg/m^3 aerosol).

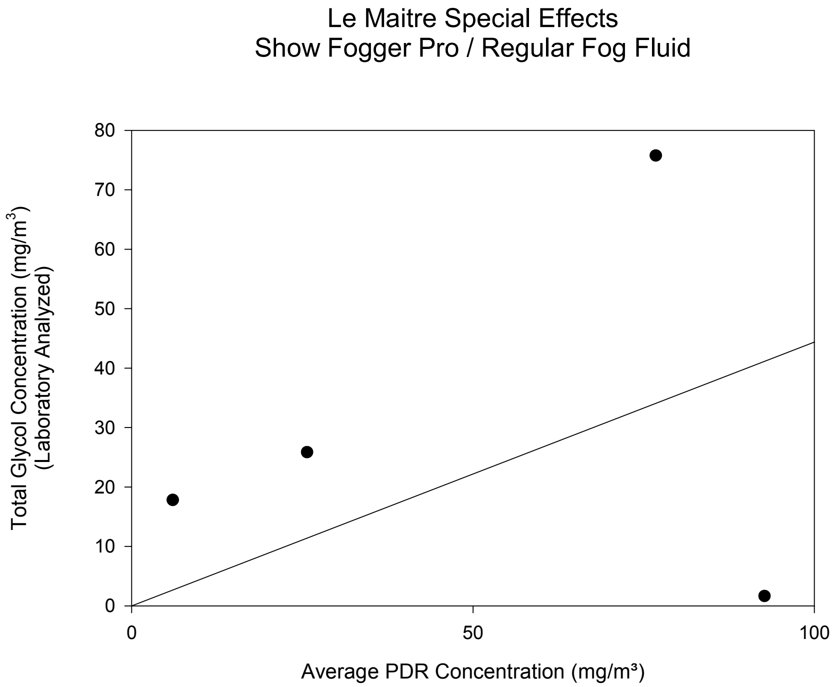


Figure 15. Calibration curve for Le Maitre Regular Fog Fluid in Show Fogger Pro. Calibration factor, based on slope of curve, is 0.444 (mg/m^3 glycols)/(mg/m^3 aerosol).

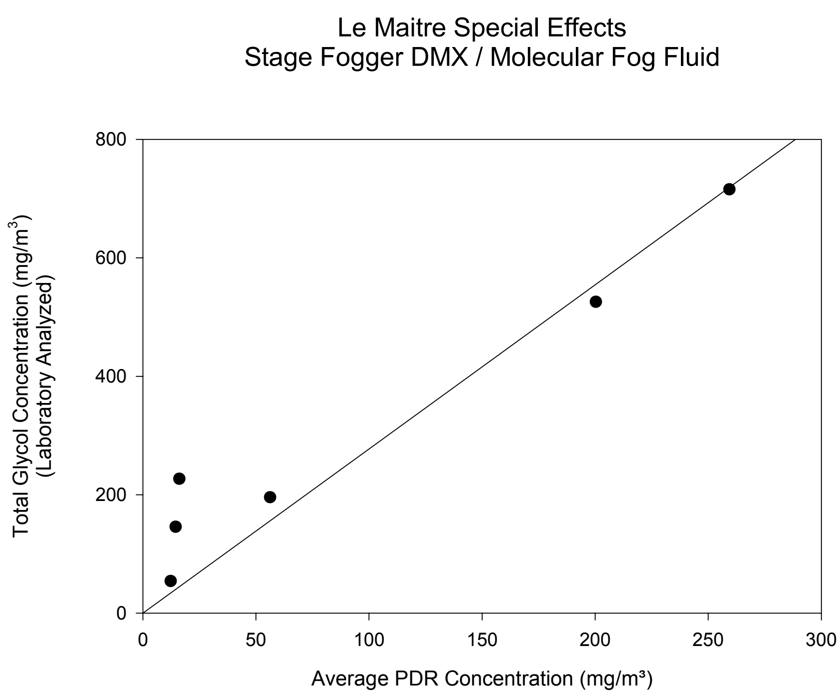


Figure 16. Calibration curve for Le Maitre Molecular Fog Fluid in Stage Fogger DMX. Calibration factor, based on slope of curve, is 2.77 (mg/m^3 glycols)/(mg/m^3 aerosol).

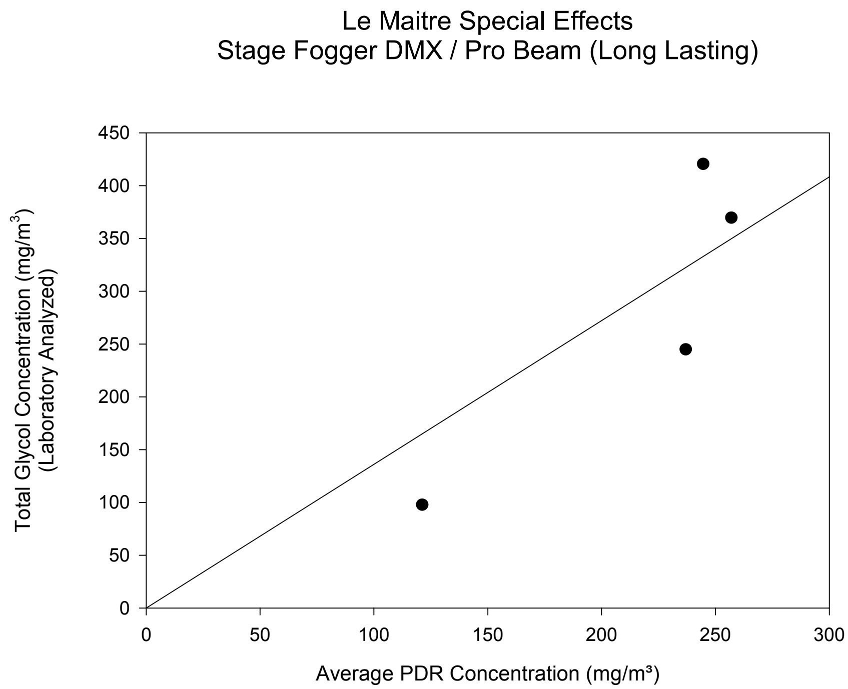


Figure 17. Calibration curve for Le Maitre Pro Beam (Long Lasting) Fluid in Stage Fogger DMX. Calibration factor, based on slope of curve, is 1.36 (mg/m^3 glycols)/(mg/m^3 aerosol).

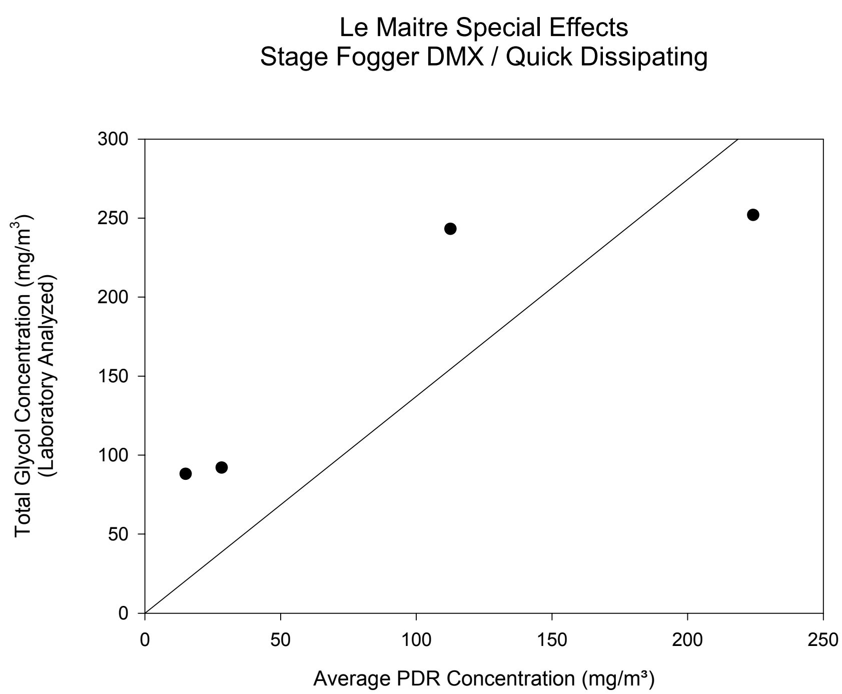


Figure 18. Calibration curve for Le Maitre Quick Dissipating Fog Fluid in Stage Fogger DMX. Calibration factor, based on slope of curve, is 1.37 (mg/m^3 glycols)/(mg/m^3 aerosol).

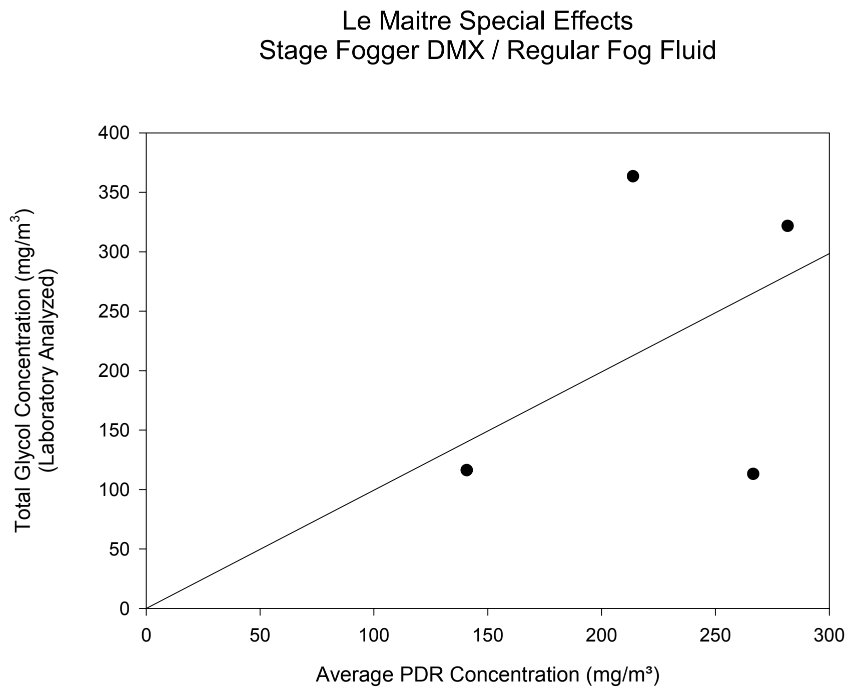


Figure 19. Calibration curve for Le Maitre Regular Fog Fluid in Stage Fogger DMX. Calibration factor, based on slope of curve, is 0.995 (mg/m^3 glycols)/(mg/m^3 aerosol).

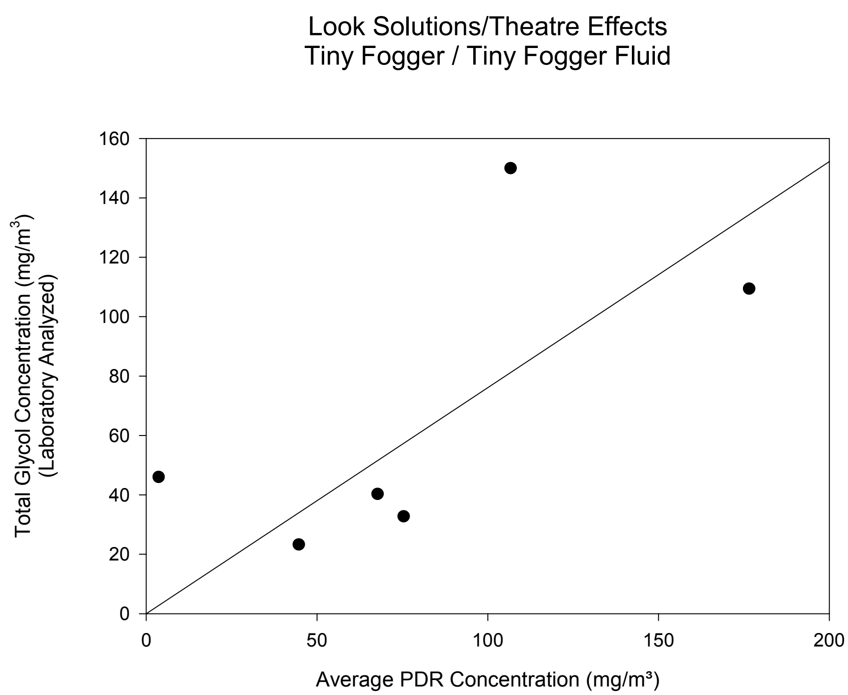


Figure 20. Calibration curve for Look Solutions/Theatre Effects Tiny Fogger Fluid in Tiny Fogger. Calibration factor, based on slope of curve, is 0.761 (mg/m^3 glycols)/(mg/m^3 aerosol).

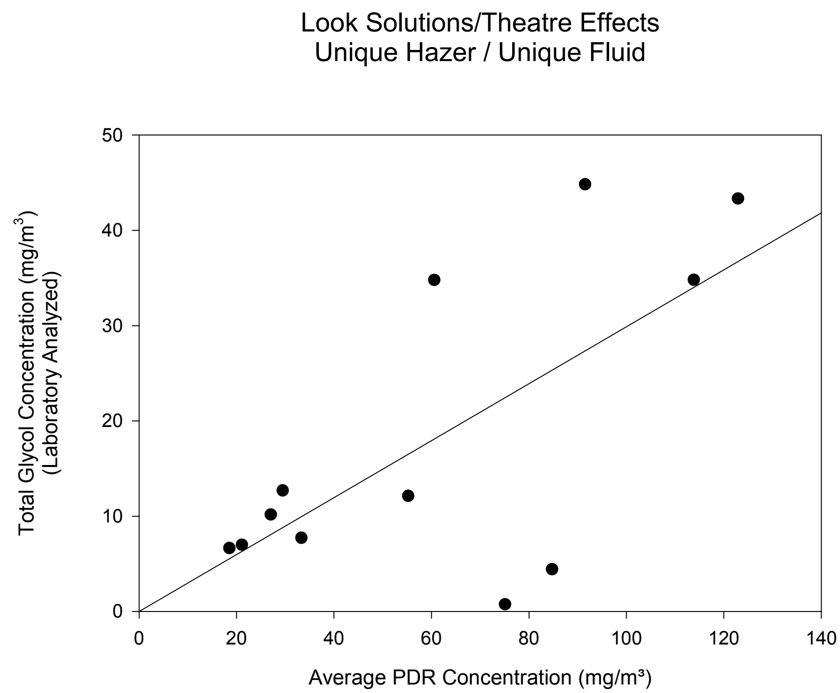


Figure 21. Calibration curve for Look Solutions/ Theatre Effects Unique Fluid in Unique Hazer. Calibration factor, based on slope of curve, is 0.299 (mg/m^3 glycols)/(mg/m^3 aerosol).

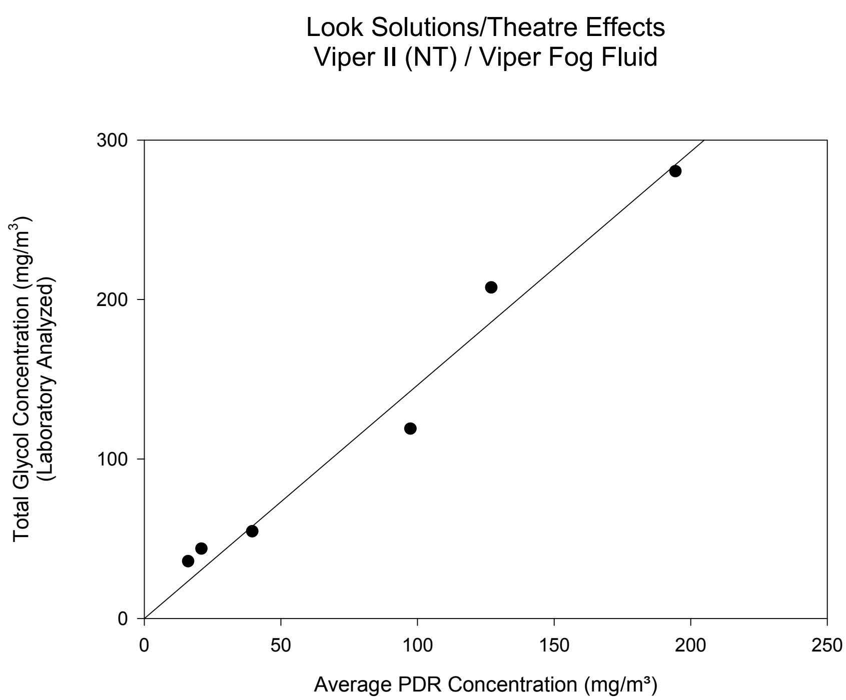


Figure 22. Calibration curve for Look Solutions/ Theatre Effects Viper Fluid in Viper II (NT). Calibration factor, based on slope of curve, is 1.46 (mg/m^3 glycols)/(mg/m^3 aerosol).

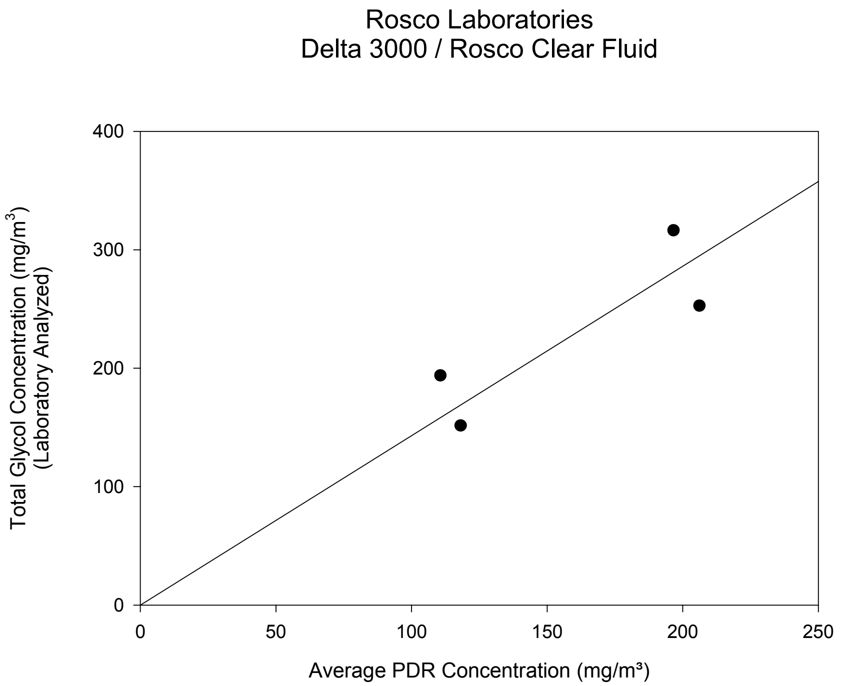


Figure 23. Calibration curve for Rosco Clear Fog Fluid in Delta 3000. Calibration factor, based on slope of curve, is 1.43 (mg/m^3 glycols)/(mg/m^3 aerosol).

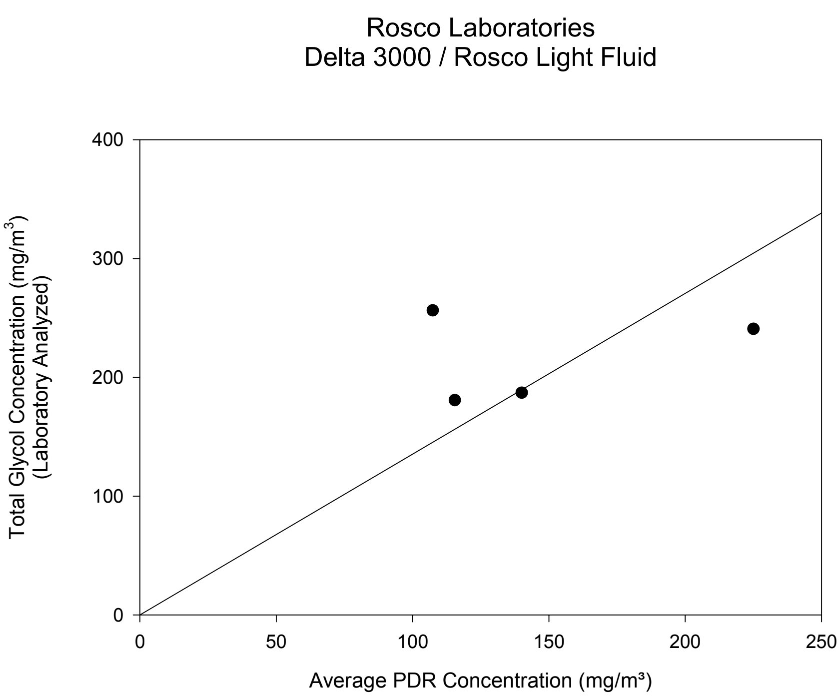


Figure 24. Calibration curve for Rosco Light Fog Fluid in Delta 3000. Calibration factor, based on slope of curve, is 1.35 (mg/m^3 glycols)/(mg/m^3 aerosol).

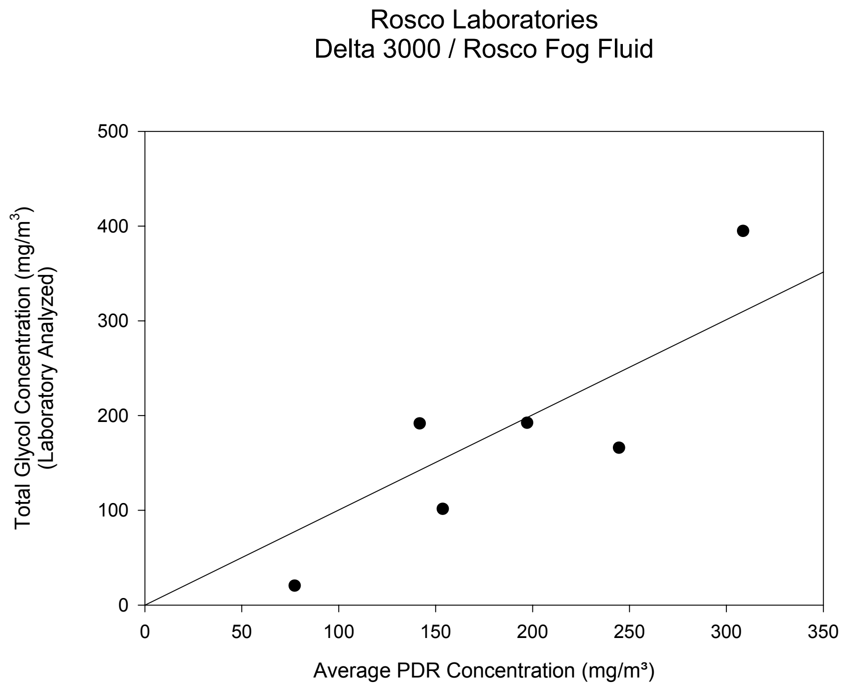


Figure 25. Calibration curve for Rosco Fog Fluid in Delta 3000. Calibration factor, based on slope of curve, is 1.00 (mg/m^3 glycols)/(mg/m^3 aerosol).

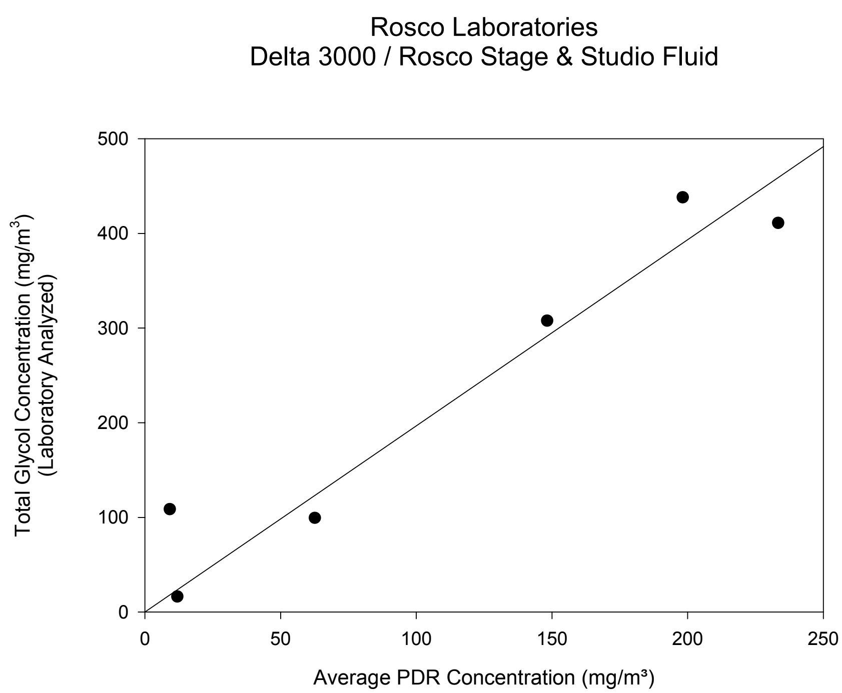


Figure 26. Calibration curve for Rosco Stage & Studio Fluid in Delta 3000. Calibration factor, based on slope of curve, is 1.97 (mg/m^3 glycols)/(mg/m^3 aerosol).

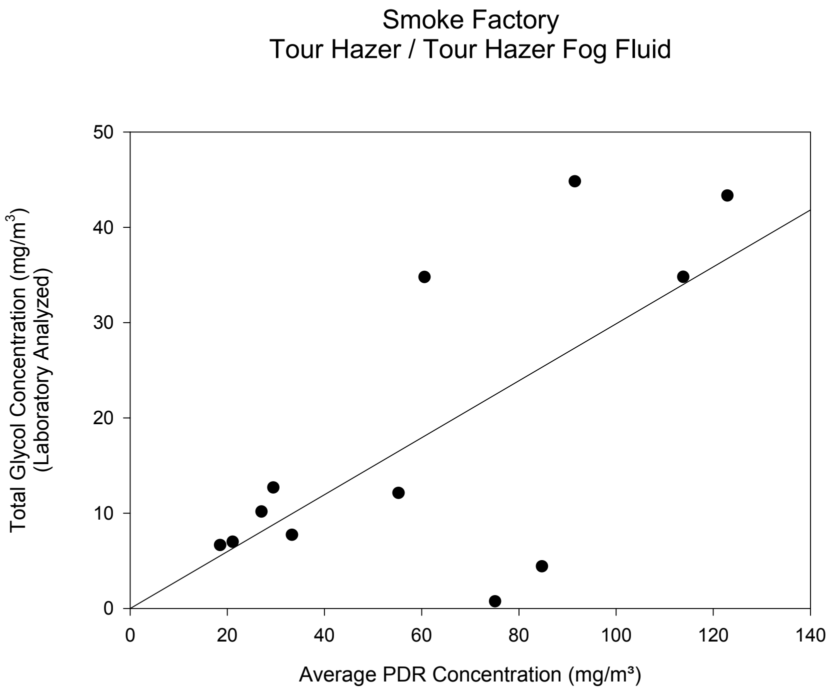


Figure 27. Calibration curve for Tour Hazer Fog Fluid in Smoke Factory Tour Hazer. Calibration factor, based on slope of curve, is 0.299 (mg/m^3 glycols)/(mg/m^3 aerosol).

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